TELEDYNE
ADVANCED POLLUTION INSTRUMENTATION
A Teledyne Technologies Company

OPERATOR'S MANUAL

MODEL 700E
DYNAMIC DILUTION CALIBRATOR

© TELEDYNE INSTRUMENTS
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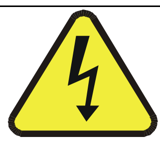
SAFETY MESSAGES

Your safety and the safety of others are very important. We have provided many important safety messages in this manual. Please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Each safety message is associated with a safety alert symbol. These symbols are found in the manual and inside the M700E Dynamic Dilution Calibrator. The definition of these symbols is described below:

	**GENERAL SAFETY HAZARD: Refer to the instructions for details on the specific hazard.**
	**CAUTION: Hot Surface Warning.**
	**CAUTION: Electrical Shock Hazard.**
	**TECHNICIAN SYMBOL: All operations marked with this symbol are to be performed by qualified maintenance personnel only.**

CAUTION

The M700E Dynamic Dilution Calibrator should only be used for the purpose and in the manner described in this manual. If you use the M700E in a manner other than that for which it was intended, unpredictable behavior could ensue with possible hazardous consequences.

NOTE

Technical Assistance regarding the use and maintenance of the M700E or any other Teledyne API products can be obtained by contacting:

Teledyne API's Customer Service Department at 800-324-5190

or

Via the internet at http://www.teledyne-api.com/

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GENERAL INFORMATION

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1. INTRODUCTION

1.1. MODEL 700E CALIBRATOR OVERVIEW

The Model 700E (M700E) is a microprocessor-based calibrator for precision gas calibrators. Using a combination of highly accurate mass flow controllers and compressed sources of standard gases, calibration standards are provided for multipoint span and zero checks. Up to four gas sources may be used.

The M700E can be equipped with an optional built-in, programmable ozone generator for accurate, dependable ozone calibrations. The M700E also produces NO_2 when blended with NO gas in the internal GPT chamber. A multi-point linearization curve is used to control the generator to assure repeatable ozone concentrations. An optional photometer allows precise control of the ozone generator, both during calibrations and during Gas Phase Titrations (GPT). To ensure accurate NO_2 output, the calibrator with photometer option measures the ozone concentration prior to doing a GPT.

As many as 50 independent calibration sequences may be programmed into the M700E, covering time periods of up to one year. The setup of sequences is simple and intuitive. These sequences may be actuated manually, automatically, or by a remote signal. The sequences may be uploaded remotely, including remote editing. All programs are maintained in non-volatile memory.

The M700E design emphasizes fast response, repeatability, overall accuracy and ease of operation. It may be combined with the M701 Zero Air Generator to provide the ultimate in easy to use, precise calibration for your gas calibrators.

Some of the exceptional features of your M700E Dynamic Dilution Calibrator are:

- Advanced E-Series electronics
- Lightweight for transportability
- Optional Ethernet connectivity
- Generates precise calibration gases for Ozone, NO, NO_2, CO, HC, H_2S, SO_2
- 12 independent timers for sequences
- Nested sequences (up to 5 levels)
- Software linearization of Mass Flow controllers
- 4 calibration gas ports configurable for single or multi-blend gases
- Glass GPT chamber
- Optional Ozone generator and photometer allows use as primary or transfer standard

1.2. USING THIS MANUAL

NOTE

Throughout this manual, words printed in capital, bold letters, such as SETUP or ENTR represent messages as they appear on the calibrator's display.

This manual is organized in the following manner:

TABLE OF CONTENTS:

Outlines the contents of the manual in the order the information are presented. This is a good overview of the topics covered in the manual. There is also a list of appendices, figures and tables. In the electronic version of the manual, clicking on any of these table entries automatically views that section.

SECTION I – GENERAL INFORMATION

INTRODUCTION
A brief description of the M700E calibrator architecture as well as a description of the layout of the manual and what information is located in its various sections and chapters.

SPECIFICATIONS AND WARRANTY
A list of the calibrator's performance specifications and if applicable a description of the conditions and configuration under which EPA equivalency was approved as well as the Teledyne API's warranty statement.

GETTING STARTED
Instructions for setting up, installing and running your calibrator for the first time.

GLOSSARY:
Answers to the most frequently asked questions about operating the calibrator and a glossary of acronyms and technical terms.

OPTIONAL HARDWARE & SOFTWARE
A description of optional equipment to add functionality to your calibrator.

SECTION II – OPERATING INSTRUCTIONS

USING THE M700E CALIBRATOR
Step-by-Step instructions for using the display/keyboard to set up and operate the M700E calibrator.

REMOTE OPERATION OF THE M700E CALIBRATOR
Information and instructions for interacting with the M700E calibrator via its several remote interface options (e.g. via RS-232, Ethernet, its built in digital control inputs/outputs, etc.)

M700E VALIDATION AND VERIFICATION
Methods and procedures for validating and verifying the correct operation of your M700E Dynamic Dilution Calibrator.

SECTION III – TECHNICAL INFORMATION

THEORY OF OPERATION
An in-depth look at the various principals by which your calibrator operates as well as a description of how the various electronic, mechanical and pneumatic components of the calibrator, work and interact with each other. A close reading of this section is invaluable for understanding the calibrator's operation.

MAINTENANCE SHEDULE AND PROCEDURES
Description of preventative maintenance procedures that should be regularly performed on your calibrator to assure good operating condition.

GENERAL TROUBLESHOOTING & REPAIR OF THE M700E CALIBRATOR
This section includes pointers and instructions for diagnosing problems with the calibrator and the Terminus as well as instructions on performing repairs on the Terminus.

A PRIMER ON ELECTRO-STATIC DISCHARGE
This section describes how static electricity occurs, why it is a significant concern and how to avoid it. This section also describes how to avoid allowing ESD to affect the reliable and accurate operation of your calibrator.

APPENDICES

For easier access and better updating, some information has been separated out of the manual and placed in a series of appendices at the end of this manual. These include version-specific software menu trees, warning messages, definitions Modbus registers and serial I/O variables as well as spare part listings, repair questionnaires, interconnect drawing, detailed pneumatic and electronic schematics.

USER NOTES:

USER NOTES:

2. SPECIFICATIONS, APPROVALS AND WARRANTY

2.1. SPECIFICATIONS

Table 2-1: M700E Dilution System Specifications

Flow Measurement Accuracy	±1.0% of Full Scale
Repeatability of Flow Control	±0.2% of Full Scale
Linearity of Flow Measurement	±0.5% of Full Scale
Flow Range of Diluent Air	0 to 10 SLPM – Optional Ranges: 0 to 5 SLPM; 0 to 20 SLPM
Flow Range of Cylinder Gases	0 to 100 cm^3/min – Optional Ranges: 0 to 50 cm^3/min; 0 to 200 cm^3/min
Zero Air Required	10 SLPM @ 30 PSIG Optional: 20 SLPM @ 30 PSIG
CAL gas input ports	4 (configurable)
Diluent Gas Input Ports	1
Response Time	60 Seconds (98%)

Table 2-2: M700E Dilution Electrical and Physical Specifications

Temperature Range	5-40ºC
Humidity Range	0 - 95% RH, non-condensing
Materials	Cal Gas Output Wetted Surfaces: PTFE. Cal Gas Output Manifold: Glass-coated Steel
Dimensions (HxWxD)	7" (178 mm) x 17" (432 mm) x 24" (609 mm)
Operating Altitude	10,000 ft Maximum
Weight	31 lbs (14.06 kg); 39.2 lbs (17.78 kg) including optional photometer, GPT, and 03 generator
AC Power	85VAC to 264VAC 47 Hz to 63Hz
Analog Outputs	1 user configurable output
Analog Output Ranges	0.1 V, 1 V, 5 V or 10 V Range with 5% under/over-range
Analog Output Resolution	1 part in 4096 of selected full-scale voltage (12 bit)
Digital Control Outputs	8 opto-isolated outputs
Digital Control Inputs	12 opto-isolated inputs
Status Outputs	8 opto-isolated outputs
Serial I/O	2 ports: 1x RS-232; 1x RS-485 or RS-232 (configurable) Communication speed: 300 - 115200 baud (user selectable)
Certifications	EN61326 (1997 w/A1: 98) Class A, FCC Part 15 Subpart B Section 15.107 Class A, ICES-003 Class A (ANSI C63.4 1992) & AS/NZS 3548 (w/A1 & A2; 97) Class A. IEC 61010-1:90 + A1:92 + A2:95,
Actual Power Draw	At 115V ~ Start up: 110 W, Steady State: 140 W At 230V ~ Start up: 159 W, Steady State: 148 W

Table 2-3: M700E Specifications for Optional Ozone Generator

Maximum Output	6 ppm LPM
Minimum Output	100 ppb LPM
Response Time:	180 Sec. (98%)
Optical Feedback	Standard
Stability (24 hours)	1% of Reading or 1 ppb, whichever is greater (Photometer Feedback Mode)

Table 2-4: M700E Specifications for Optional O_3 Photometer

Full Scale Range	100 ppb to 10 ppm ; User Selectable
Precision	1.0 ppb
Linearity	±1.0% Full Scale
Rise/Fall Time	<20 sec (photometer response)
Response Time (95%)	180 sec. (system response)
Zero Drift	<1.0 ppb / 7 days
Span Drift	<1% / 24 hours; <2% / 7 days
Minimum Gas Flow Required	800 cc^3/min

2.2. CE MARK COMPLIANCE

EMISSIONS COMPLIANCE

Teledyne API's M700E Dynamic Dilution Calibrator is designed to be fully compliant with:

EN61326 (1997 w/A1: 98) Class A, FCC Part 15 Subpart B Section 15.107 Class A, ICES-003 Class A (ANSI C63.4 1992) & AS/NZS 3548 (w/A1 & A2; 97) Class A.

Tested on 9-29-06 at CKC Laboratories, Inc., Report Number CE06-161

SAFETY COMPLIANCE

Teledyne API's M700E Dynamic Dilution Calibrator is designed to be fully compliant with:

IEC 61010-1:90 + A1:92 + A2:95,

Tested on 10-24-06 at CKC Laboratories, Inc., Report Number SAF06-014

2.3. WARRANTY

WARRANTY POLICY (02024D)

Prior to shipment, Teledyne API equipment is thoroughly inspected and tested. Should equipment failure occur, Teledyne API assures its customers that prompt service and support will be available.

COVERAGE

After the warranty period and throughout the equipment lifetime, Teledyne API stands ready to provide on-site or in-plant service at reasonable rates similar to those of other manufacturers in the industry. All maintenance and the first level of field troubleshooting is to be performed by the customer.

NON-API MANUFACTURED EQUIPMENT

Equipment provided but not manufactured by Teledyne API is warranted and will be repaired to the extent and according to the current terms and conditions of the respective equipment manufacturers warranty.

GENERAL

During the warranty period, Teledyne API warrants each Product manufactured by Teledyne API to be free from defects in material and workmanship under normal use and service. Expendable parts are excluded.

If a Product fails to conform to its specifications within the warranty period, API shall correct such defect by, in API's discretion, repairing or replacing such defective Product or refunding the purchase price of such Product.

The warranties set forth in this section shall be of no force or effect with respect to any Product: (i) that has been altered or subjected to misuse, negligence or accident, or (ii) that has been used in any manner other than in accordance with the instruction provided by Teledyne API, or (iii) not properly maintained.

THE WARRANTIES SET FORTH IN THIS SECTION AND THE REMEDIES THEREFORE ARE EXCLUSIVE AND IN LIEU OF ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY, WHETHER EXPRESSED OR IMPLIED. THE REMEDIES SET FORTH IN THIS SECTION ARE THE EXCLUSIVE REMEDIES FOR BREACH OF ANY WARRANTY CONTAINED HEREIN. API SHALL NOT BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR RELATED TO THIS AGREEMENT OF TELEDYNE API'S PERFORMANCE HEREUNDER, WHETHER FOR BREACH OF WARRANTY OR OTHERWISE

TERMS AND CONDITIONS

All units or components returned to Teledyne API should be properly packed for handling and returned freight prepaid to the nearest designated Service Center. After the repair, the equipment will be returned, freight prepaid.

USER NOTES:

USER NOTES:

3. GETTING STARTED

3.1. UNPACKING AND INITIAL SETUP

CAUTION

THE M700E WEIGHS ABOUT 17 KG (40 POUNDS) WITHOUT OPTIONS INSTALLED. TO AVOID PERSONAL INJURY, WE RECOMMEND USING TWO PERSONS TO LIFT AND CARRY THE CALIBRATOR.

1. Inspect the received packages for external shipping damage. If damaged, please advise the shipper first, then Teledyne API.

2. Included with your calibrator is a printed record of the final performance characterization performed on your instrument at the factory. This record, titled Final Test and Validation Data Sheet (P/N 05731) is an important quality assurance and calibration record for this instrument. It should be placed in the quality records file for this instrument.

3. Carefully remove the top cover of the calibrator and check for internal shipping damage.

   - Remove the locking screw located in the top, center of the Front panel.
   - Remove the two screws fastening the top cover to the unit (one per side towards the rear).
   - Slide the cover backwards until it clears the calibrator's front bezel.
   - Lift the cover straight up.

NOTE

Printed Circuit Assemblies (PCAs) are sensitive to Electro-Static Discharges (ESD) too small to be felt by the human nervous system. Failure to use ESD protection when working with electronic assemblies will void the instrument warranty.

See Chapter 12 for more information on preventing ESD damage.

CAUTION

NEVER DISCONNECT ELECTRONIC CIRCUIT BOARDS, WIRING HARNESSES OR ELECTRONIC SUBASSEMBLIES WHILE THE UNIT IS UNDER POWER.

4. Inspect the interior of the instrument to ensure all circuit boards and other components are in good shape and properly seated.

5. Check the connectors of the various internal wiring harnesses and pneumatic hoses to ensure they are firmly and properly seated.

6. Verify that all of the optional hardware ordered with the unit has been installed. These are checked on the paperwork accompanying the calibrator.

VENTILATION CLEARANCE: Whether the calibrator is set up on a bench or installed into an instrument rack, be sure to leave sufficient ventilation clearance.

AREA	MINIMUM REQUIRED CLEARANCE
Back of the instrument	10 cm / 4 inches
Sides of the instrument	2.5 cm / 1 inch
Above and below the instrument.	2.5 cm / 1 inch

Various rack mount kits are available for this calibrator. See Chapter 5 of this manual for more information.

3.1.1. M700E CALIBRATOR

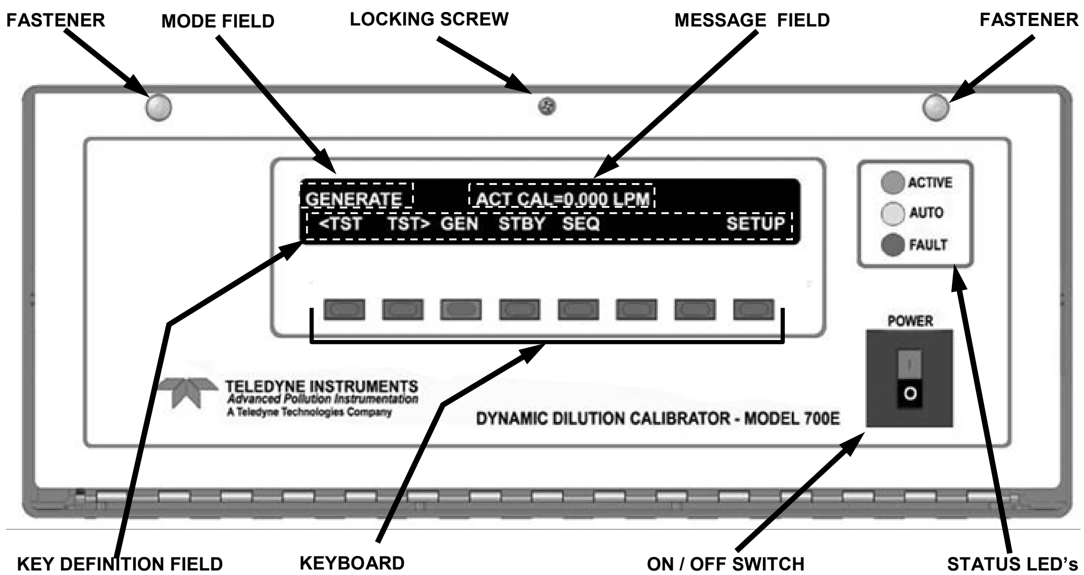


Figure 3-1: M700E Front Panel Layout

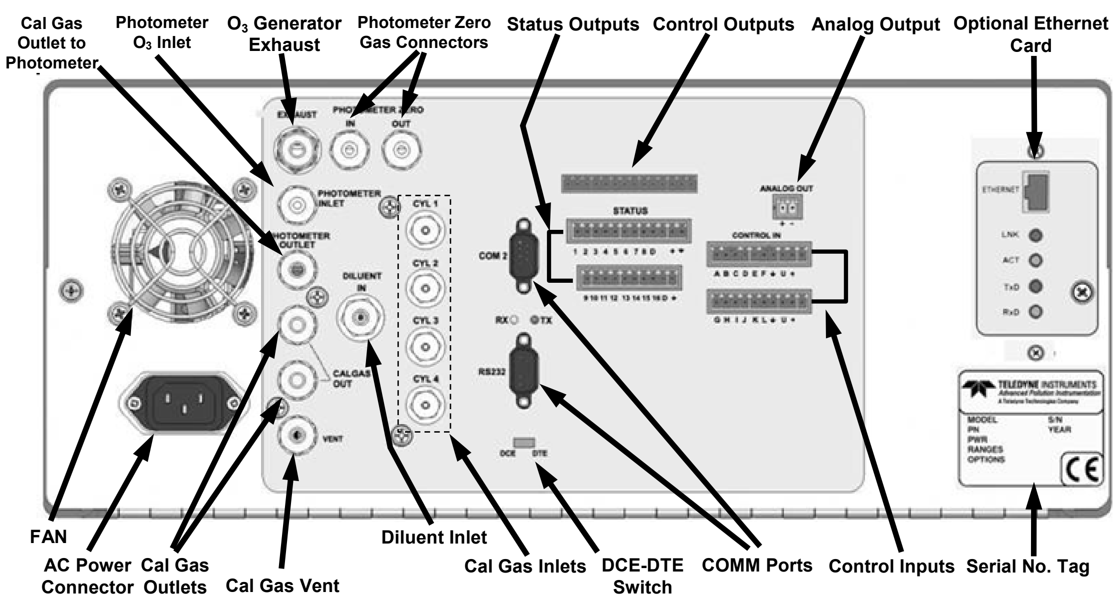


Figure 3-2: M700E Rear Panel Layout

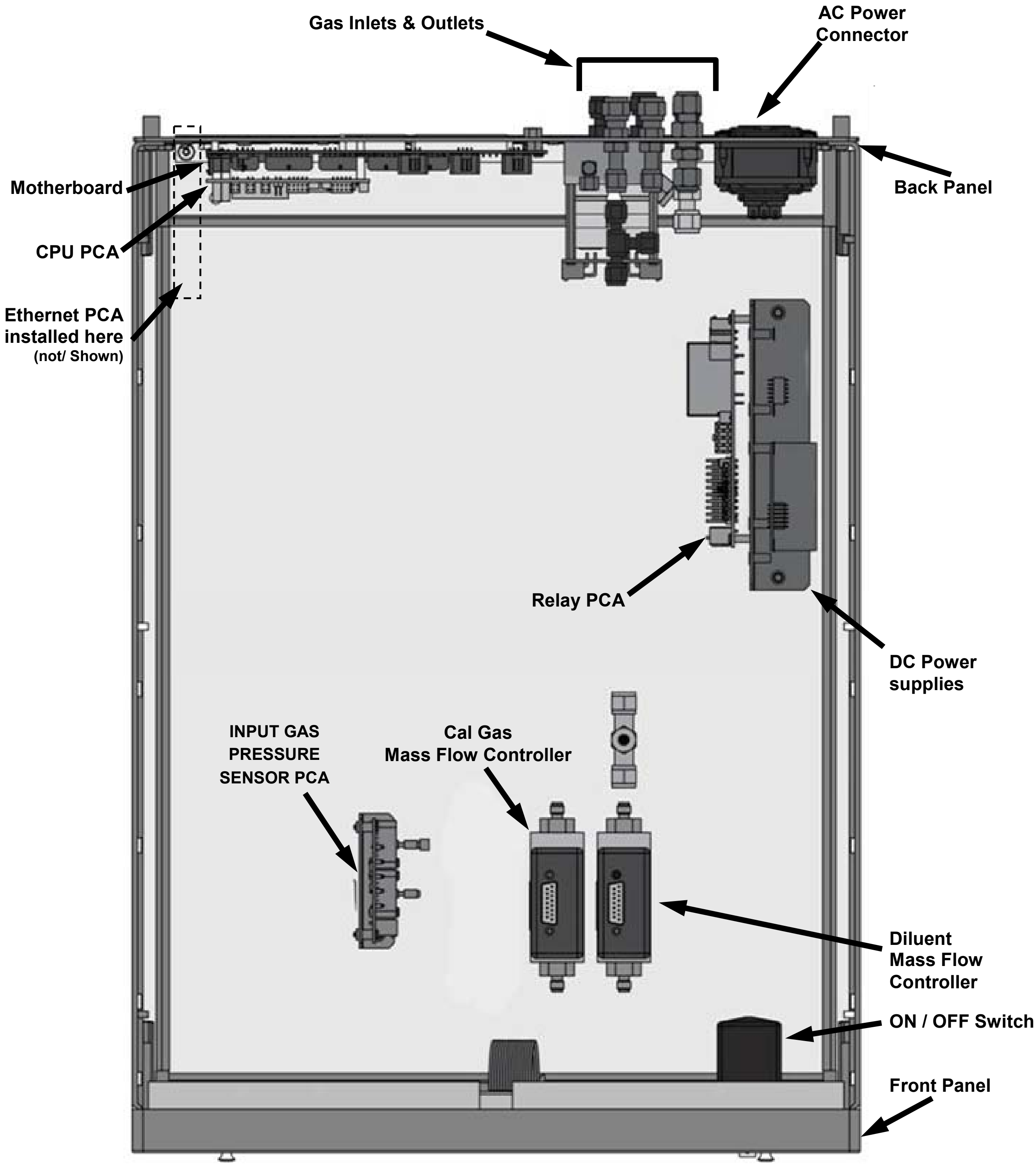


Figure 3-3: M700E Internal Layout – Top View – Base Unit

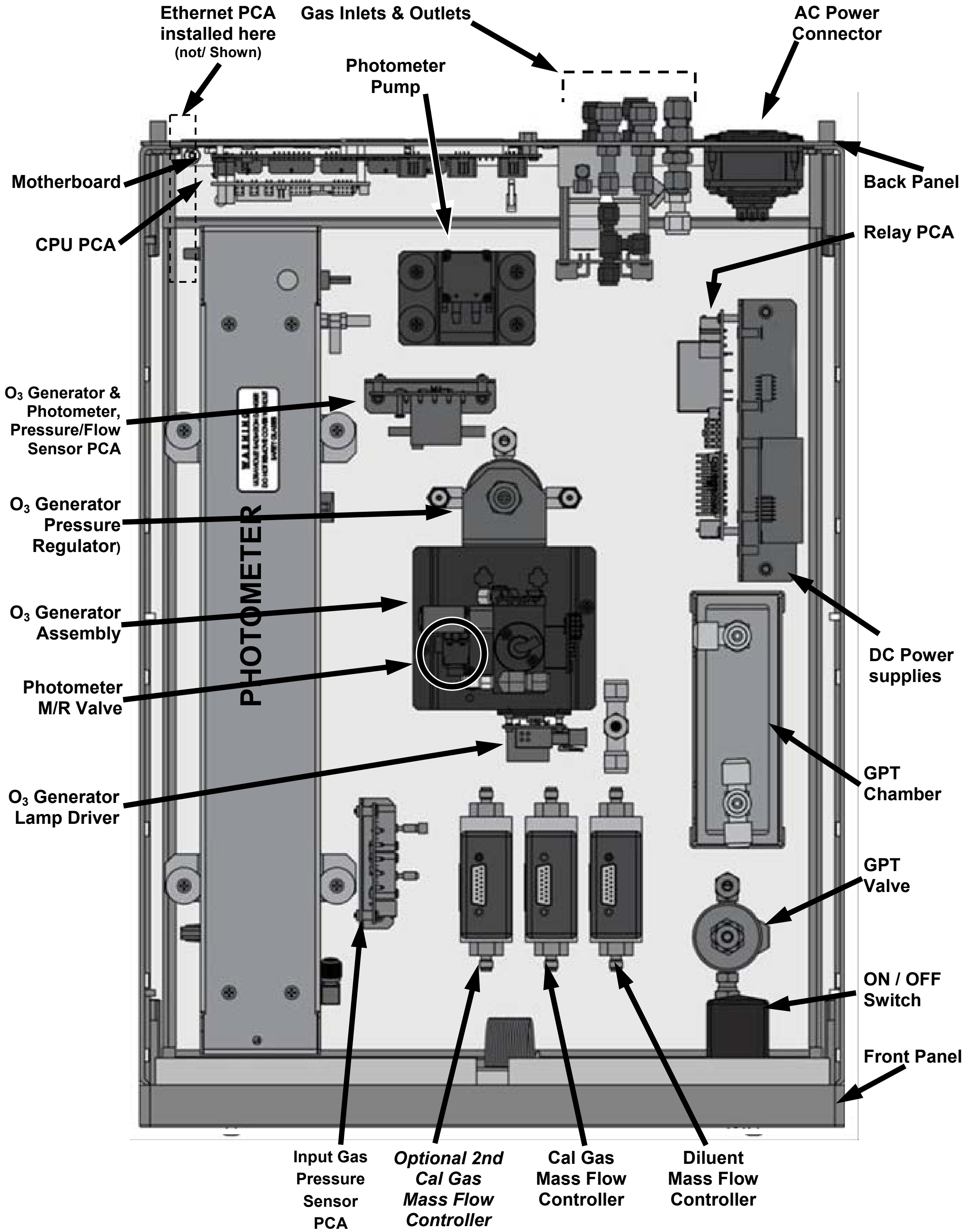


Figure 3-4: M700E Internal Layout – Top View – with Optional O_3 Generator and Photometer

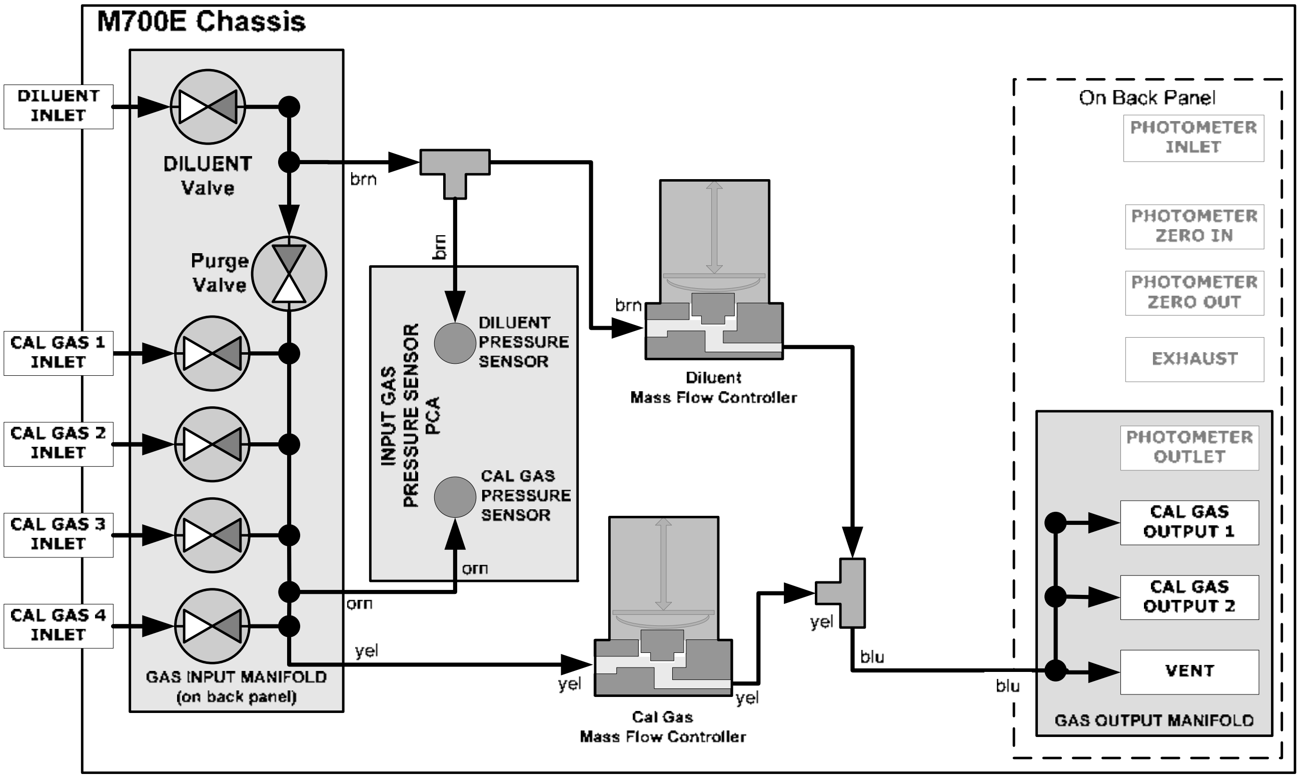


Figure 3-5: M700E Pneumatic Diagram – Base Unit

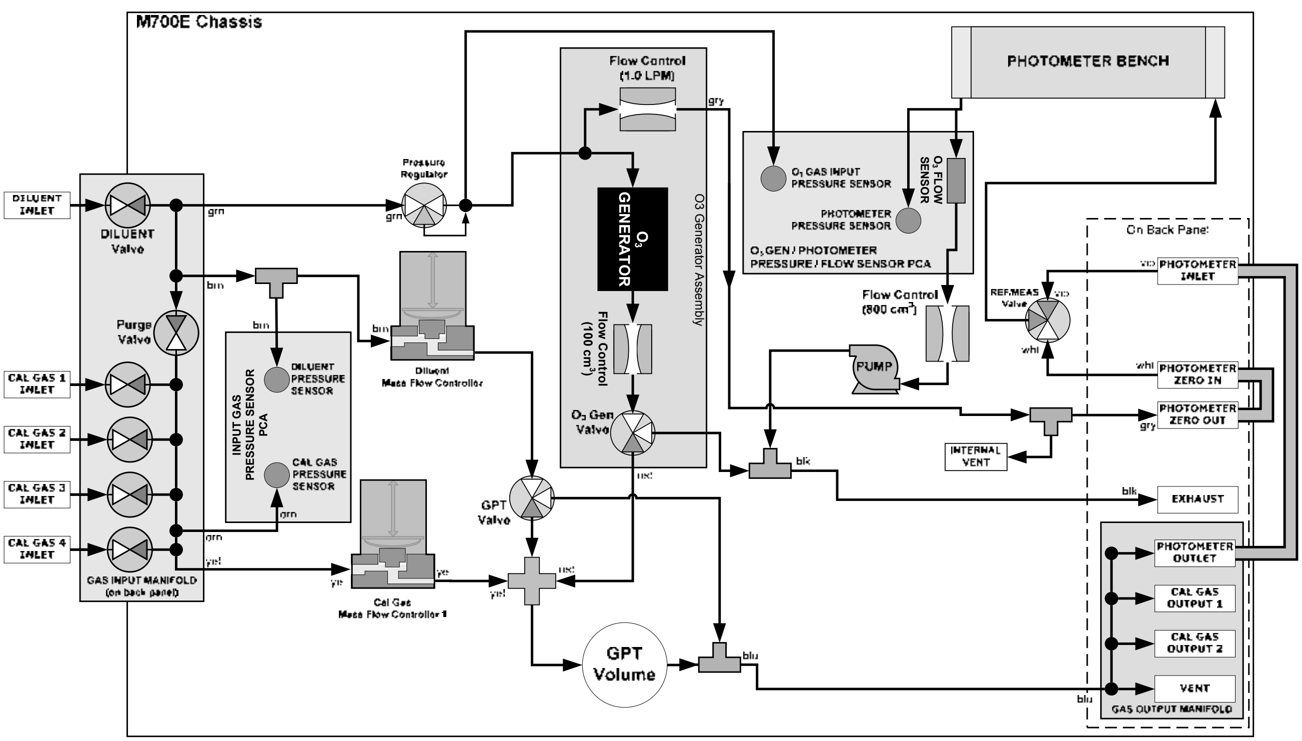


Figure 3-6: M700E Pneumatic Diagram – with O_3 Generator and Photometer

3.1.2. ELECTRICAL CONNECTIONS

3.1.2.1. Power Connection

Attach the power cord to the calibrator and plug it into a power outlet capable of carrying at least 10 A current at your AC voltage and that it is equipped with a functioning earth ground.

CAUTION

HIGH VOLTAGES ARE PRESENT INSIDE THE CALIBRATORS CASE.

POWER CONNECTION MUST HAVE FUNCTIONING GROUND CONNECTION.

DO NOT DEFEAT THE GROUND WIRE ON POWER PLUG.

TURN OFF CALIBRATOR POWER BEFORE DISCONNECTING OR CONNECTING ELECTRICAL SUBASSEMBLIES.

DO NOT OPERATE WITH COVER OFF.

CAUTION

DO NOT LOOK AT THE PHOTOMETER UV LAMP.

UV LIGHT CAN CAUSE EYE DAMAGE.

ALWAYS WEAR GLASSES MADE FROM SAFETY UV FILTERRING GLASS (PLASTIC GLASSES WILL NOT DO).

NOTE

The M700E calibrator is equipped with a universal power supply that allows it to accept any AC power configuration, within the limits specified in Table 2-2.

3.1.2.2. Analog Output Connections

The M700E is equipped with an analog output channel accessible through a connector on the back panel of the instrument. The standard configuration for this output is mVDC. It can be set by the user to output one of a variety of diagnostic test functions (see Section 6.9.1.2).

To access these signals attach a strip chart recorder and/or data-logger to the appropriate analog output connections on the rear panel of the calibrator.

Pin-outs for the analog output connector at the rear panel of the instrument are:

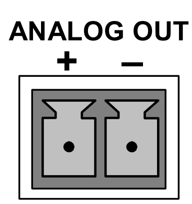


Figure 3-7: M700E Analog Output Connector

3.1.2.3. Connecting the Status Outputs

The status outputs report calibrator conditions via optically isolated NPN transistors, which sink up to 50 mA of DC current. These outputs can be used interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (PLCs). Each Status bit is an open collector output that can withstand up to 40 VDC. All of the emitters of these transistors are tied together and available at D.

NOTE

Most PLC's have internal provisions for limiting the current that the input will draw from an external device. When connecting to a unit that does not have this feature, an external dropping resistor must be used to limit the current through the transistor output to less than 50 mA. At 50 mA, the transistor will drop approximately 1.2V from its collector to emitter.

The status outputs are accessed via a 12-pin connector on the calibrator's rear panel labeled STATUS. The function of each pin is defined in Table 3-1.

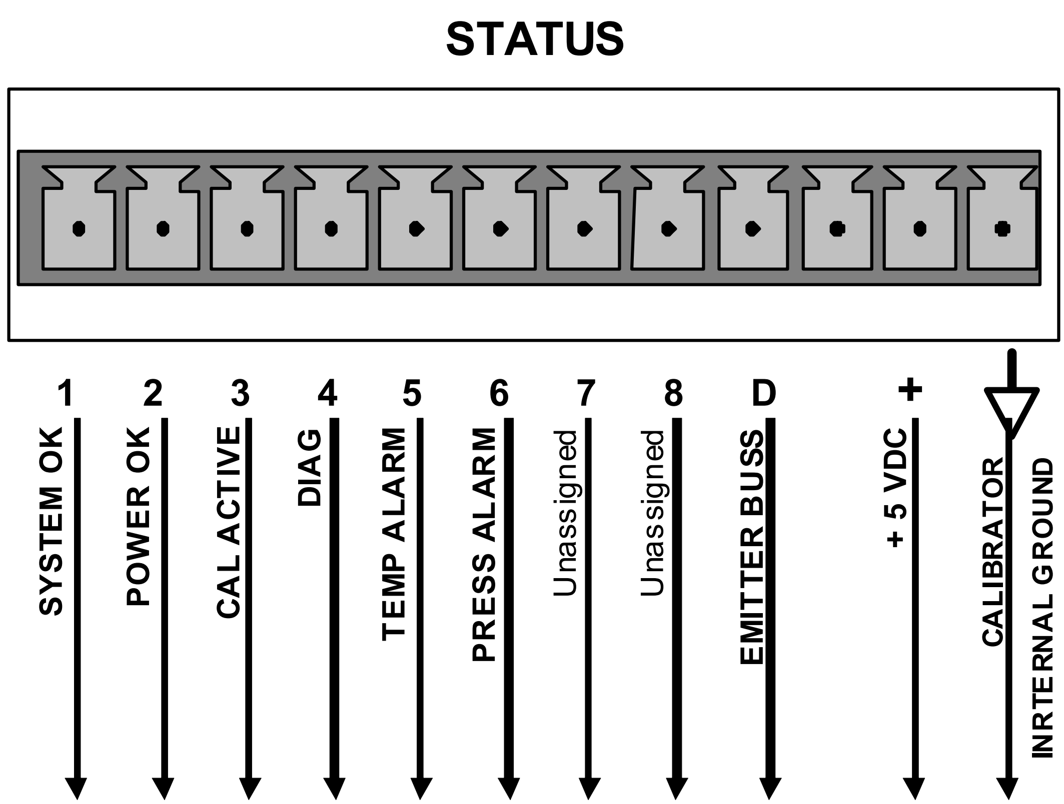


Figure 3-8: Status Output Connector

The pin assignments for the Status Outputs are:

Table 3-1: Status Output Pin Assignments

OUTPUT #	STATUS DEFINITION	CONDITION
1	**SYSTEM OK**	On if no faults are present.
2	POWER OK	On if no faults are present.
3	**CAL ACTIVE**	On if the calibrator is in **GENERATE** mode.
4	**DIAG**	On if the calibrator is in **DIAGNOSTIC** mode.
5	**TEMP ALARM**	On whenever a temperature alarm is active.
6	**PRESS ALARM**	On whenever gas pressure alarm is active.
7 & 8	Unassigned	
D	Emitter BUS	The emitters of the transistors on pins 1 to 8 are bussed together.
⏚	Digital Ground	The ground level from the calibrator's internal DC power supplies.
D	Emitter BUS	The emitters of the transistors on pins 9 to 16 are bussed together.
+	DC POWER	+ 5 VDC

3.1.2.4. Connecting the Control Inputs

The calibrator is equipped with 12 digital control inputs that can be used to Initiate various user programmable calibration sequences (see Section 6.5.1.5 for instructions on assigning the control inputs to specific calibration sequences).

Access to these inputs is via two separate 10-pin connectors, labeled CONTROL IN, that are located on the calibrator's rear panel.

Table 3-2: M700E Control Input Pin Assignments

CONNECTOR	INPUT	DESCRIPTION
Top	**1 to 6**	Can be used as either 6, separate on/off switches or as bits 1 through 6 of a 12-bit wide binary activation code.
Bottom	**7 to 12**	Can be used as either 6, separate on/off switches or as bits 7 through 12 of a 12-bit wide binary activation code.
BOTH	⏚	Chassis ground.
Top	**U**	Input pin for +5 VDC required to activate pins A – F. This can be from an external source or from the "+" pin of the connector.
Bottom	**U**	Input pin for +5 VDC required to activate pins G – L. This can be from an external source or from the "+" pin of the connector.
BOTH	**+**	Internal source of +5V used to actuate control inputs when connected to the U pin.

There are two methods for energizing the control inputs. The internal +5V available from the pin labeled "+" is the most convenient method. However, if full isolation is required, an external 5 VDC power supply should be used.

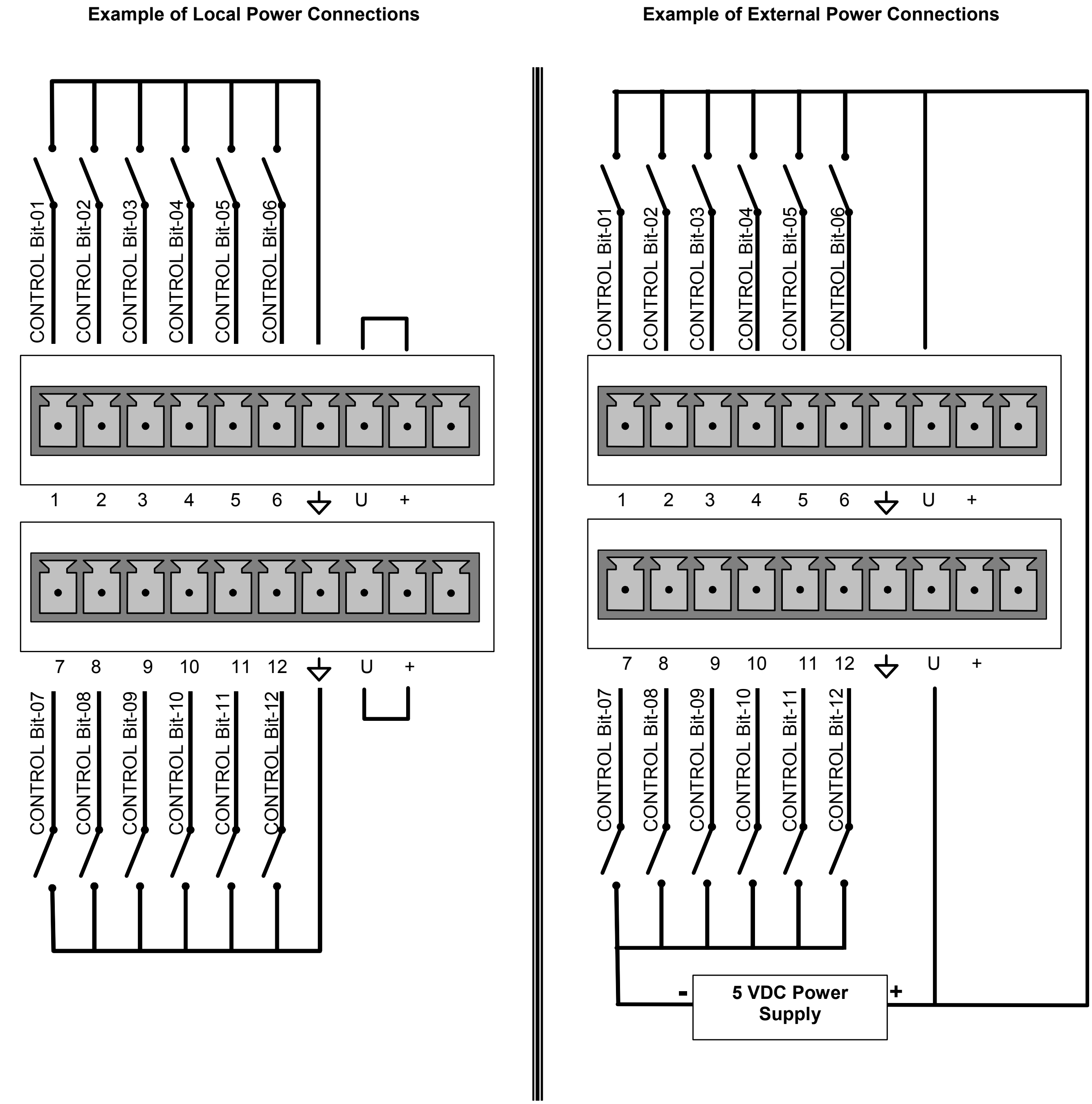


Figure 3-9: M700E Digital Control Input Connectors

3.1.2.5. Connecting the Control Outputs

The calibrator is equipped with 12 opto-isolated, digital control outputs. These outputs are activated by the M700E's user-programmable; calibration sequences (see Sections 6.5.1.6 and 6.5.2.8 for instructions on assigning the control inputs to specific calibration sequences)

These outputs may be used to interface with devices that accept logic-level digital inputs, such as Programmable Logic Controllers (PLC's), dataloggers, or digital relays/valve drivers.

They are accessed via a 14-pin connector on the calibrator's rear panel (see Figure 3-2).

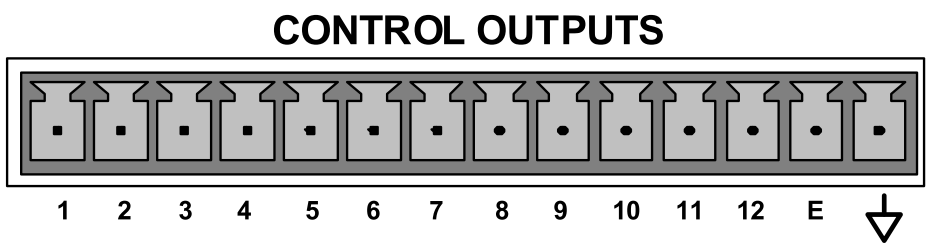


Figure 3-10: M700E Digital Control Output Connector

> **NOTE**
>
> **Most PLC's have internal provisions for limiting the current the input will draw. When connecting to a unit that does not have this feature, external resistors must be used to limit the current through the individual transistor outputs to ≤50mA (120 Ω for 5V supply).**

The pin assignments for the control outputs are:

Table 3-3: M700E Control Input Pin Assignments

PIN #	STATUS DEFINITION	CONDITION
1 - 12	Outputs 1 through 12 respectively	Closed if the sequence or sequence step activating output is operating
E	Emitter BUS	The emitters of the transistors on pins 1 to 8 are bussed together.
⏚	Digital Ground	The ground level from the calibrator's internal DC power supplies.

3.1.2.6. Connecting the Serial Ports

If you wish to utilize either of the calibrator's two serial interface COMM ports, refer to Chapter 7 of this manual for instructions on their configuration and usage.

3.1.2.7. Connecting to a LAN or the Internet

If your unit has a Teledyne API's Ethernet card (Option 63), plug one end into the 7' CAT5 cable supplied with the option into the appropriate place on the back of the calibrator and the other end into any nearby Ethernet access port.

NOTE

The M700E firmware supports dynamic IP addressing or DHCP.

If your network also supports DHCP, the calibrator will automatically configure its LAN connection appropriately,

If your network does not support DHCP, see Section 7.4 for instructions on manually configuring the LAN connection.

3.1.2.8. Connecting to a Multi-drop Network

If your unit has a Teledyne API's RS-232 multi-drop card (Option 62), see Section 7.2.1 for instructions on setting it up.

3.2. PNENUMATIC CONNECTIONS

3.2.1. ABOUT DILUENT GAS (ZERO AIR)

Zero Air is similar in chemical composition to the Earth's atmosphere but scrubbed of all components that might affect the calibrator's readings.

- Diluent Air should be dry (approximately -20ºC of Dew Point).
- Diluent Air should be supplied at a gas pressure of between 25 PSI and 35 PSI with a flow greater than the flow rate for the calibrator. For the standard unit this means greater than 10 SLPM.
  - For calibrator's with the 20 LPM diluent flow option (OPT) the diluent air should be supplied at a gas pressure of between 30 PSI and 35 PSI.
- M700E calibrator's with optional O_3 generators installed require that the zero air source supply gas flowing at a continuous rate of at least 100 cm^3/min.
  - If the calibrator is also equipped with an internal photometer, the zero air source supply gas must be capable of a continuous rate of flow of at least 1.1 LPM.

Zero Air can be purchased in pressurized canisters or created using a Teledyne API's Model 701 Zero Air Generator.

3.2.2. ABOUT CALIBRATION GAS

Calibration gas is a gas specifically mixed to match the chemical composition of the type of gas being measured at near full scale of the desired measurement range. Usually it is a single gas type mixed with N_2 although bottles containing multiple mixtures of compatible gases are also available (e.g. H_2S, O_2 and CO mixed with N_2).

- Calibration gas should be supplied at a pressure of between 25 PSI and 35 PSI with a flow greater than the flow rate for the calibrator.

3.2.2.1. NIST Traceable Calibration Gas Standards

All calibration gases should be verified against standards of the National Institute for Standards and Technology (NIST). To ensure NIST traceability, we recommend acquiring cylinders of working gas that are certified to be traceable to NIST Standard Reference Materials (SRM). These are available from a variety of commercial sources.

The following tables lists some of the most common NIST Primary gas standards

Table 3-4: NIST Standards for CO_2

SRM	Description	Nominal Amount of Substance
1676	Carbon Dioxide in Air	365 ppm
1674b	Carbon Dioxide in Nitrogen	7 %
1675b	Carbon Dioxide in Nitrogen	14 %
2619a	Carbon Dioxide in Nitrogen	0.5 %
2620a	Carbon Dioxide in Nitrogen	1.0 %
2621a	Carbon Dioxide in Nitrogen	1.5 %
2622a	Carbon Dioxide in Nitrogen	2.0 %
2623a	Carbon Dioxide in Nitrogen	2.5 %
2624a	Carbon Dioxide in Nitrogen	3.0 %
2625a	Carbon Dioxide in Nitrogen	3.5 %
2626a	Carbon Dioxide in Nitrogen	4.0 %
2745	Carbon Dioxide in Nitrogen	16 %

Table 3-5: NIST Standards for CO

SRM	Description	Nominal Amount of Substance
2612a	Carbon Monoxide in Air	10 ppm
2613a	Carbon Monoxide in Air	20 ppm
2614a	Carbon Monoxide in Air	42 ppm
1677c	Carbon Monoxide in Nitrogen	10 ppm
1678c	Carbon Monoxide in Nitrogen	50 ppm
1679c	Carbon Monoxide in Nitrogen	100 ppm
1680b	Carbon Monoxide in Nitrogen	500 ppm
1681b	Carbon Monoxide in Nitrogen	1000 ppm
2635a	Carbon Monoxide in Nitrogen	25 ppm
2636a	Carbon Monoxide in Nitrogen	250 ppm
2637a	Carbon Monoxide in Nitrogen	2500 ppm
2638a	Carbon Monoxide in Nitrogen	5000 ppm
2639a	Carbon Monoxide in Nitrogen	1 %
2640a	Carbon Monoxide in Nitrogen	2 %
2641a	Carbon Monoxide in Nitrogen	4 %
2642a	Carbon Monoxide in Nitrogen	8 %
2740a	Carbon Monoxide in Nitrogen	10 %
2741a	Carbon Monoxide in Nitrogen	13 %

Table 3-6: NIST Standards for H_2S

SRM	Description	Nominal Amount of Substance
2730	Hydrogen Sulfide in Nitrogen	5 ppm
2731	Hydrogen Sulfide in Nitrogen	20 ppm

Table 3-7: NIST Standards for CH_4

SRM	Description	Nominal Amount of Substance
1658a	Methane in Air	1 ppm
1659a	Methane in Air	10 ppm
2750	Methane in Air	50 ppm
2751	Methane in Air	100 ppm
1660a	Methane-Propane in Air	4 : 1

Table 3-8: NIST Standards for O_2

SRM	Description	Nominal Amount of Substance
2657a	Oxygen in Nitrogen	2 %
2658a	Oxygen in Nitrogen	10 %
2659a	Oxygen in Nitrogen	21 %

Table 3-9: NIST Standards for SO_2

SRM	Description	Nominal Amount of substance
1661a	Sulfur Dioxide in Nitrogen	500
1662a	Sulfur Dioxide in Nitrogen	1000 ppm
1663a	Sulfur Dioxide in Nitrogen	1500 ppm
1664a	Sulfur Dioxide in Nitrogen	2500 ppm
1693a	Sulfur Dioxide in Nitrogen	50 ppm
1694a	Sulfur Dioxide in Nitrogen	100 ppm
1696a	Sulfur Dioxide in Nitrogen	3500 ppm

Table 3-10: NIST Standards for NO

SRM	Description	Nominal Amount of Substance
1683b	Nitric Oxide in Nitrogen	50 ppm
1684b	Nitric Oxide in Nitrogen	100 ppm
1685b	Nitric Oxide in Nitrogen	250 ppm
1686b	Nitric Oxide in Nitrogen	500 ppm
1687b	Nitric Oxide in Nitrogen	1000 ppm
2627a	Nitric Oxide in Nitrogen	5 ppm
2628a	Nitric Oxide in Nitrogen	10 ppm
2629a	Nitric Oxide in Nitrogen	20 ppm
2630	Nitric Oxide in Nitrogen	1500 ppm
2631a	Nitric Oxide in Nitrogen	3000 ppm
2735	Nitric Oxide in Nitrogen	800 ppm
2736a	Nitric Oxide in Nitrogen	2000 ppm
2737	Nitric Oxide in Nitrogen	500 ppm
2738	Nitric Oxide in Nitrogen	1000 ppm

Table 3-11: NIST Standards for Propane (C_3H_8)

SRM	Description	Nominal Amount of Substance
1665b	Propane in Air	3 ppm
1666b	Propane in Air	10 ppm
1667b	Propane in Air	50 ppm
1668b	Propane in Air	100 ppm
1669b	Propane in Air	500 ppm
2764	Propane in Air	0.25 ppm
2644a	Propane in Nitrogen	250 ppm
2646a	Propane in Nitrogen	1000 ppm
2647a	Propane in Nitrogen	2500 ppm
2648a	Propane in Nitrogen	5000 ppm

3.2.2.2. Minimum Calibration Gas Source Concentration

Determining minimum Cal Gas Concentration to determine the minimum concentration of a calibration gas required by your system:

1. Determine the Total Flow required by your system by adding the gas flow requirement of each of the analyzers in the system.
2. Multiply this by 1.5.
3. Decide on a Calibration Gas flow rate.
4. Determine the Calibration Gas ratio by divide the Total Flow by the Calibration Gas Flow Rate.
5. Multiply the desired target calibration gas concentration by the result from step 4.

EXAMPLE: Your system has two analyzers each requiring 2SLPM of cal gas flow.

1. 2SLPM + 2SLPM = 4SLPM
2. 4SLPM x 1.5 = 6SLPM = Total Gas Flow Rate
3. If you set your M700E calibrator so that the cal gas flow rate is 2SLPM (therefore the Diluent Flow Rate would need to be set at 4 SLPM) the Calibration Gas ratio would be:

   6SLPMm ÷ 2SLPM = 3:1
4. Therefore if your Target Calibration Gas Concentration is intended to be 200 ppm, the minimum required source gas concentration for this system operating at these flow rates would be:

   3 x 200ppm = 600 ppm

3.2.3. CONNECTING DILUENT GAS TO THE M700E CALIBRATOR

1. Attach the zero air source line to the port labeled **DILUENT IN**.
2. Use the fittings provided with the calibrator to connect the zero air source line.
   - First, finger tighten.
   - Then using the properly sized wrench, make an additional 1 and ¼ turn.

3.2.4. CONNECTING CALIBRATION SOURCE GAS TO THE M700E CALIBRATOR

3. Connect the source gas line(s) to the ports labeled **CYL1** through **CYL4** on the back of the calibrator (see Figure 3-2).
   - Source gas delivery pressure should be regulated between 25 PSI to 30 PSI.
   - Use stainless steel tubing with a 1/8 inch outer diameter.

3.2.5. MAKING GAS OUTPUT CONNECTIONS FROM THE M700E

3.2.5.1. Set up for Direct Connections to Other Instruments

Use this setup if you are connecting the M700E calibrator directly to other instruments without the use of any shared manifolds.

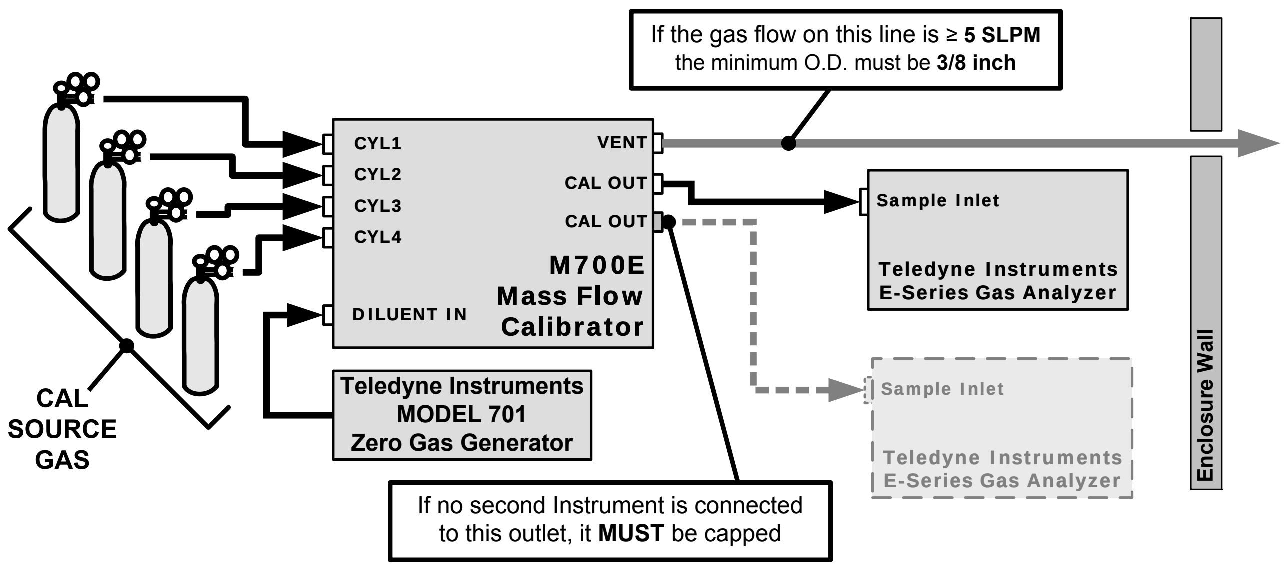


Figure 3-11: Set up for M700E – Connecting the Basic M700E to a Sample Manifold

To determine if the gas flow on the vent line is ≥ 5 SLPM subtract the gas flow for each instrument connected to the outlets of the M700E from the TOTAL FLOW setting for the calibrator (see Section 3.3.10).

If the M700E has the optional O_3 photometer installed remember that this option requires 800 cc^3/min (0.8 LPM) of additional flow (see Section 3.2.6.2 or Figure 5-2).

EXAMPLE: Your system has two analyzers each requiring 2SLPM of cal gas flow and the M700E includes the O_3 photometer. If the TOTAL FLOW rate for the calibrator is set at 10 SLPM:

10LPM - 2LPM - 2LPM - 0.8 LPM = 5.2LPM

Therefore, the vent would require a gas line with an O.D. 3/8 inch.

3.2.5.2. Connecting the M700E Calibrator to a Sample Gas Manifold

Use this setup when connecting the M700E calibrator to an analyzer network using a sample manifold. In this case, the sampling cane and the manifold itself act as the vent for the M700E.

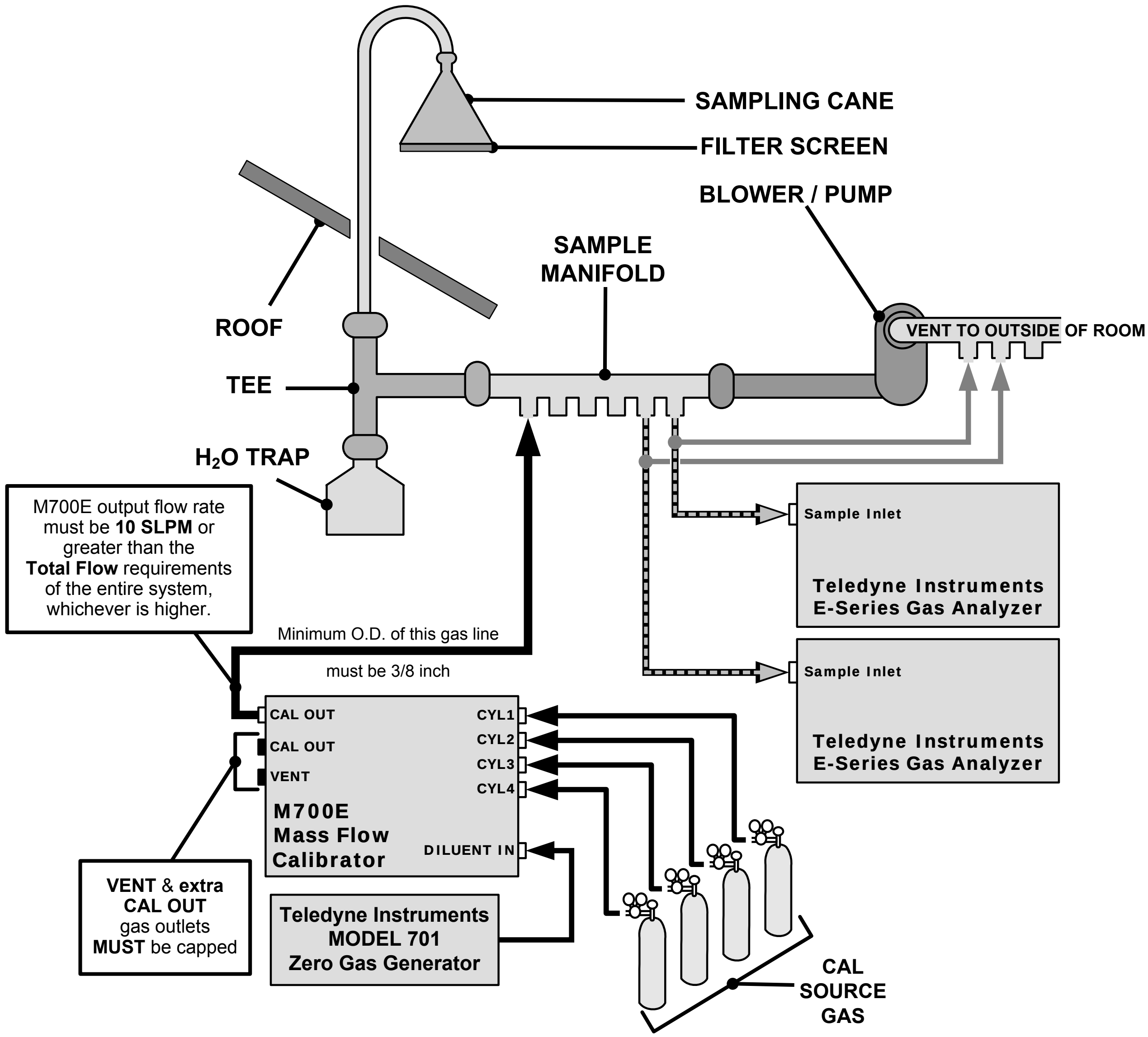


Figure 3-12: Set up for M700E – Connecting the M700E to a Sample Manifold

NOTES

- **This is the recommended method for connecting the M700E calibrator to a system with analyzers that DO NOT have internal zero/span valves.**
- **The manifolds as shown in the above drawing are oriented to simplify the drawing. Their actual orientation in your set-up is with the ports facing upward. All unused ports must be capped.**
- **When initiating calibration, wait a minimum of 15 minutes for the calibrator to flood the entire sampling system with calibration gas.**

3.2.5.3. Connecting the M700E Calibrator to a Calibration Manifold

Using a calibration manifold provides a pneumatic interface between the calibration system and other devices (or systems) which use the calibrator's gas output. Calibration manifolds usually have one or more ports for connections to other external devices (such as an analyzer).

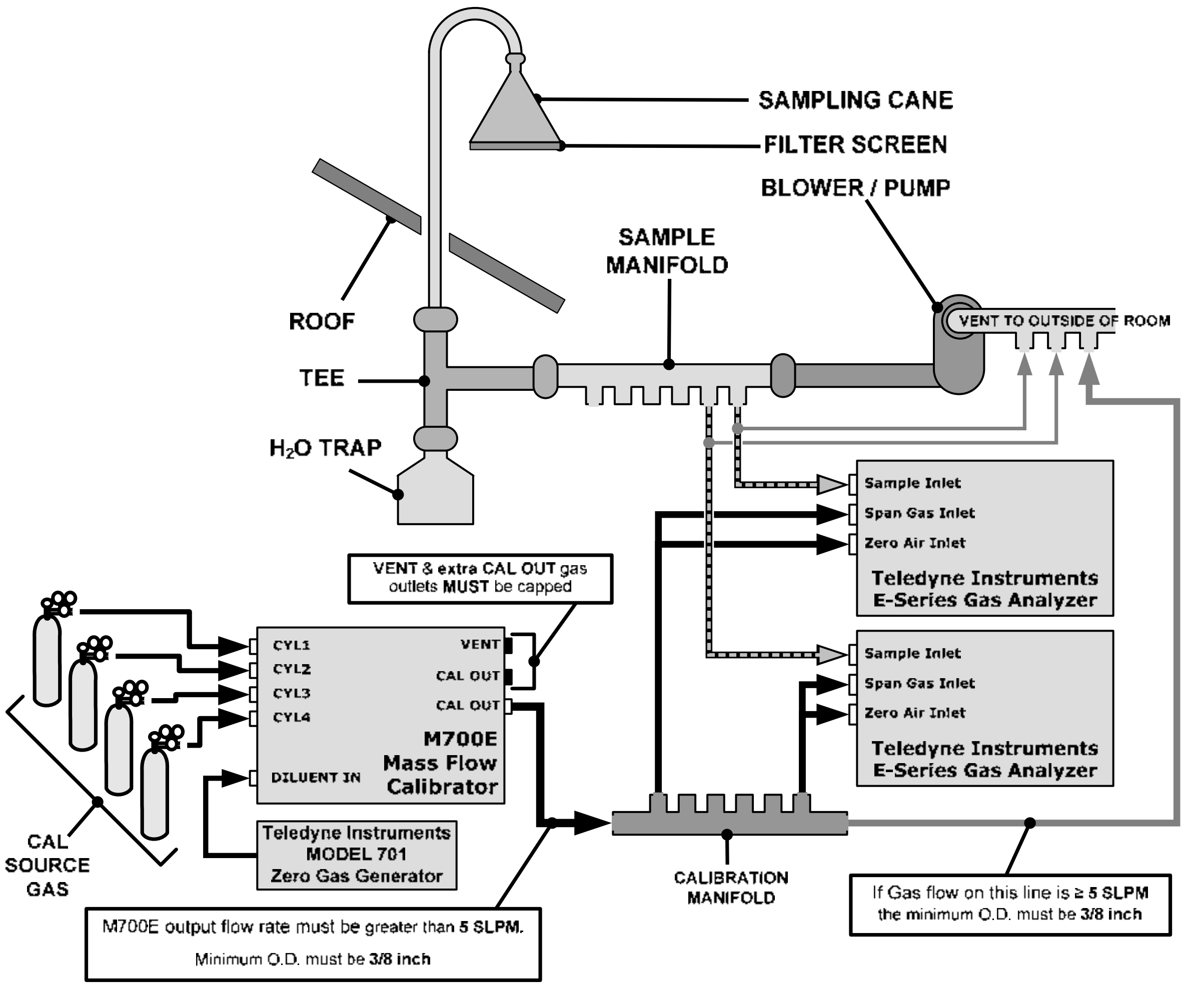


Figure 3-13: Set up for M700E – Connecting the M700E to a Calibration Manifold

NOTES

- **This method requires the analyzers connected to the calibration system have internal zero/span valves.**
- **The manifold should be kept as clean as possible to avoid loss of sample gas flow from blockages or constrictions.**
- **The manifolds as shown in the above drawing are oriented to simplify the drawing. Their actual orientation in your set-up is with the ports facing upward. All unused ports must be capped.**
- **When initiating calibration, wait a minimum of 15 minutes for the calibrator to flood the entire calibration manifold with calibration gas.**

CALIBRATION MANIFOLD EXHAUST/VENT LINE

The manifold's excess gas should be vented outside of the room. This vent should be of large enough internal diameter to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to assure that no ambient air enters the manifold due to eddy currents or back diffusion.

3.2.5.4. Connecting the M700E Calibrator to a Dual Span Gas / Zero Air Calibration Manifold

Another type of calibration setup utilizes separate span gas and the zero air manifolds (see Figure 3-14).

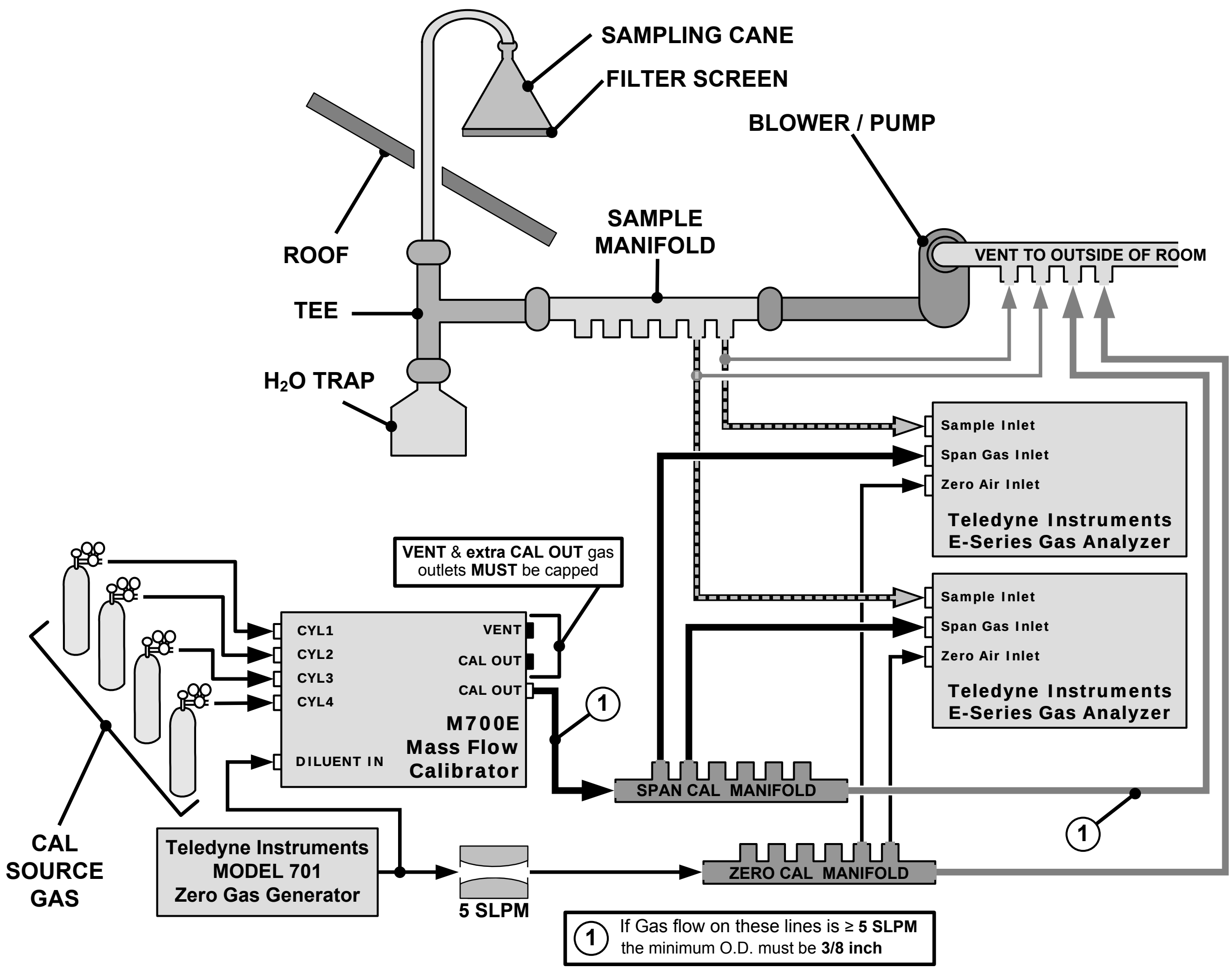


Figure 3-14: Set up for M700E – Connecting the M700E to a Dual Span Gas / Zero Air Manifold

NOTES

This set up is subject to the same notes and conditions as the single calibration manifold described in Section 3.2.5.2 except that:

- **The M700E total gas flow rate (Cal Gas Flow Rate + Diluent Flow Rate) out should be greater than the Total Flow requirements of the entire system.**
- **The manifolds as shown in the above drawing are oriented to simplify the drawing. Their actual orientation in your set-up is with the ports facing upward. All unused ports must be capped.**

CALIBRATION MANIFOLD EXHAUST/VENT LINES

The span and zero air manifolds' excess gas should be vented to a suitable vent outside of the room. This vent should be of large enough internal diameter to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to assure that no ambient air enters the manifold due to eddy currents or back diffusion.

3.2.6. OTHER PNEUMATIC CONNECTIONS

Some of the M700E Dynamic Dilution Calibrator's optional equipment requires additional pneumatic connections.

3.2.6.1. O_3 Generator Option

In addition to the connections discussed in Sections 3.2.3, 3.2.4 and 3.2.5 above, this option also requires an O_3 exhaust line be connected to the **EXHAUST** outlet on the back of the M700E (see Figure 3-2).

NOTE

The EXHAUST line must be vented to atmospheric pressure using maximum of 10 meters of ¼" PTEF tubing.

Venting must be outside the shelter or immediate area surrounding the instrument.

3.2.6.2. O_3 Generator with Photometer Option

In addition to the connections discussed in the previous sections, this option also requires the following:

- Loop back lines must be connected between:
  - PHOTOMETER OUTLET fixture and the PHOTOMETER INLET fixture.
  - PHOTOMETER ZERO OUT fixture and the PHOTOMETER ZERO IN fixture.
- An O_3 exhaust line must be connected to the **EXHAUST** outlet.

See Figure 3-2 for the location of these fixtures.

NOTE

The EXHAUST line must be vented to atmospheric pressure using maximum of 10 meters of ¼" PTEF tubing.

Venting must be outside the shelter or immediate area surrounding the instrument.

3.3. INITIAL OPERATION

If you are unfamiliar with the M700E theory of operation, we recommend that you read Chapter 9.

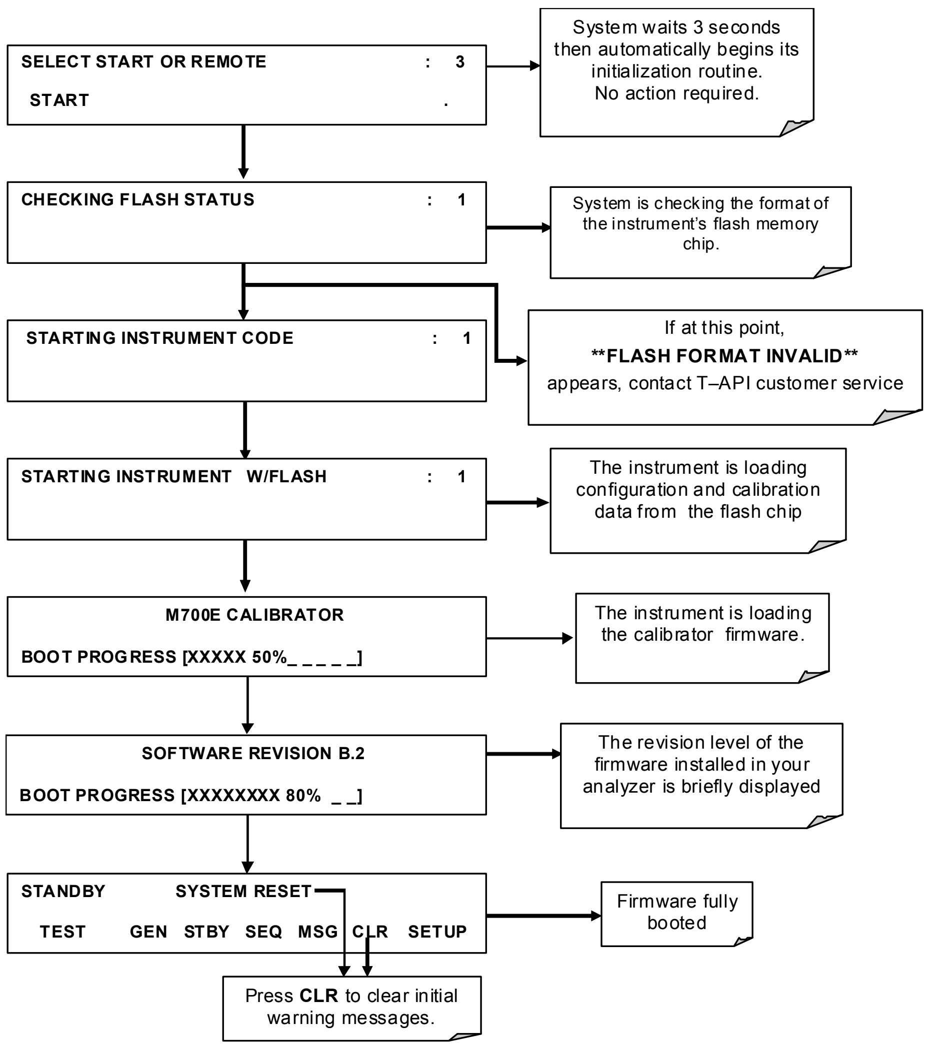
For information on navigating the calibrator's software menus, see the menu trees described in Appendix A.1.

3.3.1. START UP

After all of the electrical and pneumatic connections are made, turn on the instrument. The exhaust fan and should start immediately. If the instrument is equipped with an internal photometer installed, the associated pump should also start up.

The display should immediately display a single, horizontal dash in the upper left corner of the display. This will last approximately 30 seconds while the CPU loads the operating system.

Once the CPU has completed this activity, it will begin loading the calibrator firmware and configuration data. During this process, string of messages will appear on the calibrator's front panel display:



The calibrator should automatically switch to **STANDBY** mode after completing the boot-up sequence.

3.3.2. WARM UP

The M700E dynamic dilution calibrator requires a minimum of 30 minutes for all of its internal components to reach a stable operating temperature. During that time, various portions of the instrument's front panel will behave as follows. See Figure 3-1 for locations.

Table 3-12: Front Panel Display during System Warm-Up

Name	Color	Behavior	Significance
Main Message Field	N/A	Displays Warning messages and Test Function values	At initial start up the various warning messages will appear here (see Section 3.3.3 below).
Mode Field	N/A	Displays "STANDBY"	Instrument is in **STANDBY** mode.
STATUS LEDs			
Active	Green	OFF	Unit is operating in **STANDBY** mode. This LED glows green when the instrument is actively producing calibration gas.
Auto	Yellow	OFF	This LED only glows when the calibrator is performing an automatic calibration sequence.
Fault	Red	BLINKING	The calibrator is warming up and therefore many of its subsystems are not yet operating within their optimum ranges. Various warning messages will appear.

3.3.3. WARNING MESSAGES

Because internal temperatures and other conditions may be outside be specified limits during the calibrator's warm-up period, the software will suppress most warning conditions for 30 minutes after power up. If warning messages persist after the 30 minutes warm up period is over, investigate their cause using the troubleshooting guidelines in Chapter 11 of this manual.

To view and clear warning messages, press:

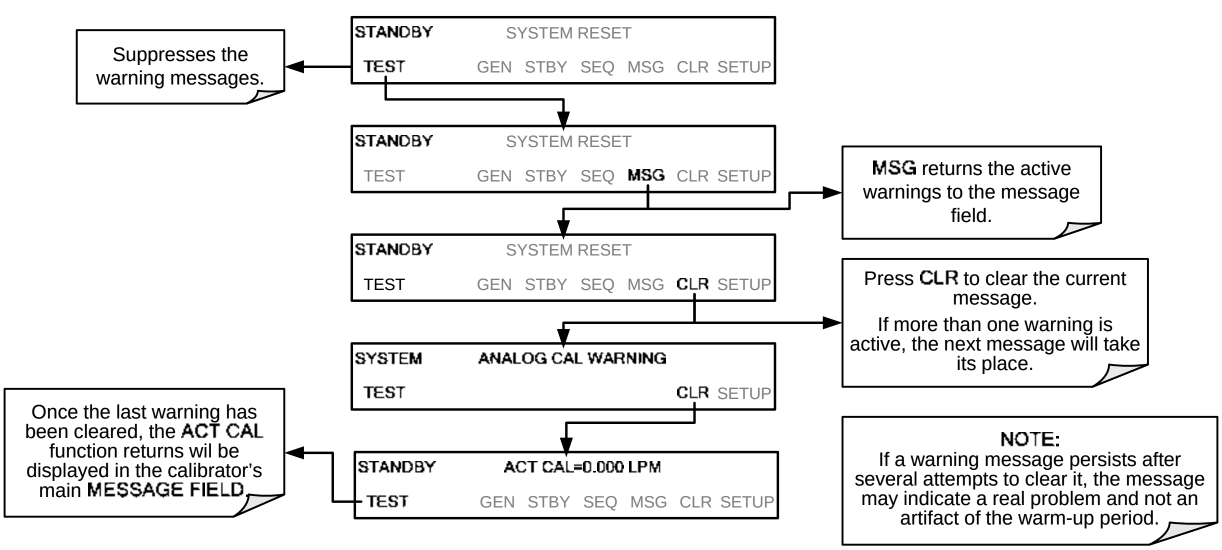


Table 3-13 lists brief descriptions of the warning messages that may occur during start up.

Table 3-13: Possible Warning Messages at Start-Up

MESSAGE	MEANING
ANALOG CAL WARNING	The calibrator's A/D converter or at least one analog input channel has not been calibrated.
CONFIG INITIALIZED	Stored Configuration information has been reset to the factory settings or has been erased.
DATA INITIALIZED	The calibrator's data storage was erased.
FRONT PANEL WARN	The firmware is unable to communicate with the front panel.
LAMP DRIVER WARN[1, 2]	The firmware is unable to communicate with either the O_3 generator or photometer lamp I^2C driver chips.[1, 2]
MFC CALIBRATION WARNING	The flow setting for one of the calibrator's mass flow controllers is less than 10% or greater than 100% of the flow rating for that controller.
MFC COMMUNICATION WARNING	Firmware is unable to communicate with any MFC.
MFC FLOW WARNING[3]	One of the calibrator's mass flow controllers is being driven at less than 10% of full scale or greater than full scale.
MFC PRESSURE WARNING	One of the calibrator's mass flow controllers internal gas pressure is outside of allowable limits.
O3 GEN LAMP TEMP WARNING[1]	The O_3 generator lamp temperature is outside of allowable limits.[1]
O3 GEN REFERENCE WARNING[1]	The O_3 generator's reference detector has dropped below the minimum allowable limit.[1]
O3 PUMP WARNING[1]	The pump associated with the O_3 photometer has failed to turn on.[1]
PHOTO LAMP TEMP WARNING[2]	The photometer lamp temperature is outside of allowable limits.[2]
PHOTO LAMP STABILITY WARNING	Photometer lamp reference step changes occur more than 25% of the time.
PHOTO REFERENCE WARNING[2]	The photometer reference reading is outside of allowable limits.[2]
REAR BOARD NOT DET	The calibrator's motherboard was not detected during power up. - THIS WARNING only appears on Serial I/O COMM Port(s). - The Front Panel Display will be frozen, blank or will not respond.
REGULATOR PRESSURE WARNING	The gas pressure regulator associated with the internal O_3 generator option is reporting a pressure outside of allowable limits.
RELAY BOARD WARN	The firmware is unable to communicate with the calibrator's relay PCA.
SYSTEM RESET	The calibrator has been turned off and on or the CPU was reset.
VALVE BOARD WARN	The firmware is unable to communicate with the valve controller board.

[1] Only applicable for calibrators with the optional the O_3 generator installed.

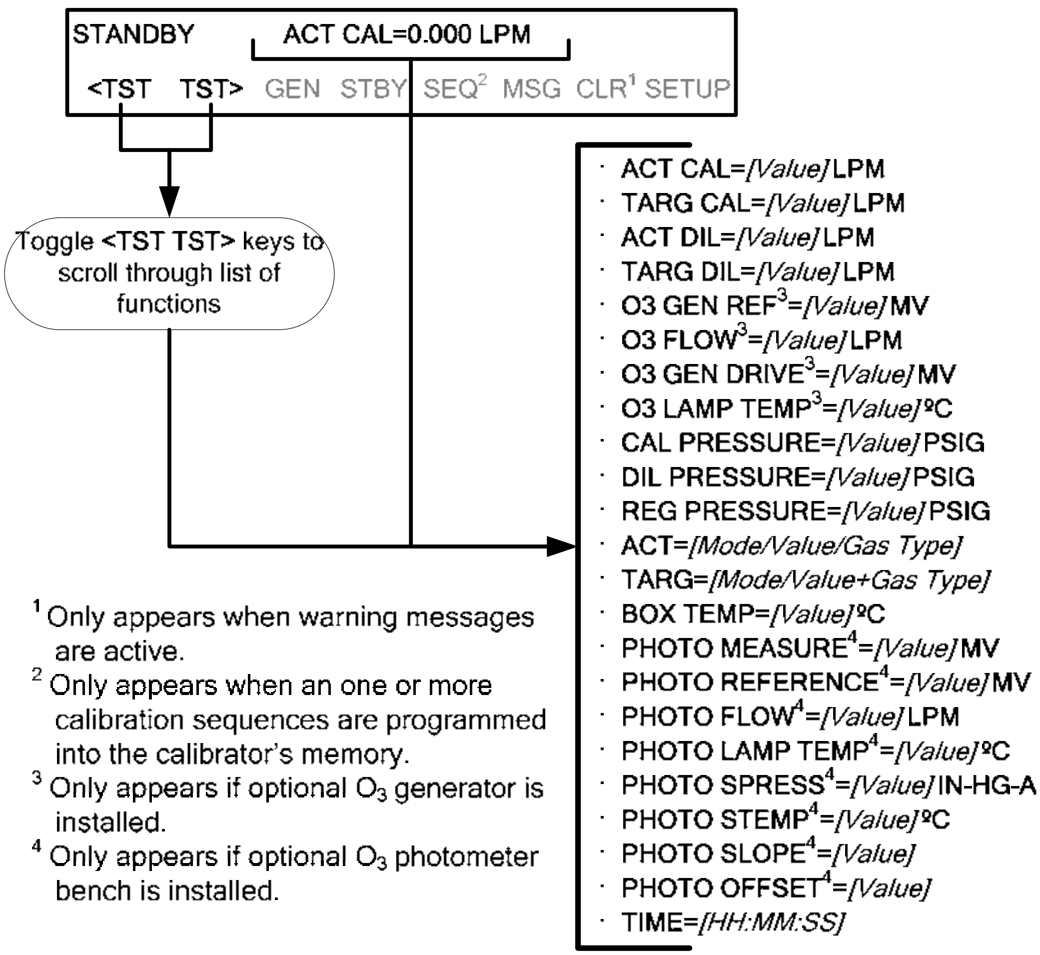
[2] Only applicable for calibrators with the optional photometer installed.

[3] On instrument with multiple Cal Gas MFC's installed, the **MFC FLOW WARNING** occurs when the flow rate requested is <10% of the range of the lowest rated MFC (i.e. all of the cal gas MFC are turned off).

3.3.4. FUNCTIONAL CHECK

1. After the calibrator's components have warmed up for at least 30 minutes, verify that the software properly supports any hardware options that are installed.
2. Check to ensure that the calibrator is functioning within allowable operating parameters. Appendix C includes a list of test functions viewable from the calibrator's front panel as well as their expected values. These functions are also useful tools for diagnosing problems with your calibrator (Section 11.1.2). The enclosed Final Test and Validation Data sheet (P/N 05731) lists these values before the instrument left the factory.

   To view the current values of these parameters press the following key sequence on the calibrator's front panel. Remember until the unit has completed its warm up these parameters may not have stabilized.



3. If your calibrator has an Ethernet card (Option 63) installed and your network is running a dynamic host configuration protocol (DHCP) software package, the Ethernet option will automatically configure its interface with your LAN. However, it is a good idea to check these settings to ensure that the DHCP has successfully downloaded the appropriate network settings from your network server (See Section 7.4.2).

   If your network is not running DHCP, you will have to configure the calibrator's interface manually (See Section 7.4.2.1).

3.3.5. SETTING UP THE CALIBRATION GAS INLET PORTS

The M700E Dynamic Dilution Calibrator generates calibration gases of various concentrations by precisely mixing component gases of known concentrations with diluent (zero air). When the instrument is equipped with the optional O_3 generator and photometer, it can also use the gas phase titration method for generating very precise concentrations of NO_2.

In either case, it is necessary to program the concentrations of the component gases being used into the M700E's memory.

3.3.6. DEFAULT GAS TYPES

The M700E calibrator is programmed with the following default gas types corresponding to the most commonly used component gases:

Table 3-14: M700E Default Gas Types

NAME	GAS TYPE
NONE	Used for gas inlet ports where no gas bottle is attached
SO_2	sulfur dioxide
H_2S	hydrogen sulfide
N_2O	nitrous oxide
NO	nitric oxide
NO_2	nitrogen dioxide
NH_3	Ammonia[1]
CO	carbon monoxide, and;
CO_2	carbon dioxide
HC	General abbreviation for hydrocarbon
[1] It is not recommended that ammonia be used in the M700E.	

3.3.7. USER DEFINED GAS TYPES

3.3.7.1. User Defined Gas Types – General

The M700E calibrator can accept up to four different user defined gases. This allows the use of:

- Less common component gases not included in the M700E's default list;
- More than one bottle of the same gas but at different concentrations. In this case, different user-defined names are created for the different bottles of gas.

EXAMPLE: Two bottles of CO_2 are being used, allow the calibrator to create two different CO_2 calibration gases at the same flow rate.

Since identical names must not be assigned to two different bottles, one bottle can be programmed using the default name "CO2" and the other bottle programmed by assigning a user defined name such as "CO2A".

Alternatively both bottles can be assigned user defined names; e.g. CO2A and CO2B

User defined gas names are added to the M700E's gas library and will appear as choices during the various calibrator operations along with the default gas names listed in Section 3.3.6.

In its default state, the M700E's four user defined gases are named **USR1**, **USR2**, **USR3** and **USR4**, each with a default **MOLAR MASS** of **28.890** (the **MOLAR MASS** of ambient air). All four are **ENABLED.**

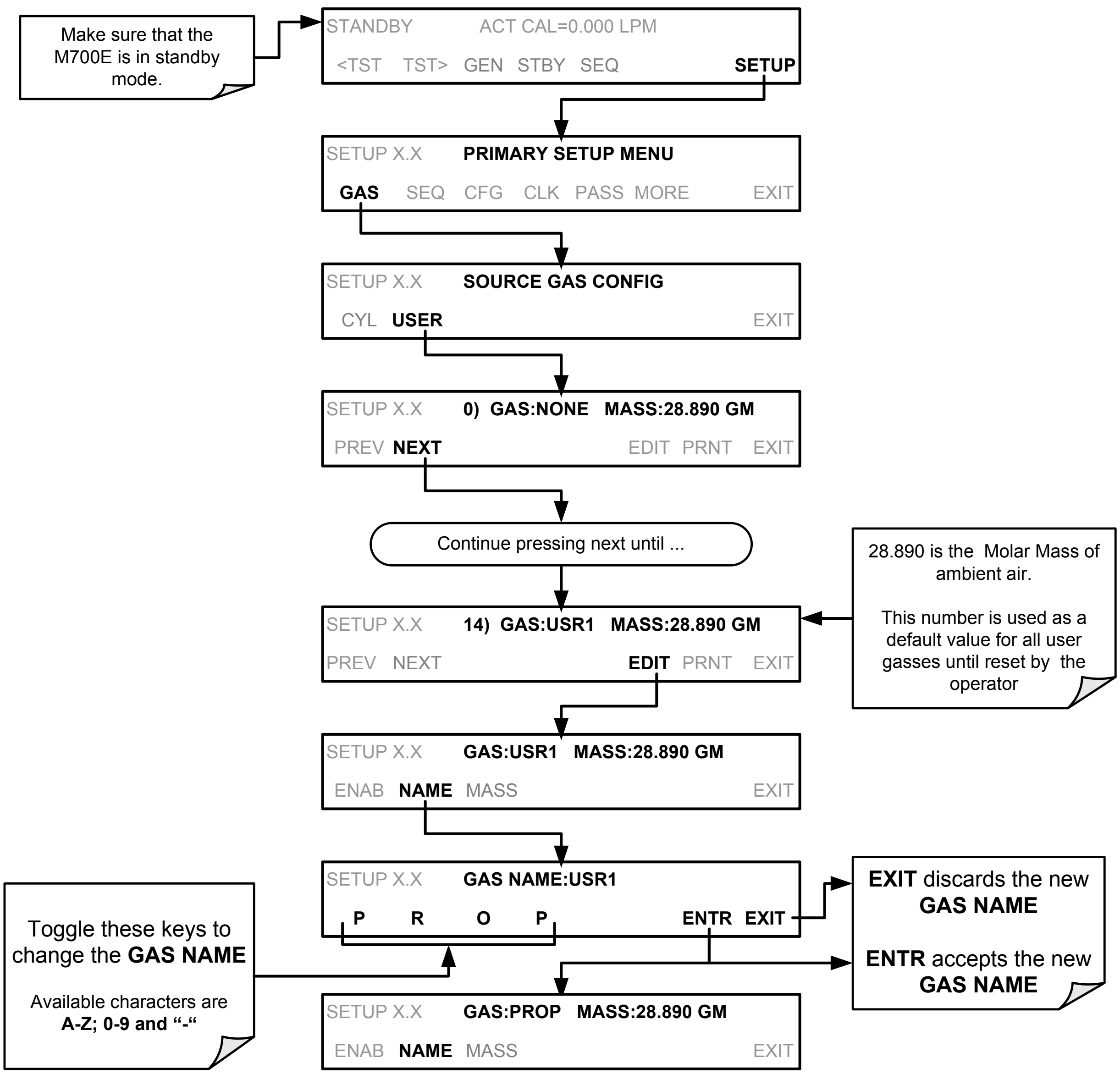
Defining a **USER GAS** is a 2-step process.

4. Define th**e GAS NAME.**
5. Set the **MOLAR MASS.**

3.3.7.2. User Defined Gas Types – Defining the Gas Name

In this example, we will be using PROPANE (C_2H_8).

Press:



Alternatively, one could chose use the chemical formula for this gas, $\mathbf{C_2H_8}$ or any other 4-letter name (e.g. PRPN, MY-1, etc.)

NOTE

If you have the same type of gas, but two different concentrations (for example, two concentrations of CO_2), assign the second concentration to one of the user defined gases (e.g. CO2 {default name} and CO2B {user defined}).

3.3.7.3. User Defined Gas Types – Setting the MOLAR MASS

The molar mass of a substance is the mass, expressed in grams, of 1 mole of that specific substance. Conversely, one mole is the amount of the substance needed for the molar mass to be the same number in grams as the atomic mass of that substance.

EXAMPLE: The atomic weight of Carbon is 12.011 therefore the molar mass of Carbon is 12.011 grams, conversely, one mole of carbon equals the amount of carbon atoms that weighs 12.011 grams.

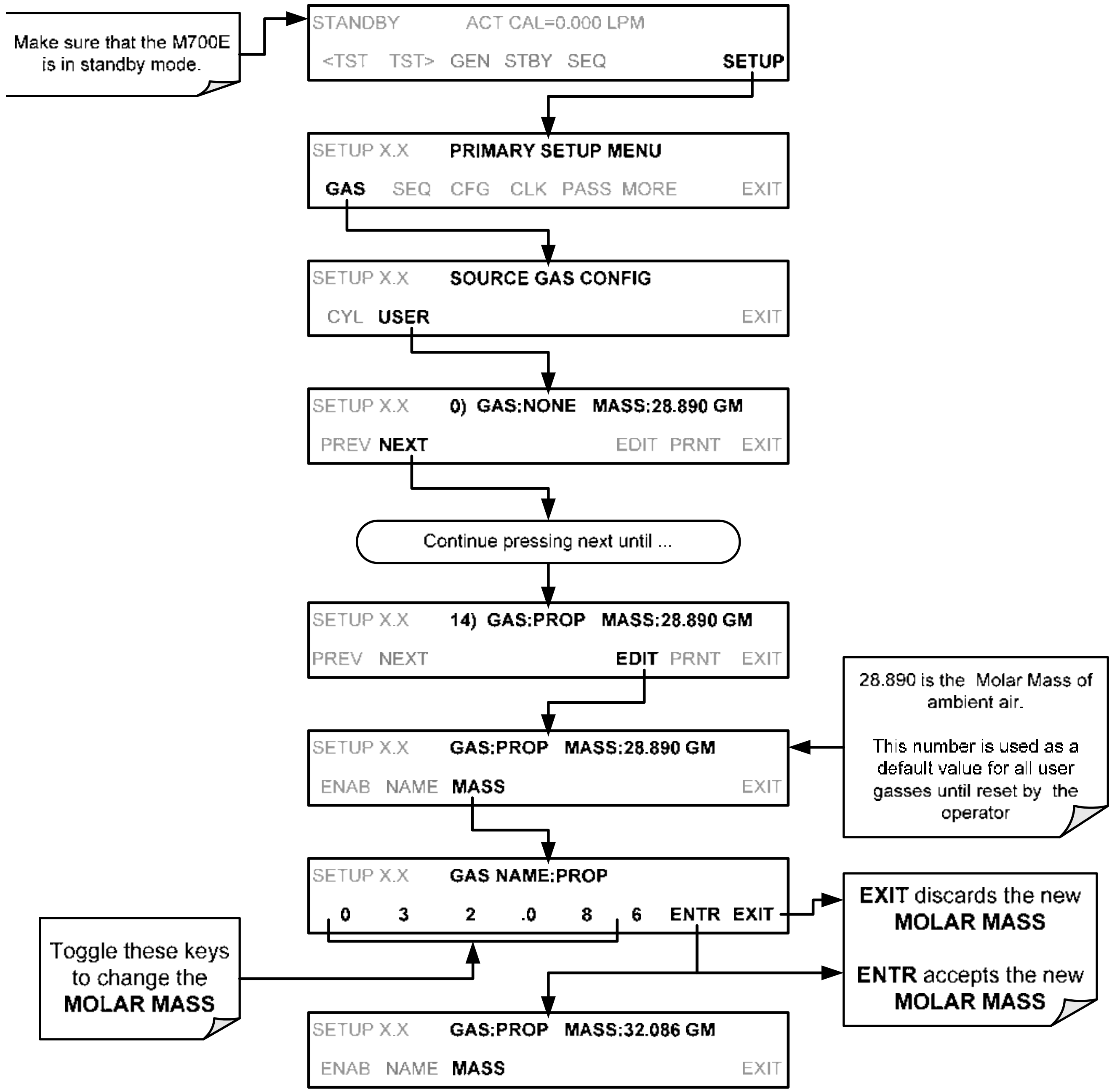
Atomic weights can be found on any Periodic Table of Elements.

To determine the Molar mass of a gas, add together the atomic weights of the elements that make up the gas.

EXAMPLE: The chemical formula for Propane is $\mathbf{C_2H_8}$. Therefore the molecular mass of propane is:

$$(12.011 \times 2) + (1.008 \times 8) = 24.022 + 8.064 = \mathbf{32.086}$$

TO SET THE MOLAR MASS OF A USER DEFINED GAS, PRESS:



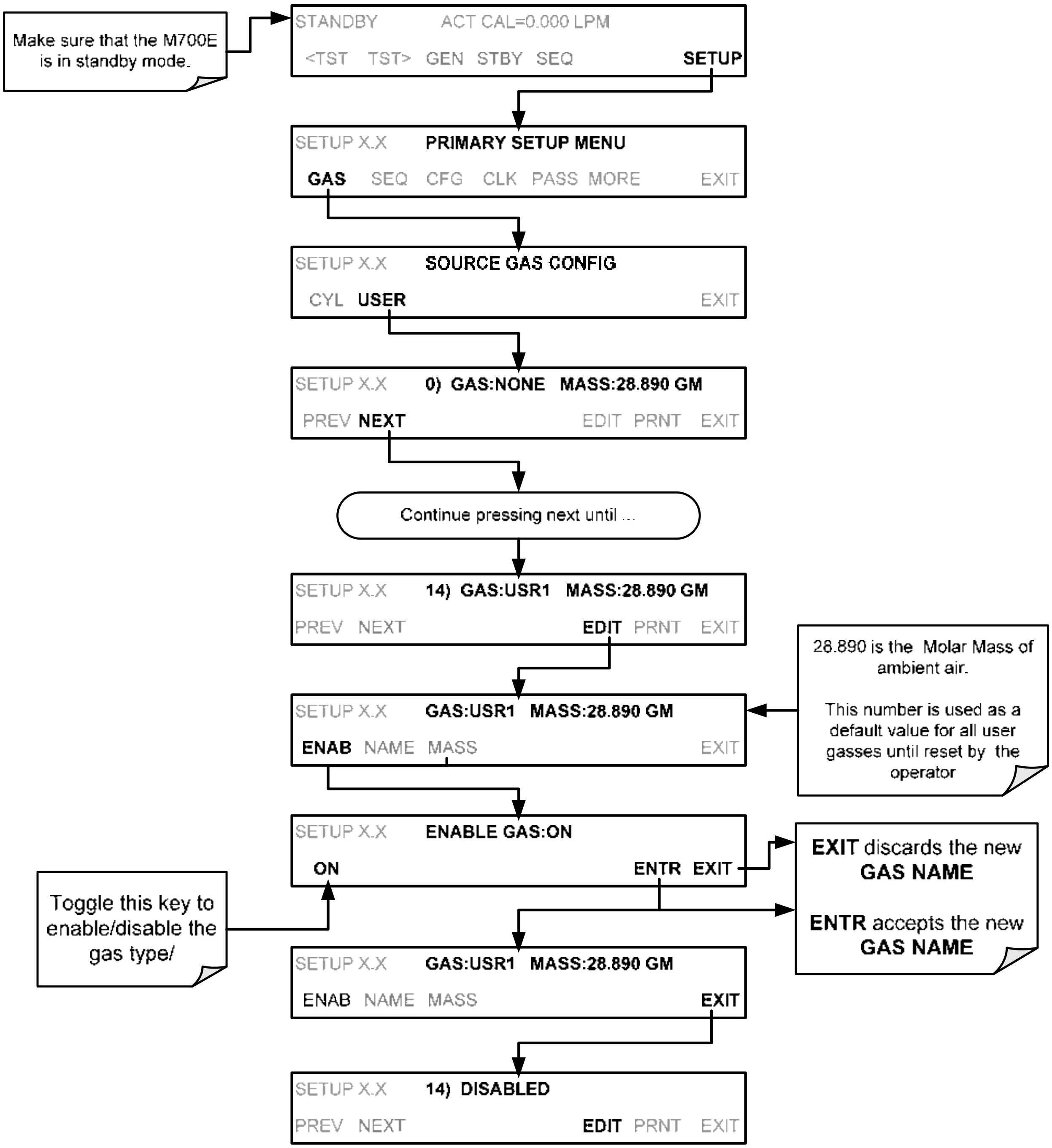
NOTE

If the contents of the bottle are predominantly N_2, use the molar mass of N_2 (28.01).

3.3.7.4. Enabling and Disabling Gas Types

By default, all of the gases listed in Section 3.3.6 and the four undefined **USER** gases are **ENABLED.** Any of these can be disabled. Disabling a gas type means that it does not appear in certain prompts during portions of the M700E's operation (e.g. setting up sequences) and is not figured into the calibrators calculating when determining calibration mixtures.

To disable a gas type, press:



3.3.8. DEFINING CALIBRATION SOURCE GAS CYLINDERS

3.3.8.1. Setting Up the Ports with Single Gas Cylinders

To program the M700E calibrator's source gas input ports for a single gas cylinder, press:

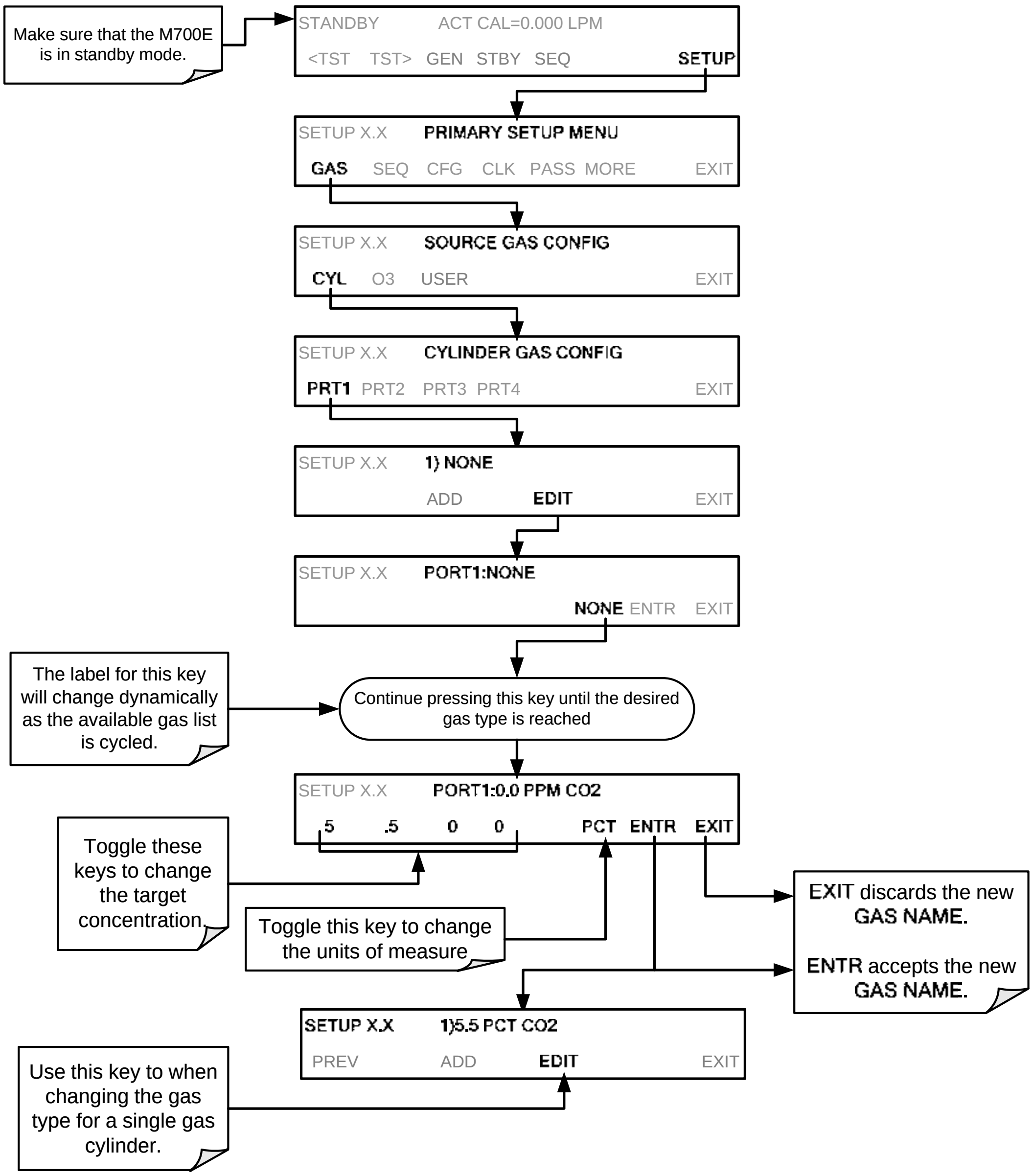


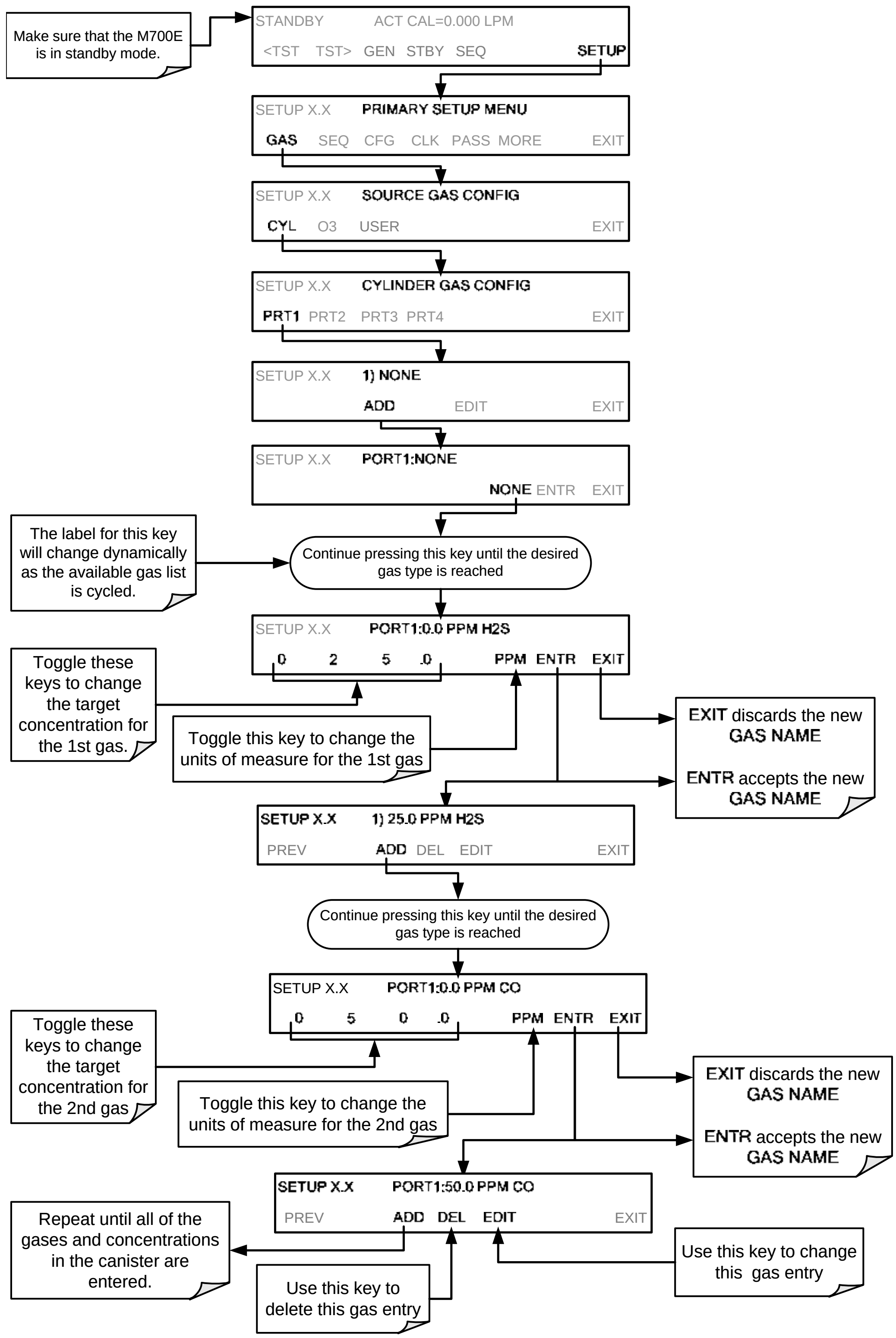
Table 3-15: M700E Units of Measure List

SYMBOL	UNITS	RESOLUTION
PPM	parts per million	000.0
PPB	parts per billion	000.0
MGM	milligrams per cubic meter	000.0
UGM	micrograms per cubic meter	000.0
PCT	percent	0.000
PPT	parts per thousand	00.00

Repeat the above steps for each of the M700E calibrator's four gas inlet port. If no gas is present on a particular port, leave it set for the default setting of **NONE.**

3.3.8.2. Setting Up the Ports with Multiple Gas Cylinders

Some applications utilize canisters of source gas that contain more than one component gas. To program a cylinder containing multiple gases, press.



3.3.9. SELECTING AN OPERATING MODE THE O_3 GENERATOR

The O_3 generator can be set to operate in three different modes:

3.3.9.1. CNST (CONSTANT)

In this mode, the O_3 output of the generator is based on a single, constant, drive voltage. There is no Feedback loop control by the M700E's CPU in this mode.

3.3.9.2. REF (REFERENCE)

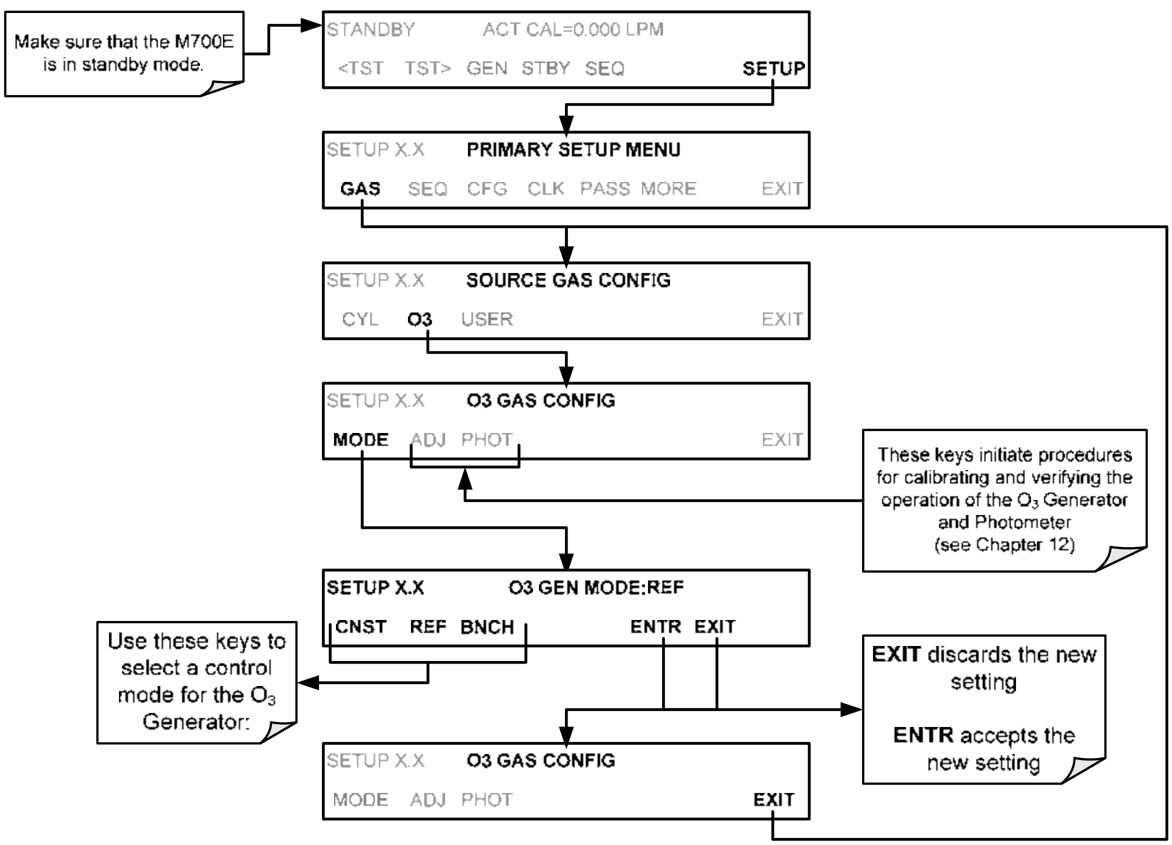
The O_3 control loop will use the generator reference detector's UV lamp measurement as input. This mode does not use the photometer to control the ozone generator.

This setting will be the default mode of the M700E calibrator and will be mused whenever the calibrator is using the **GENERATE → AUTO** command or the **GENERATE** sequence step to create a calibration mixture. When the **GENERATE → MAN** command or the **MANUAL** sequence steps are active, the local O_3 generator mode (chosen during when the command/step is programmed) will take precedence.

3.3.9.3. BNCH (BENCH)

The O_3 concentration control loop will use the photometer's O_3 measurement as input.

- To select a default O_3 generator mode, press:



3.3.10. SETTING THE M700E'S TOTAL GAS FLOW RATE

The default total gas flow rate for the M700E Dynamic Dilution Calibrator is 2 LPM. The calibrator uses this flow rate, along with the concentrations programmed into the calibrator for the component gas cylinders during set up, to compute individual flow rates for both diluent gas and calibration source gasses in order to produce calibration mixtures that match the desired output concentrations.

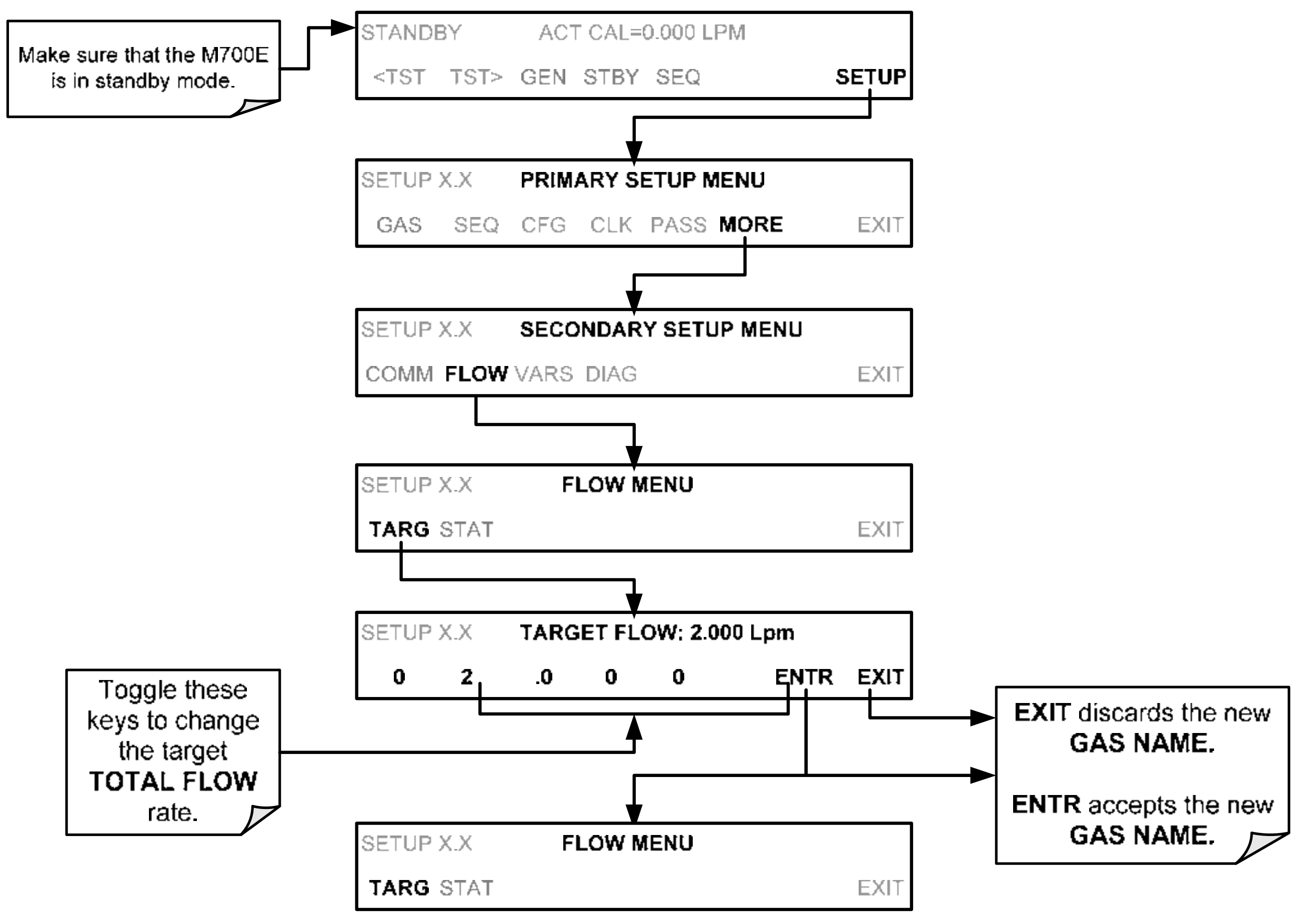
This Total Flow rate may be changed to fit the users' application. Once the flow is changed, then the new flow value becomes the total flow for all the gas concentration generated and recomputes the individual flow rates of the component gases and diluent accordingly.

NOTE

- **The minimum total flow should equal 150% of the flow requirements of all of the instruments to which the M700E will be supplying calibration gas.**
- **Example: If the M700E is will be expected to supply calibration gas mixtures simultaneously to a system in composed of three analyzers each requiring 2 LPM , the proper Total Flow output should be set at:**

(2 + 2 + 2) x 1.5 = 7.500 LPM

To set the **TOTAL FLOW** of the of the M700E Dynamic Dilution Calibrator, press:



NOTE
It is not recommended that your set the TOTAL FLOW rate to be <10% or >100% of the full scale rating.
For M700E's with multiple calibration mass flow controllers, the limits are <10% of the lowest rated MFC or >100% of the combined full-scale ratings for both mass flow controllers.

The **TOTAL FLOW** is also affected by the following:

- The **GENERATE → AUTO** menu (see Section 6.4.2) or;
- As part of a **GENERATE** step when programming a sequence (see Section 6.5.2.1).

The operator can individually set both the diluent flow rate and flow rates for the component gas cylinders as part of the following:

- The **GENERATE → MANUAL** menu (see Section **Error! Reference source not found.**) or;
- As part of a **MANUAL** step when programming a sequence (see Section 6.5.2.9).

NOTE
When calculating total required flow for M700E's with O_3 photometers installed ensure to account for the 800 cc/min flow it requires.

USER NOTES:

4. FREQUENTLY ASKED QUESTIONS AND GLOSSARY

4.1. FAQ'S

The following list is a list from the Teledyne API'S Customer Service Department of the 10 most commonly asked questions relating to the M700E Dynamic Dilution Calibrator.

Q: My ozone ACT =XXXX why?

A: Look at the Photo Ref/Meas. These are most likely too low and need to be adjusted up to 4500mV. Another possible cause would be no gas flow to the photometer causing the O_3 reading to be out of range - low

Q: When I generate ozone, it takes a long time to settle out or it fluctuates around the number until finally stabilizing.

A: Perform an O_3 Gen Adjust, and then an O_3 Gen Calibration. Re-run points. See Chapter 8.

Q: Why does the **ENTR** key sometimes disappear on the front panel display?

A: Sometimes the **ENTR** key will disappear if you select a setting that is invalid or out of the allowable range for that parameter, such as trying to set the 24-hour clock to 25:00:00.

Once you adjust the setting to an allowable value, the **ENTR** key will re-appear.

Q: How do I make the RS-232 Interface Work?

A: See Section 7.1

Q: When should I change the sintered filter(s) in the calibrators critical flow orifice(s) and how do I change them?

A: The sintered filters do not require regular replacement. Should one require replacement as part of a troubleshooting or repair exercise see Section 11.7.1.

Q: How often should I rebuild the photometer pump on my calibrator?

A: The diaphragm of the photometer pump should be replaced approximately once a year.

Q: How long do the UV lamps of the optional O_3 generator and photometer last?

A: The typical lifetime is about 2-3 years.

4.2. GLOSSARY

Acronym – A short form or abbreviation for a longer term. Often artificially made up of the first letters of the phrase's words.

APICOM – Name of a remote control program offered by Teledyne-API to its customers

ASSY – Acronym for *Assembly.*

cm^3 – metric abbreviation for *Cubic Centimeter*. Same as the obsolete abbreviation "cc".

Chemical formulas used in this document:

- CO_2 – carbon dioxide
- C_2H_8 – propane

- CH_4 – methane
- H_2O – water vapor
- HC – general abbreviation for hydrocarbon
- HNO_3 – nitric acid
- H_2S – hydrogen sulfide
- NO_X – nitrogen oxides, here defined as the sum of NO and NO_2
- NO – nitric oxide
- NO_2 – nitrogen dioxide
- NOy – nitrogen oxides, often called odd nitrogen, the sum of NO, NO_2 (NO_X) plus other compounds such as HNO_3. Definitions vary widely and may include nitrate (NO_3-), PAN, N_2O and other compounds.
- NH_3 – ammonia
- O_2 – molecular oxygen
- O_3 – ozone
- SO_2 – sulfur dioxide

DAS – Acronym for *Data Acquisition System*, the old acronym of iDAS

DIAG – Acronym for *Diagnostics*, the diagnostic menu or settings of the system

DHCP – Acronym for *Dynamic Host Configuration Protocol.* A protocol used by LAN or Internet servers that automatically sets up the interface protocols between themselves and any other addressable device connected to the network.

DOC – Acronym for *Disk-on-Chip*, the system's central storage area for system operating system, firmware and data. This is a solid-state device without mechanical, moving parts that acts as a computer hard disk drive under DOS with disk drive label "C". DOC chips come with 8 mb space in the E-series system standard configuration but are available in larger sizes

DOS – Acronym for *Disk Operating System*. The E-series systems use DR DOS

EEPROM – also referred to as a FLASH chip.

ESD – Acronym for *Electro-Static Devices*.

FEP – Acronym for Fluorinated Ethylene Propylene polymer, one of the polymers that *du Pont* markets as *Teflon*® (along with PFA and PTFE).

FLASH – flash memory is non-volatile, solid-state memory.

I^2C Bus – read: I-square-C Bus. A serial, clocked serial bus for communication between individual system components

IC – Acronym for *Integrated Circuit*, a modern, semi-conductor circuit that can contain many basic components such as resistors, transistors, capacitors etc in a miniaturized package used in electronic assemblies.

iDAS – Acronym for *Internal Data Acquisition System*, previously referred to as DAS.

LAN – Acronym for *local area network.*

LED – Acronym for *Light Emitting Diode.*

LPM – Acronym for *Liters Per Minute.*

MFC – Acronym for *Mass Flow Controller*.

MOLAR MASS – The molar mass is the mass, expressed in grams, of 1 mole of a specific substance. Conversely, one mole is the amount of the substance needed for the molar mass to be the same number in grams as the atomic mass of that substance.

EXAMPLE: The atomic weight of Carbon is 12 therefore the molar mass of Carbon is 12 grams. Conversely, one mole of carbon equals the amount of carbon atoms that weighs 12 grams.

Atomic weights can be found on any Periodic Table of Elements

PCA – Acronym for *Printed Circuit Assembly*, this is the → PCB with electronic components installed and ready to use

PCB – Acronym for *Printed Circuit Board*, the bare circuit board without components

PLC – Acronym for *Programmable Logic Controller*, a device that is used to control instruments based on a logic level signal coming from the system

PFA – Acronym for *Per-Fluoro-Alkoxy*, an inert polymer. One of the polymers that *du Pont* markets as *Teflon*® (along with FEP and PTFE).

PTFE – Acronym for *Poly-Tetra-Fluoro-Ethylene*, a very inert polymer material used to handle gases that may react on other surfaces. One of the polymers that *du Pont* markets as *Teflon*® (along with FEP and PFA).

PVC – Acronym for *Poly Vinyl Chloride*.

RS-232 – An electronic communication protocol of a serial communications port.

RS-485 – An electronic communication protocol of a serial communications port.

SLPM – Acronym for standard liters per minute; liters per minute of a gas at standard temperature and pressure

TCP/IP – Acronym for *Transfer Control Protocol / Internet Protocol*, the standard communications protocol for Ethernet devices and the Internet

VARS – Acronym for *Variables*, the variables menu or settings of the system

USER NOTES:

5. OPTIONAL HARDWARE AND SOFTWARE

This includes a brief description of the hardware and software options available for the M700E Dynamic Dilution Calibrator. For assistance with ordering these options, please contact the Sales department of Teledyne – Advanced Pollution Instruments at:

TOLL-FREE: 800-324-5190
FAX: 858-657-9816
TEL: 858-657-9800
E-MAIL: api-sales@teledyne.com
WEB SITE: www.teledyne-api.com

5.1. OZONE OPTIONS

5.1.1. INTERNAL OZONE GENERATOR (OPT 01A)

Because ozone (O_3) quickly breaks down into molecular oxygen (O_2), this calibration gas cannot be supplied in precisely calibrated bottles like other gases such as SO_2, CO, CO_2 NO, H_2S, etc. The optional O_3 generator extends the capabilities of the M700E Dynamic Dilution Calibrator dynamically generate calibration gas mixtures containing O_3.

Additionally a glass mixture volume, designed to meet US EPA guidelines for Gas Phase Titration (GPT), is included with this option. This chamber, in combination with the O_3 generator, allow the M700E to use the GPT technique to more precisely create NO_2 calibration mixtures

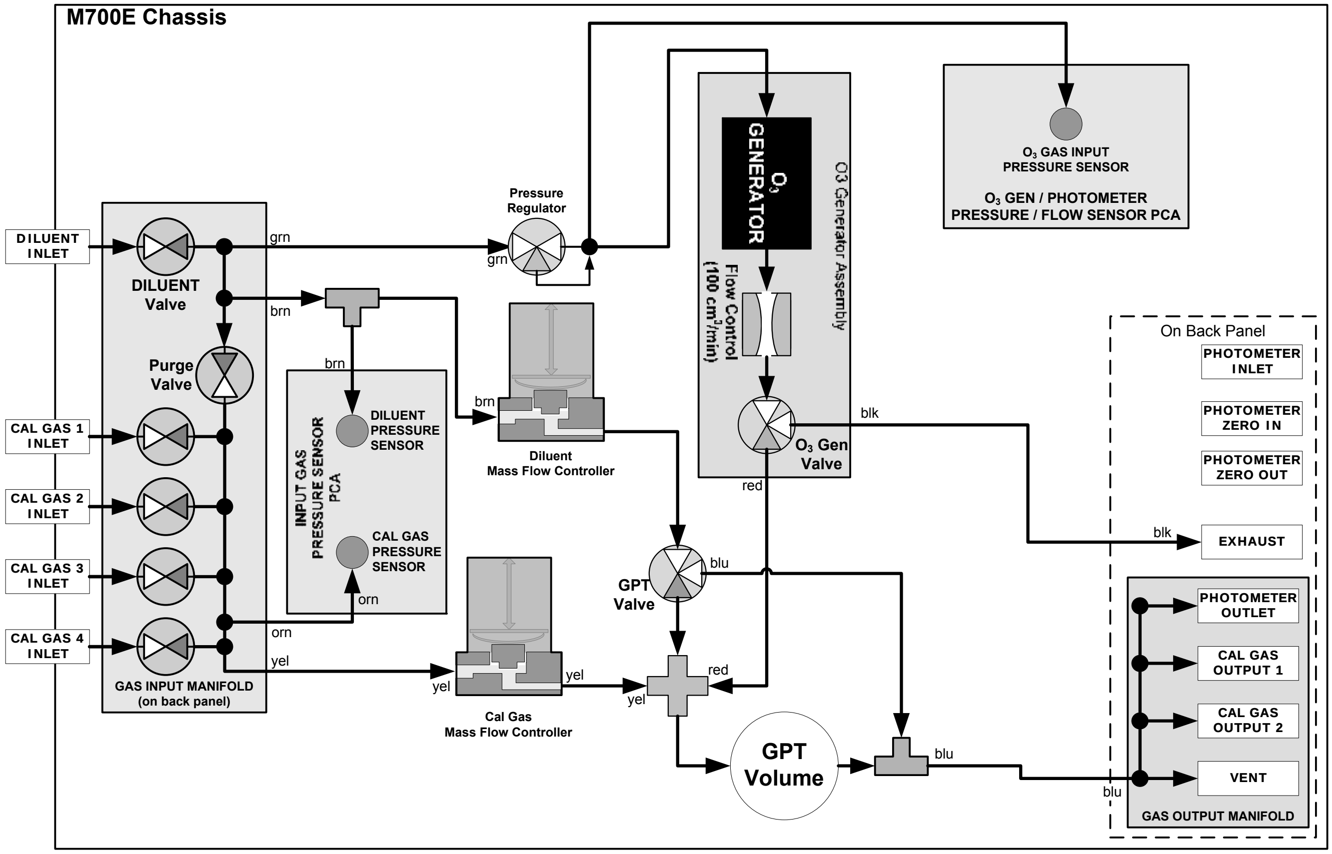


Figure 5-1: Internal Pneumatics for M700E Calibrator with Optional O_3 Generator and GPT Chamber.

Table 5-1: Operating Mode Valve States for M700E Calibrator with Optional O_3 Generator.

MODE	VALVES (X = Closed; O = Open)								MFC's		
	CYL 1	CYL 2	CYL 3	CYL 4	PURGE	DILUENT	GPT	O_3 GEN	CAL1	CAL2[1]	DILUENT
Generate Source Gas	O[2]	O[2]	O[2]	O[2]	X	O	X	X	ON[3]	ON[3]	ON
Generate O_3	X	X	X	X	X	O	X	O	OFF	OFF	OFF
GPT	O[2]	O[2]	O[2]	O[2]	X	O	O	O	ON[3]	ON[3]	ON
GPTPS	X	X	X	X	X	O	O	O	OFF	OFF	ON
PURGE	X	X	X	X	O	O	O	O	ON[3]	ON[3]	ON
STANDBY	X	X	X	X	X	O	X	X	OFF	OFF	OFF

[1] Only present if multiple cal gas MFC option is installed.

[2] The valve associated with the cylinder containing the chosen source gas is open.

[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.

The output of the O_3 generator can be controlled in one of two ways:

- CONSTANT mode: By selecting a specific, constant drive voltage (corresponding to a specific O_3 concentration) for the generator, or;
- REFERENCE mode: The user selects a desired O_3 concentration and the calibrator's CPU sets the intensity of the O_3 generator's UV lamp to an intensity corresponding to that concentration. The voltage output of a reference detector, also internal to the generator, is digitized and sent to the M700E's CPU where it is used as input for a control loop that maintains the intensity of the UV lamp at a level appropriate for the chosen set point.

See Section 9.6 for more details on the operation of the O_3 generator.

5.1.2. UV PHOTOMETER MODULE (OPT 02A)

The photometer option increases the accuracy of the M700E calibrator's optional O_3 generator (**OPT 01A –** see Section 5.1.1) by directly measuring O_3 content of the gas output by the generator.

The photometer's operation is based on the principle that ozone molecules absorb UV light of a certain wavelength. A mercury lamp internal to the photometer emits UV light at that wavelength. This light shines down a hollow glass tube that is alternately filled with sample gas (the measure phase), and zero gas (the reference phase). A detector, located at the other end of the glass tube measure the brightness of the UV light after it passes though the gas in the tube. The O_3 content of the gas is calculated based on the ratio the UV light intensity during the measure phase (O_3 present) and the reference phase (no O_3 present).

When the photometer option is installed, a third, more precise and stabile, option, called the **BENCH** feedback mode, exists for controlling the output of the O_3 generator. In **BENCH** mode the intensity of the O_3 generator's UV lamp is controlled (and therefore the concentration of the O_3 created) by the M700E's CPU based on the actual O_3 concentration measurements made by the photometer.

See Section 9.7 for more details on the operation of the O_3 photometer.

This option requires that the O_3 generator (**OPT 01A**) be installed.

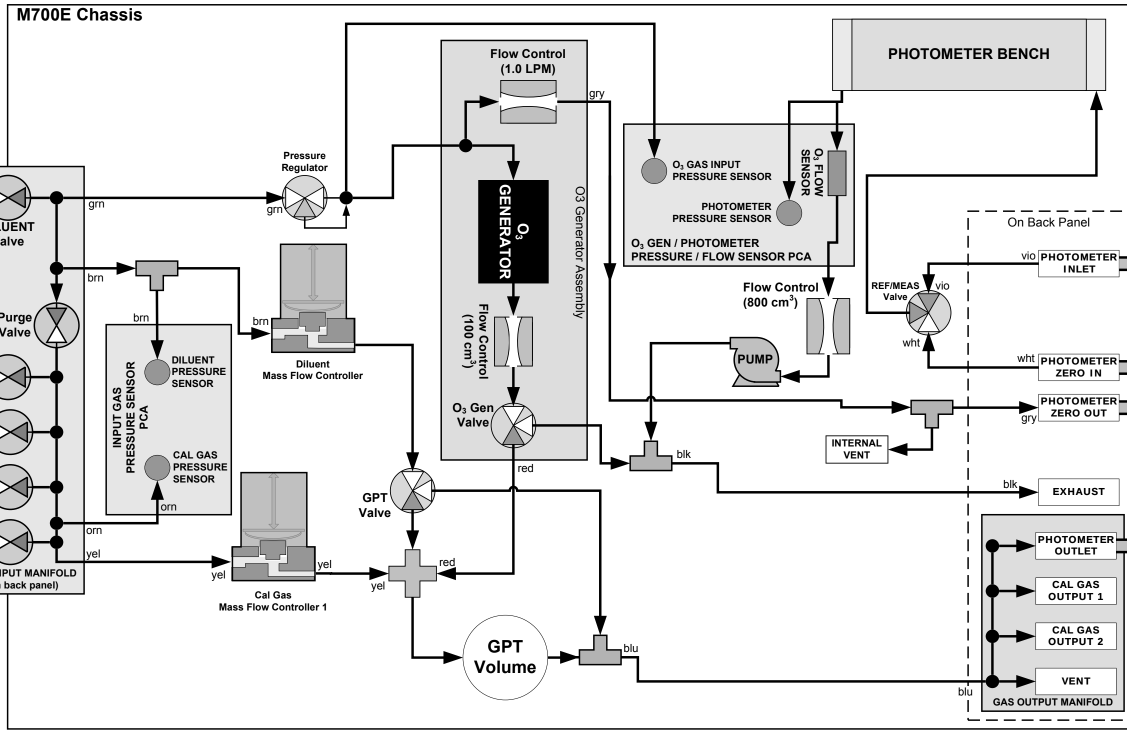


Figure 5-2: Internal Pneumatics for M700E Calibrator with Optional O_3 Generator and Photometer

Table 5-2: Operating Mode Valve States for M700E Calibrator with Optional O_3 Generator and Photometer

GAS TYPE	VALVES (X = Closed; O = Open)									MFC's			PHOT PUMP
	CYL 1	CYL 2	CYL 3	CYL 4	PURGE	DILUENT	GPT	O_3 GEN	PHOT M/R	CAL1	CAL2[1]	DILUENT	
Generate Source Gas	O[2]	O[2]	O[2]	O[2]	X	O	X	X	Reference Phase	ON[3]	ON[3]	ON	OFF
Generate O_3	X	X	X	X	X	O	X	O	Switching	OFF	OFF	OFF	ON[4]
GPT	O[2]	O[2]	O[2]	O[2]	X	O	O	O	Reference Phase	ON[3]	ON[3]	ON	OFF
GPTPS	X	X	X	X	X	O	O	O	Switching	OFF	OFF	ON	ON[4]
PURGE	X	X	X	X	O	O	O	O	Reference Phase	ON[3]	ON[3]	ON	OFF
STANDBY	X	X	X	X	X	O	X	X	Reference Phase	OFF	OFF	OFF	OFF

[1] Only present if multiple cal gas MFC option is installed.
[2] The valve associated with the cylinder containing the chosen source gas is open.
[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.
[4] When generating O_3 or in GPT Pre-Set mode, the photometer pump is the primary creator of gas flow through the M700E. Flow rates are controlled by critical flow orifice(s) located in the gas stream

5.2. GAS FLOW OPTIONS

5.2.1. FLOW RATE OPTIONS (OPT 07A, OPT 7B, OPT 08A & OPT 08B)

The standard M700E Dynamic Dilution Calibrator is equipped with one calibration gas mass flow controller and one diluent gas mass flow controller. Table 5-3 shows the flow rates for the standard M700E, as well as various flow rate options.

Table 5-3: M700E Gas Flow Rate Options

Option	Affected Mass Flow Controller	Flow rates	NOTES:
STANDARD	Cal/Source Gas MFC	0 – 100 cm^3/min	
	Diluent Gas MFC	0 – 10 LPM	
OPT – 07A	Cal/Source Gas MFC	0 – 50 cm^3/min	Replaces 0 – 100 cm^3/min Cal Gas MFC
OPT – 07B	Cal/Source Gas MFC	0 – 200 cm^3/min	Replaces 0 – 100 cm^3/min Cal Gas MFC
OPT – 08A	Diluent Gas MFC	0 – 5 LPM	Replaces 0 – 10 LPM Diluent Gas MFC
OPT – 08B	Diluent Gas MFC	0 – 20 LPM	Replaces 0 – 10 LPM Diluent Gas MFC

5.2.2. MULTIPLE CALIBRATION SOURCE GAS MFC

This option adds an additional mass flow controller on the calibration gas stream. When this option is installed the M700E has both calibration gas MFC's on the same gas stream, installed in parallel (see Figure 5-3 and Figure 5-4). The calibrator turns on the MFC with the lowest flow rate that can accommodate the requested flow and can therefore supply the most accurate flow control. When a flow rate is requested that is higher than the highest rated MFC (but lower than their combined maximum flow rating), both controllers are activated.

EXAMPLE:

- Calibrator with one calibration gas MFC configured for 0-5 LPM:

  Maximum gas flow = 5 LPM
  Minimum gas flow = 500 cm^3/min

- Calibrator with two calibration gas MFC's configured for 0-1 LPM and 0-5 LPM:

  Calibration gas flow rates:
  5.001 to 6.000 LPM; both MFC's active
  1.001 LPM – 5.000 LPM; High MFC active;
  10 cm^3/min – 1.000 LPM; Low MFC active

When this option is installed the test measurements that show the MFC actual and target flows (e.g **ACT CAL**; **TARG CAL**) show the sum of the flows of all the active MFC's. On the other hand, the pressure test measurements show the pressure for only one MFC, not the sum as it is assumed that gas pressure is the same for all MFC's.

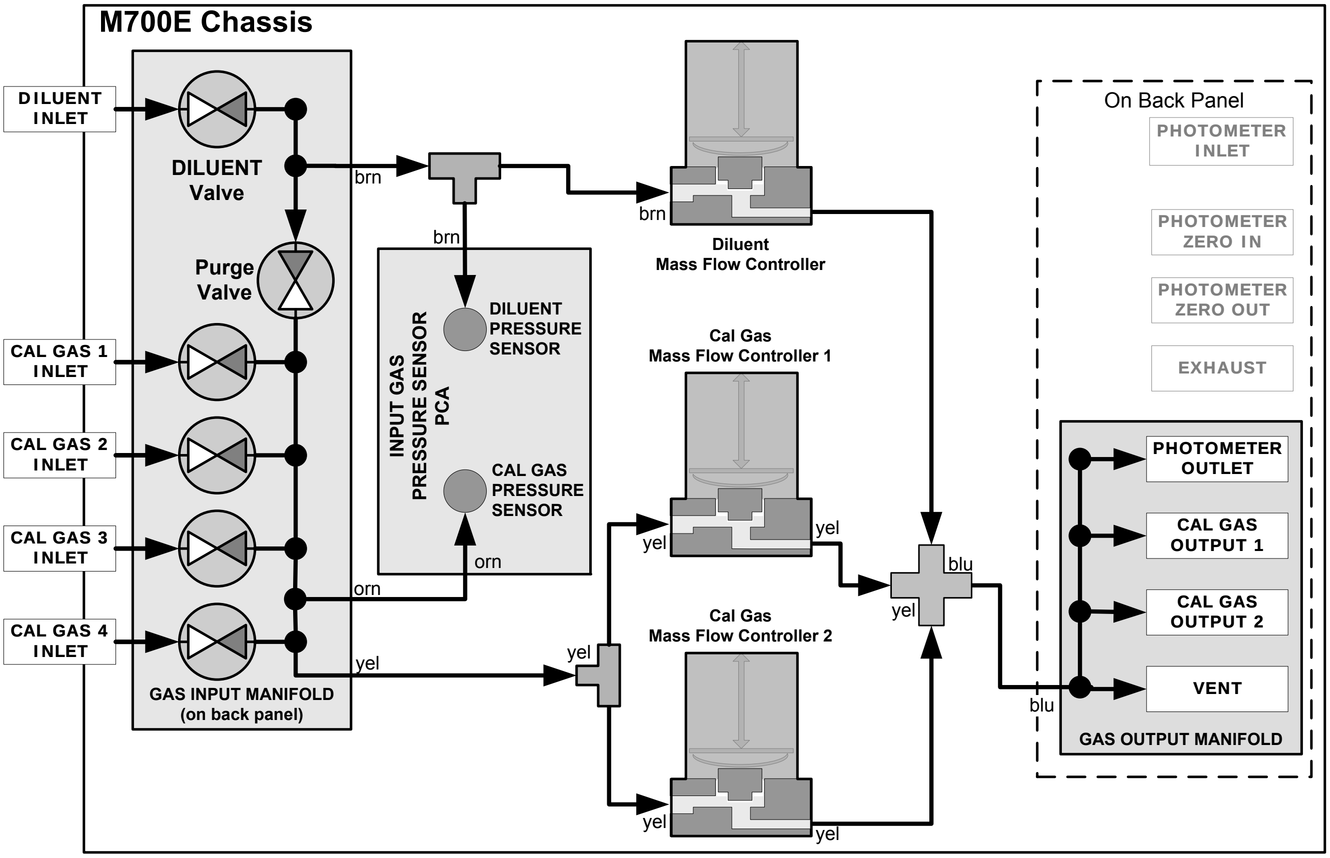


Figure 5-3: Basic M700E with Multiple Calibration Gas MFC's

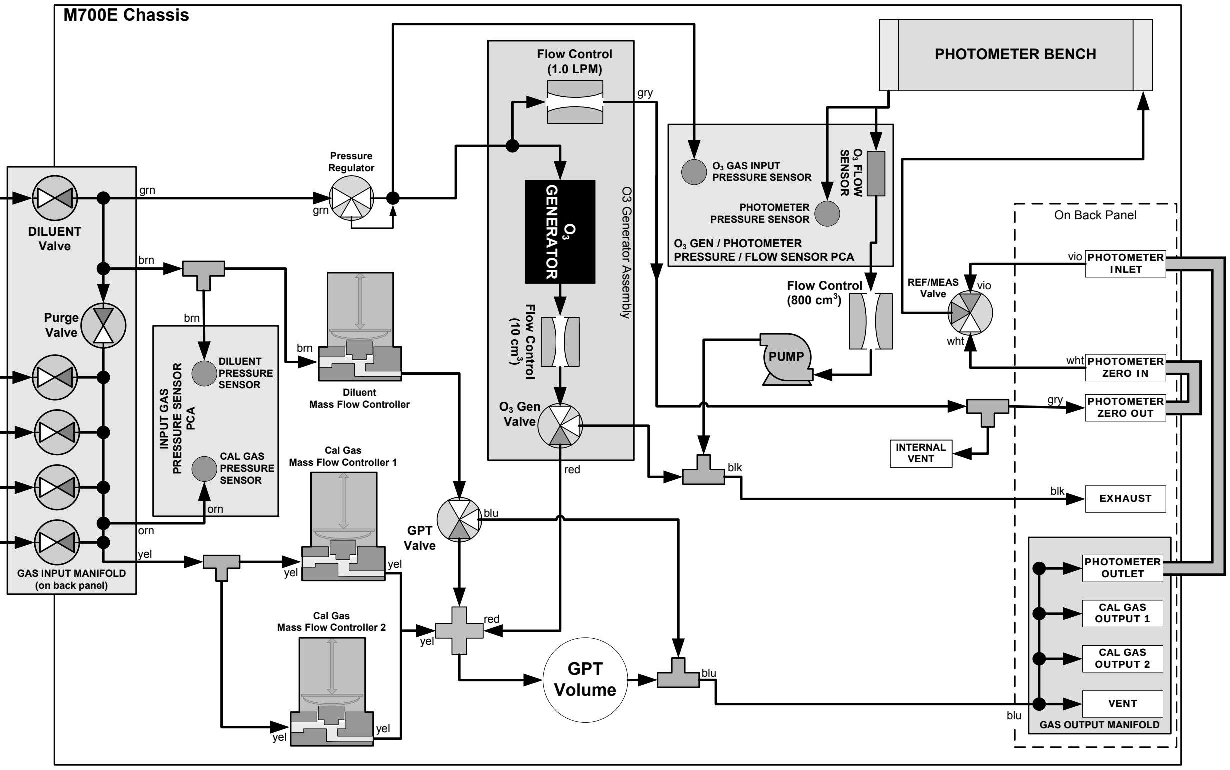


Figure 5-4: M700E with Multiple Calibration Gas MFC's and O_3 Options OPT 01A and OPT 02A Installed

5.3. RACK MOUNT KITS (OPT 20A, OPT 20B & OPT 21)

There are several options for mounting the calibrator in standard 19" racks. The slides are three-part extensions, one mounts to the rack, one mounts to the calibrator chassis and the middle part remains on the rack slide when the calibrator is taken out. The calibrator locks into place when fully extended and cannot be pulled out without pushing two buttons, one on each side.

The rack mount brackets for the calibrator require that you have a support structure in your rack to support the weight of the calibrator. The brackets cannot carry the full weight of a calibrator and are meant only to fix the calibrator to the front of a rack, preventing it from sliding out of the rack accidentally.

OPTION NUMBER	DESCRIPTION
OPT 20A	Rack mount brackets with 26 in. chassis slides, STD.
OPT 20B	Rack mount brackets with 24 in. chassis slides.
OPT 21	Rack mount brackets only

5.4. CARRYING STRAP HANDLE (OPT 29)

The chassis of the M700E calibrator allows to attach a strap handle for carrying the instrument. The handle is located on the right side and pulls out to accommodate a hand for transport. When pushed in, the handle is nearly flush with the chassis, only protruding out about 9 mm (3/8").

Figure 5-5: M700E with Carrying Strap Handle and Rack Mount Brackets

Installing the strap handle prevents the use of the rack mount slides, although the rack mount brackets, Option 21, can still be used.

CAUTION

A FULLY LOADED M700E WITH BOTH THE O_3 GENERATOR AND PHOTOMETER OPTIONS INSTALLED WEIGHS ABOUT 17 KG (40 POUNDS).

TO AVOID PERSONAL INJURY WE RECOMMEND TWO PERSONS LIFT AND CARRY THE CALIBRATOR.

ENSURE TO DISCONNECT ALL CABLES AND TUBING FROM THE CALIBRATOR BEFORE CARRYING IT.

5.5. SPARE PARTS KITS

5.5.1. M700E EXPENDABLES KIT (OPT 46A)

This kit includes a recommended set of expendables and spare parts (for 1 unit) for one year of operation of the M700E. See Appendix B for a detailed listing of the contents.

5.5.2. M700E SPARE PARTS KIT (OPT 46B & OPT 46C)

This kit includes a recommended set of spare parts for one year of operation of M700E's that have the optional O_3 generator and photometers installed. See Appendix B for a detailed listing of the contents.

OPTION NUMBER	DESCRIPTION
OPT 46B	Photometer Spares Kit for 1 unit.
OPT 46C	Photometer with IZS Spares Kit for 1 unit.

5.6. COMMUNICATION OPTIONS

5.6.1. RS232 MODEM CABLES (OPT 60A & OPT 60B)

Option 60A consists of a shielded, straight-through serial cable of about 1.8 m length to connect the calibrator's COM1 port to a computer, a code activated switch or any other communications device that is equipped with a DB-25 female connector. The cable is terminated with one DB-9 female connector and one DB-25 male connector. The DB-9 connector fits the calibrator's RS-232 port.

The calibrator is shipped with a standard, shielded, straight-through DB-9F to DB-9F cable of about 1.8 m length, which should fit most computers of recent build. An additional cable of this type can be ordered as Option 60B.

5.6.2. ETHERNET CABLE (OPT 60C)

Option 60C consists of a 7-foot (2 meters) long, CAT-5 network cable, terminated at both ends with standard RJ-45 connectors. This cable is used to connect the M700E to any standard ETHERNET socket.

5.6.3. RS-232 MULTI-DROP (OPT 62)

The multi-drop option is used with any of the RS-232 serial ports to enable communications of up to eight calibrators with the host computer over a chain of RS-232 cables via the instruments COM1 Port. It is subject to the distance limitations of the RS-232 standard.

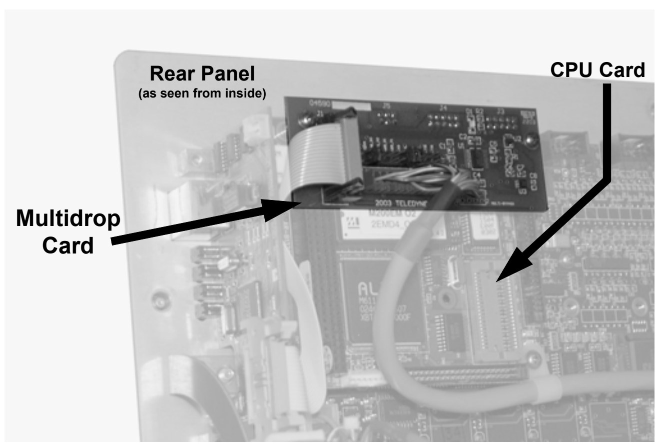


Figure 5-6: M700E Multi-drop Card

The option consists of a small printed circuit assembly, which is plugs into to the calibrator's CPU card (see Figure 5-6) and is connected to the RS-232 and COM2 DB9 connectors on the instrument's back panel via a cable to the motherboard. One Option 62 is required for each calibrator along with one 6' straight-through, DB9 male → DB9 Female cable (P/N WR0000101).

5.6.4. ETHERNET (OPT 63A)

The ETHERNET option allows the calibrator to be connected to any Ethernet local area network (LAN) running TCP/IP. The local area network must have routers capable of operating at 10BaseT. If Internet access is available through the LAN, this option also allows communication with the instrument over the public Internet. Maximum communication speed is limited by the RS-232 port to 115.2 kBaud.

When installed, this option is electronically connected to the instrument's COM2 serial port making that port no longer available for RS-232/RS-485 communications.

The option consists of a Teledyne API designed Ethernet card (see figures below), and a 7-foot long CAT-5 network cable, terminated at both ends with standard RJ-45 connectors.

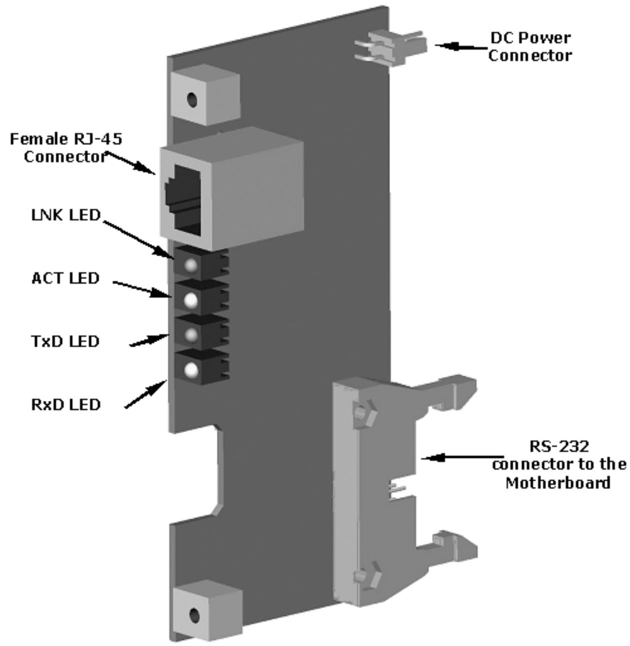


Figure 5-7: M700E Ethernet Card

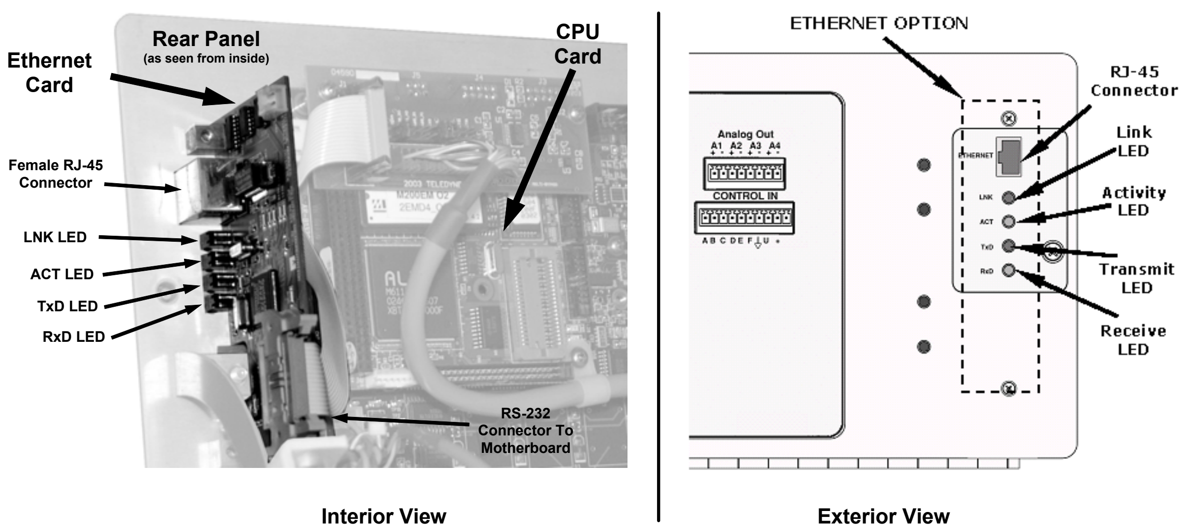


Figure 5-8: M700E Rear Panel with Ethernet Installed

For more information on setting up and using this option, see Section 7.4.

5.6.5. ETHERNET + MULTI-DROP (OPT 63C)

This option allows the instrument to communicate on both RS-232 and ETHERNET networks simultaneously. It includes the following:

- RS232 MODEM CABLES (OPT 60A or OPT 60B)
- ETHERNET CABLE (OPT 60C)
- RS-232 MULTI-DROP (OPT 62)
- ETHERNET (OPT 63A)

5.7. ADDITIONAL MANUAL (OPT 70A & OPT 70B)

Additional copies of the printed user's manual can be purchased from the factory as Option 70A. Please specify the serial number of your calibrator so that we can match the manual version.

This operator's manual is also available on CD as option 70B. The electronic document is stored in Adobe Systems Inc. *Portable Document Format* (PDF) and is viewable with Adobe Acrobat Reader® software, which can be downloaded for free at http://www.adobe.com/.

The electronic version of this manual can also be downloaded for free at http://www.teledyne-api.com/manuals/. Note that the online version is optimized for fast downloading and may not print with the same quality as the manual on CD.

5.8. EXTERNAL VALVE DRIVER (OPT 48A & OPT 48B)

An external valve driver assembly, is available that can drive up to 8, eight-watt valves based on the condition of the status block bits described above. The option consists of a custom Printed Circuit Assembly (PCA) that mounts to the back of the M700E and a universal AC-to-DC power supply.

Figure 5-9: M700E Rear Panel Valve Driver Installed

OPTION NUMBER	DESCRIPTION
OPT 48A	External Valve Driver Capability – 12V
OPT 48B	External Valve Driver Capability – 24 V

Depending upon the capacity of the external supply either four (standard) or eight valves can be simultaneously energized.

The PCA (P/N 05697) is constructed such that it plugs through the rear panel into the Control Output connector, J1008, on the M700E's motherboard.

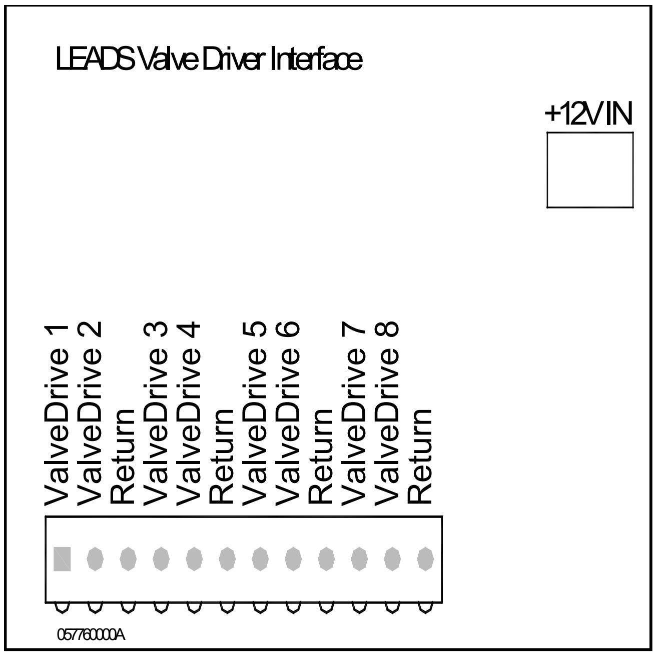


Figure 5-10: Valve Driver PCA Layout

When one of the Control Outputs is energized, the base of the associated PNP valve driver transistor (U1 through U8) is taken to ground and the emitter-collector junction becomes active.

NOTE

This interface sources DC current to the valves rather than previous versions that sinks current from an external supply through the valve in question.

Electronic connections should be made as follows:

- Valves should be connected between one of the Valve Drive outputs and one of the Return pins.
- The external power supply must be connected to the Valve Driver Interface using the +12V coaxial input connector on the top, right-hand side of the assembly.
- The external supply in turn must be connected to 85-264V, 47-63Hz mains.

The Valve Driver Outputs are mapped one-for-one to the Control Outputs 1 through 8 and can be manually actuated for troubleshooting using the Signal-I/O diagnostic function in the M700E software (see Section 11.4.10.5). However, the drive outputs are mapped in reverse to the status control bits such that Bit-0 (LSB) is valve drive 8 and Bit-7 is valve drive 1.

5.9. NIST TRACEABLE, PRIMARY STANDARD CERTIFICATION (OPT 95A, OPT 95B & OPT 95C)

The Model M700E calibrator can be used as a Primary Ozone Standard if purchased with the O_3 generator (OPT 01A) and photometer (OPT 02A) options. For this application the performance of the M700E Dynamic Dilution Calibrator calibrated to Standard Reference Photometer (SRP).

Calibrators ordered with this option are verified and validated in accordance with the procedures prescribed by the U.S. Environmental Protection Agency (EPA) under Title 40 of the Code of Federal Regulations, Part 50, Appendix D (40 CFR Part 50).

OPTION NUMBER	DESCRIPTION
OPT 95A	Factory Calibration
OPT 95B	Calibration as a primary standard
OPT 95C	Calibration to NIST-SRP

5.10. PERMEATION TUBE OVEN OPTION (OPT 05)

The permeation tube gas generator (see Figure 5-11) is an alternative method for producing known concentrations of stable gas such as SO_2, NO_2, etc. The generator consists of a temperature regulated permeation tube oven, a flow restrictor, an optional output desorber, and a user-supplied permeation tube. The optional desorber can improve the response time of the calibrator especially when operating with NO_2 tubes (when operating with sulfur based gases it **MUST** be removed).

The permeation tube consists of a small container of a liquefied gas, with a small window of PTFE which the gas slowly permeates through at a rate in the nanogram/min range. If the tube is kept at constant temperature, usually about 50°C, the device will provide a stable source of gas for a year or more. A pneumatic schematic of the M700E with this option is shown in Figure 5-12, as well as an exploded view of the generator.

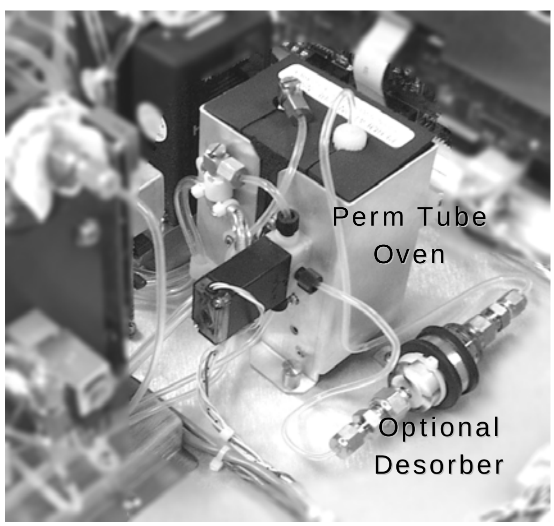


Figure 5-11: Permeation Tube Gas Generator Option

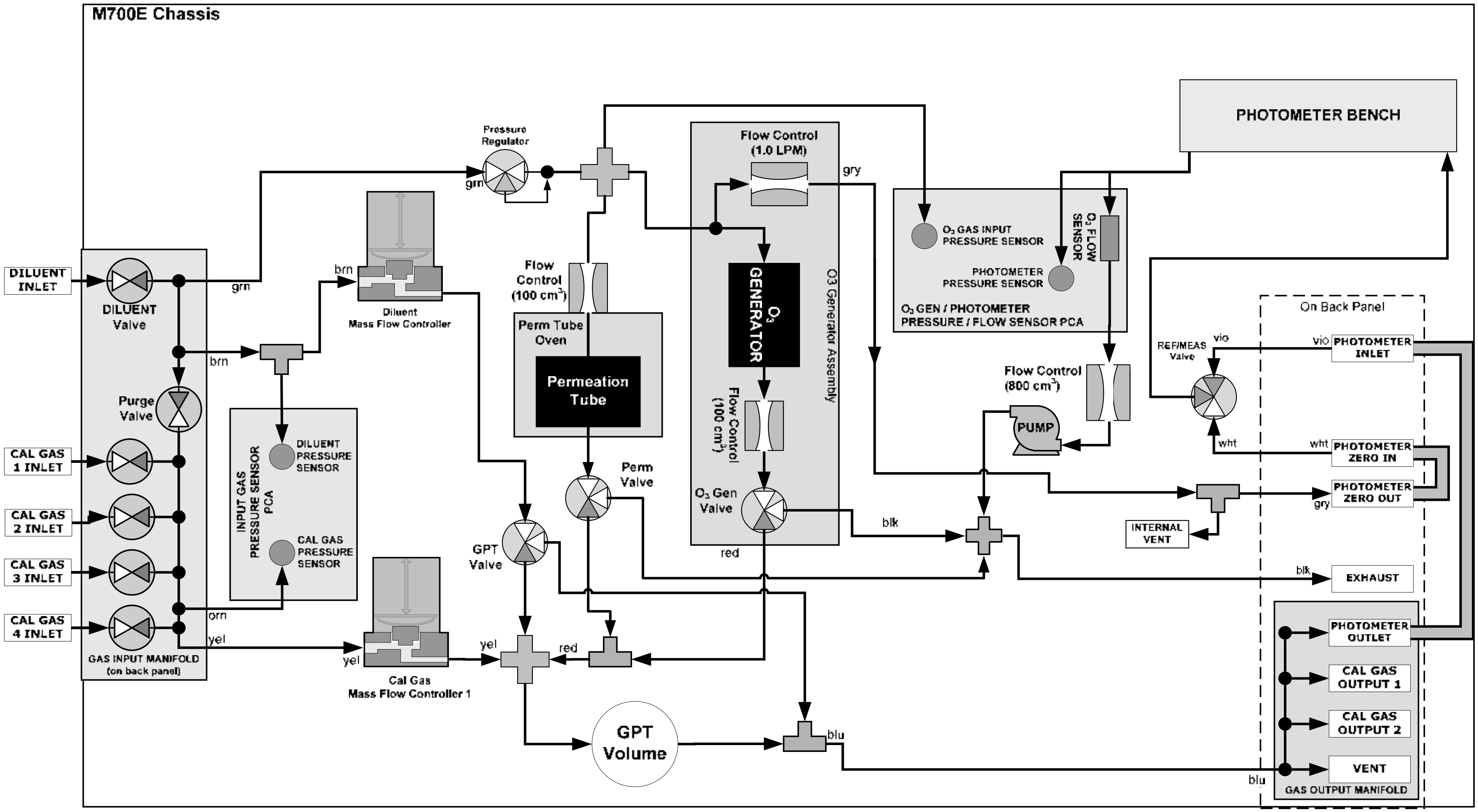


Figure 5-12: Pneumatic Diagram of M700E with Permeation Generator

Once installed and stabilized, generating a calibration gas from the M700E with a permeation generator is the same as if the gas was being produced using a gas cylinder as the source, with the following exceptions and note:

- If you need a particular flow and don't require a specific concentration then use MANUAL mode. When generating in MANUAL mode the output concentration is set by adjusting the DILUENT flow. The target and actual concentrations are displayed as test values.

- If you need a particular concentration but don't require a specific flow then use AUTO mode. When generating in AUTO mode the output concentration is set by entering the desired concentration. The TOTAL flow entry has no effect; the calibrator's output flow depends on the target concentration. Again the target and actual concentrations as well as the target and actual flows will be indicated as test parameters.

- Please note that the name for the permeation tube gas MUST be different than any gas supplied to the calibrator from a bottle. For example if there is a H_2S permeation tube installed and a bottle of H_2S gas connected to the calibrator, one should be named H_2S, while the second should be named something like H_2S_2.

The generator is shipped **WITHOUT** a permeation tube installed. The tube **MUST** be **removed** during shipping or anytime that there is no dilutant gas connected to the calibrator since there must be a continuous purge flow across the tube. Permeation tubes require 48 hours at 50°C to reach a stable output. We recommend waiting this long before any calibration checks, adjustments, or conclusions are reached about the permeation tube. Once the M700E has stabilized, the response to the permeation tube is not expected to change more than ± 5% if the zero air is provided for Teledyne API's M701 or other dry zero air source.

Teledyne API recommends that you purchase replacement permeation tubes from:

VICI METRONICS
2991 Corvin Drive
Santa Clara, CA 95051 USA
Phone 408-737-0550 Fax 408-737-0346

5.10.1. PERMEATION TUBE SETUP FOR THE M700E

1. Press SETUP and GAS

2. Press PERM

3. Enter the elution rate for the permeation tube and Select the type of gas by pressing the gas button until the desired gas is shown.

NOTE

The name of the gas produced by the permeation tube generator MUST be different than the name of any bottle connected to the calibrator.

4. Then enter the gas flow through the permeation tube. This should be done with the flow standard connected at the outlet of the perm tube oven.

5.10.2. PERMEATION TUBE CALCULATION

The permeation tube concentration is determined by the permeation tube's specific output or elution rate (which is normally stated in ng/min), the permeation tube temperature (°C) and the air flow across it (slpm). The elution rate of the tube is normally stated at an operating temperature of 50°C and is usually printed on the tube's shipping container. By design, there is nominally 100 ccm of air flow across the tube and the tube is maintained at 50°C. The output of the calibrator is the product of the elution rate with the total of the 100 sccm through the generator and the flow of dilutent gas.

The temperature is set at 50.0°C. Check SETUP-MORE-VARS and scroll to the IZS-TEMP variable to verify that the temperature is properly set. It should be set to 50°C with over-and-under temperature warnings set at 49°C and 51°C. There is a 105 cm^3/min flow across the permeation tube at all times to prevent build-up of the gas in the tubing.

This permeation tube source gas is diluted with zero air to generate desired concentration of the specific gas. The calibrator's output concentration (gas concentration) can be calculated using the following equation:

$$C = \frac{P \times Km}{F}$$

Where, P = permeation rate, ng/min @ 50°C.

Km = $\frac{24.46}{MW}$, where 24.46 is the molar volume in liters @ 25°C

and MW is the molecular weight.
760mmHg . Km for SO_2 = 0.382, NO_2 = 0.532, H_2S = 0.719, and NH_3 = 1.436.

F = total flow rate (sum of 100 cm^3/min and diluent flow), cm^3/min.

C = concentration, ppm.

Thus, $$C = \frac{P}{F} \times \frac{24.46}{MW}\left(\frac{323}{298}\right)$$

Where, Temperature at 50°C = 323

Temperature at 25°C = 298

5.11. EXTENDED WARRANTY (OPT 92B & OPT 92C)

Two options are available for extending Teledyne API's standard warranty (see Section 2.3). Both options have to be specified upon ordering the analyzer.

Option Number	Description
OPT 92B	3 YEAR WARRANTY (Includes 1 year standard, 2 years additional). Extends warranty to cover a three (3) year period from the date of purchase.
OPT 92C	WARRANTY BEYOND 3 YEARS (Consult factory for pricing).

5.12. DUAL GAS OUTPUT (NO_Y – SPECIAL) (OPT 73)

The standard output manifold has been removed and replaced with 2 output fittings, labeled "Output A" and "Output B." Output A is the primary calibration gas output, all calibration functions can be performed on this output. Output B is a secondary output, commonly used for NOy probe calibrations. This output cannot be used for ozone generation using the photometer feedback. It can be used for standard dilution calibrations as well as GPT using ozone.

The dual output option consists of an internal output selector value that can be used to output calibration gas to one of two output fittings, labeled "Output A" and "Output B", take the place of the output manifold. When this option is enabled, the output must be selected when generating gas. See example as follows:

1. Press SETUP.

```
STANDBY       TARG CAL=0.0000 LPM
<TST TST>   GEN STBY                    SETUP
```

2. Press MORE.

```
SETUP D.0     PRIMARY SETUP MENU
 GAS    SEQ   CFG   CLK PASS MORE        EXIT
```

3. Press DIAG.

```
SETUP D.0     SECONDARY SETUP MENU
COMM FLOW VARS DIAG                      EXIT
```

WARNING

THERE ARE MORE VARS AVAILABLE WHEN USING THE 929 PASSWORD. USE CAUTION WHEN PRESSING ANY BUTTONS WHILE IN THIS SETUP. ANY CHANGES MADE MAY ALTER THE PERFORMANCE OF THE INSTRUMENT OR CAUSE THE INSTRUMENT TO NOT FUNCTION PROPERLY. NOTE THAT IF THERE IS AN ACCIDENTAL CHANGE TO A SETUP, PRESS "EXIT" TO DISCARD THE CHANGES MADE.

4. Enter the password 929 and press ENTR.

```
SETUP D.0     ENTER PASSWORD:818
  8     1     8                    ENTR EXIT
```

5. Press NEXT until you get to the next screen.

```
DIAG          SIGNAL I/O
     NEXT                 ENTR      EXIT
```

6. Press ENTR.

```
DIAG          FACTORY OPTIONS
PREV                      ENTR      EXIT
```

7. Press NEXT until you get to the next screen.

```
DIAG OPT      PHOTOMETER:ON
     NEXT    ON                ENTR EXIT
```

8. Press OFF to turn ON the DUAL GAS OUTPUT.

```
DIAG OPT      DUAL GAS OUTPUT:OFF
PREV NEXT    OFF               ENTR EXIT
```

9. Press ENTR. This step will return to the FACTORY OPTIONS screen.

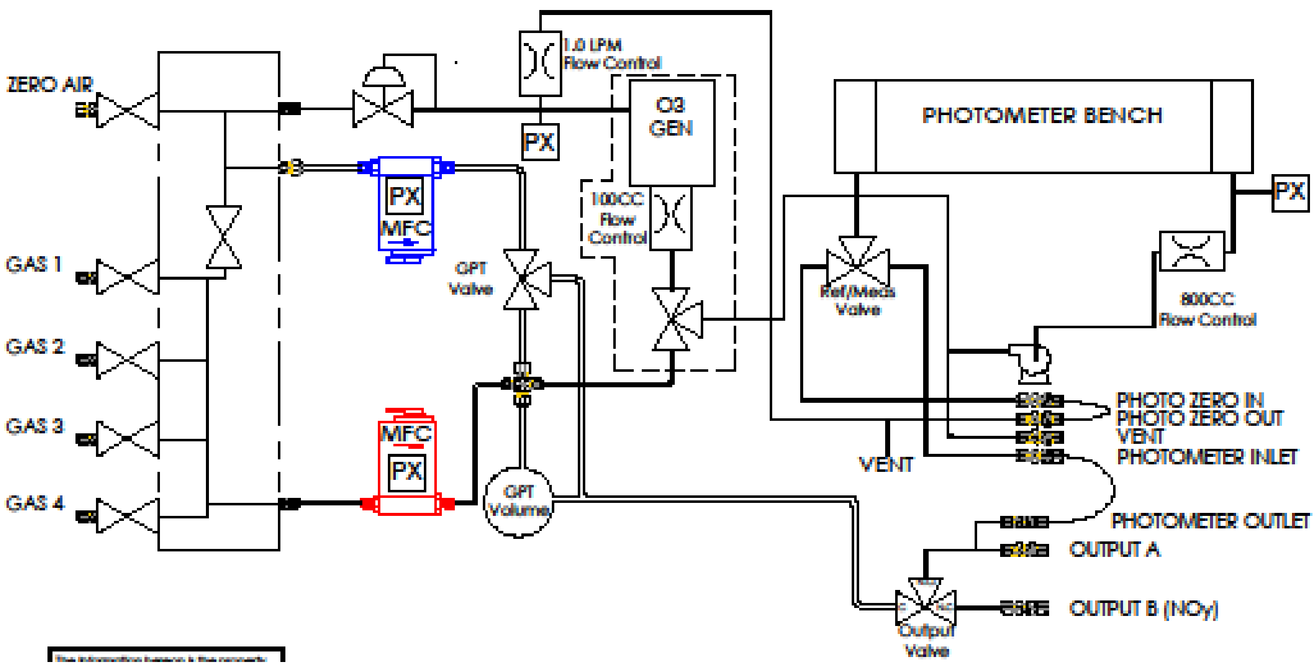


Figure 5-13: Internal Pneumatics for M700E Calibrator with Optional Dual Gas Output (NO_y – Special)

USER NOTES:

SECTION II
–
OPERATING INSTRUCTIONS

USER NOTES:

6. OPERATING THE M700E CALIBRATOR

The M700E calibrator is a computer-controlled calibrator with a dynamic menu interface for easy and yet powerful and flexible operation. All major operations are controlled from the front panel display and keyboard through these user-friendly menus.

To assist in navigating the system’s software, a series of menu trees can be found in Appendix A of this manual.

NOTE

The flowcharts in this chapter depict the manner in which the front panel display/keyboard interface is used to operate the M700E Dynamic Dilution Calibrator.

They depict typical representations of the display during the various operations being described.

They are not intended to be exact and may differ slightly from the actual display of your system.

NOTE

The ENTR key may disappear if you select a setting that is invalid or out of the allowable range for that parameter, such as trying to set the 24-hour clock to 25:00:00. Once you adjust the setting to an allowable value, the ENTR key will reappear.

6.1. TEST FUNCTIONS

A variety of **TEST** functions are available for viewing at the front panel whenever the calibrator is at the **MAIN MENU**. These functions provide information about the present operating status of the calibrator and are useful during troubleshooting (see Chapter 11). Table 6-1 lists the available **TEST** functions.

To view these **TEST** functions, press:

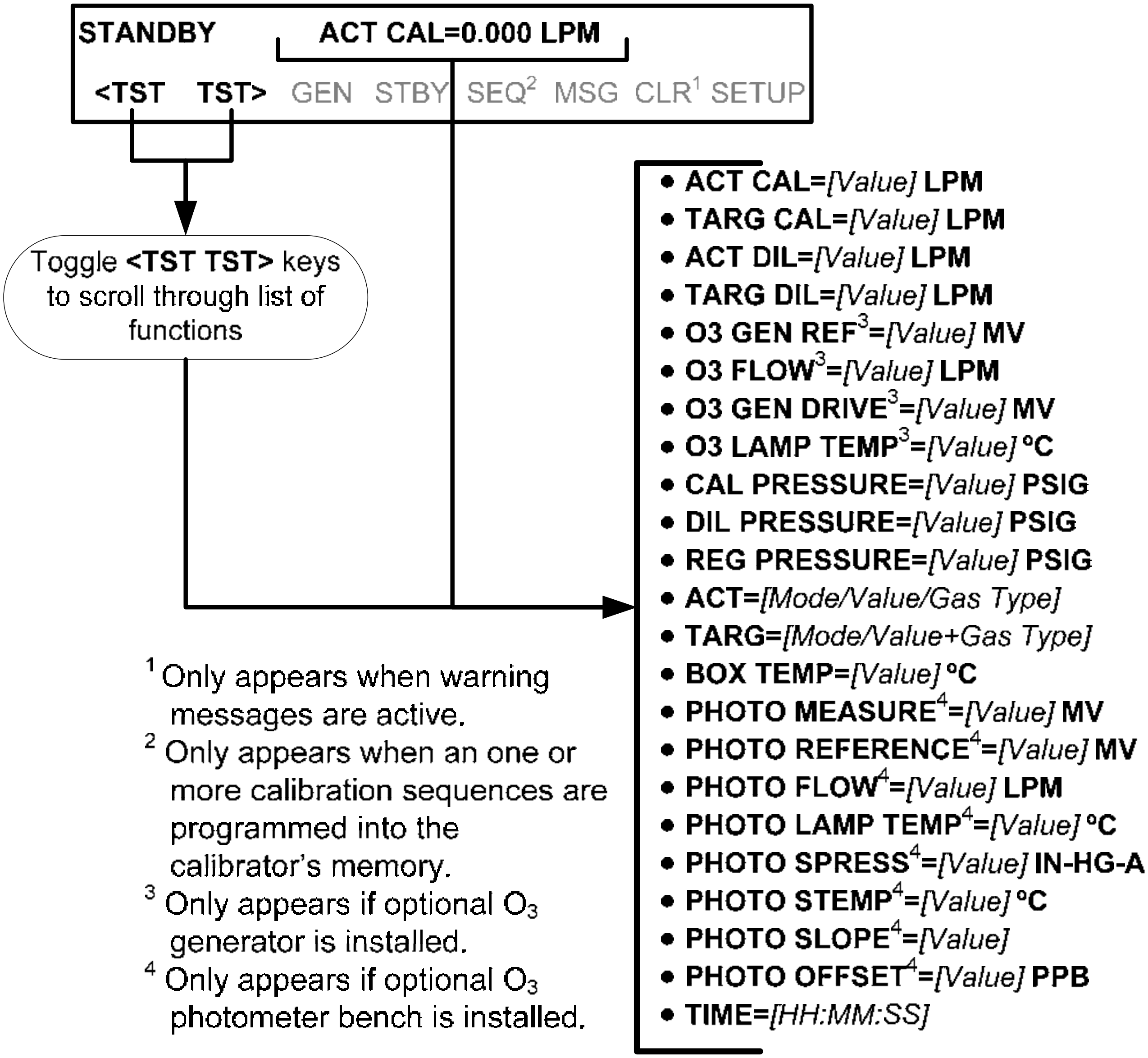


Figure 6-1: Viewing M700E Test Functions

Table 6-1: Test Functions Defined

DISPLAY	PARAMETER	UNITS	DESCRIPTION
ACT CAL	ACTCALFLOW	LPM	The actual gas flow rate of source gas being output by the calibrator.
TARG CAL	TARGCALFLOW	LPM	Target source gas flow rate for which the calibrator output is set.
ACT DIL	ACTDILFLOW	LPM	The actual gas flow rate of diluent (zero) gas being output by the calibrator.
TARG DIL	TARGDILFLOW	LPM	Target diluent (zero) gas flow rate for which the calibrator output is set.
O3 GEN REF[1]	O3GENREF	mV	The voltage being output by the O_3 generator reference detector.
O3 FLOW[1]	O3GENFLOW	LPM	The gas flow rate for which the O_3 generator is set.
O3 GEN DRIVE[1]	O3GENDRIVE	mV	The drive voltage of the O_3 generator UV lamp.
O3 LAMP TEMP[1]	O3GENTEMP	°C	O_3 generator UV lamp temperature.
CAL PRESSURE	CALPRESS	PSIG	The gas pressure of the source gas being supplied to the calibrator.
DIL PRESSURE	DILPRESS	PSIG	The gas pressure of the Diluent gas being supplied to the calibrator Diluent pressure.
REG PRESSURE[2]	REGPRESS	PSIG	The gas pressure at the pressure regulator on the O_3 generator supply line.
ACT	*Message Varies depending on mode*		Actual concentration, and in some modes the actual flow rate, of the source gas in the calibration mixture being generated is displayed.
TARG	*Message Varies depending on mode*		The Target concentration, and in some modes the target flow rate, of the source gas in the calibration mixture being generated is displayed.
BOX TEMP	BOXTEMP	°C	Internal chassis temperature.
PHOTO MEASURE[2]	PHOTOMEAS	mV	The average UV Detector output during the SAMPLE PORTION of the optional photometer's measurement cycle.
PHOTO REFERENCE[2]	PHOTOREF	mV	The average UV Detector output during the REFERENCE portion of the optional photometer's measurement cycle.
PHOTO FLOW[2]	PHOTOFLOW	LPM	The gas flow rate as measured by the flow sensor located between the optical bench and the internal pump.
PHOTO LAMP TEMP[2]	PHOTOLTEMP	°C	The temperature of the UV lamp in the photometer bench.
PHOTO SPRESS[2]	PHOTOSPRESS	In-hg-A	The pressure of the gas inside the photometer's sample chamber as measured by a solid-state pressure sensor located downstream of the photometer.
PHOTO STEMP[2]	PHOTOSTEMP	°C	The temperature of the gas inside the sample chamber of the photometer.
PHOTO SLOPE[2]	PHOTOSLOPE	1.000	Photometer slope computed when the photometer was calibrated at the factory.
PHOTO OFFSET[2]	PHOTOOFFSET	ppb	Photometer offset computed when the photometer was calibrated at the factory.
TEST	TESTCHAN	mV	Displays the analog signal level of the **TEST** analog output channel. Only appears when the **TEST** channel has been activated.
TIME	CLOCKTIME	HH:MM:SS	Current time as determined by the calibrator's internal clock.

[1] Only appears when the optional O_3 generator is installed.

[2] Only appears when the optional O_3 photometer is installed.

6.2. OVERVIEW OF OPERATING MODES

The M700E calibrator software has a variety of operating modes. The most common mode that the calibrator will be operating in is the **STANDBY** mode. In this mode, the calibrator and all of its subsystems are inactive although **TEST** functions and **WARNING** messages are still updated and can be examined via the front panel.

The second most important operating mode is **SETUP** mode. This mode is used for performing certain configuration operations, such as programming the concentration of source gases, setting up automatic calibration sequences and configuring the analog/digital inputs and outputs. The **SETUP** mode is also used for accessing various diagnostic tests and functions during troubleshooting.

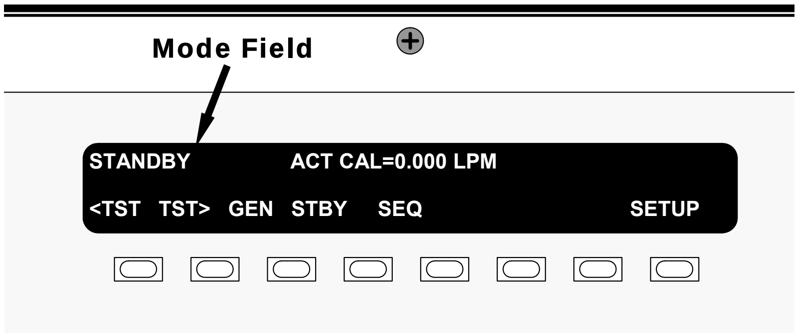


Figure 6-2: Front Panel Display

The mode field of the front panel display indicates to the user which operating mode the unit is currently running.

Besides **STANDBY** and **SETUP**, other modes the calibrator can be operated in are listed in Table 6-2:

Table 6-2: Calibrator Operating Modes

MODE	MEANING
DIAG	One of the calibrator's diagnostic modes is being utilized. When the diagnostic functions that have the greatest potential to conflict with generating concentrations are active, the instrument is automatically placed into standby mode.
GENERATE	In this mode, the instrument is engaged in producing calibration gas mixtures.
GPT[1]	The calibrator is using the O_3 generator and source gas inputs to mix and generate calibration gas using the gas phase titration method.
GPTPS[2]	Stands for Gas Phase Titration Preset. In this mode the M700E determines the precise performance characteristics of the O_3 generator at the target values for an upcoming GPT calibration.
MANUAL	In this mode, the instrument is engaged in producing calibration gas mixtures.
PURGE	The calibrator is using diluent (zero air) to purge its internal pneumatics of all source gas and previously created calibration mixtures.
SETUP[3]	**SETUP** mode is being used to configure the calibrator.
STANDBY	The calibrator and all of its subsystems are inactive.

[1] This mode is not available in units without O_3 generators installed.

[2] This mode is not available in units without internal photometers installed.

[3] The revision of the Teledyne API software installed in this calibrator will be displayed following the word **SETUP**. E.g. "**SETUP G.4**"

6.3. STANDBY MODE

When the M700E Dynamic Dilution Calibrator is in standby mode, it is at rest. All internal valves are closed except the diluent inlet valve. The mass flow controllers are turned off. On units with O_3 generator and photometer options installed, these subsystems are inactive.

- The **SETUP → GAS** submenu is only available when the instrument is in **STANDBY** mode.
- Some functions under the **SETUP → MORE → DIAG** submenu, those which conflict with accurate creation of calibration gas mixtures (e.g. **ANALOG OUTPUT STEP TEST**) automatically place the calibrator into **STANDBY** mode when activated.
- The MFC pressures are not monitored in standby mode since the MFC's are turned OFF. This prevents erroneous **MASS FLOW WARNING** messages from appearing.

NOTE

The M700E calibrator should always be placed in STANDBY mode when not needed to produce calibration gas.

The last step of any calibration sequences should always be the STANDY instruction.

Table 6-3 shows the status of the M700E's various pneumatic components when the calibrator is in **STANDBY** mode.

Table 6-3: Status of Internal Pneumatics During STANDBY Mode

VALVES (X = Closed; O = Open)									MFC's			PHOT PUMP
CYL1	CYL2	CYL3	CYL4	PURGE	DILUENT	GPT	O_3 GEN	PHOT M/R[1]	CAL1	CAL2[1]	DILUENT	
X	X	X	X	X	O	X	X	Reference Phase	OFF	OFF	OFF	OFF

[1] Only present if multiple cal gas MFC option is installed.

In instruments with optional O_3 generators installed, airflow is maintained during **STANDBY** mode so that the generator can continue to operate at its most efficient temperature.

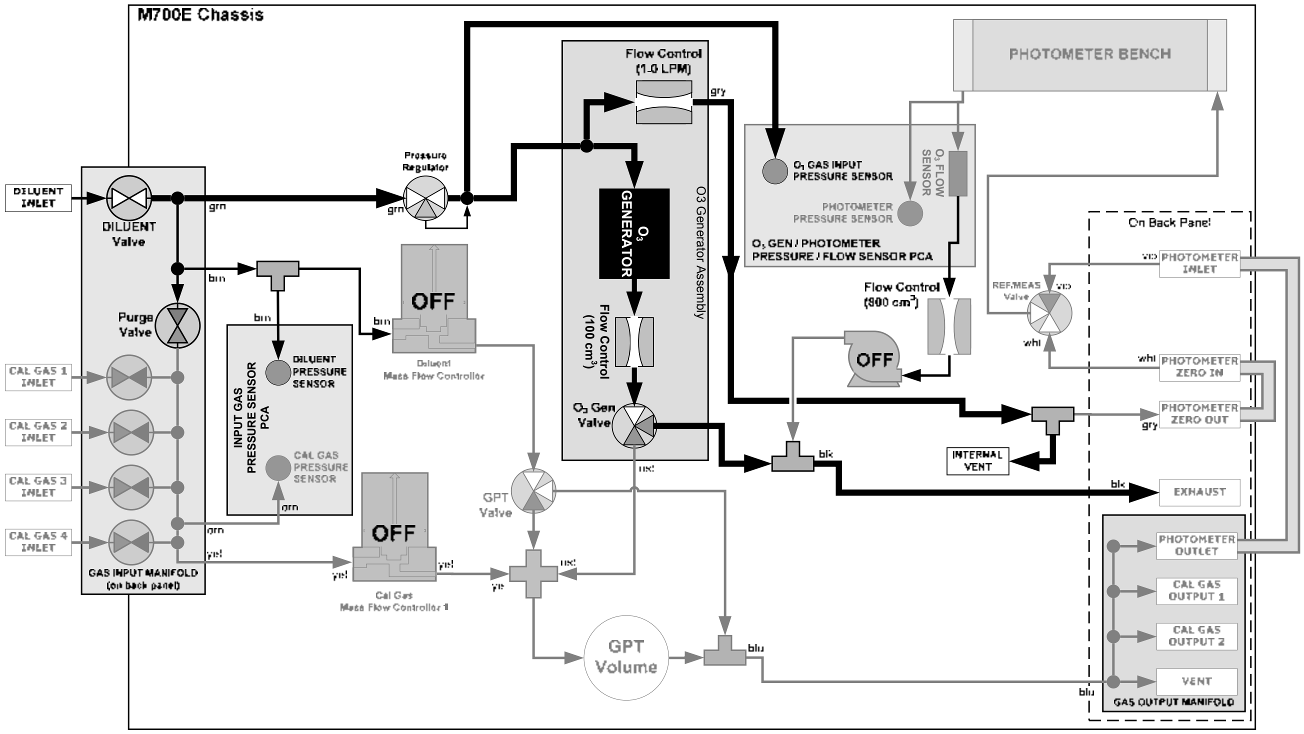


Figure 6-3: Gas Flow through M700E with O_3 Generator and Photometer Options during STANDBY

6.4. GENERATE MODE

6.4.1. GENERAL INFORMATION ABOUT THE GENERATE MODE

This mode allows the user to generate the desired calibration gas mixtures. The types of gas include NO, NO_2, SO_2, CO, HC or ZERO gas based on the source gas concentration entered during initial setup (see Section 3.3.8). If the units has an optional O_3 generator installed, various concentrations of O_3 can be generated as well.

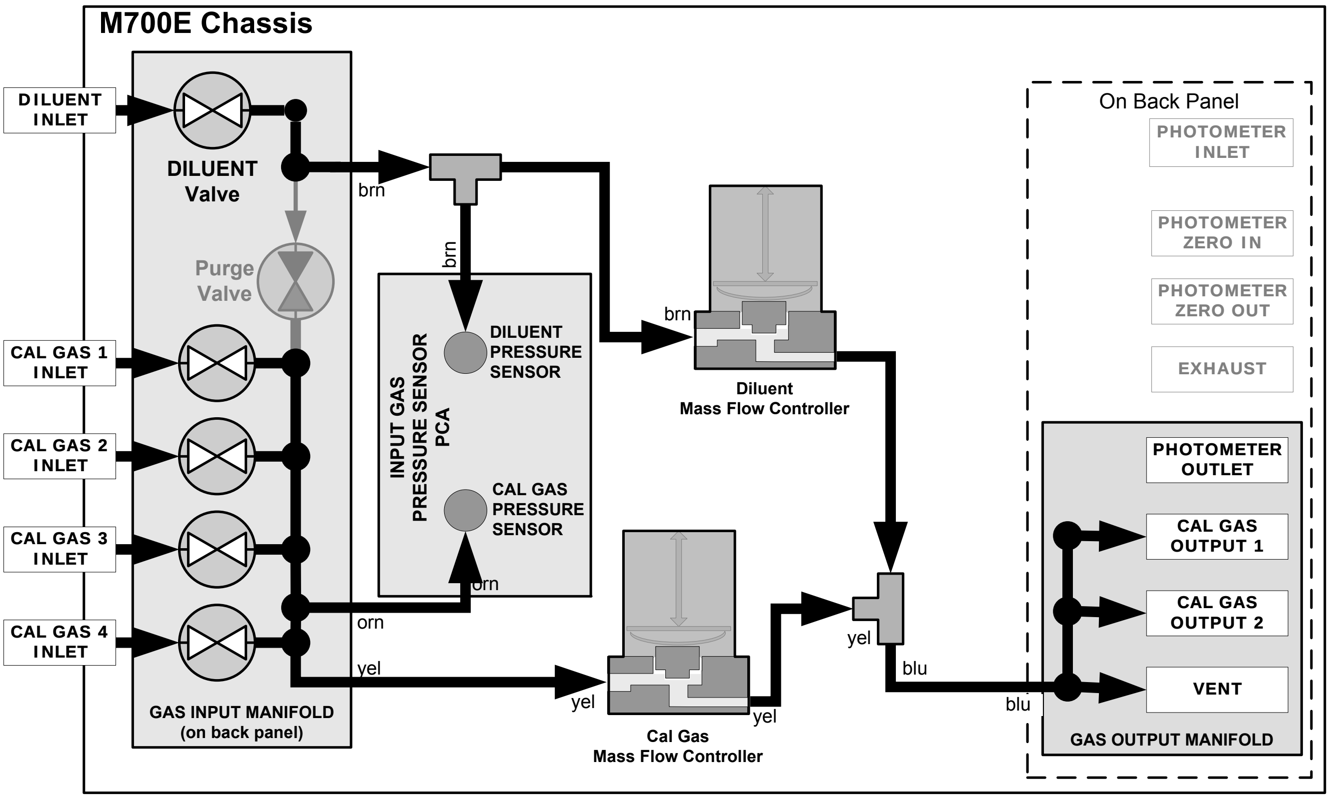


Figure 6-4: Gas Flow through Basic M700E in GENERATE Mode

Table 6-4 shows the status of the M700E's various pneumatic components when the calibrator is in **GENERATE** mode:

Table 6-4: Status of Internal Pneumatics During GENERATE Mode

GAS TYPE	VALVES (X = Closed; O = Open)									MFC's			PHOT PUMP
	CYL 1	CYL 2	CYL 3	CYL 4	PURGE	DILUENT	GPT	O_3 GEN	PHOT M/R	CAL1	CAL2[1]	DILUENT	
Generate Source Gas	O[2]	O[2]	O[2]	O[2]	X	O	X	X	Reference Phase	ON[3]	ON[3]	ON	OFF
Generate O_3	X	X	X	X	X	O	X	O	Switching	OFF	OFF	OFF	ON

[1] Only present if multiple cal gas MFC option is installed.

[2] The valve associated with the cylinder containing the chosen source gas is open.

[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.

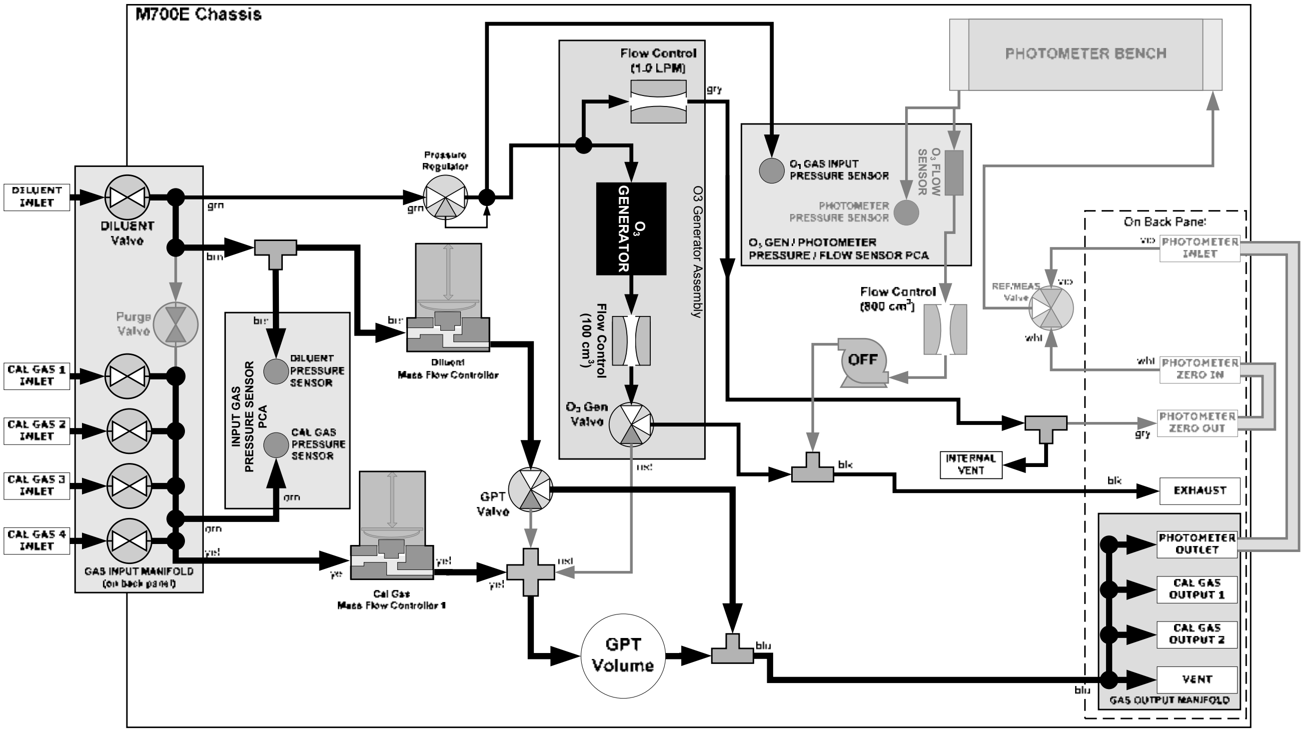


Figure 6-5: Gas Flow through M700E with O_3 Options when Generating Non-O_3 Source Gas

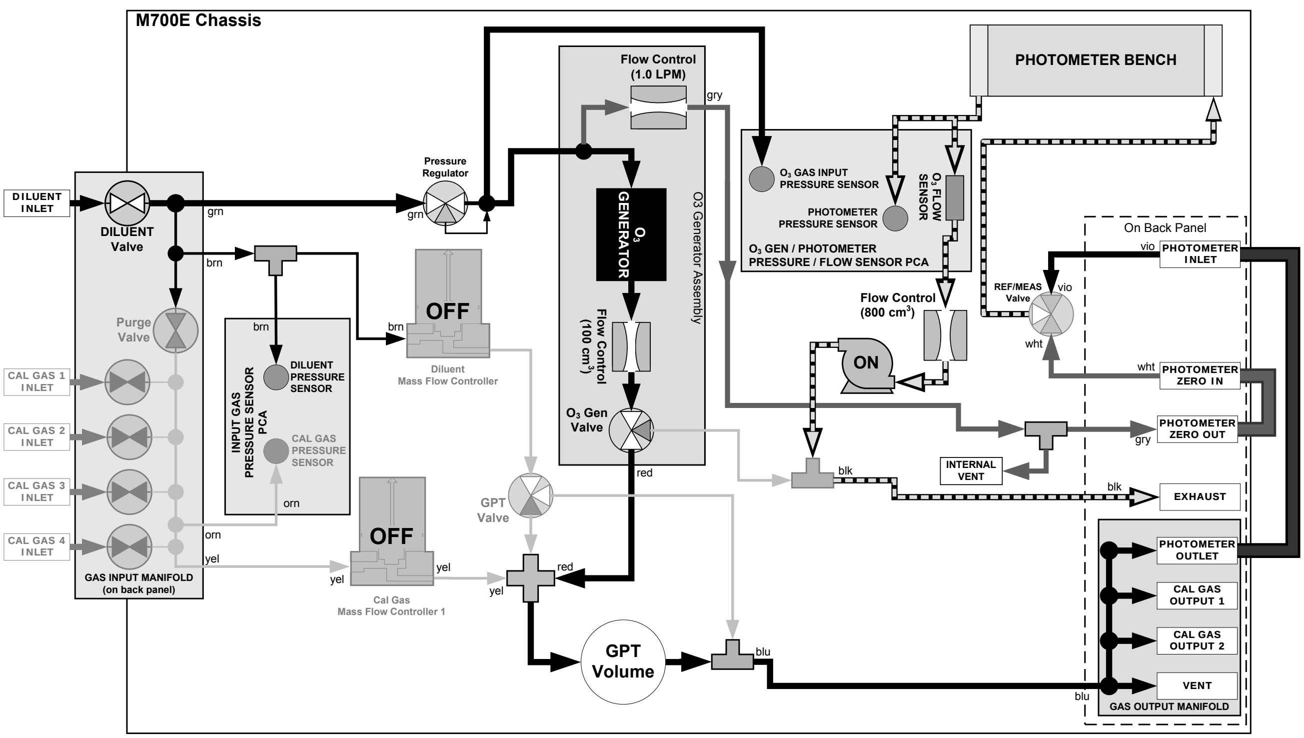


Figure 6-6: Gas Flow through M700E with O_3 Options when Generating O_3

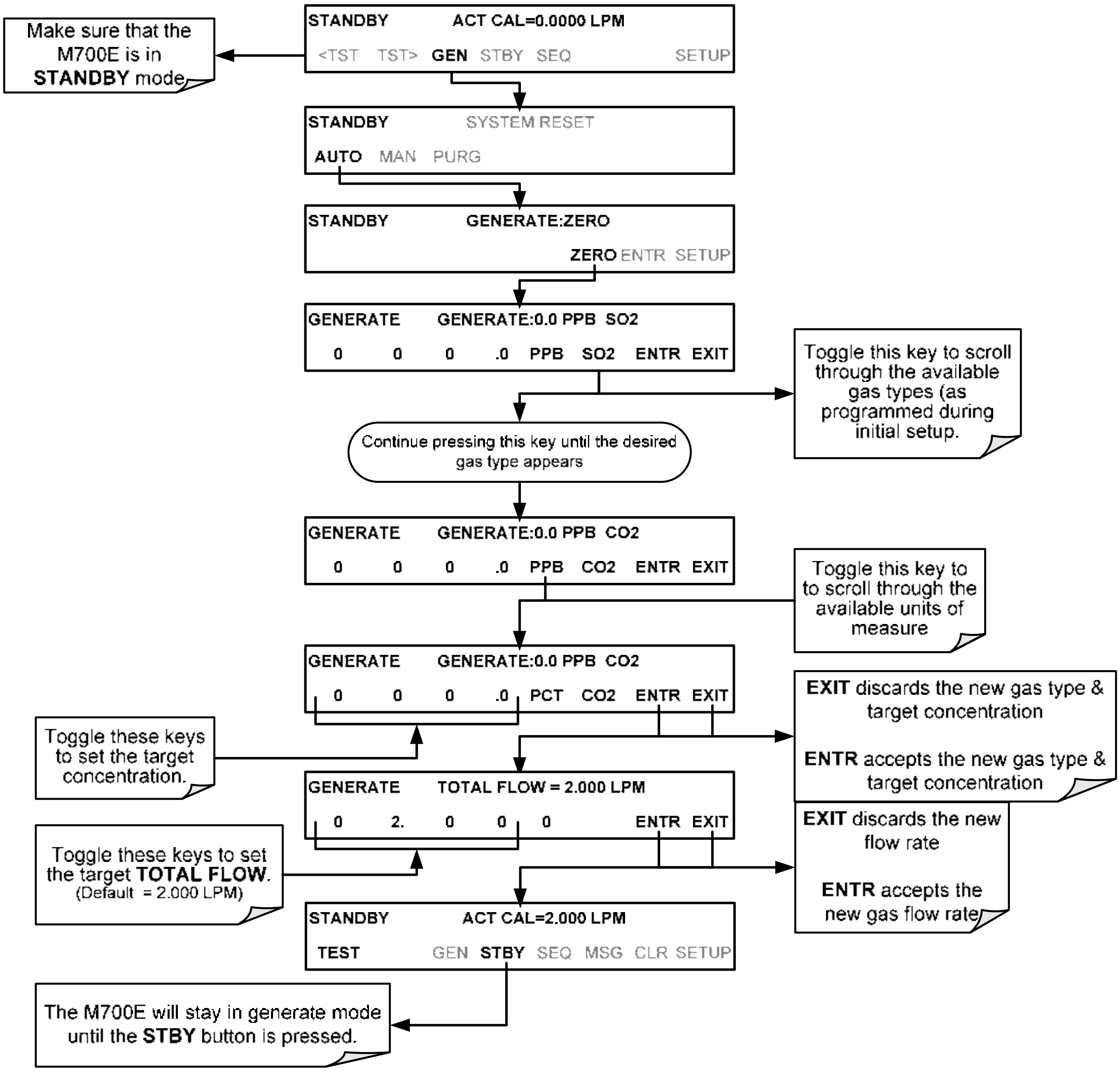
6.4.2. GENERATE → AUTO: Basic Generation of Calibration Mixtures

This is the simplest procedure for generating calibration gas mixtures. In this mode, the user makes three choices:

- The type of component gas to be used from the list of gases input during initial set up (see Section 3.3.8);
- The target concentration, and;
- The **TOTAL FLOW** to be output by the M700E.

Using this information, the M700E calibrator automatically calculates and sets the individual flow rates for the Diluent and chosen component gases to create the desired calibration mixture.

To use the **GENERATE → AUTO** feature, press:


Make sure that the M700E is in STANDBY mode
STANDBY ACT CAL=0.0000 LPM
<TST TST> GEN STBY SEQ SETUP
STANDBY SYSTEM RESET
AUTO MAN PURG
STANDBY GENERATE:ZERO
ZERO ENTR SETUP
GENERATE GENERATE:0.0 PPB SO2
0 0 0 .0 PPB SO2 ENTR EXIT
Toggle this key to scroll through the available gas types (as programmed during initial setup.
Continue pressing this key until the desired gas type appears
GENERATE GENERATE:0.0 PPB CO2
0 0 0 .0 PPB CO2 ENTR EXIT
Toggle this key to to scroll through the available units of measure
GENERATE GENERATE:0.0 PPB CO2
0 0 0 .0 PCT CO2 ENTR EXIT
Toggle these keys to set the target concentration.
EXIT discards the new gas type & target concentration
ENTR accepts the new gas type & target concentration
GENERATE TOTAL FLOW = 2.000 LPM
0 2. 0 0 0 ENTR EXIT
Toggle these keys to set the target TOTAL FLOW.
(Default = 2.000 LPM)
EXIT discards the new flow rate
ENTR accepts the new gas flow rate
STANDBY ACT CAL=2.000 LPM
TEST GEN STBY SEQ MSG CLR SETUP
The M700E will stay in generate mode until the STBY button is pressed.

6.4.3. GENERATE → MAN: Generating Calibration Mixtures Manually

This mode provides complete the user with more complete control of the gas mixture process. Unlike the **AUTO** mode, **MAN** mode requires the user set the both the component gas flow rate and diluent airflow rate. This allows the user control over the mixing ratio and total calibration gas flow rate.

In addition, if the M700E calibrator is equipped with the optional O_3 generator and O_3 is to be included in the calibration mixture (e.g. using the GPT or GPTPS features), the user also needs to set the ozone generator mode and set point.

The **TOTAL FLOW** is defined by the user depending on system requirements.

NOTE

- **The minimum total flow should equal 150% of the flow requirements of all of the instruments to which the M700E will be supplying calibration gas.**
- **Example: If the M700E is will be expected to supply calibration gas mixtures simultaneously to a system in composed of three analyzers each requiring 2 LPM , the proper Total Flow output should be set at:**

(2 + 2 + 2) x 1.5 = 9.000 LPM

6.4.3.1. Determining the Source Gas Flow Rate

To determine the required flow rate of the component source gas use the following formula

Equation 6-1

$$GAS_{flow} = \frac{C_f \times Totalflow}{C_i}$$

WHERE:

C_f = target concentration of diluted gas
C_i = concentration of the source gas
GAS_{flow} = source gas flow rate

EXAMPLE:

- A target concentration of 200 ppm of SO_2 is needed.
- The Concentration of the SO_2 Source is 600 ppm
- The requirement of the system are 9.000 LPM
- The required source gas flow rate would be:

GAS_{flow} = (200 ppm x 9.000 LPM) ÷ 600 ppm
GAS_{flow} = 1800.000 ppm/LPM) ÷ 600 ppm
GAS_{flow} = 3.000 LPM

6.4.3.2. Determining the Diluent Gas Flow Rate

To determine the required flow rate of the diluent gas use the following formula:

Equation 6-2

$$DIL_{flow} = Totalflow - GAS_{flow}$$

WHERE:

GAS_{flow} = source gas flow rate (from Equation 6-1)

Totalflow = total gas flow requirements of the system

DIL_{flow} = required diluent gas flow

EXAMPLE:

- If the requirement of the system is 9.000 LPM,
- The source gas flow rate is set at 3.00 LPM.
- The required source gas flow rate would be:

DIL_{flow} = 9.0 LPM – 3.0 LPM
DIL_{flow} = 6.0 LPM

6.4.3.3. Determining the Diluent Gas Flow Rate with the Optional O_3 Generator Installed

If the optional O_3 generator is installed and in use, Equation 6.2 will be slightly different, since the O_{3flow} is a constant value and is displayed as a **TEST** function on the M700E's front panel. A typical value for O_{3flow} is 105 cm^3/min.

Equation 6-3

$$DIL_{flow} = Totalflow - O_{3\,flow}$$

WHERE:

GAS_{flow} = source gas flow rate (from Equation 6-1)

Totalflow = total gas flow requirements of the system.

$O_{3\ flow}$ = the flow rate set for the O_3 generator; a constant value (typically about 0.105 LPM)

DIL_{flow} = required diluent gas flow

EXAMPLE:

- If the requirement of the system are 9.000 LPM,
- The source gas flow rate is set at 3.00 LPM.
- The required source gas flow rate would be:

DIL_{flow} = 9.0 LPM – 0.105 LPM
DIL_{flow} = 8.895 LPM

NOTE

It is not recommended to set any flow rate to <10% or >100% of the full scale rating of that associated mass flow controller.

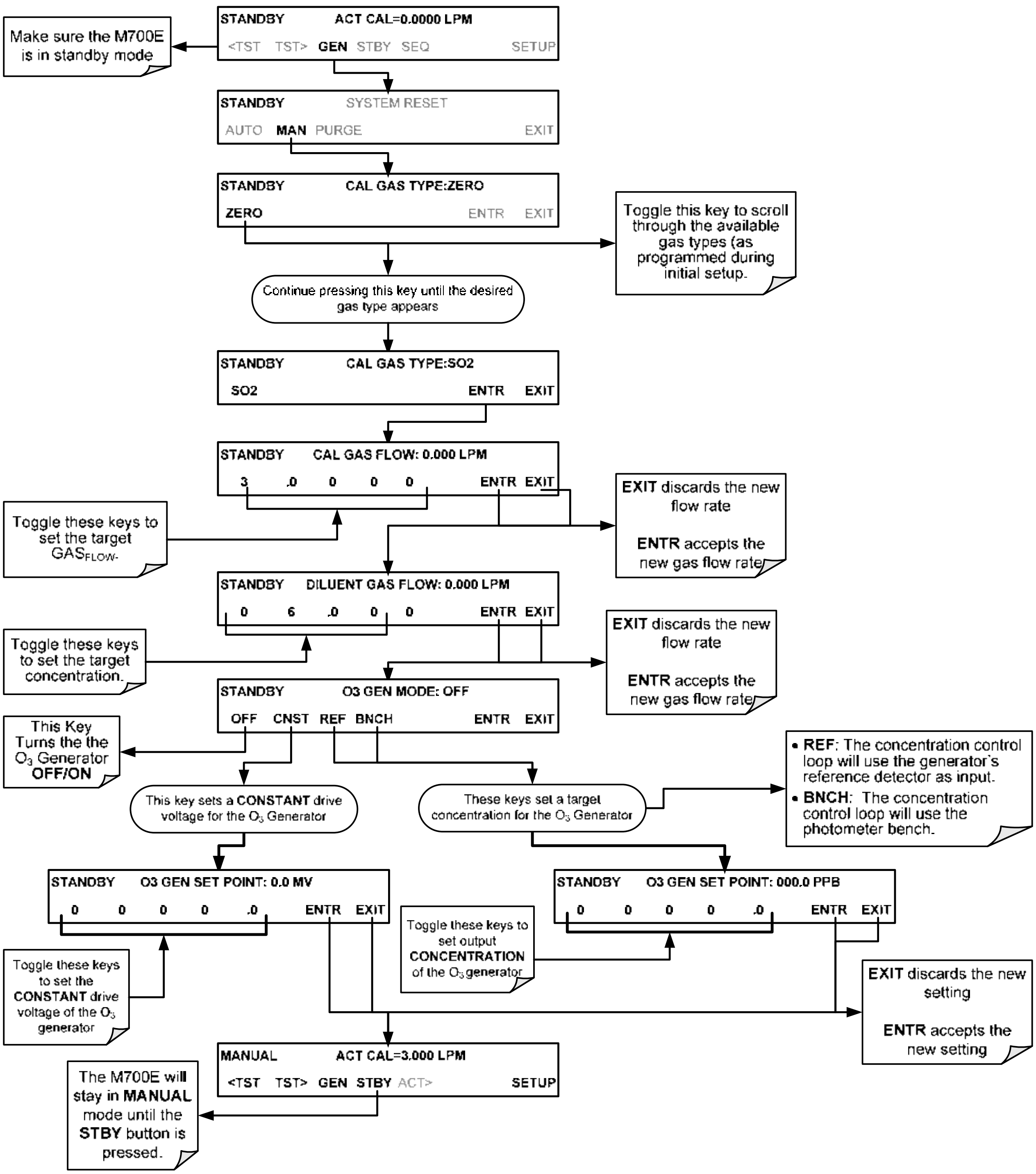
<u>FOR M700E'S WITH MULTIPLE CALIBRATIONS MASS FLOW CONTROLLERS INSTALLED.</u>

- **The combined flow potential of both mass flow controllers is available with the following limits:**
  - **The limits are <10% of the lowest rated MFC or >100% of the combined full-scale ratings for both mass flow controllers.**
- **The M700E will automatically select the MFC with the lowest flow rate that can accommodate the requested flow, thereby affording the most precise flow control.**
- **If no single MFC can accommodate the requested flow rate, multiple mass flow controllers are used.**

6.4.3.4. Setting the Source Gas and Diluent Flow Rates Using the GENERATE → MAN Menu

In the following demonstration we will be using the values from the examples given with Equations 6-1 and 6-2 above and assume a M700E calibrator with at least one source gas mass flow controller capable of 3.0 LPM output.

Using the example from Equations 6-1 and 6-2 above, press:



6.4.4. GENERATE → GPT: Performing a Gas Phase Titration Calibration

6.4.4.1. GPT Theory

The principle of GPT is based on the rapid gas phase reaction between NO and O_3, which produces quantities of NO_2 as shown by the following equation:

Equation 6-4

$$NO + O_3 \rightarrow NO_2 + O_2 + h\nu_{(light)}$$

It has been empirically determined that under controlled circumstances the NO-O_3 reaction is very efficient (<1% residual O_3), therefore the concentration of NO_2 resulting from the mixing of NO and O_3 can be precisely predicted and controlled as long as the following conditions are met:

a) The amount of O_3 used in the mixture is known.

b) The amount of NO used in the mixture is **AT LEAST** 10% greater than the amount O_3 in the mixture.

c) The volume of the mixing chamber is known.

d) The NO and O_3 flow rates (from which the time the two gases are in the mixing chamber) are low enough to give a residence time of the reactants in the mixing chamber of >2.75 ppm min.

Given the above conditions, the amount of NO_2 being output by the M700E will be equal to (at a 1:1 ratio) to the amount of O_3 added.

Since the O_3 flow rate of the M700E's O_3 generator is a set fixed value (typically about 0.105 LPM) and the GPT chamber's volume is known, once the **TOTAL GAS FLOW** requirements, the source concentration of NO, and the target concentration for the O_3 generator are entered into the calibrator's software. The M700E adjusts the NO flow rate and diluent (zero air) flow rate to create the appropriate NO_2 concentration at the output.

6.4.4.2. Choosing an Input Concentration for the NO.

It is important to ensure that there is enough NO in the GPT chamber to use up all of the O_3. Excess O_3 will react with the resulting NO_2 to produce NO_3. Since NO_3 is undetectable by most NO_x analyzers, this will result in false low readings.

The EPA requires that the NO content of a GPT mixture be at least 10% higher than the O_3 content. Since there is no negative effect to having too much NO in the GPT chamber, Teledyne API recommends that the NO concentration be chosen to be some value higher (as much as twice as high) as the highest intended target NO_2 value and kept constant.

As long as the flow rate is also kept constant three of the four conditions listed in Section 6.4.4.1 above are therefore constant and the NO_2 output can be easily and reliably varied by simply changing the O_3 concentration.

EXAMPLE:

- Calibration values of NO_2 from 200 ppb to 450 ppb will be needed.
- The NO gas input concentration should be no lower than 495 ppb and can be as high as 900 ppb.

6.4.4.3. Determining the TOTAL FLOW for GPT Calibration Mixtures

The total flow rate is defined by the user depending on system requirements.

The minimum total flow should equal 150% of the flow requirements of all of the instruments to which the M700E will be supplying calibration gas.

EXAMPLE:

- If the M700E is will be expected to supply calibration gas mixtures simultaneously to a system in composed of three analyzers each requiring 2 LPM, the proper Total Flow output should be set at:
- (2 + 2 + 2) x 1.5 = 9.000 LPM

NOTE

It is not recommended to set any flow rate to <10% or >100% of the full scale rating of that associated mass flow controller.

FOR M700E'S WITH MULTIPLE CALIBRATIONS MASS FLOW CONTROLLERS INSTALLED.

- **The full combined flow potential of both mass flow controllers is available to use with the following limits:**
  - **The limits are <10% of the lowest rated MFC or >100% of the combined full-scale ratings for both mass flow controllers.**
- **The M700E will automatically select the MFC with the lowest flow rate that can accommodate the requested flow, thereby affording the most precise flow control.**
- **If no single MFC can accommodate the requested flow rate, multiple mass flow controllers are used.**

Given this information, the M700E calibrator determines the NO gas flow by the formula:

Equation 6-5

$$NO\ GAS_{flow} = \frac{C_{NO_2} \times Totalflow}{C_{NO}}$$

WHERE:

C_{NO2} = target concentration for the NO_2 output
C_{NO} = concentration of the NO gas input
$NO\ GAS_{flow}$ = NO source gas flow rate

And the diluent (zero air) gas flow by the formula:

Equation 6-6

$$DIL_{flow} = Totalflow - NO\,GAS_{flow} - O_{3\,flow}$$

WHERE:

GAS_{flow} = source gas flow rate (from Equation 6-1)
Totalflow = total gas flow requirements of the system.
$O_{3\ flow}$ = the flow rate set for the O_3 generator; a constant value (typically about 0.105 LPM)
DIL_{flow} = required diluent gas flow

6.4.4.4. M700E Calibrator GPT Operation

The following table and figures show the status of the M700E's internal pneumatic components and internal gas flow when the instrument is in **GPT** generating modes.

Table 6-5: Status of Internal Pneumatics During GENERATE → GPT Mode

MODE	VALVES (X = Closed; O = Open)									MFC's			PHOT PUMP
	CYL 1	CYL 2	CYL 3	CYL 4	PURGE	DILUENT	GPT	O_3 GEN	PHOT M/R	CAL1	CAL2[1]	DILUENT	
GPT	O[2]	O[2]	O[2]	O[2]	X	O	O	O	Reference Phase	ON[3]	ON[3]	ON	OFF

[1] Only present if multiple cal gas MFC option is installed.

[2] The valve associated with the cylinder containing NO source gas is open.

[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.

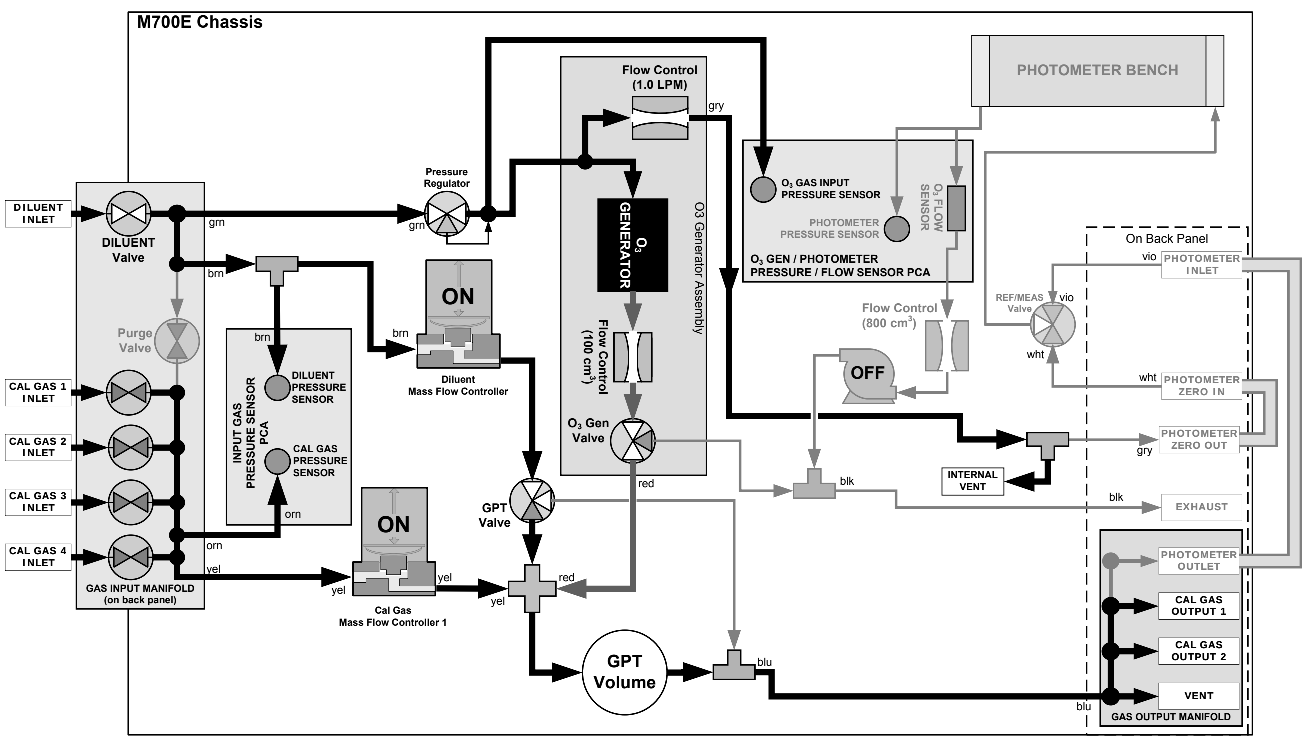


Figure 6-7: Gas Flow through M700E with O_3 Options when in GPT Mode

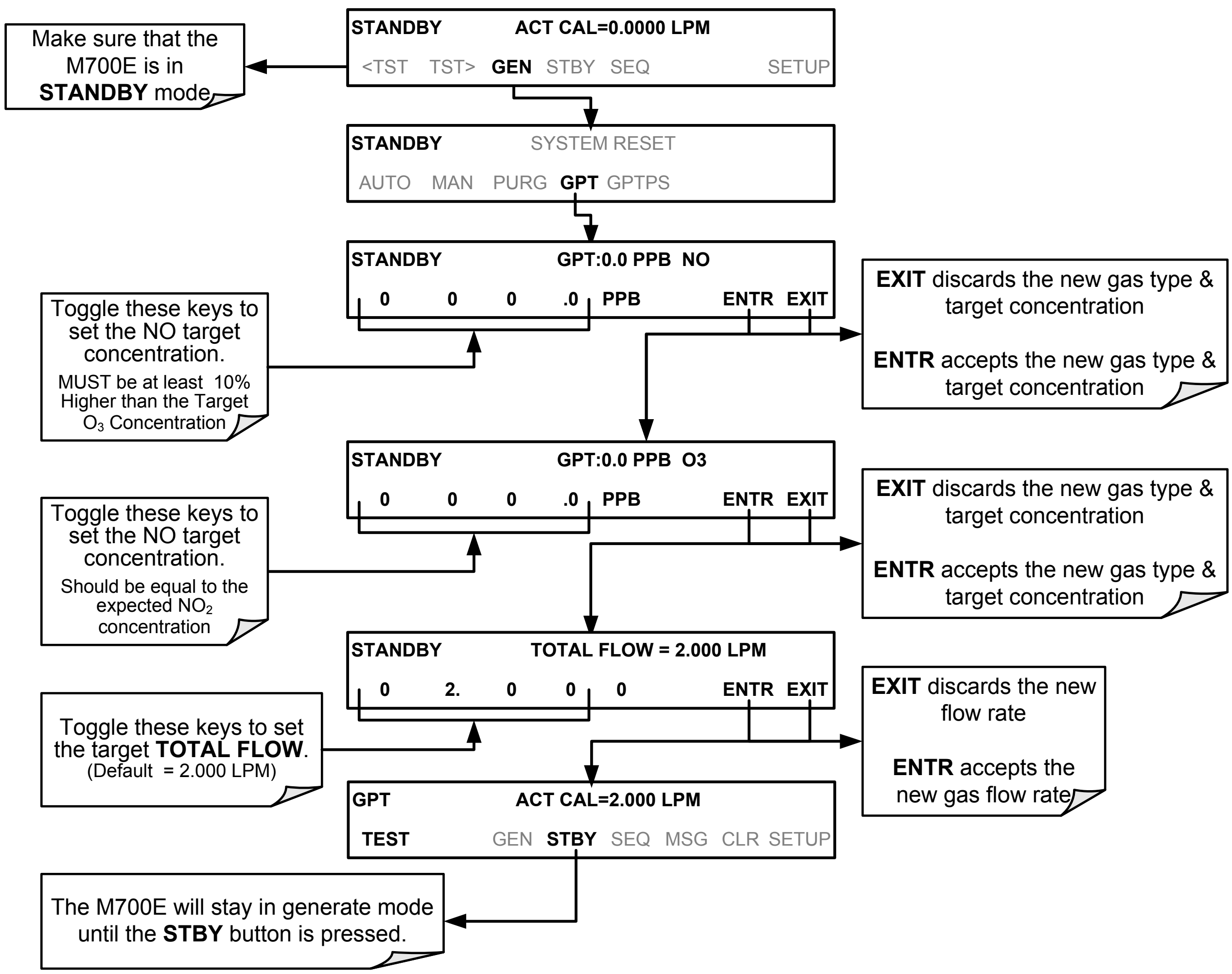
6.4.4.5. Initiating a GPT Calibration Gas Generation

NOTE
It is highly recommended to perform a GPT Pre-Set before initiating any GPT gas generation.

To initiate GPT gas generation you will need to know:

- The **TOTAL GAS FLOW** for the mixture output;
- The Target O_3 concentration (equal to the target NO_2 concentration to be generated), and;
- The NO source gas concentration.

Then, press:



6.4.5. GENERATE → GPTPS: Performing a Gas Phase Titration Pre-Set

The GPT Pre-Set feature simulates a **GPT** mixing operation in order to determine the exact output of the calibrators O_3 generator. As described in Section 6.4.4.1, all other things being equal, the concentration of the NO_2 being generated using the GPT feature will be equal to the amount of O_3 used. Therefore, the more accurately the O_3 generator performs the more accurate the NO_2 output will be.

When operating in **GPTPS** mode diluent gas (zero air) is substituted for the NO gas that would be mixed with the O_3 in normal GPT mode. The resulting unaffected O_3 output of the O_3 generator is shunted through the M700E's internal photometer, which measures the ACTUAL O_3 concentration in the gas.

Once the exact O_3 concentration being output by the generator is determined, the calibrator's software adjusts the O_3 drive voltage up or down so that the output of the generator matches as closely as possible, the target concentration requested. This adjusted generator setting will be used during any subsequent real GPT operation.

NOTE

The M700E has a learning algorithm during the O_3 generation (see Section 6.4) or Gas Phase Titration Pre-Set Mode (GPTPS) (Sections 6.4.4.5 and 6.4.5). It may take up to one hour for each new concentration/flow (point) that is entered into the instrument. Once the instrument has several points memorized in its cache, any new point that is entered will automatically be estimated within ±1% error (with photometer) and ±10% error (with O_3 generator and GPTPS).

NOTE

This adjustment is only valid for the O_3 concentration used during the Pre-Set operation. GPT Presets must be re-run for each different target NO_2 value.

In order to keep the resulting concentration of O_3 consistent with the GPT mixture being simulated, the instrument's software adjust the flow rate of the diluent gas to substitutes an amount of diluent gas equal to the amount of NO gas that would normally be used.

6.4.5.1. M700E Calibrator GPTPS Operation

The following table and figures show the status of the M700E's internal pneumatic components and internal gas flow when the instrument is in **GPTPS** generating modes.

Table 6-6: Status of Internal Pneumatics During GENERATE → GPTPS Mode

MODE	VALVES (X = Closed; O = Open)									MFC's			PHOT PUMP
	CYL 1	CYL 2	CYL 3	CYL 4	PURGE	DILUENT	GPT	O_3 GEN	PHOT M/R	CAL1	CAL2[1]	DILUENT	
GPTPS	X	X	X	X	X	O	O	O	Switching	OFF	OFF	ON	ON

[1] Only present if multiple cal gas MFC option is installed.

[2] The valve associated with the cylinder containing NO source gas is open.

[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.

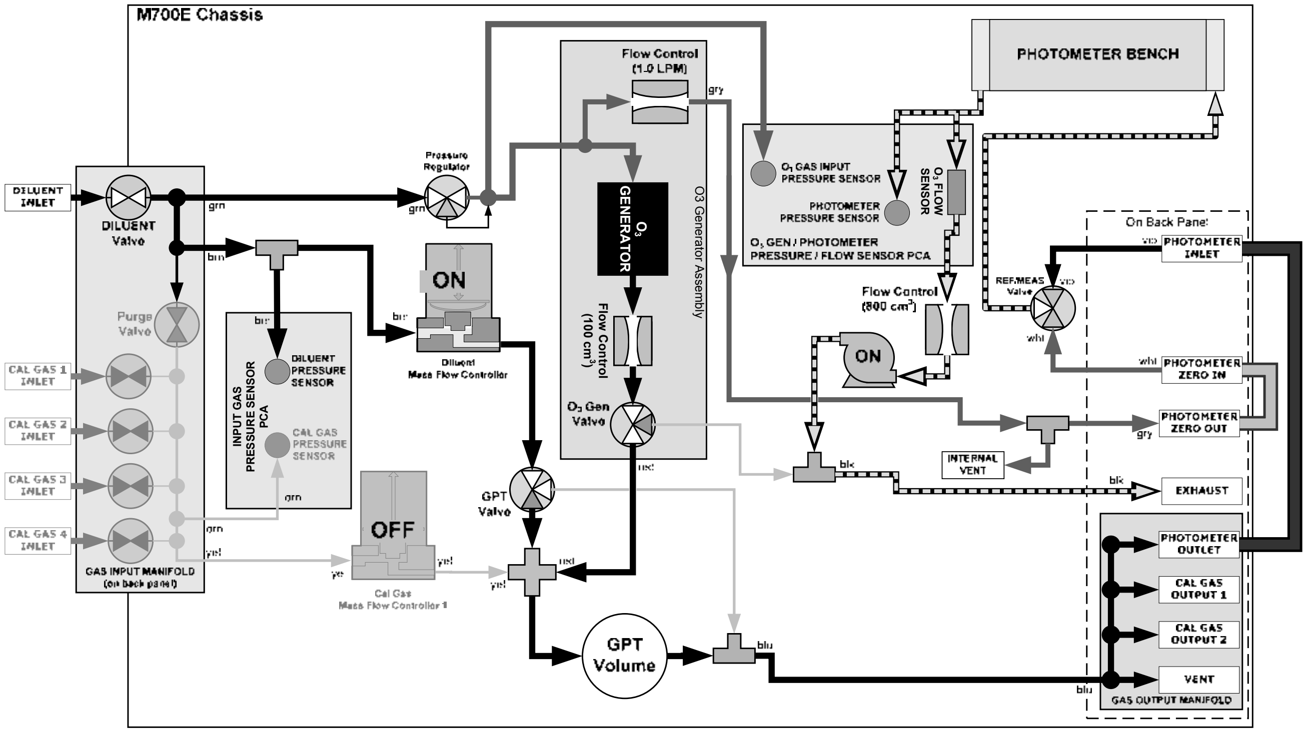


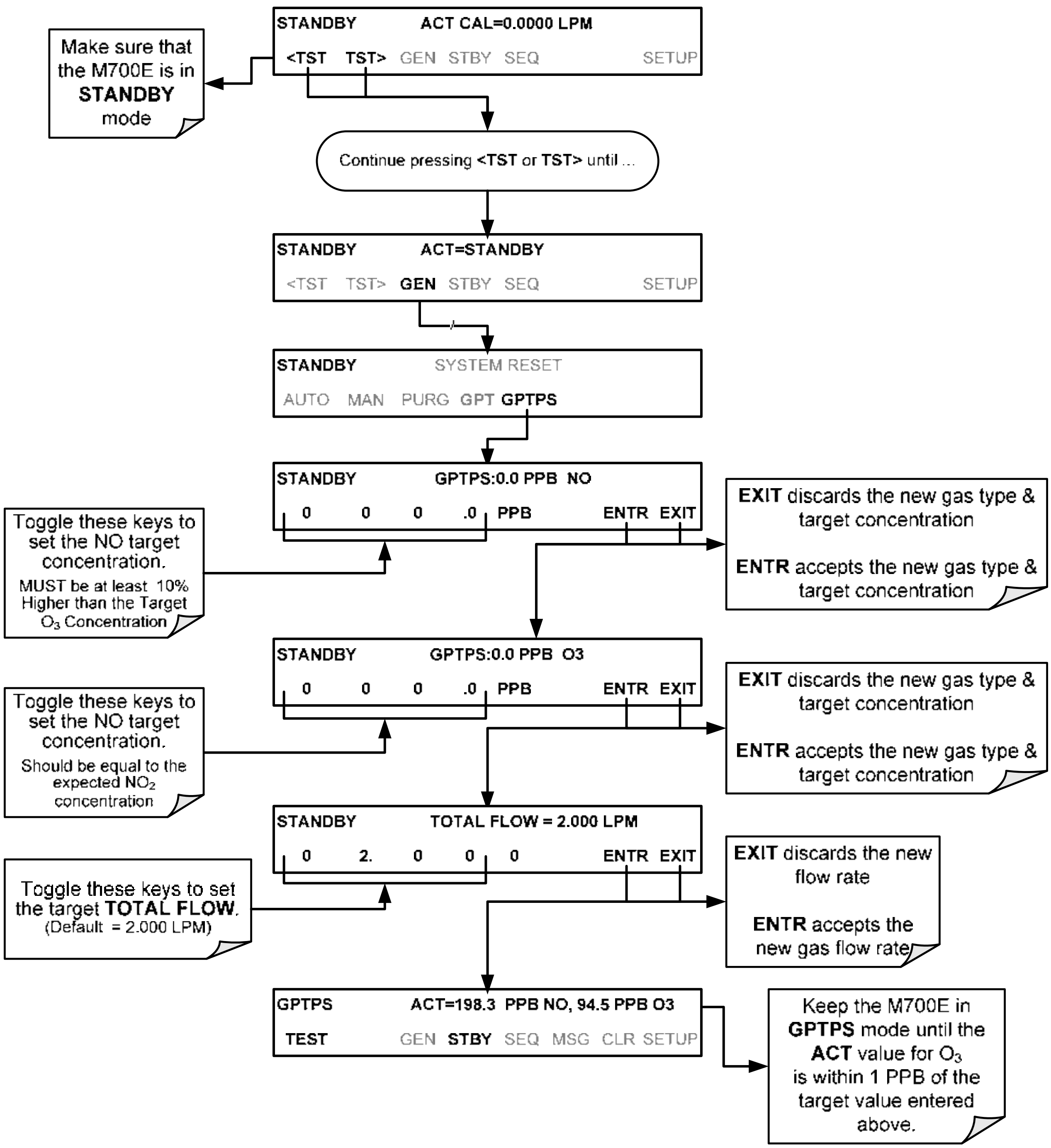
Figure 6-8: Gas Flow through M700E with O_3 Options when in GPTPS Mode

6.4.5.2. Initiating a GPT Pre-Set

To activate the **GPTPS** feature you will need to know:

- The **TOTAL GAS FLOW** for the mixture output;
- The Target O_3 concentration (equal to the target NO_2 concentration being simulated), and;
- The NO source gas concentration.

Then, press:



6.4.6. GENERATE → PURGE: Activating the M700E's Purge Feature

The M700E calibrator's PURGE feature clears residual source gases and calibration mixtures gases from the previous generated steps from the instruments internal pneumatics as well as any external pneumatic lines down stream from the calibrator.

When activated, the **PURGE** feature:

- Opens the Diluent (zero air) inlet valve allowing zero air to flow into the calibrator form its external, pressurized source;
- Adjusts the diluent air mass flow controller (MFC1) to maximum flow;
- Adjusts all of the component gas mass flow controllers installed in the calibrator to maximum flows, 10 SLPM and 100 SCCPM accordingly, to flush out the pneumatic system of the M700E.

The **PURGE** air is vented through the VENT port of the rear panel of the instrument (see Figure 3-2).

Table 6-7: Internal Pneumatics During Purge Mode

MODE	VALVES (X = Closed; O = Open)									MFC's			PHOT PUMP
	CYL 1	CYL 2	CYL 3	CYL 4	PURGE	DILUENT	GPT	O_3 GEN	PHOT M/R	CAL1	CAL2[1]	DILUENT	
PURGE	**X**	**X**	**X**	**X**	**O**	**O**	**O**	**O**	Switching	**ON[3]**	**ON[3]**	**ON**	**ON**

[1] Only present if multiple cal gas MFC option is installed.

[2] The valve associated with the cylinder containing the chosen source gas is open.

[3] In instrument with multiple MFC's the CPU chooses which MFC to use depending on the target gas flow requested.

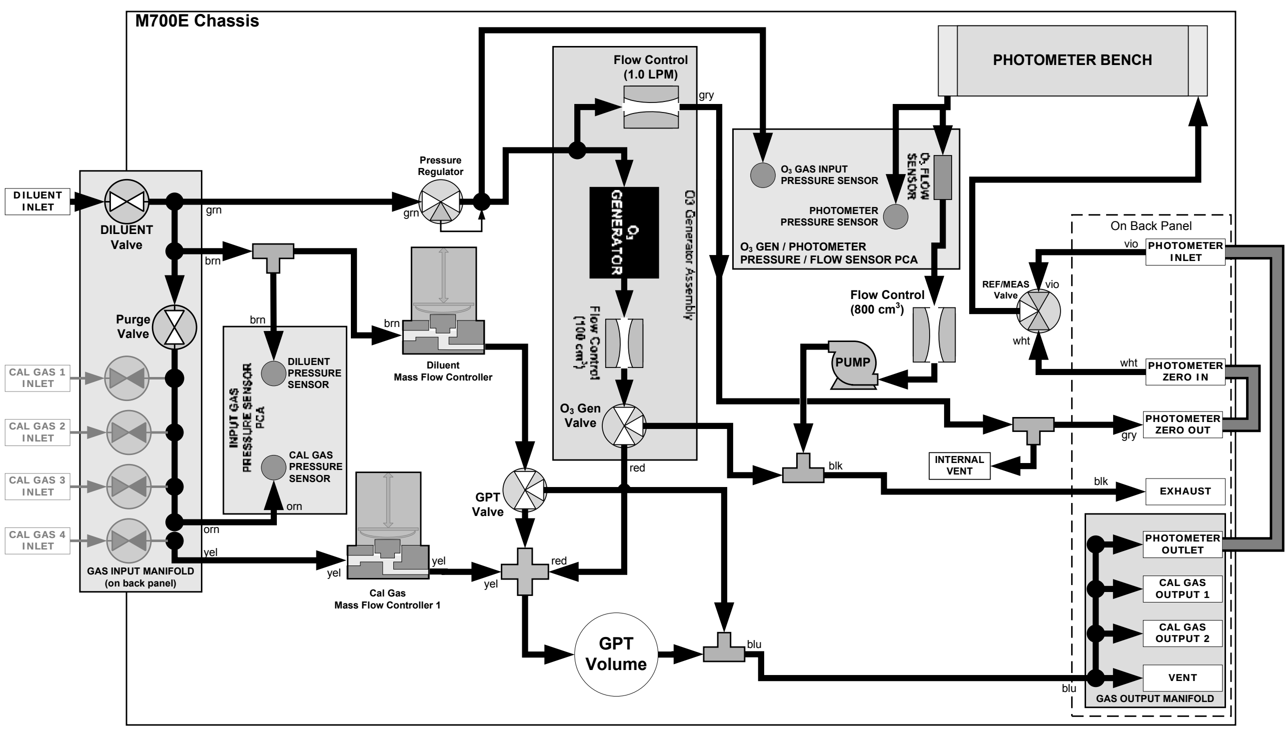
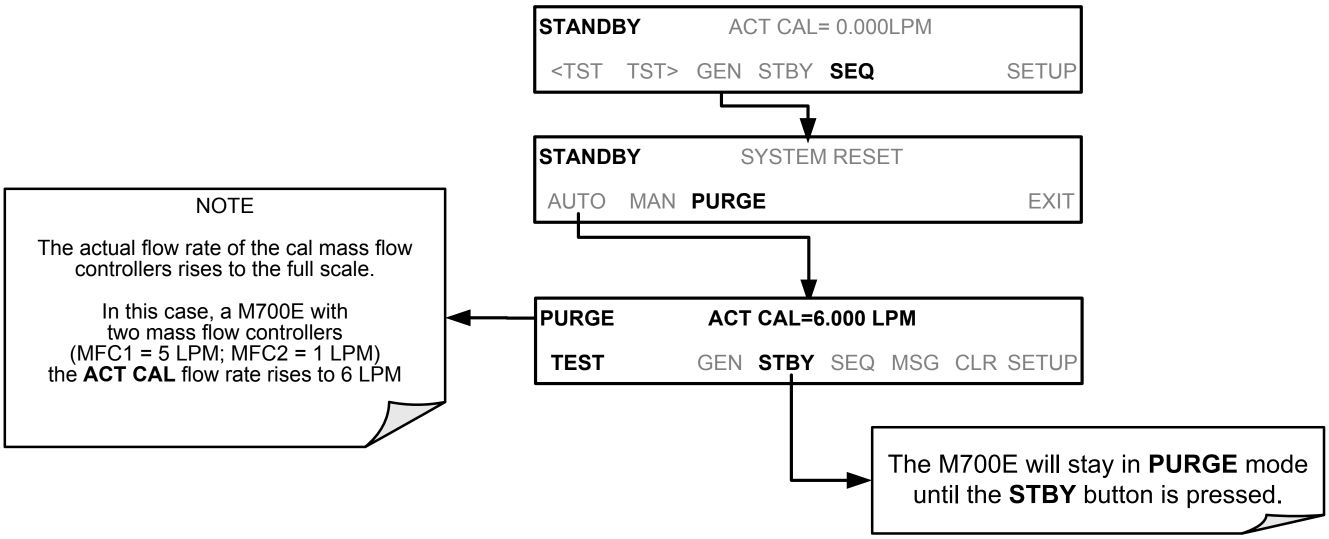


Figure 6-9: Gas Flow through M700E with O_3 Options when in PURGE mode

To activate the **PURGE** feature, press:



	CAUTION **THIS PURGE FEATURE DOES NOT STOP AUTOMATICALLY.** **THE USER MUST MANUALLY PRESS THE STBY KEY TO STOP THE PURGING PROCESS.**

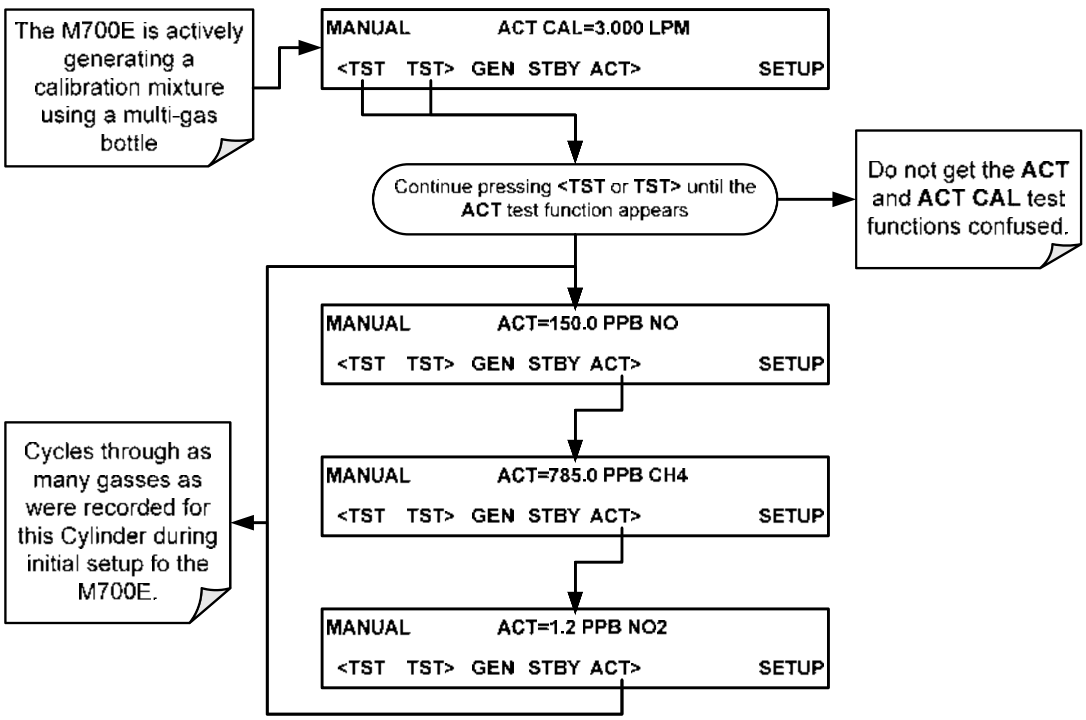
6.4.7. GENERATE →ACT>: VIEWING CONCENTRATIONS GENERATED FROM MULTI-GAS CYLINDERS

When a concentration mixture is being generated, using a multiple-gas cylinder as a source the software uses the Diluent and Cal gas flow rates to calculate the actual concentration for each gas in the cylinder so that it is possible to see the concentrations of all of the gases being output by the M700E calibrator.

EXAMPLE: For a cylinder containing a blend of CH_4, NO and NO_2, a common contaminant is present in small quantities in bottles containing NO:

This will display the actual concentration being generated for each gas in the multiple-gas cylinder.

When generating a concentration of one of the two primary gases in the cylinder (e.g. NO or CH_4) using the **GEN → AUTO**, **GEN → MANUAL** buttons or a preprogrammed calibration **SEQUENCE**, press:



NOTE

If the ACT> button only appears if the M700E is generating gas from a multiple-gas cylinder.

For NO cylinders, the instrument will only display the amount of NO_2 in the calibration mixture if the concentration of NO_2 present in the bottle is known and was programmed into the bottle's definition (see Section 3.3.8).

6.4.7.1. Using the M700E Calibrator as a O_3 Photometer

If the M700E calibrator is equipped with the optional O_3 photometer the **ACT>** test function allows it to be used as an O_3 photometer to measure external sources of O_3.

6.5. AUTOMATIC CALIBRATION SEQUENCES

The M700E calibrator can be set up to perform automatic calibration sequences of multiple steps. These sequences can perform all of the calibration mixture operations available for manual operation and can be set up to be triggered by using the front panel buttons of the M700E's internal timer, the external digital control inputs, the RS-232 interface via the optional Ethernet interface or even as sub-processes in another sequence.

6.5.1. SETUP → SEQ: PROGRAMMING CALIBRATION SEQUENCES

A sequence is a database of single or multiple steps where each single step is an instruction that causes the instrument to perform an operation. These steps are grouped under a user defined SEQUENCE NAME.

For each sequence, there are seven attributes that must be programmed. They attributes are listed in Table 6-8.

Table 6-8: Automatic Calibration SEQUENCE Set Up Attributes

ATTRIBUTE NAME	DESCRIPTION
NAME	Allows the user to create a text string of up to 10 characters identifying the sequence.
REPEAT COUNT	Number of times, between 0 and 100, to execute the same sequence. A value of 0 (zero) causes the sequence to execute indefinitely.
CC INPUT	Specifies which of the M700E's Digital Control Inputs will initiate the sequence.
CC OUTPUT	Specifies which of the M700E's Digital Control Outputs will be set when the sequence is active.
TIMER ENABLE	Enables or disables an internal automatic timer that can initiate sequences using the M700E's built in clock.
STEPS	A series of submenus for programming the activities and instructions that make up the calibration sequence.
PROGRESS MODE	Allows the user to select the reporting style the calibrator uses to report the progress of the sequences , on the front panels display, as it runs

The types of instruction steps available for creating calibration sequences are listed in Table 6-9.

Table 6-9: Calibration SEQUENCE Step Instruction

INSTRUCTION NAME	DESCRIPTION
GENERATE	Puts the instrument into **GENERATE** mode. Similar in operation and effect to the **GENERATE → AUTO** function used at the front panel.
GPT	Initiates a Gas Phase Titration operation.
GPTPS	Initiates a Gas Phase Titration Preset procedure.
PURGE	Puts the calibrator into **PURGE** mode.
DURATION	Adds a period of time between the previous instruction and the next
EXECSEQ	Calls another sequence to be executed at this time. The calling sequence will resume running when the called sequence is completed. Up to 5 levels of nested sequences can be programmed.
SETCCOUTPUT	Allows the sequence to activate the M700E's digital control outputs. Similar to the CC OUPUT attribute, but can be set and reset by individual steps.
MANUAL	Puts the instrument into **GENERATE** mode. Similar in operation and effect to the **GENERATE → MAN** function used at the front panel.

NOTE

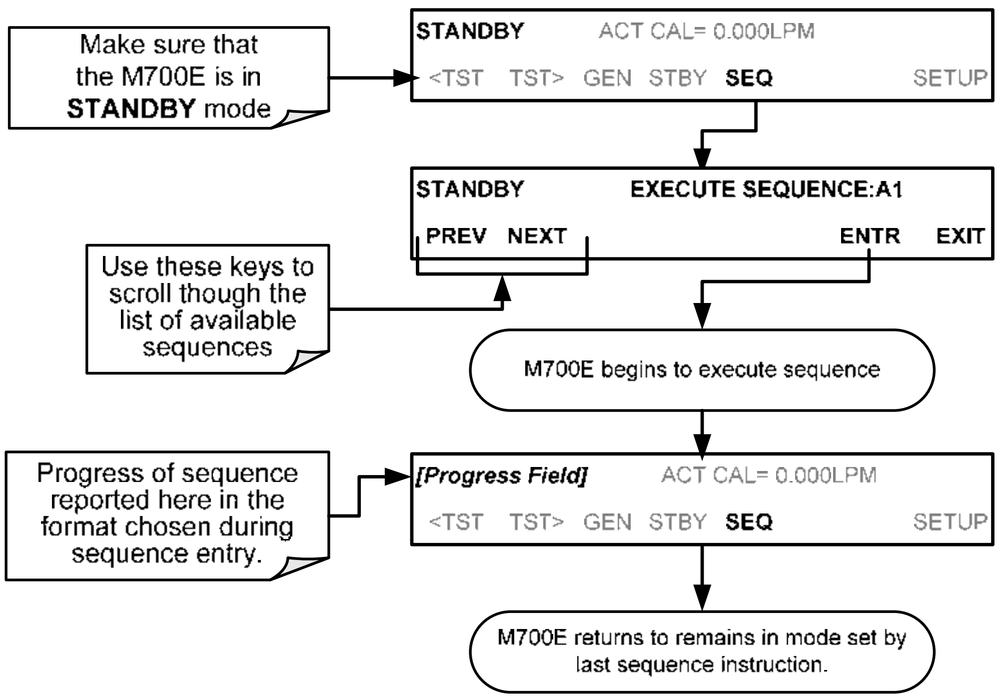
It is generally a good idea to end each calibration sequence with a PURGE instruction followed by an instruction to return the instrument to STANDBY mode.

Even if a PURGE is not included, the last instruction in a sequence should always be an instruction placing the M700E into STANDBY mode.

To create a sequence, use the instructions in the following sections to name the sequence, set its associated parameters and define the steps to be included.

6.5.1.1. Activating a Sequence from the M700E Front Panel

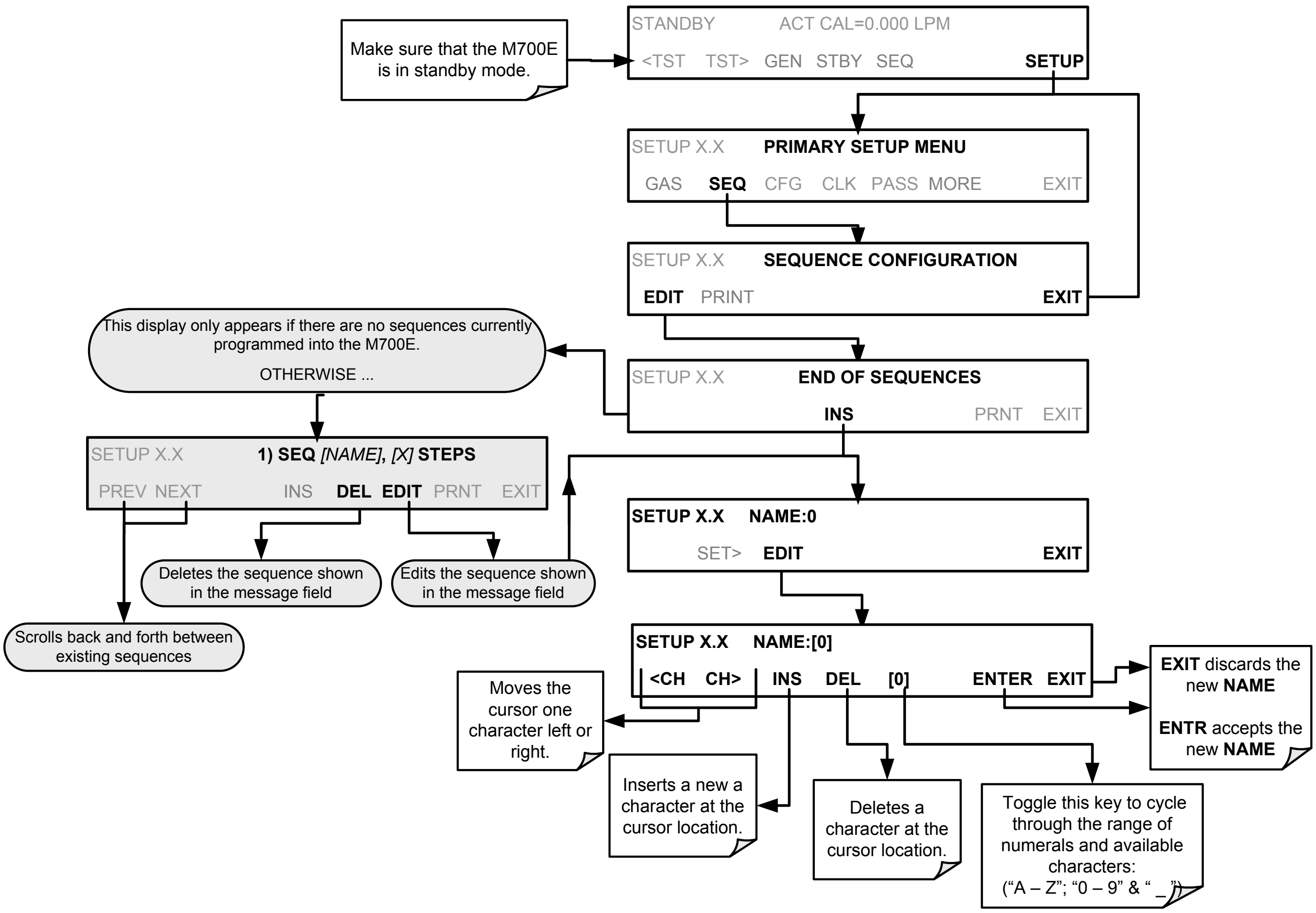
To activate an already programmed sequence from the front panel, press:



6.5.1.2. Naming a Sequence

The first step of creating a calibration sequence is to assign it a name. The name can be up to 10 characters and can be comprised of any alpha character (A to Z), and numeral (0 to 9) or the underscore character ("_").

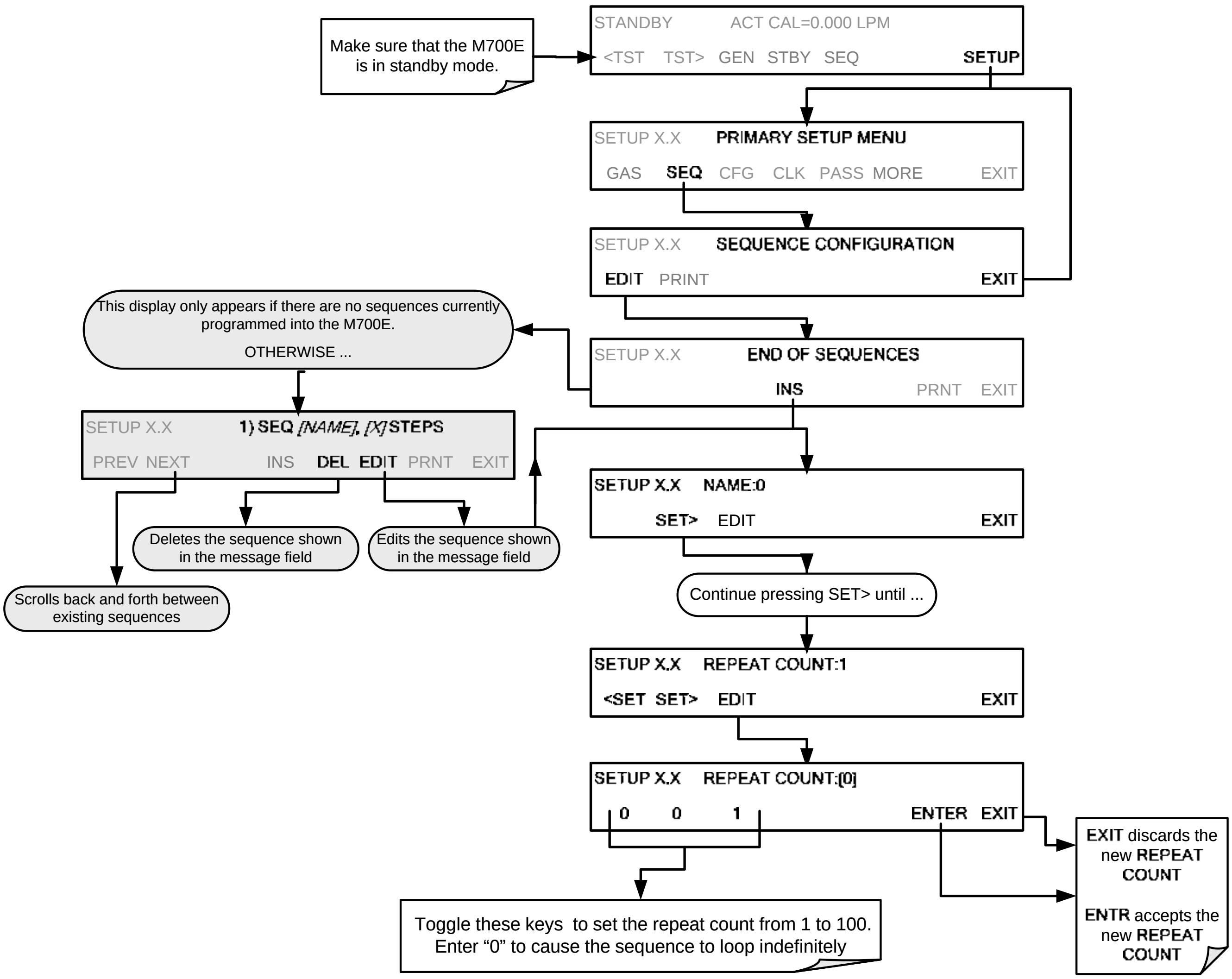
To assign a name to a sequence, press:



6.5.1.3. Setting the Repeat Count for a Sequence

The sequence can be set to repeat a certain number of times, from 1 to 100. It can also be set to repeat indefinitely by inputting a zero (0) into the **REPEAT COUNTER**.

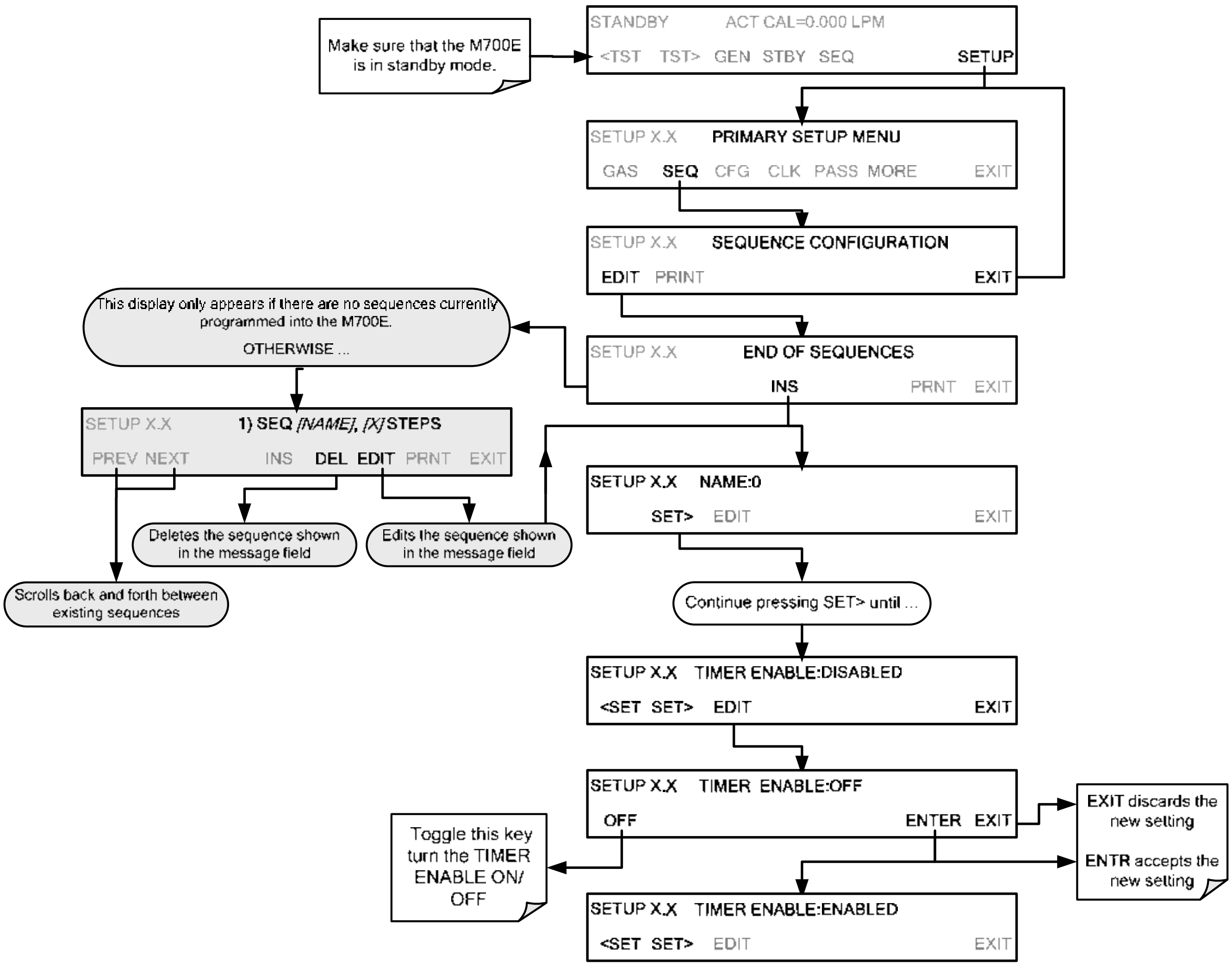
To set the **REPEAT COUNTER**, press:



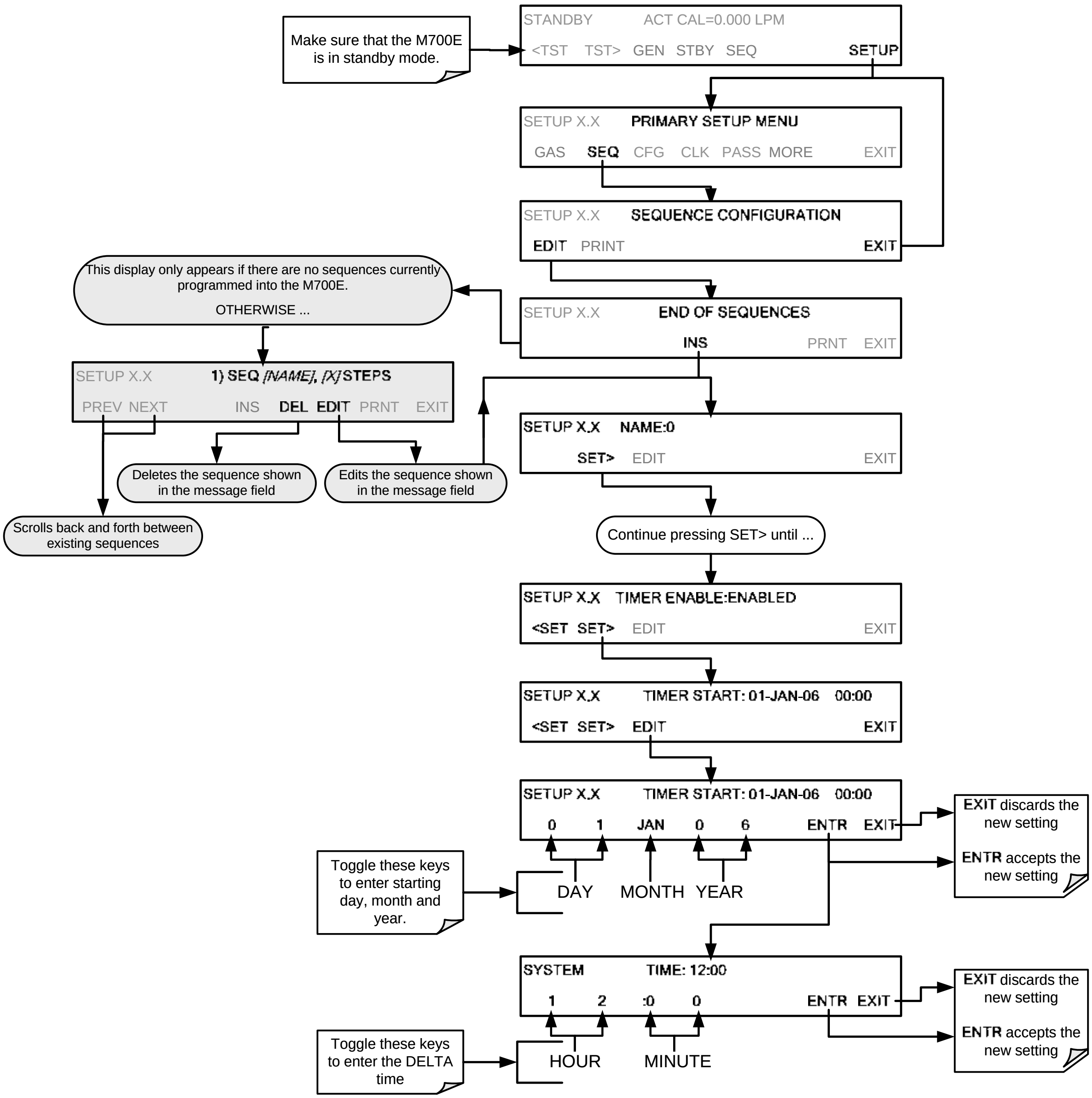
6.5.1.4. Using the M700E's Internal Clock to Trigger Sequences

Sequences can be set to trigger based on the M700E's internal clock. The sequence can be set up to start at a predetermined date and time. It can also be set to repeat after a predetermined delay time.

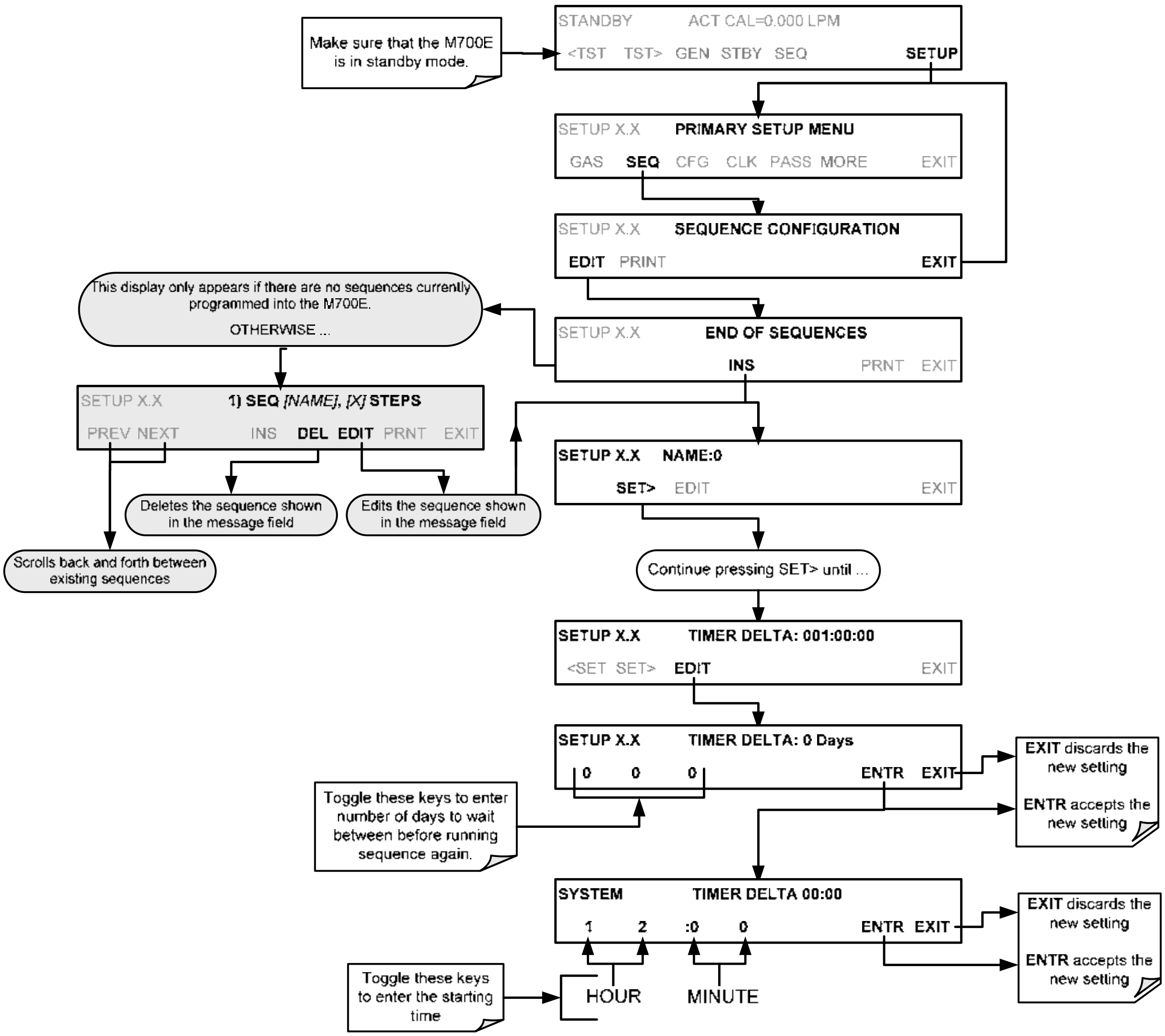
So activate and sequence timer, press:



To specify a starting time for the sequence, press:



To set the delta timer, press:



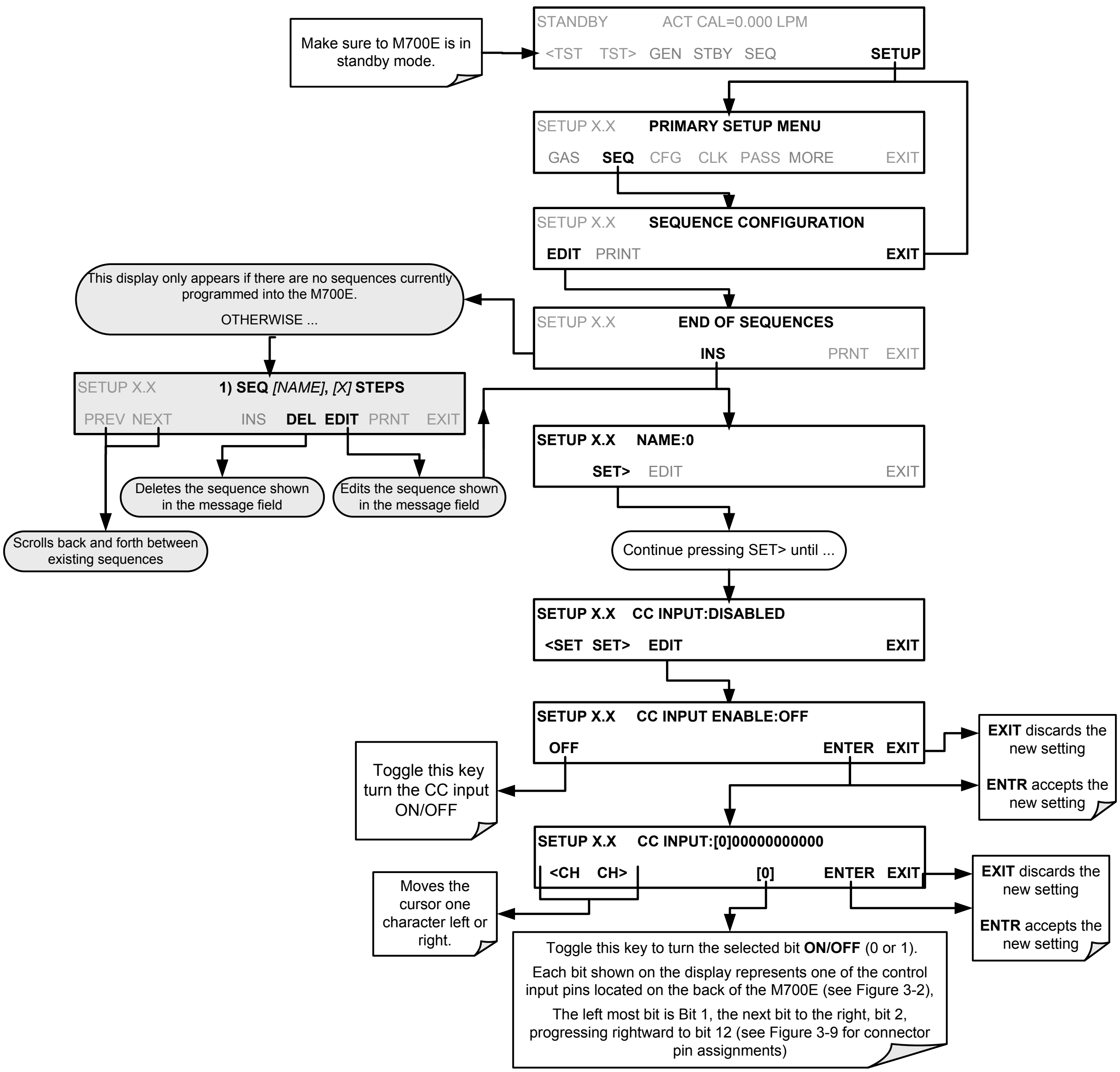
6.5.1.5. Setting Up Control Inputs for a Sequence

The M700E calibrator's control inputs allow the entire sequence to be triggered from an external source. This feature allows the calibrator to operate in a slave mode so that external control sources, such as a datalogger can initiate the calibration sequences.

Each of the M700E calibrator's control outputs is located on the back of the instrument (see Figure 3-2).

- 12 separate ON/OFF switches assigned to separate calibration sequences or;
- A 12-bit wide bus allowing the user to define activation codes for up to 4095 separate calibration sequences.

To assign a **CC INPUT** pattern/code to a particular sequence, press:



6.5.1.6. Setting Up Control Outputs for a Sequence

The M700E calibrator's control outputs allow the entire sequence to be triggered from an external source. This feature allows the calibrator to control devices that accept logic-level digital inputs, such as programmable logic controllers (PLC's), dataloggers, or digital relays/valve drivers.

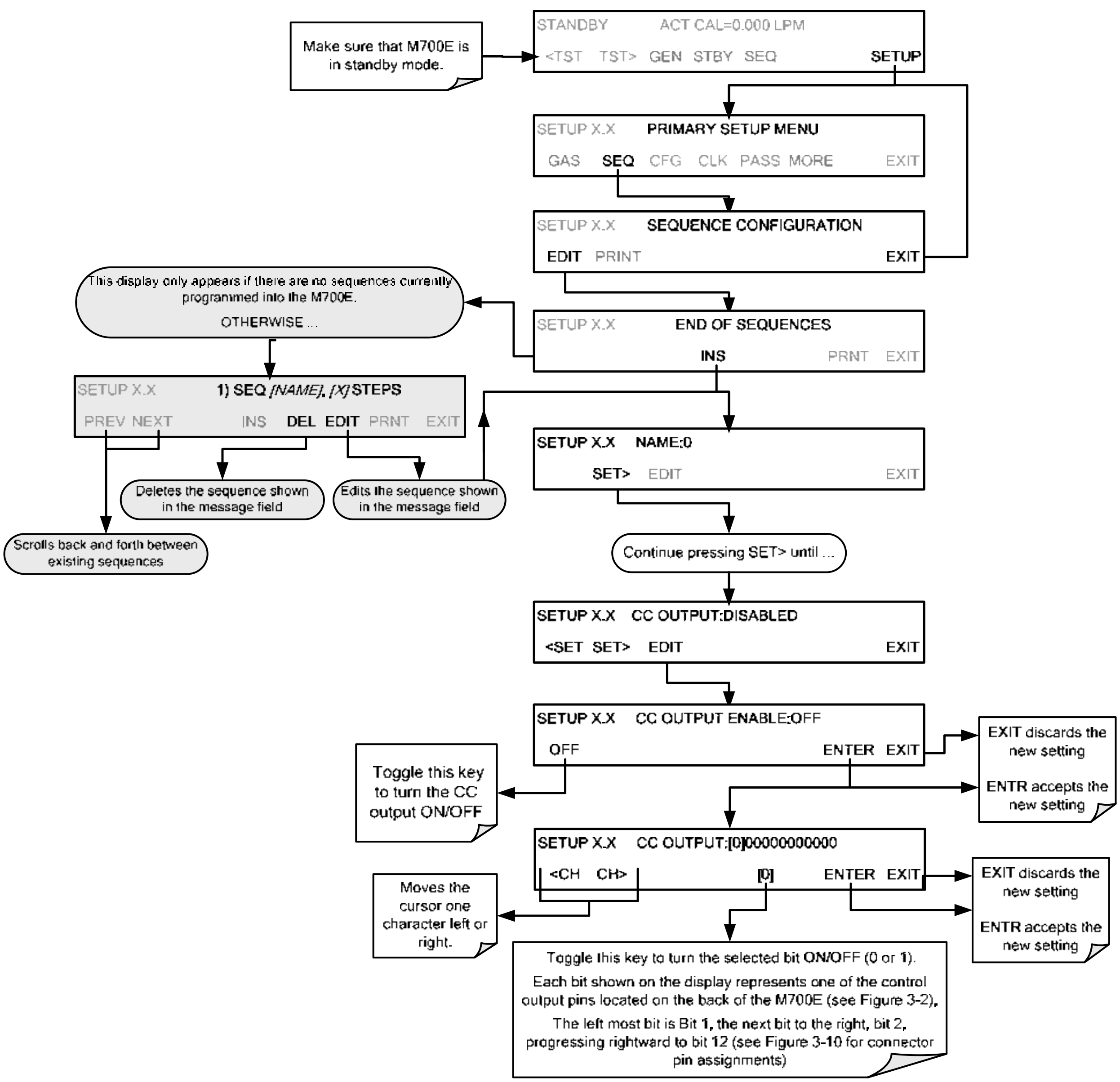
They can be used as:

- 12 separate ON/OFF switches assigned to separate calibration sequences, or;
- A 12-bit wide bus allowing the user to define activation codes for up to 4095 separate calibration sequences.

They can be set to:

- Be active whenever a particular calibration sequence is operating, or;
- Activate/deactivate as individual steps within a calibration sequence are run (see Section 6.5.2.8).

To assign a **CC OUTPUT** pattern/code to a particular sequence, press:



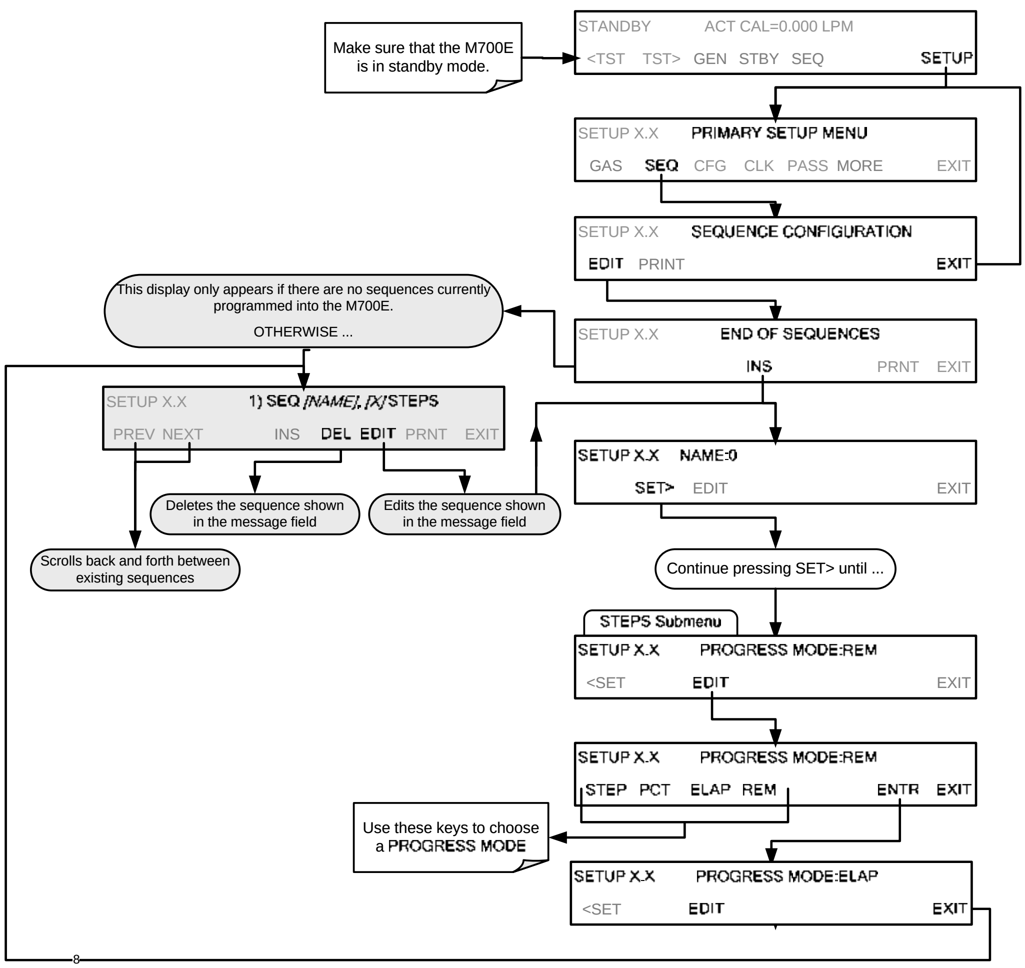
6.5.1.7. Setting the PROGRESS Reporting Mode for the Sequences

As sequences run, the M700E calibrator reports progress by displaying a message in the MODE field of the front panel display (See Figure 3-1). There are several types of report modes available (see Table 6-10).

Table 6-10: Sequence Progress Reporting Mode

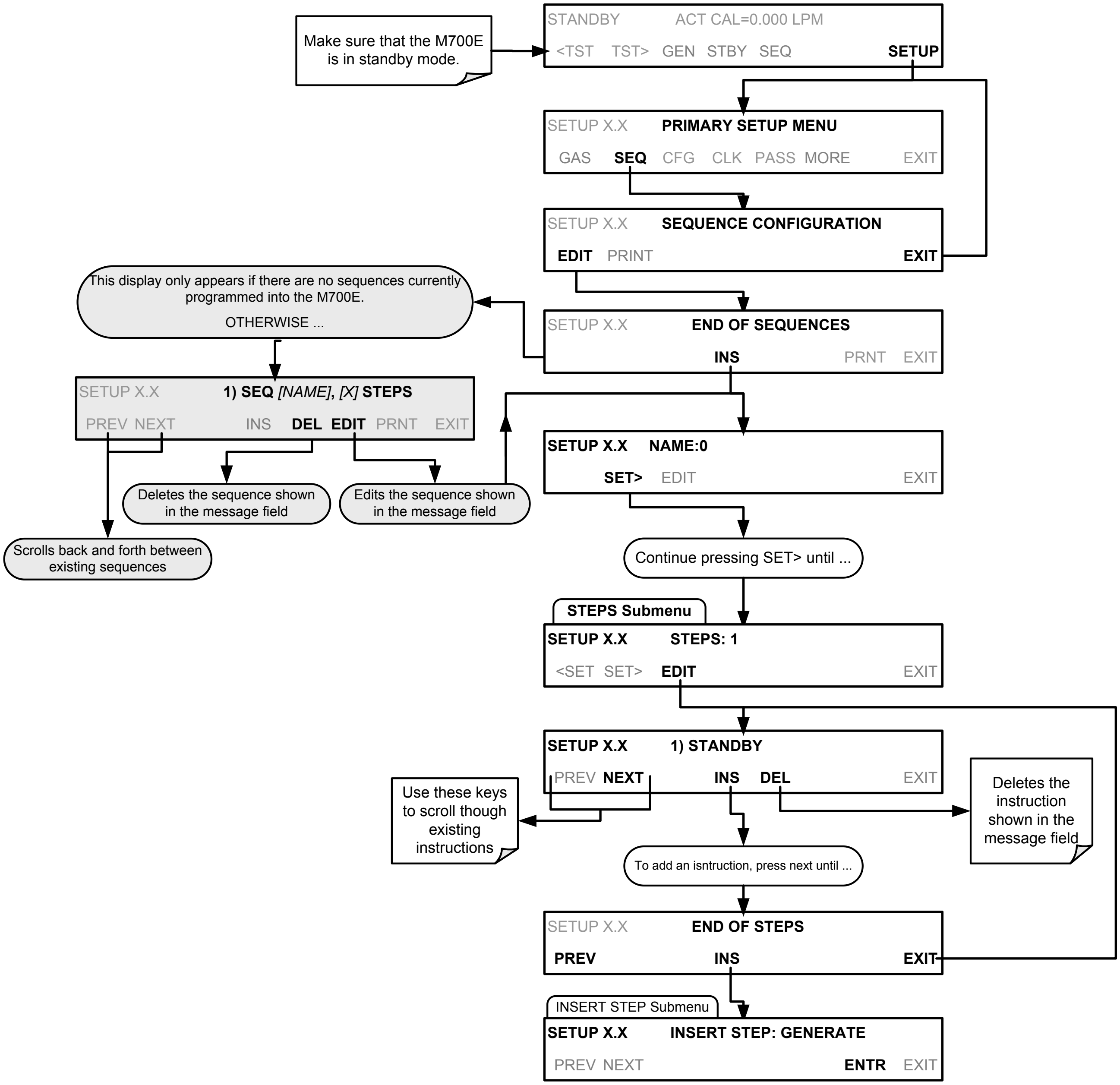
MODE	DESCRIPTION
STEP	• Shows the progress as the sequence name and step number. This is the traditional display. Example: "SO2_Test-2".
PCT	• Shows the progress as a percent (0–100%) of the total sequence duration. Example: "SEQ 48%"
ELAP	• Shows the progress as days, hours, minutes and seconds elapsed, counting from 0. Example (<1 day): "T+01:30:25" (i.e. 1 hour, 30 minutes, 25 seconds elapsed) Example (>=1 day): "T+1d30:25" (i.e. 1 day, 30 hours, 25 minutes elapsed)
REM	• Shows the progress as days, hours, minutes, and seconds remaining, counting down to 0. Example (<1 day): "T–01:30:25" (i.e. 1 hour, 30 minutes, 25 seconds remaining) Example (>=1 day): "T–1d30:25" (i.e. 1 day, 30 hours, 25 minutes remaining)

To select a PROGRESS report mode, press:



6.5.2. ADDING SEQUENCE STEPS

To insert an instruction step into a sequence, navigate to the **INSERT STEP** submenu by pressing:

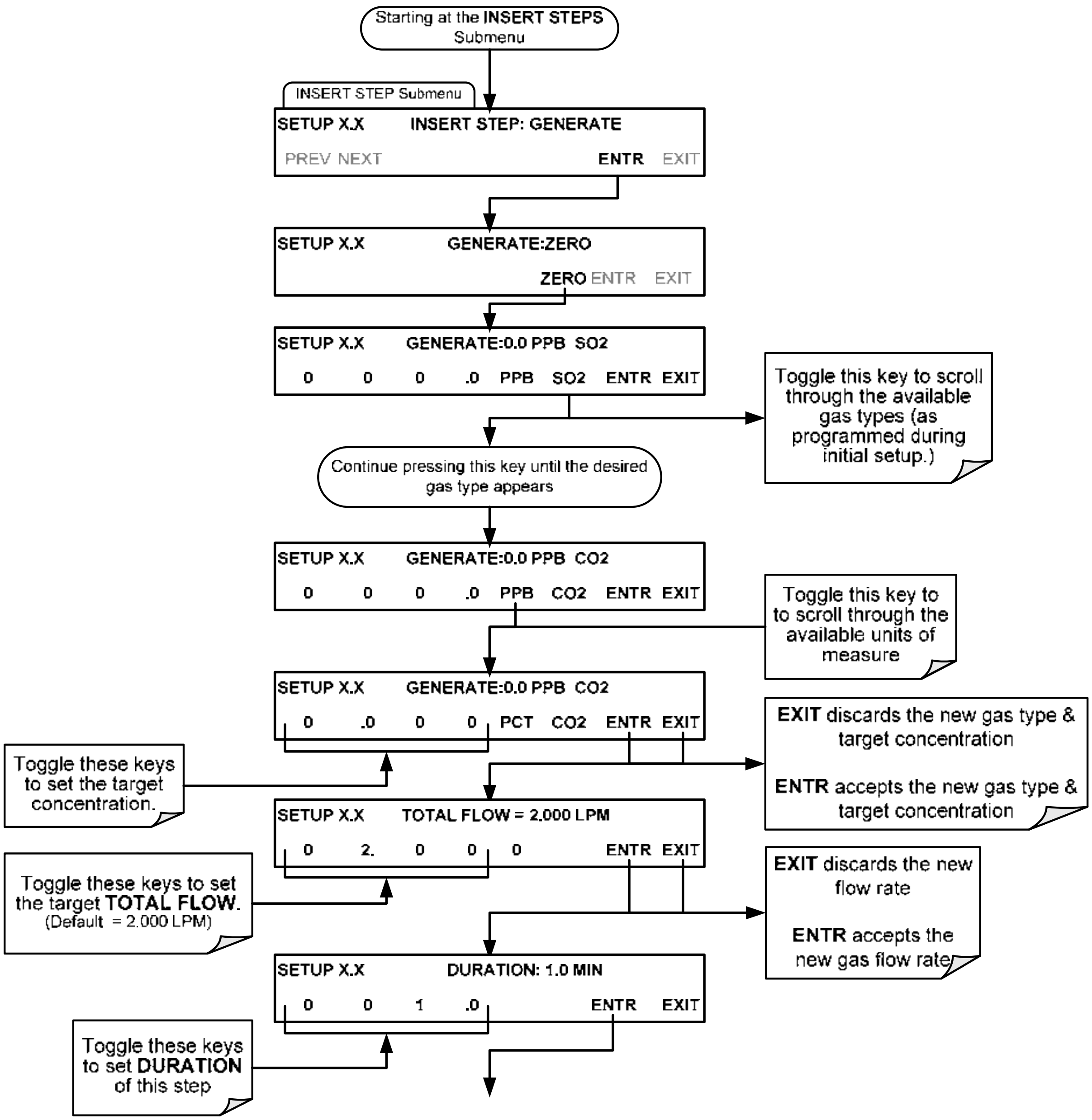


6.5.2.1. The GENERATE Step

This step operates and is programmed similarly to the **GENERATE → AUTO.**

At the end of the programming sequence, the M700E firmware will automatically insert a **DURATION** step that needs to be defined.

To insert a **GENERATE** step into a sequence, press:



NOTE

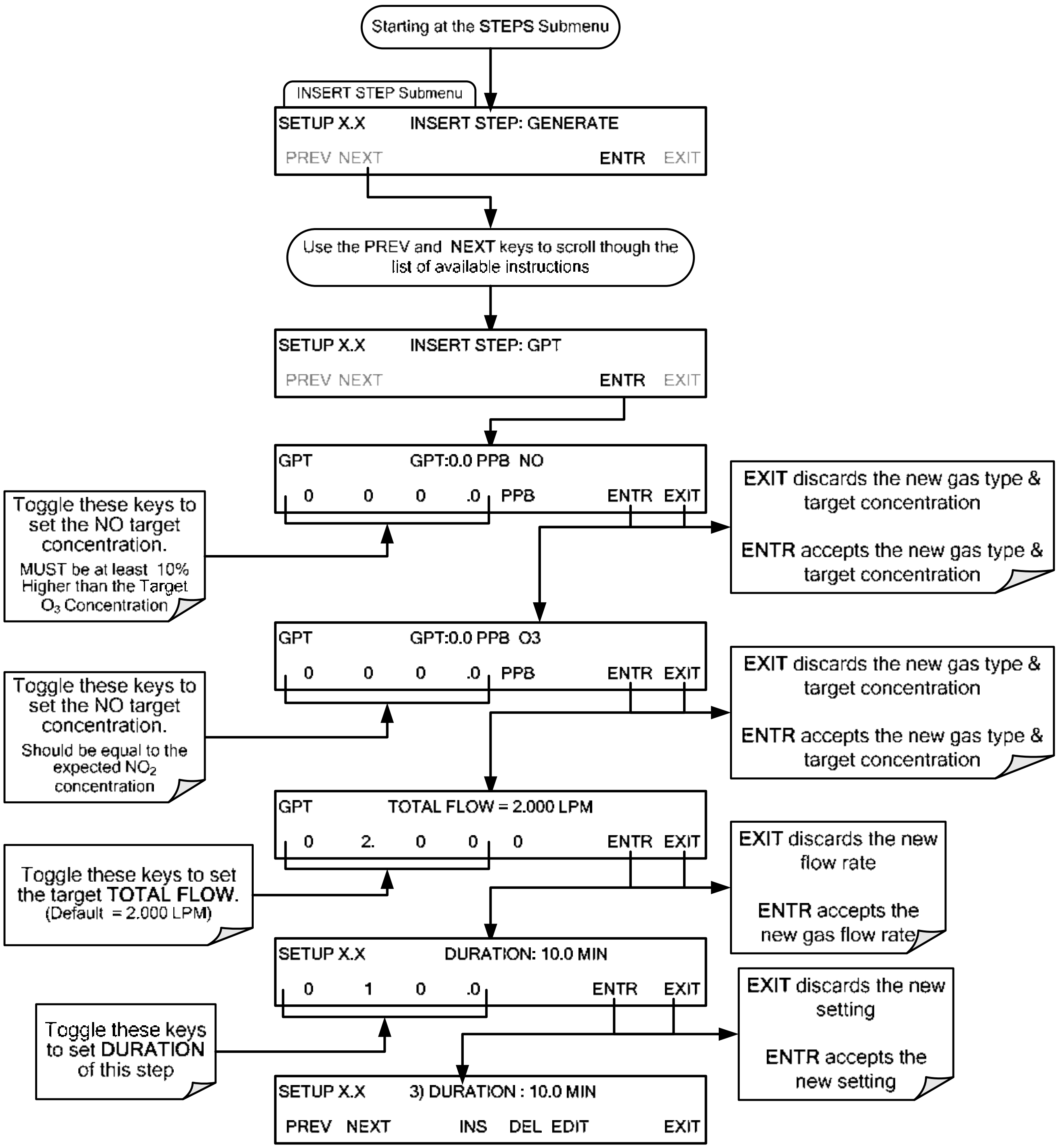
If the user attempts to generate a source gas type that has not been entered into the M700E's gas library, the sequence will freeze and after a certain time-out period, stop running.

6.5.2.2. The GPT Step

This step operates and is programmed similarly to the **GENERATE →GPT** (see Section 6.4.4 for information on choosing the correct input values for this step)**.**

At the end of the programming sequence, the M700E firmware will automatically insert a **DURATION** step that needs to be defined.

To insert a **GPT** step into a sequence, press:

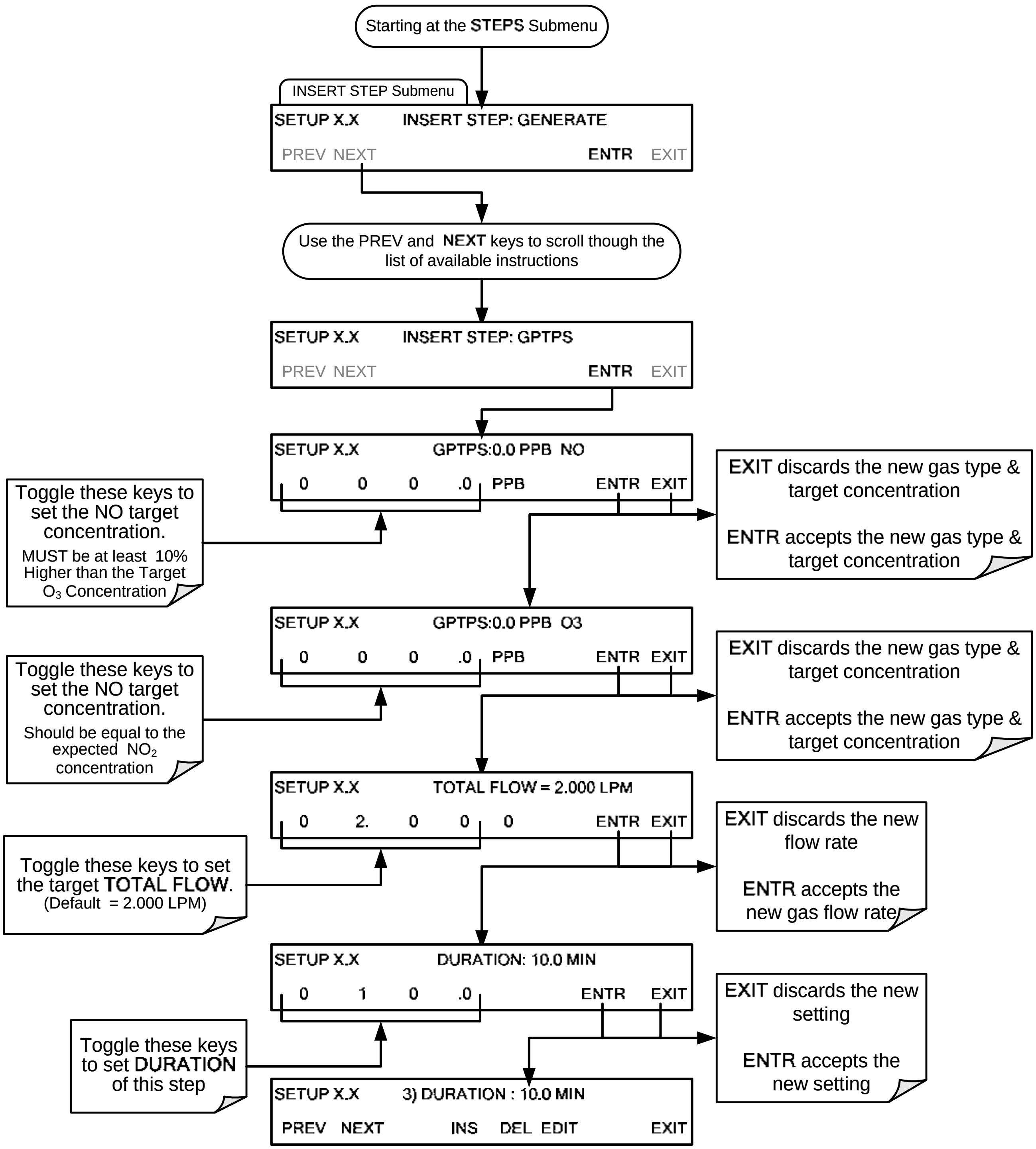


6.5.2.3. The GPTPS Step

This step operates and is programmed similarly to the **GENERATE →GPTPS** (see Section 6.4.5 for information on choosing the correct input values for this step)**.**

At the end of the programming sequence, the M700E firmware will automatically insert a **DURATION** step that needs to be defined.

To insert a **GPTPS** step into a sequence, press:

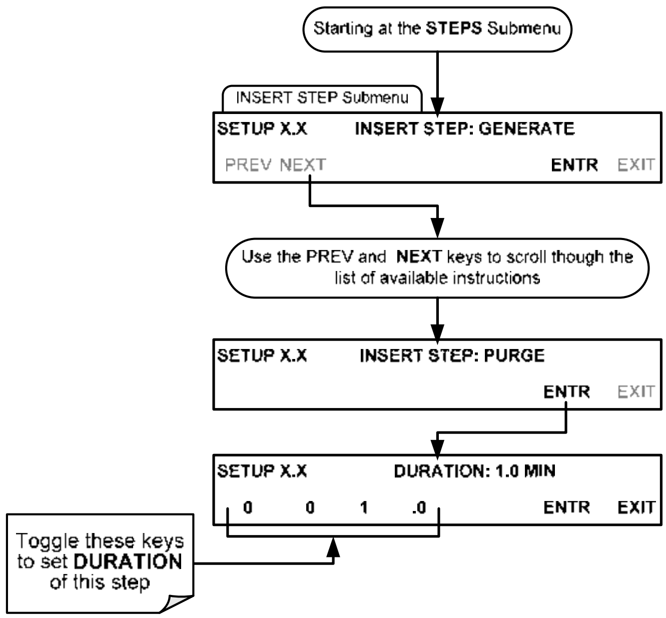


6.5.2.4. The PURGE Step

This step places the M700E into **PURGE** mode.

At the end of the programming sequence, the M700E firmware will automatically insert a **DURATION** step that needs to be defined.

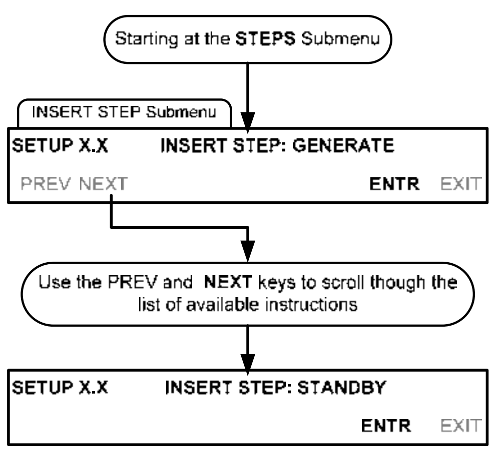
To insert a **PURGE** step into a sequence, press:



6.5.2.5. The STANDBY Step

The **STANDBY** step places the M700E into **STANDBY** mode. It is recommended, but not required to follow this with a **DURATION** step.

To insert a **STANDBY** step into a sequence, press:

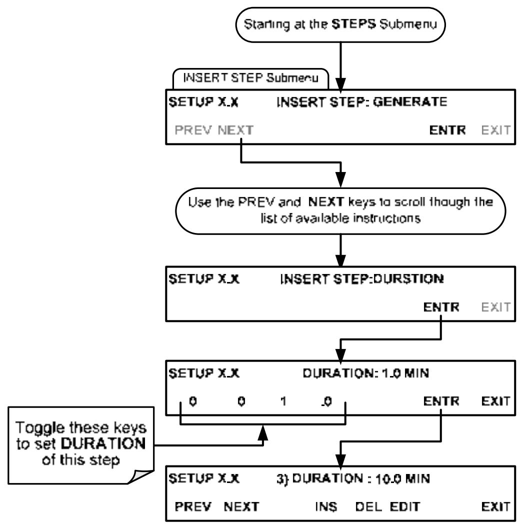


6.5.2.6. The DURATION Step

The duration step causes the M700E to continue performing whatever action was called for by the preceding step of the sequence.

- If that step put the instrument into **STANDBY** mode, the calibrator stays in **STANDBY** mode for the period specified by the **DURATION** step,
- If that step put the instrument into **GENERATE** mode, the will continue to **GENERATE** whatever calibration mixture was programmed into that step for the period specified by the **DURATION** step.

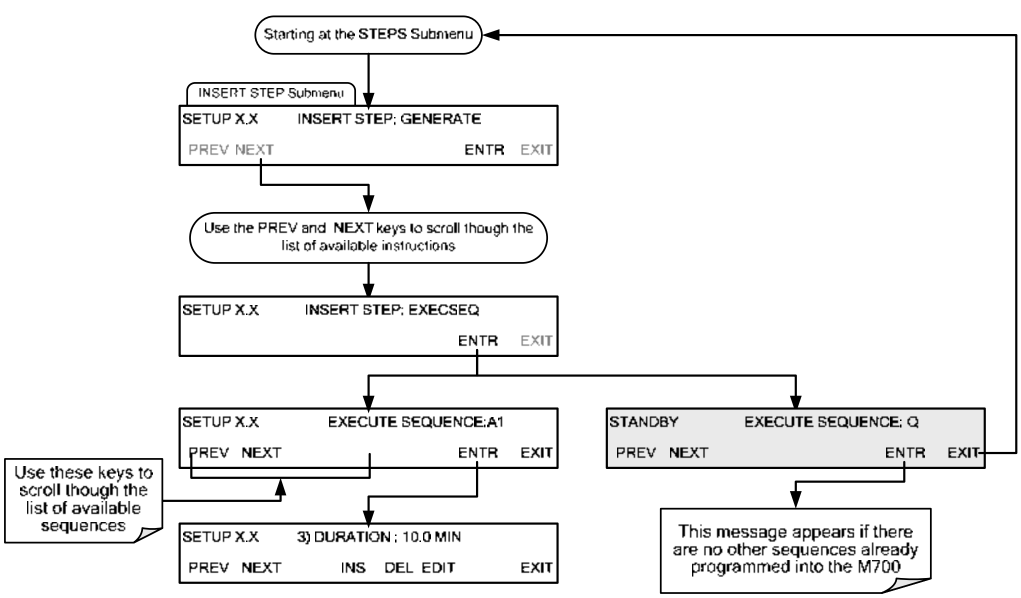
To insert a **DURATION** step into a sequence, press:



6.5.2.7. The EXECSEQ Step

The **EXECSEQ** step allows the sequence to call another, already programmed sequence. This is a very powerful tool in that it allows the user to create a "toolbox" of often-used operations that can then be mixed and matched by an overhead sequence.

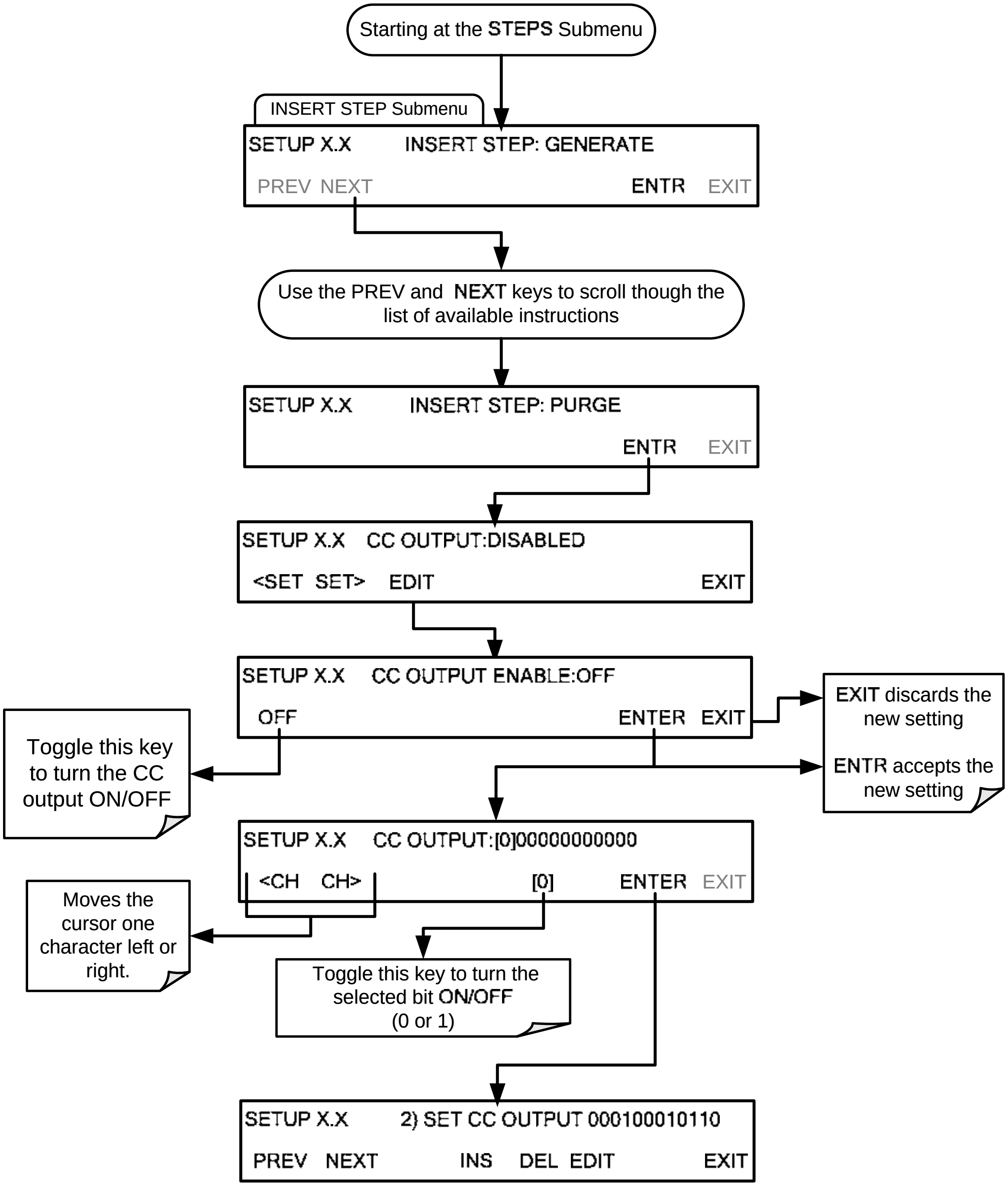
To insert an **EXECSEQ** step into a sequence, press:



6.5.2.8. The CC OUTPUT Step

This instruction causes the sequence to set or reset the M700E's digital control outputs. It is very useful in situations where the control outputs are being used to trigger other devices that need to be turned off and on in synch with the operation of the calibrator as it progress through the sequence.

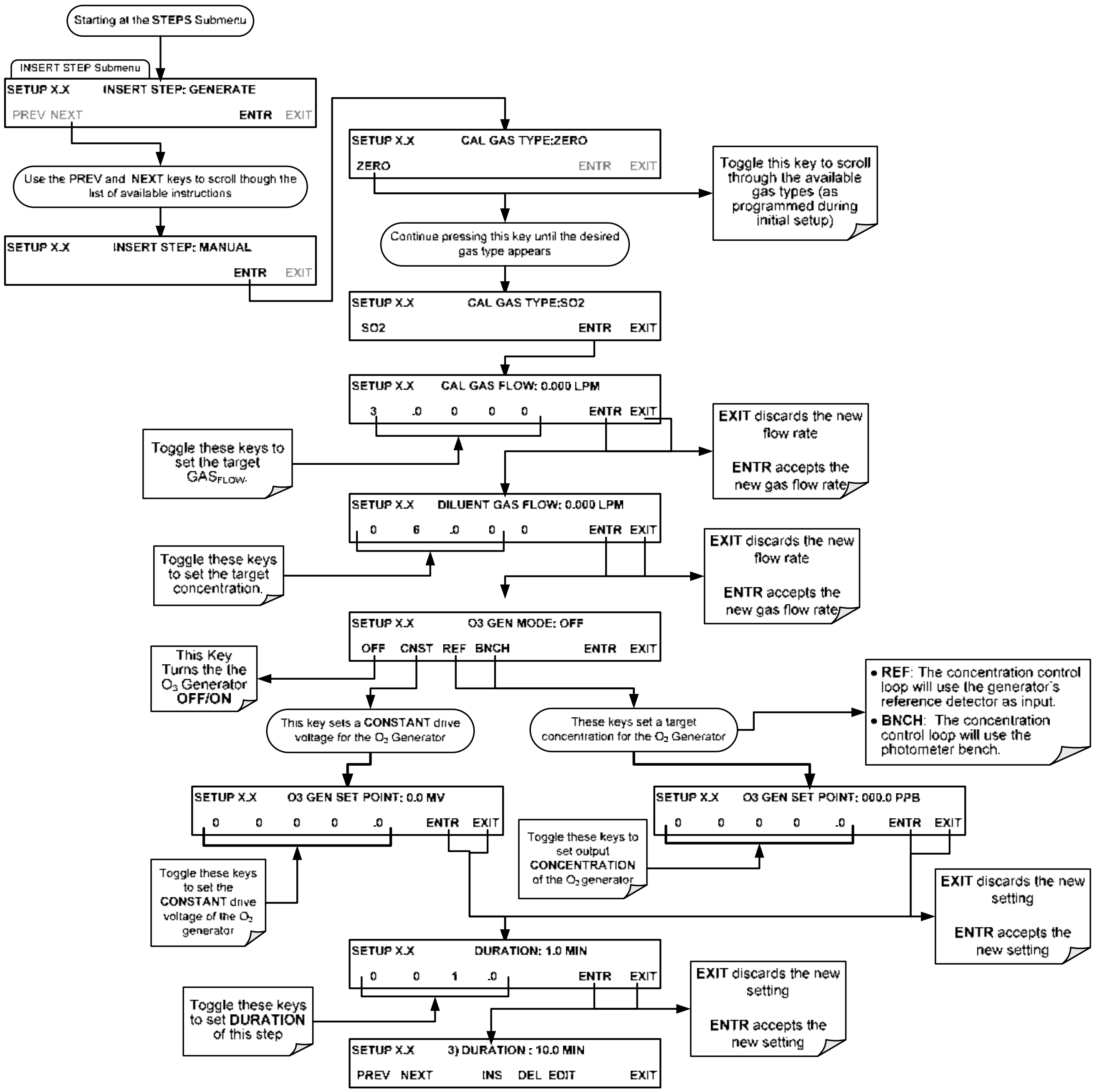
To insert a **CC OUTPUT** step into a sequence, press:



6.5.2.9. The MANUAL Gas Generation Step

The **MANUAL** step causes the M700E calibrator to enter **MANUAL CALIBRATION MODE**. It is programmed in a similar manner to the calibrator's **GENERATE → MANUAL** function. AT the end of the programming sequence, the M700E firmware will automatically insert a DURATION step that needs to be defined.

To insert a **MANUAL** step into a sequence, press:

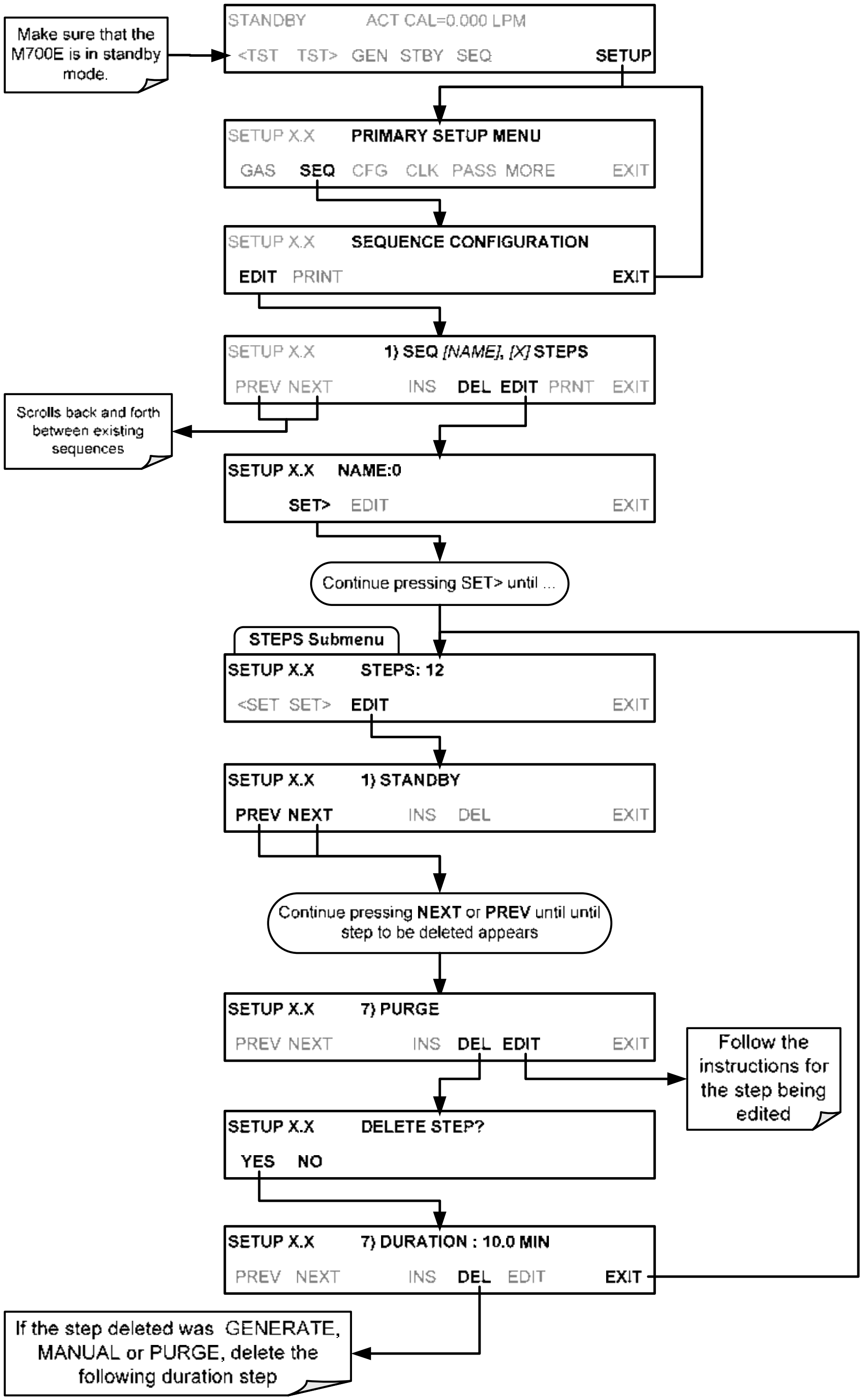


NOTE

If the user attempts to generate a source gas type that has not been entered into the M700E's gas library, the sequence will freeze and after a certain time-out period, stop running.

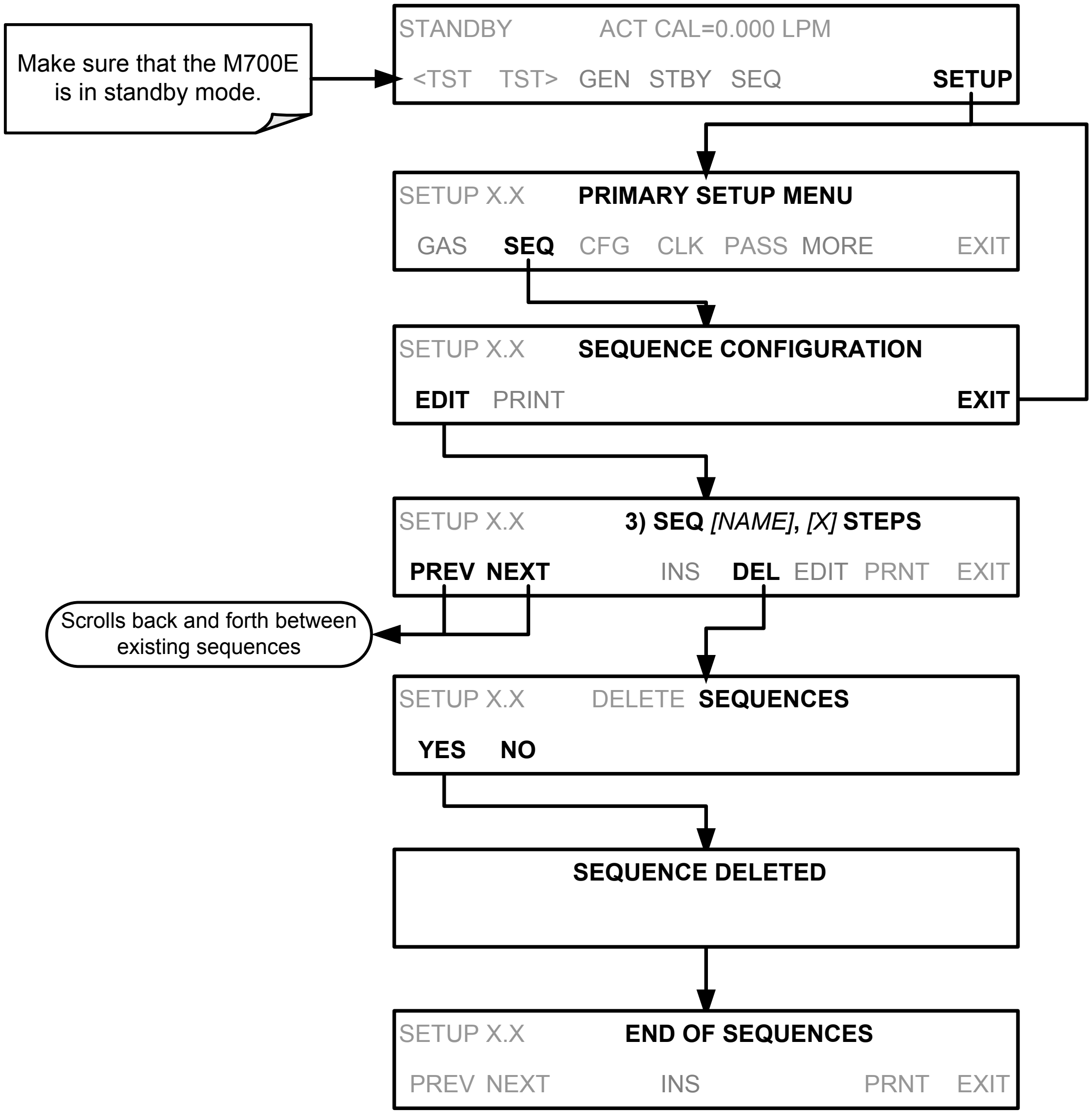
6.5.2.10. Deleting or Editing an Individual Step in a Sequence

To delete or edit an individual step in an existing Sequence, press:



6.5.3. DELETING A SEQUENCE

To delete a sequence from the M700E calibrator's memory, press:

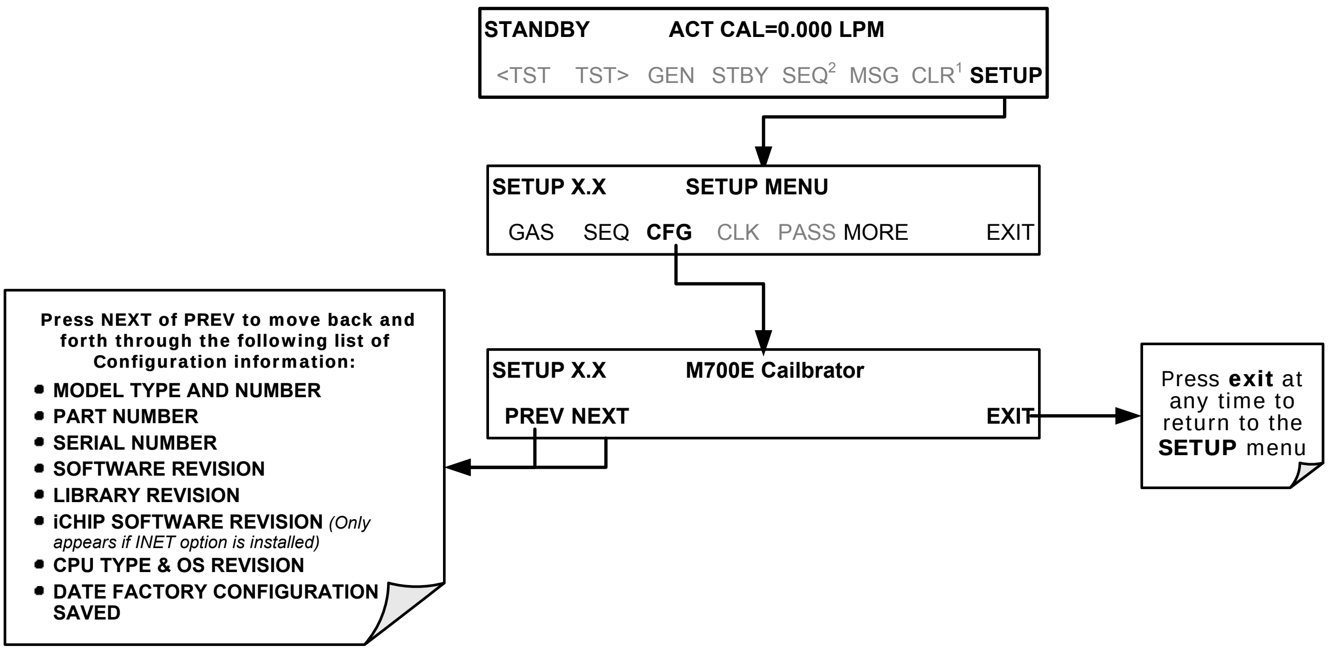


6.6. SETUP → CFG

Pressing the CFG key displays the instrument's configuration information. This display lists the calibrator model, serial number, firmware revision, software library revision, CPU type and other information.

Use this information to identify the software and hardware when contacting customer service.

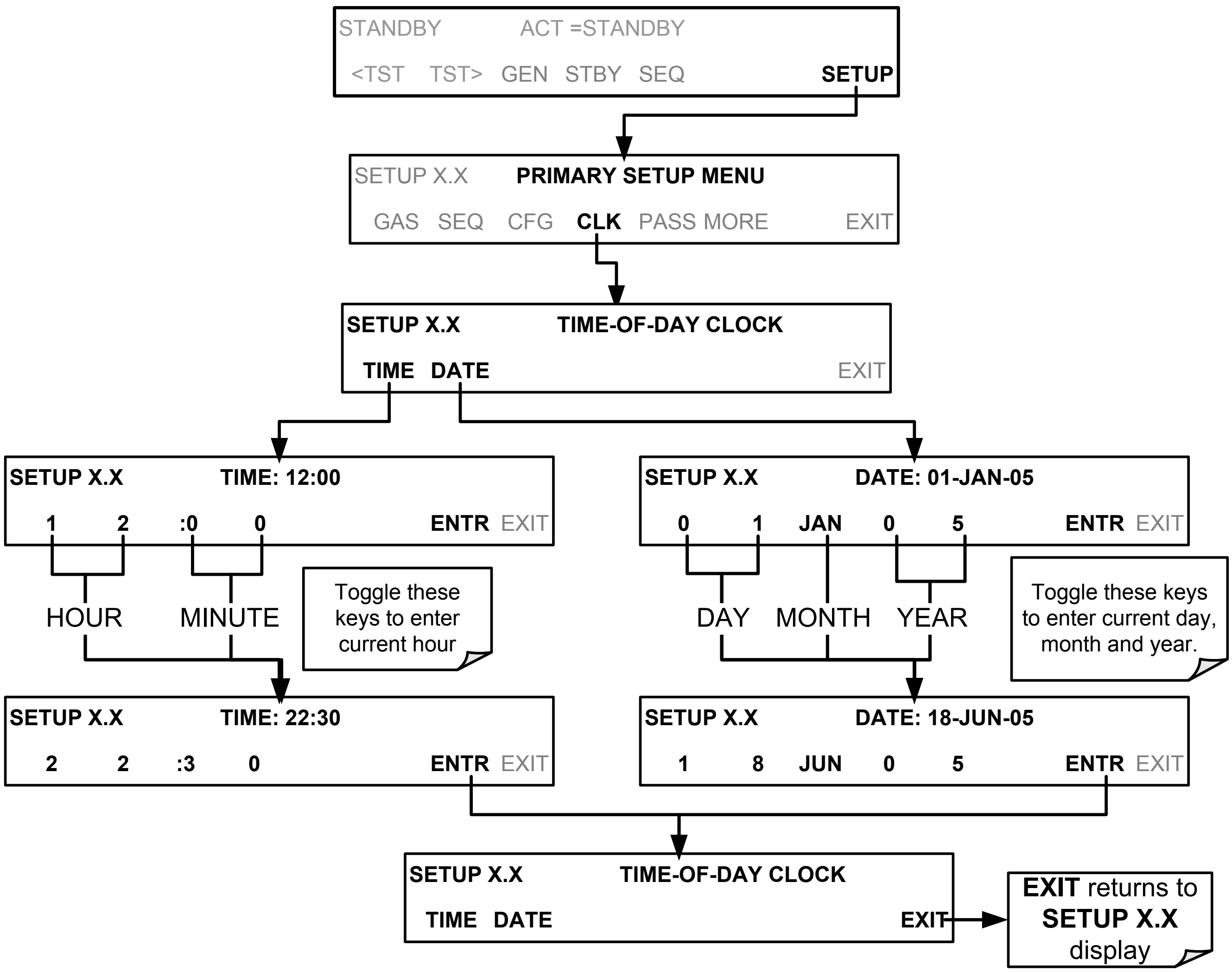
Special instrument or software features or installed options may also be listed here.



6.7. SETUP → CLK

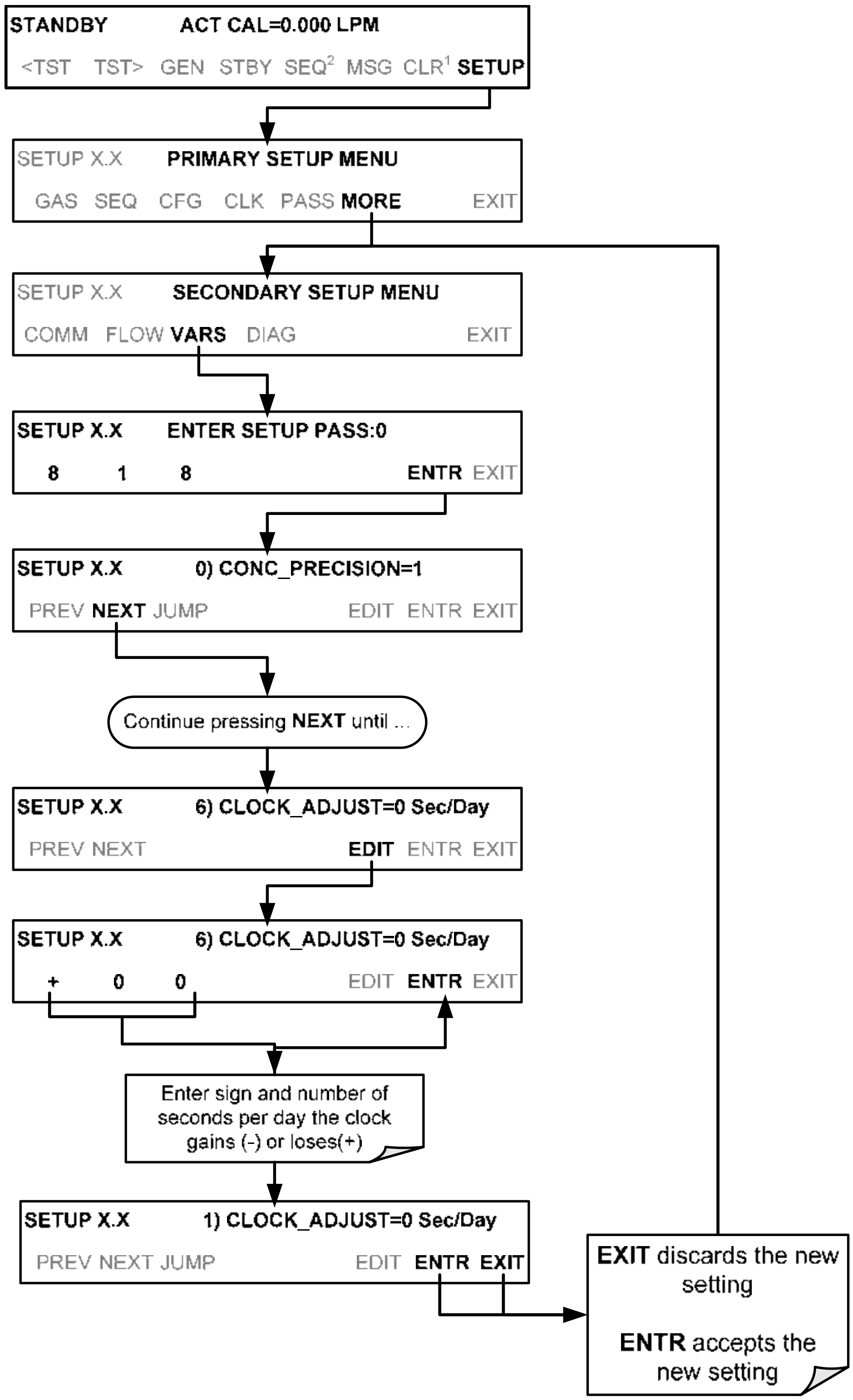
6.7.1. SETTING THE INTERNAL CLOCK'S TIME AND DAY

The M700E has a time of day clock that supports the **DURATION** step of the calibration sequence feature, time of day TEST function, and time stamps on most COMM port messages. To set the clock's time and day, press:



6.7.2. ADJUSTING THE INTERNAL CLOCK'S SPEED

In order to compensate for CPU clocks which run faster or slower, you can adjust a variable called **CLOCK_ADJ** to speed up or slow down the clock by a fixed amount every day. To change this variable, press:



6.8. SETUP → PASS

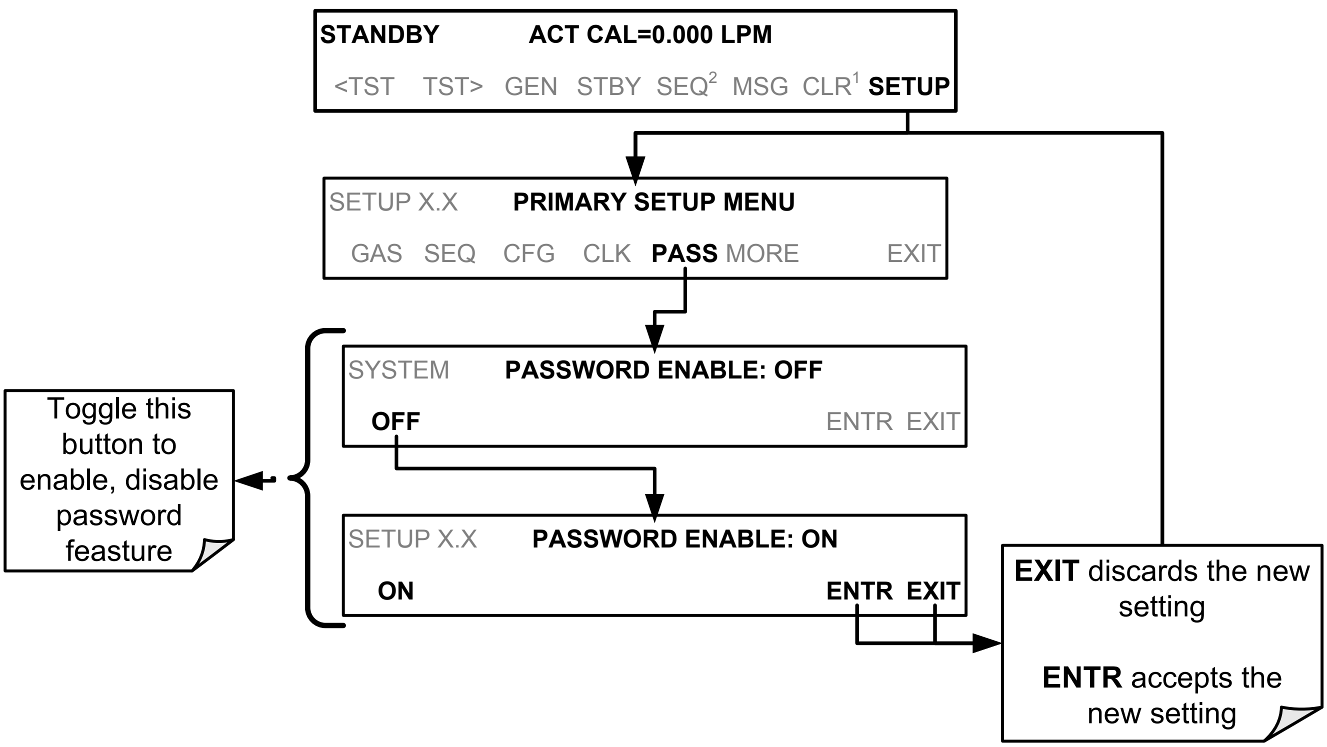
The M700E provides password protection of the calibration and setup functions to prevent unauthorized adjustments. When the passwords have been enabled in the **PASS** menu item, the system will prompt the user for a password anytime a password-protected function is requested.

There are three levels of password protection, which correspond to operator, maintenance and configuration functions. Each level allows access to all of the functions in the previous level.

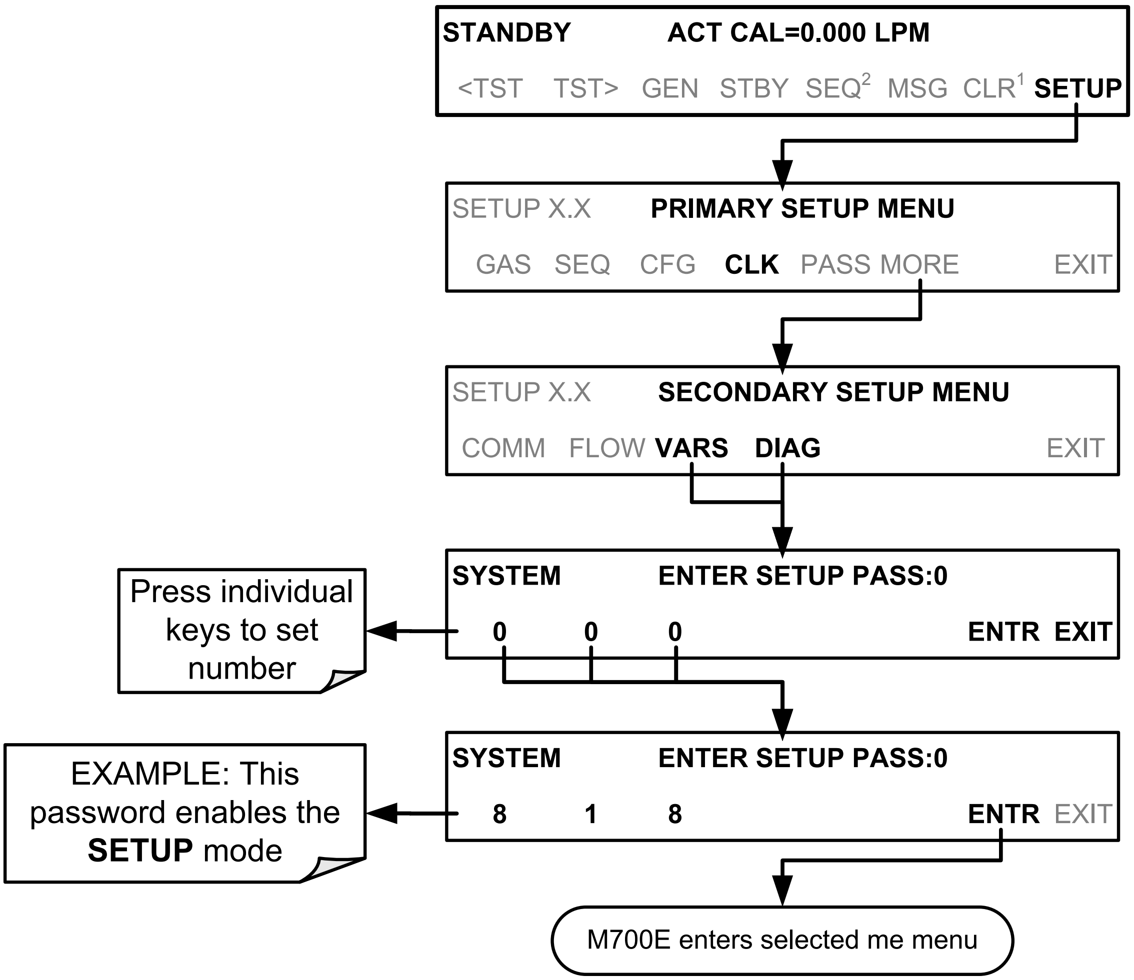
Table 6-11: Password Levels

PASSWORD	LEVEL	MENU ACCESS ALLOWED
No password	Operator	All functions of the MAIN menu: **TEST, GEN,** initiate **SEQ , MSG, CLR**
101	Maintenance	Access to Primary and Secondary Setup Menus except for **VARS** and **DIAG**
818	Configuration	Secondary SETUP Submenus **VARS** and **DIAG**

To enable or disable passwords, press:



Example: If all passwords are enabled, the following keypad sequence would be required to enter the VARS or DIAG submenus:



NOTE

The instrument still prompts for a password when entering the VARS and DIAG menus, even if passwords are disabled, but it displays the default password (818) upon entering these menus. The user only has to press ENTR to access the password-protected menus but does not have to enter the required number code.

6.9. SETUP → DIAG → TEST CHAN OUTPUT: USING THE TEST CHANNEL ANALOG OUTPUT

The M700E calibrator comes equipped with one analog output. It can be set by the user to carry the current signal level of any one of the parameters listed in Table 6-13 and will output an analog VDC signal that rises and falls in relationship with the value of the parameter.

Pin-outs for the analog output connector at the rear panel of the instrument are:

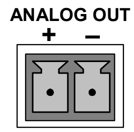


Figure 6-10: M700E the TEST CHANNEL Connector

6.9.1. CONFIGURING THE TEST CHANNEL ANALOG OUTPUT

6.9.1.1. The Analog I/O Configuration Submenu.

Table 6-12 lists the analog I/O functions that are available in the M700E calibrator.

Table 6-12: DIAG – Analog I/O Functions

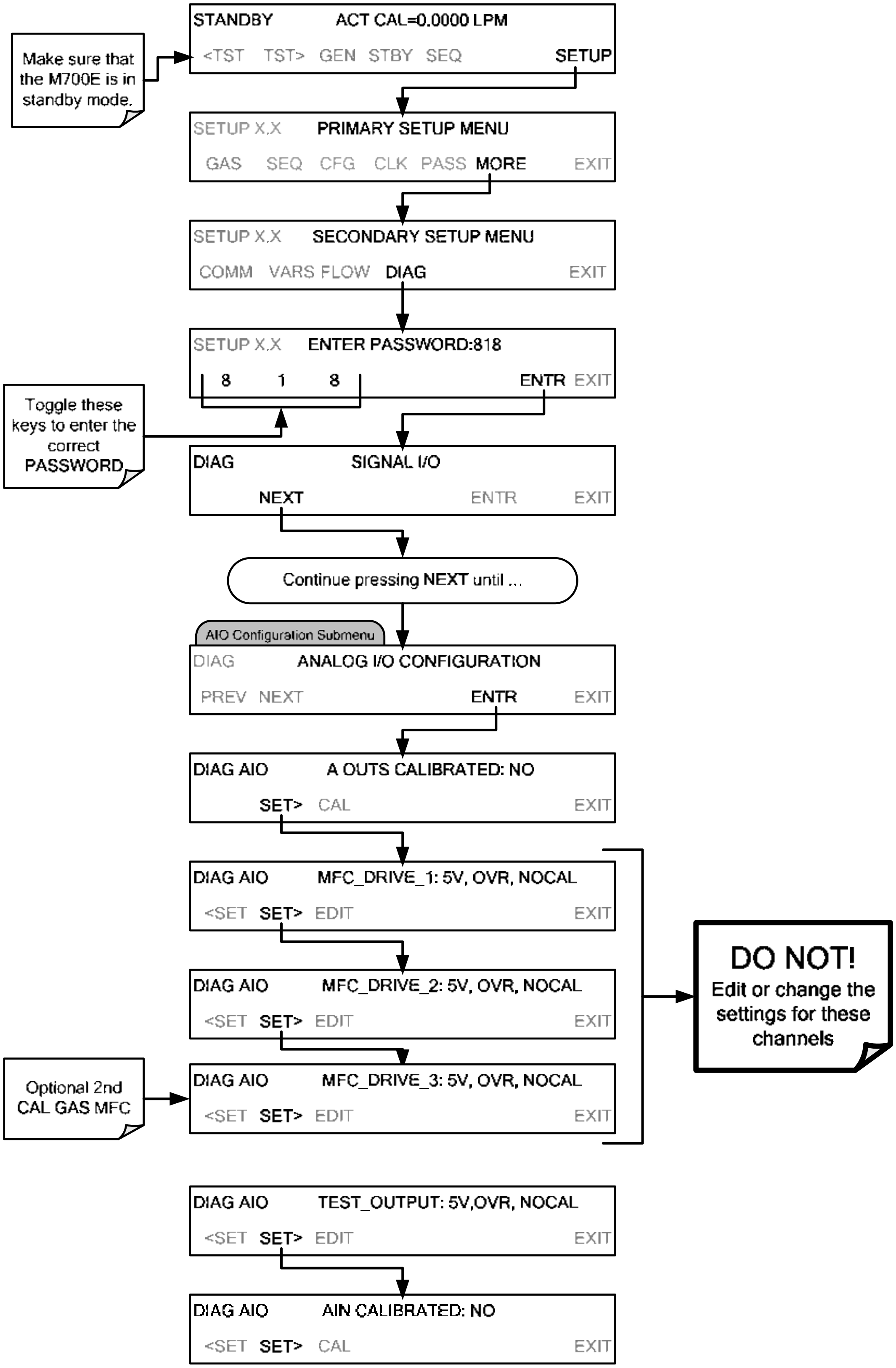
SUB MENU	FUNCTION
AOUTS CALIBRATED:	Shows the status of the analog output calibration (YES/NO) and initiates a calibration of all analog output channels.
MFC_DRIVE_1	**These channels are used by the M700E calibrator internally as drive voltages for instruments with analog MFC's.** **DO NOT alter the settings for these channels.**
MFC_DRIVE_2	
MFC_DRIVE_3 (OPTIONAL)	
TEST OUTPUT	Configures the analog output: **RANGE**[1]: Selects the signal type (voltage or current loop) and full-scale value of the output. **OVERRANGE:** Turns the ± 5% over-range feature ON/OFF for this output channel. **REC_OFS**[1]: Sets a voltage offset (not available when **RANGE** is set to **CURR**ent loop. **AUTO_CAL**[1]: Sets the channel for automatic or manual calibration **CALIBRATED**[1]**:** Performs the same calibration as **AOUT CALIBRATED**, but on this one channel only.
AIN CALIBRATED	Shows the calibration status (YES/NO) and initiates a calibration of the analog to digital converter circuit on the motherboard.
[1]Changes to **RANGE** or **REC_OFS** require recalibration of this output.	

To configure the calibrator's **TEST CHANNEL**, set the electronic signal type of each channel and calibrate the outputs. This consists of:

1. Choosing a **TEST CHANNEL** function to be output on the channel.
2. Selecting a signal level that matches the input requirements of the recording device attached to the channel.
3. Determining if the over-range feature is needed and turn it on or off accordingly.
4. Adding a bipolar recorder offset to the signal if required (Section 6.9.1.5).

5. Calibrating the output channel. This can be done automatically or manually for each channel (see Section 6.9.2).

To access the analog I/O configuration sub menu, press:



6.9.1.2. Selecting a Test Channel Function to Output

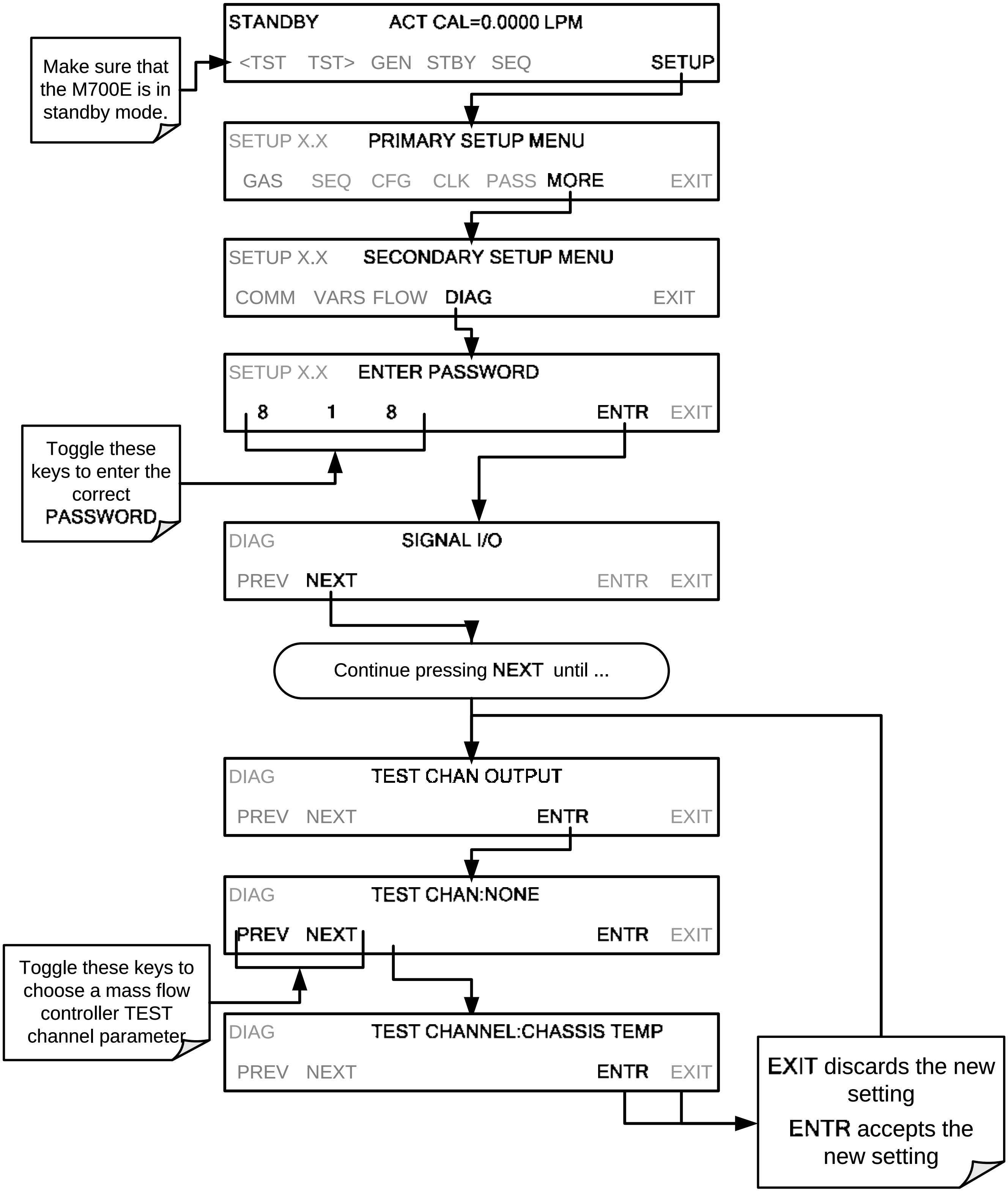
The Test Functions available to be reported are listed on Table 6-13:

Table 6-13: Test Channels Functions available on the M700E's Analog Output

TEST CHANNEL	DESCRIPTION	ZERO	FULL SCALE
NONE	**TEST CHANNEL IS TURNED OFF**		
O3 PHOTO MEAS	The raw output of the photometer during its measure cycle	0 mV	5000 mV
O3 PHOTO REF	The raw output of the photometer during its reference cycle	0 mV	5000 mV
O3 GEN REF	The raw output of the O_3 generator's reference detector	0 mV	5000 mV
SAMPLE PRESSURE	The pressure of gas in the photometer absorption tube	0" Hg-In-A	40" Hg-In-A
SAMPLE FLOW	The gas flow rate through the photometer	0 cm^3/min	1000 cm^3/min
SAMPLE TEMP	The temperature of gas in the photometer absorption tube	0 C°	70 C°
PHOTO LAMP TEMP	The temperature of the photometer UV lamp	0 C°	70 C°
O3 LAMP TEMP	The temperature of the O_3 generator's UV lamp	0 mV	5000 mV
CHASSIS TEMP	The temperature inside the M700E's chassis (same as **BOX TEMP**)	0 C°	70 C°
O3 PHOTO CONC	The current concentration of O_3 being measured by the photometer.	0 PPM	1 ppm

Once a function is selected, the instrument not only begins to output a signal on the analog output, but also adds **TEST** to the list of Test Functions viewable via the Front Panel Display.

To activate the **TEST** Channel and select a function press:



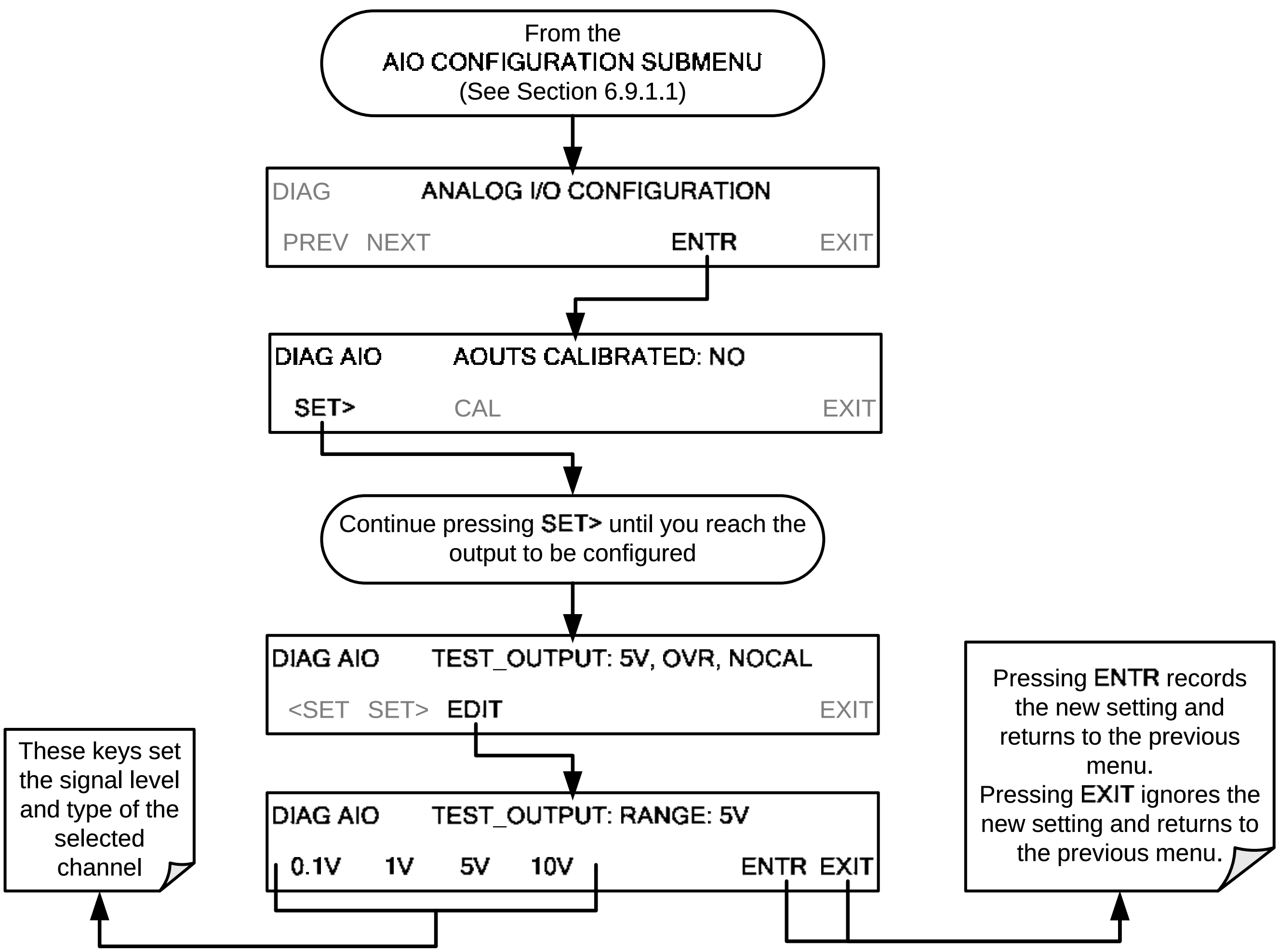
6.9.1.3. TEST CHANNEL VOLTAGE RANGE Configuration

In its standard configuration, the analog outputs is set to output a 0 – 5 VDC signals. Several other output ranges are available (see Table 6-14). Each range is usable from -5% to + 5% of the rated span.

Table 6-14: Analog Output Voltage Range Min/Max

RANGE SPAN	MINIMUM OUTPUT	MAXIMUM OUTPUT
0-100 mVDC	-5 mVDC	105 mVDC
0-1 VDC	-0.05 VDC	1.05 VDC
0-5 VDC	-0.25 VDC	5.25 VDC
0-10 VDC	-0.5 VDC	10.5 VDC
The default offset for all ranges is 0 VDC.		

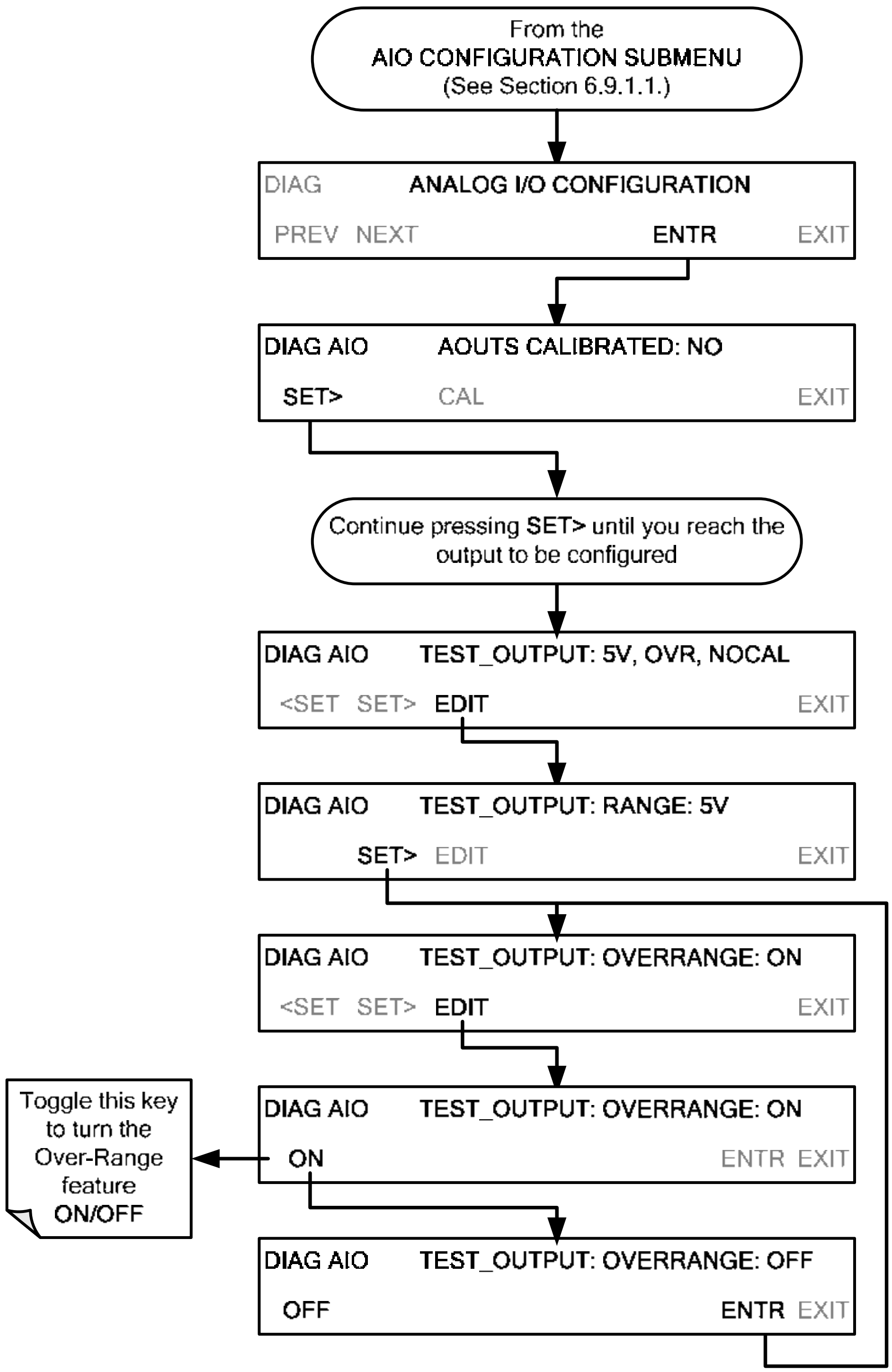
To change the output range, press:



6.9.1.4. Turning the TEST CHANNEL Over-Range Feature ON/OFF

In its default configuration, a ± 5% over-range is available on each of the M700E's **TEST CHANNEL** output. This over-range can be disabled if your recording device is sensitive to excess voltage or current.

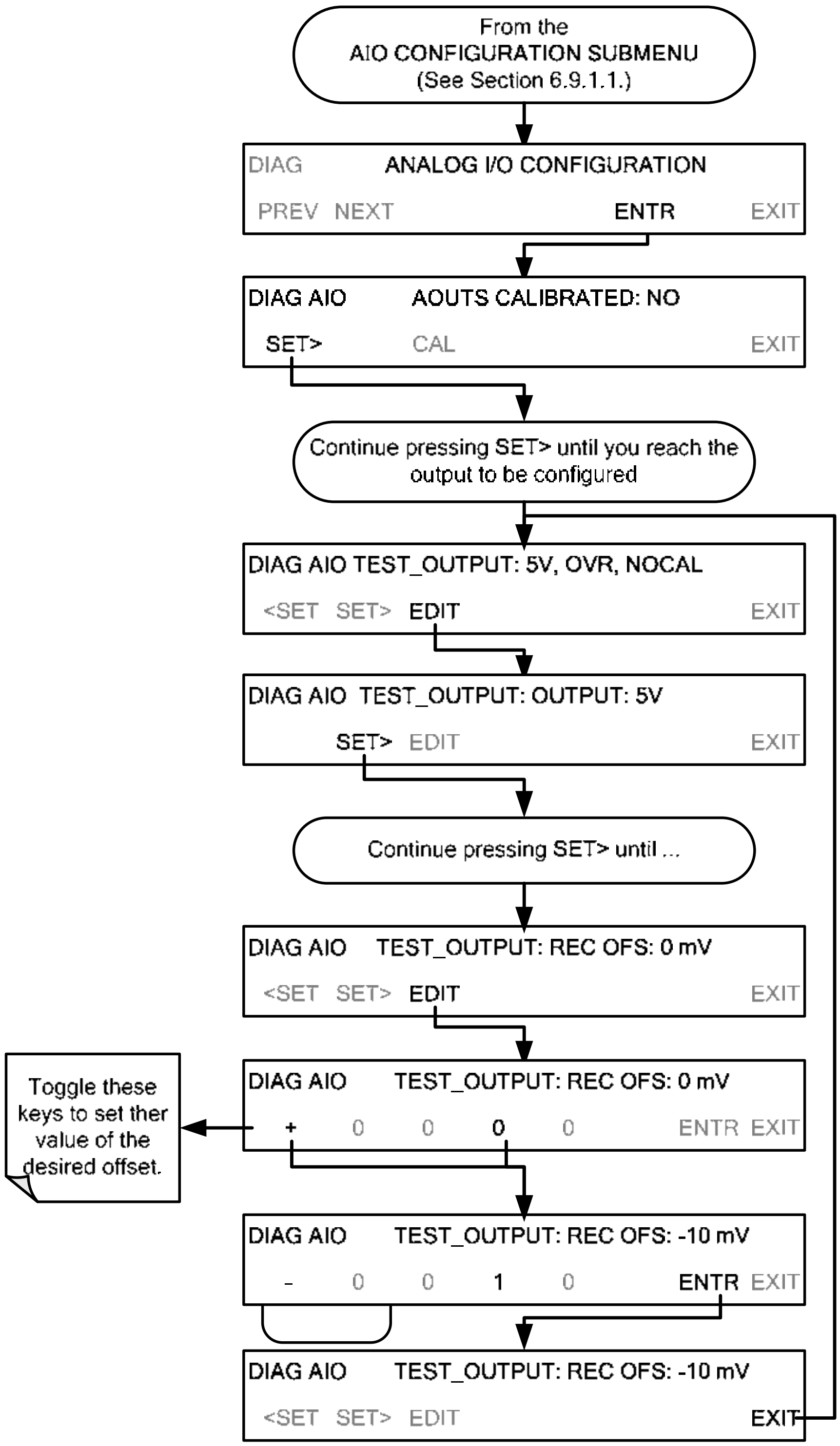
To turn the over-range feature on or off, press:



6.9.1.5. Adding a Recorder Offset to the TEST CHANNEL

Some analog signal recorders require that the zero signal is significantly different from the baseline of the recorder in order to record slightly negative readings from noise around the zero point. This can be achieved in the M700E by defining a zero offset, a small voltage (e.g., 10% of span).

To add a zero offset to a specific analog output channel, press:



6.9.2. TEST CHANNEL CALIBRATION

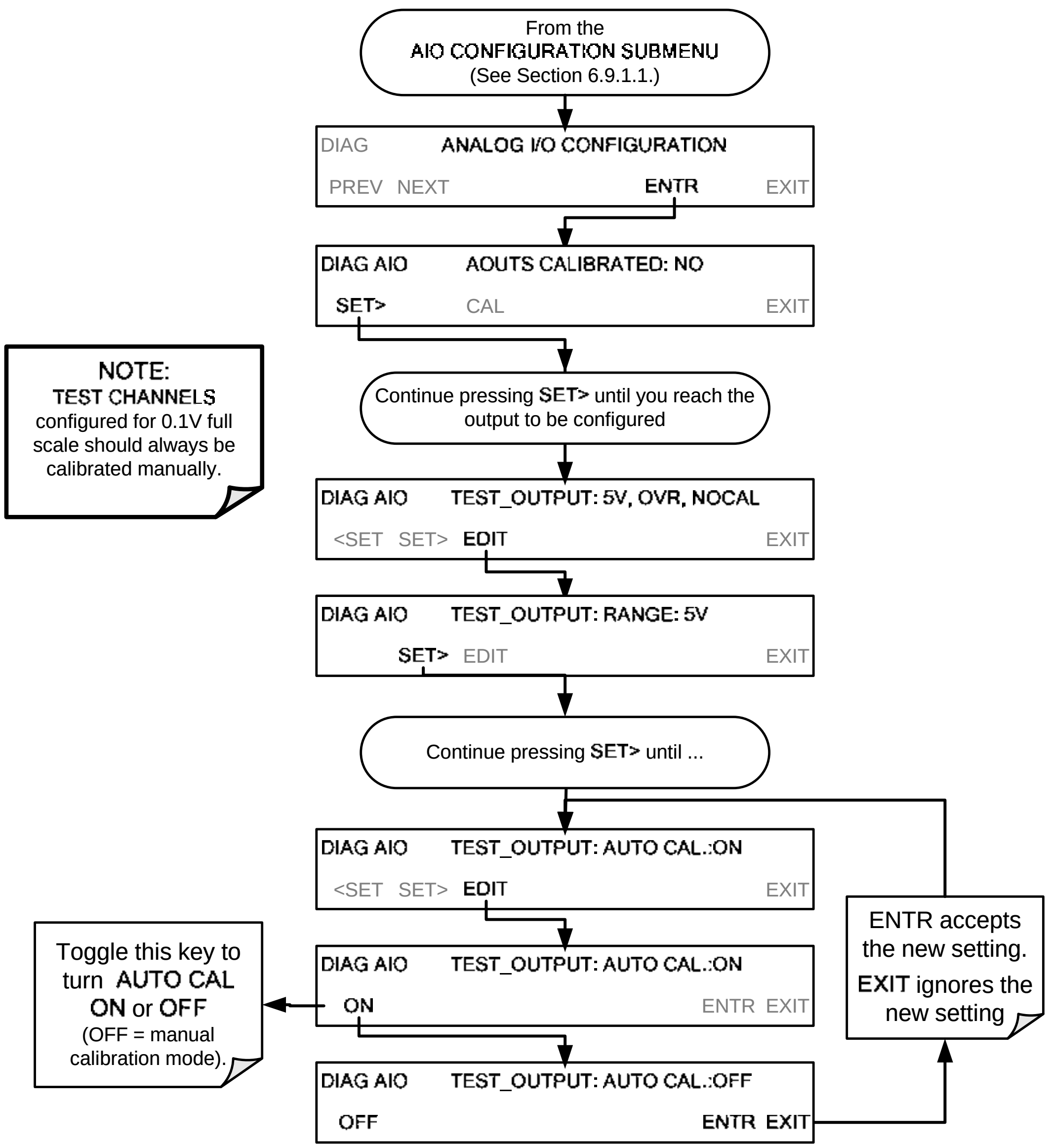
TEST CHANNEL calibration needs to be carried out on first startup of the calibrator (performed in the factory as part of the configuration process) or whenever recalibration is required. The analog outputs can be calibrated automatically or adjusted manually.

During automatic calibration, the calibrator tells the output circuitry to generate a zero mV signal and high-scale point signal (usually about 90% of chosen analog signal scale) then measures actual signal of the output. Any error at zero or high-scale is corrected with a slope and offset.

Automatic calibration can be performed via the **AOUTS CALIBRATION** command, or by using the **CAL** button located inside **TEST_CHANNEL** submenu. By default, the calibrator is configured so that calibration of **TEST CHANNEL** can be initiated with the **AOUTS CALIBRATION** command.

6.9.2.1. Enabling or disabling the TEST CHANNEL Auto-Cal Feature

To enable or disable the Auto-Cal feature for the **TEST CHANNEL**, press:



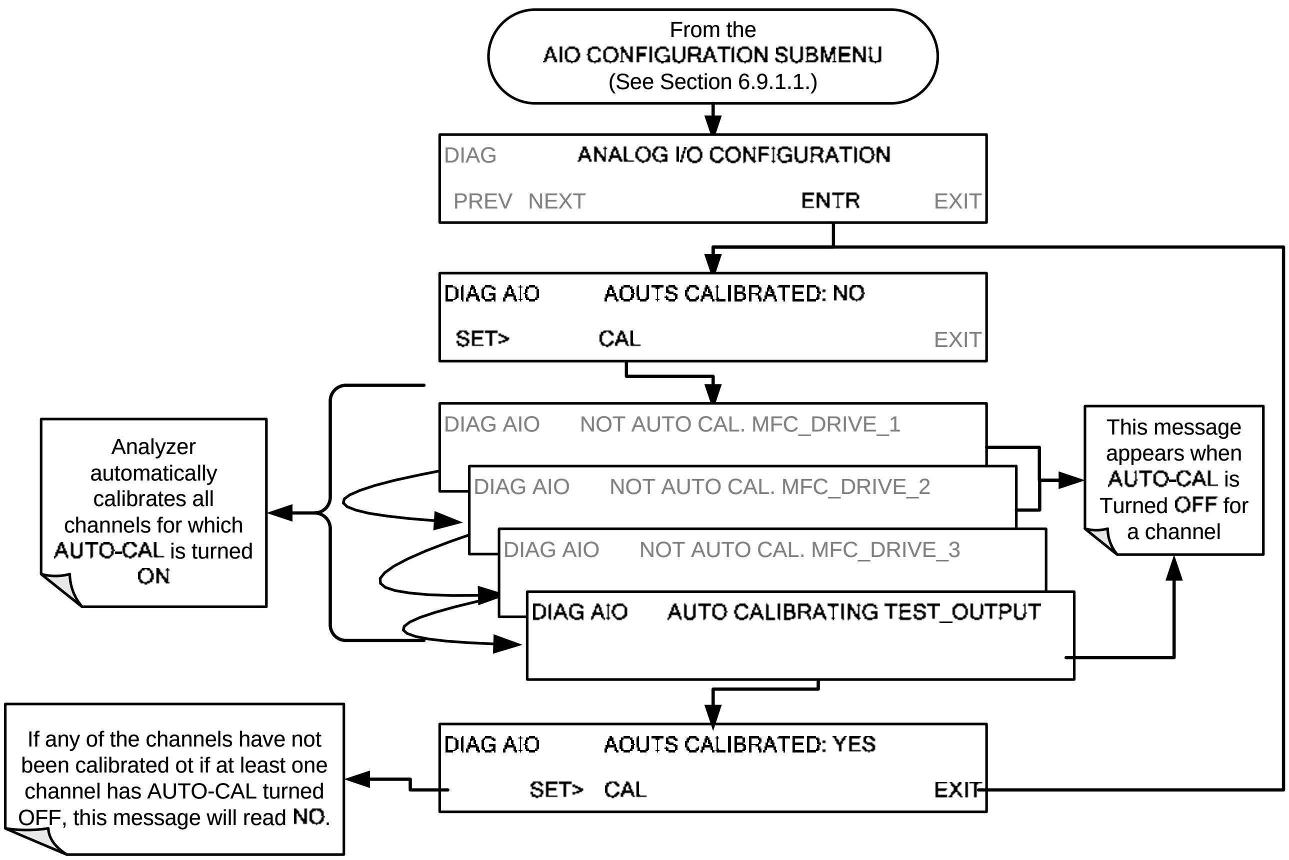
6.9.2.2. Automatic TEST CHANNEL Calibration

NOTE

Before performing this procedure, ensure that the AUTO CAL feature is turned OFF for MFC_DRIVE_1, MFC_DRIVE_2 and MFC_DRIVE_3 9 if installed)

Ensure that the AUTO CAL feature is turned ON for the TEST CHANNEL (See Section 6.9.2.1)

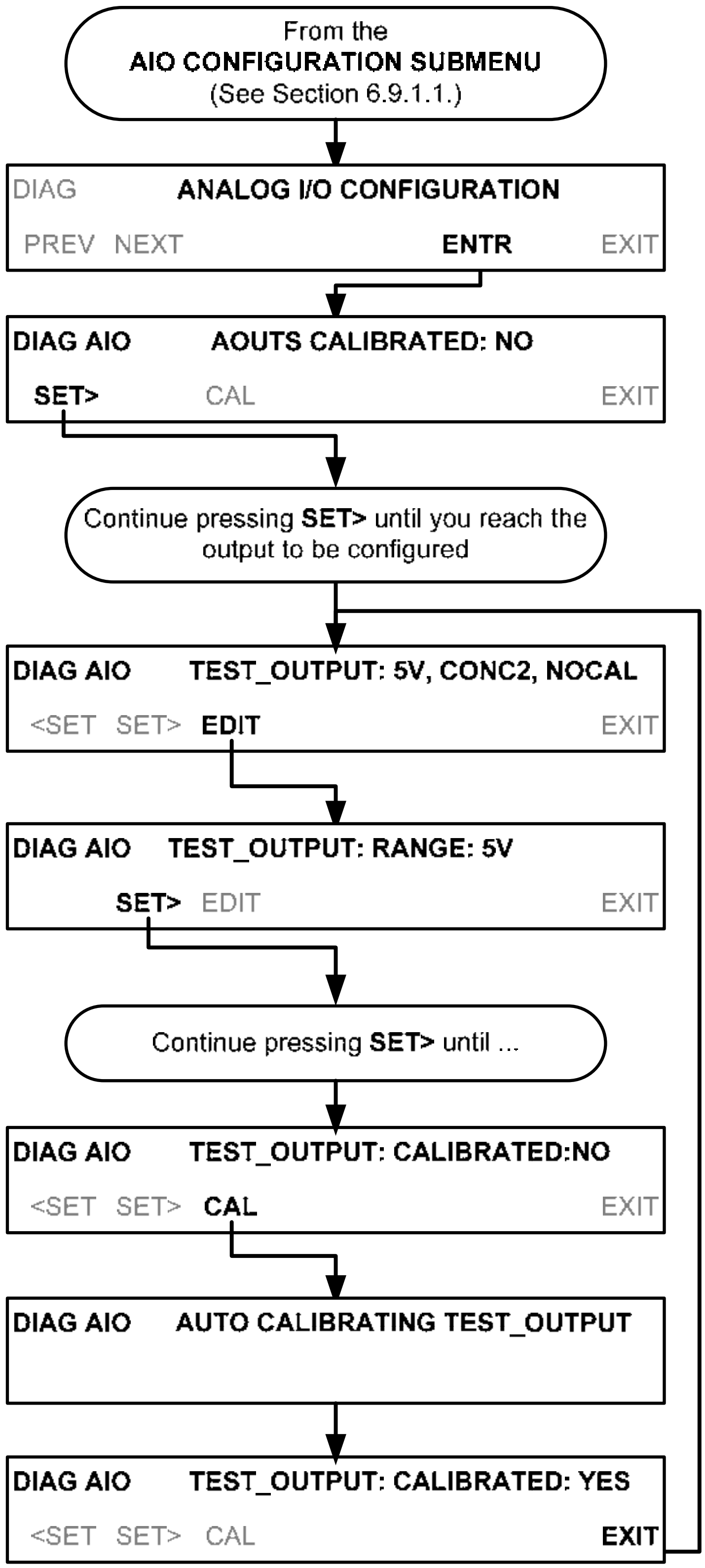
To calibrate the outputs as a group with the **AOUTS CALIBRATION** command, press:



NOTE

Manual calibration should be used for the 0.1V range or in cases where the outputs must be closely matched to the characteristics of the recording device.

To initiate an automatic calibration from inside the **TEST CHANNEL** submenu, press:



6.9.2.3. Manual Calibration of the TEST CHANNEL Configured for Voltage Ranges

For highest accuracy, the voltages of the analog outputs can be calibrated manually.

NOTE

The menu for manually adjusting the analog output signal level will only appear if the AUTO-CAL feature is turned off for the channel being adjusted (see Section 6.9.2.1).

Calibration is performed with a voltmeter connected across the output terminals and by changing the actual output signal level using the front panel keys in 100, 10 or 1 count increments.

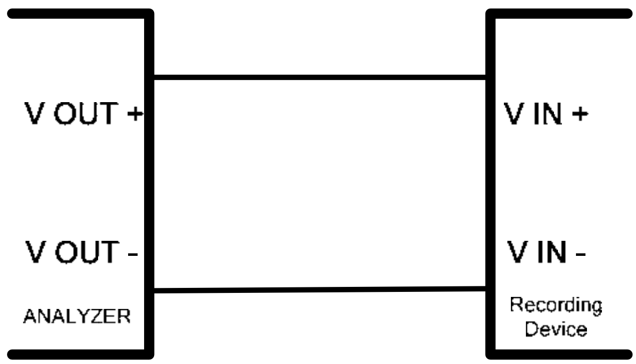
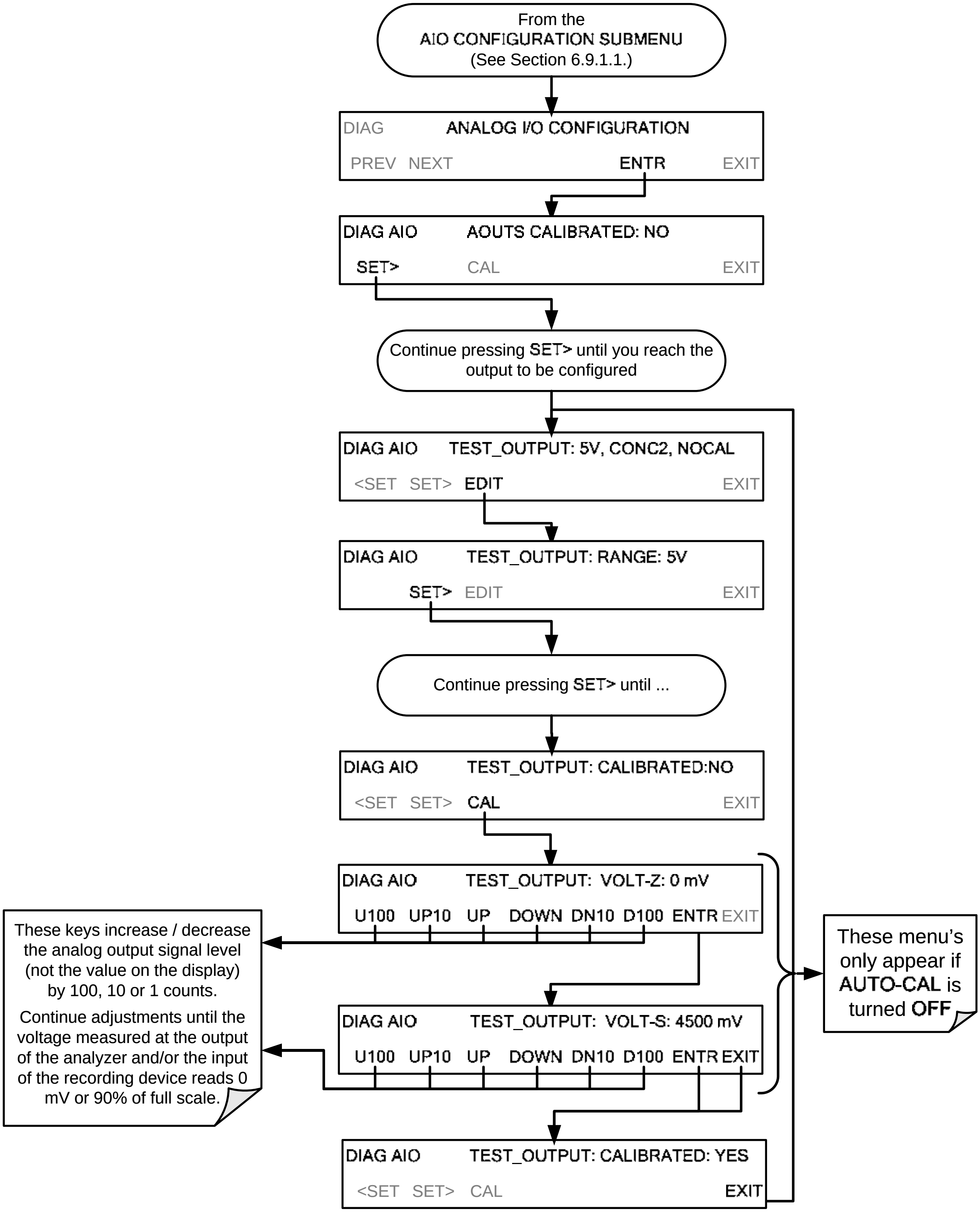


Figure 6-11: Setup for Calibrating the TEST CHANNEL

Table 6-15: Voltage Tolerances for the TEST CHANNEL Calibration

FULL SCALE	ZERO TOLERANCE	SPAN VOLTAGE	SPAN TOLERANCE	MINIMUM ADJUSTMENT (1 count)
0.1 VDC	±0.0005V	90 mV	±0.001V	0.02 mV
1 VDC	±0.001V	900 mV	±0.001V	0.24 mV
5 VDC	±0.002V	4500 mV	±0.003V	1.22 mV
10 VDC	±0.004V	4500 mV	±0.006V	2.44 mV

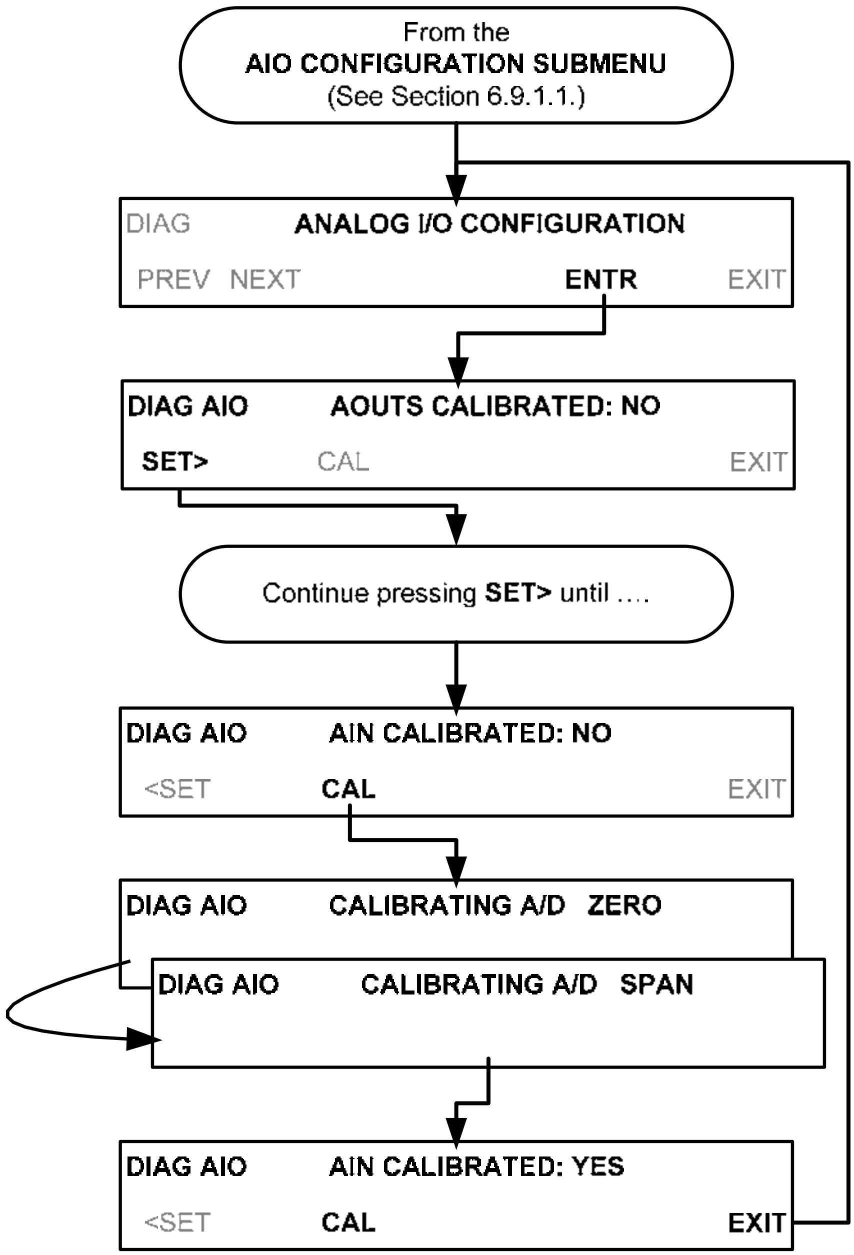
To adjust the signal levels of an analog output channel manually, press:



6.9.3. AIN CALIBRATION

This is the sub-menu calibrates the calibrator's A-to-D conversion circuitry. This calibration is only necessary after amajor repair such as the replacement of a CPU, a motherboard or a power supply.

To perform an **AIN CALIBRATION**, press:



6.10. SETUP → MORE → VARS: INTERNAL VARIABLES (VARS)

The M700E has several user-adjustable software variables, which define certain operational parameters. Usually, these variables are automatically set by the instrument's firmware, but can be manually redefined using the VARS menu.

The following table lists all variables that are available within the 818 password protected level. See Appendix A2 for a detailed listing of all of the M700E variables that are accessible through the remote interface.

Table 6-16: Variable Names (VARS)

NO.	VARIABLE	DESCRIPTION	ALLOWED VALUES	DEFAULT VALUES
0	*PHOTO_LAMP[1,2]*	*Sets the photometer lamp temperature set point and warning limits.*	*0ºC and 100ºC*	*58ºC Warning limits 56ºC - 61ºC*
1	*O3_GEN LAMP[1,2]*	*Sets the O_3 generator lamp temperature set point and warning limits.*	*0ºC and 100ºC*	*48ºC Warning limits 43ºC - 53ºC*
2	**O3_CONC_RANGE**	Set the upper span point of the O_3 concentration range for TEST CHANNEL analog signal **O3_PHOTO_CONC**.	0.1–20000 ppb	500 ppb
3	**O3_PHOTO_BENCH_ONLY[2]**	O_3 bench control flag. • ON turns on the photometer pump and switches measure/reference valve only when the O_3 mode is set for BNCH (See Section 3.3.9).	ON/OFF	OFF
4	**UNASSIGNED**			
5	*STD_TEMP[1]*	*Sets the standard Temperature used in calculating O_3 flow rates and concentrations.*	*0ºC and 100ºC*	*25ºC*
6	*STD PRESSURE[1]*	*Sets the standard pressure used in calculating O_3 flow rates and concentrations.*	*15.00 – 50 .00 in-Hg-A*	*29.92 in-Hg-A*
7	**CLOCK_ADJ**	Adjusts the speed of the analyzer's clock. Choose the + sign if the clock is too slow, choose the - sign if the clock is too fast (See Section 6.7).	-60 to +60 s/day Default=0	0

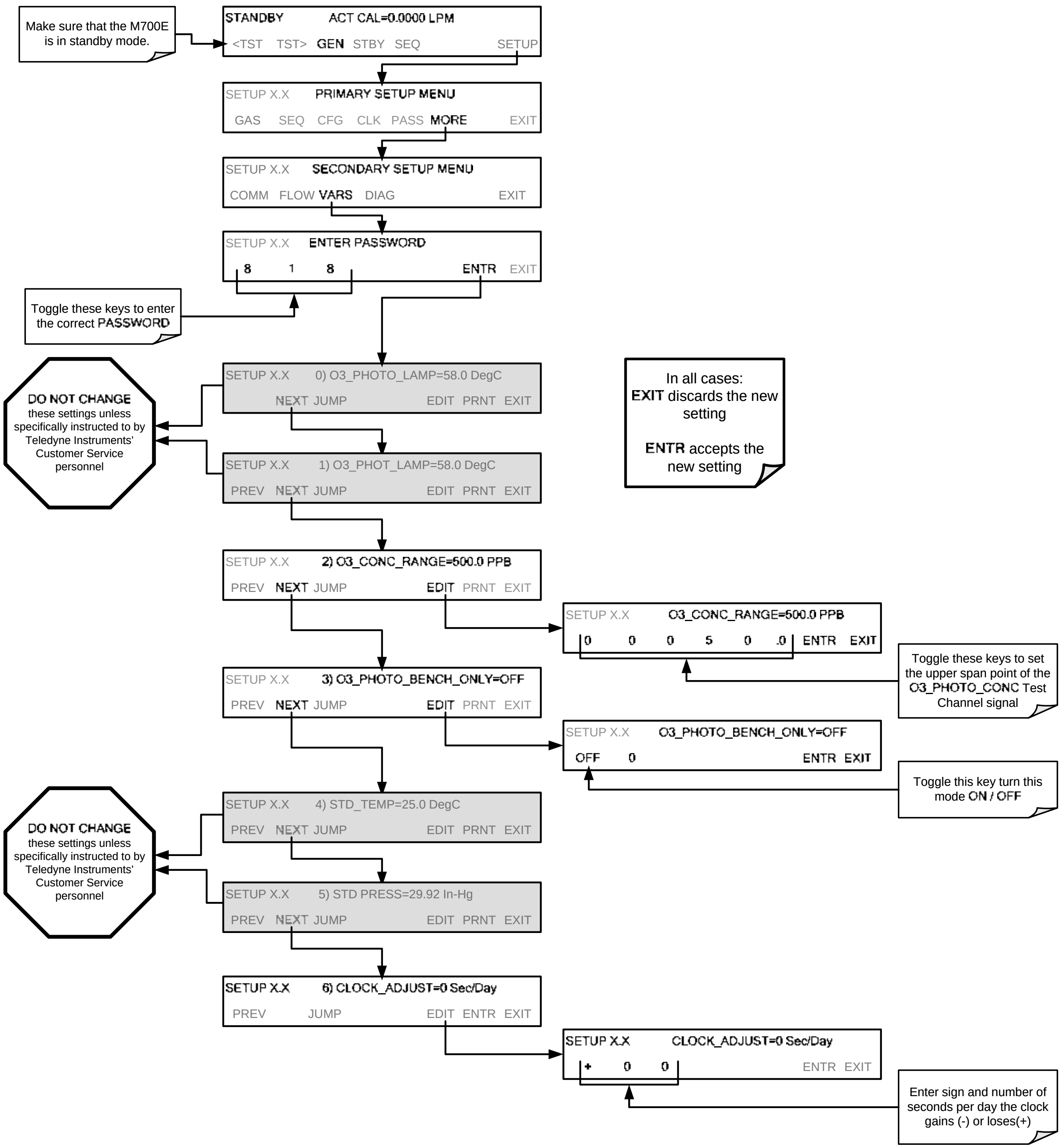
[1] **DO NOT ADJUST OR CHANGE** these values unless instructed to by Teledyne API's customer service personnel.
[2] Only available in calibrators with O_3 photometer and generator options installed.

NOTE

There is a 2-second latency period between when a VARS value is changed and the new value is stored into the analyzer's memory.

DO NOT turn the analyzer off during this period or the new setting will be lost.

To access and navigate the VARS menu, use the following key sequence:



6.11. SETUP → LVL: SETTING UP AND USING LEADS (DASIBI) OPERATING LEVELS

6.11.1. GENERAL INFORMATION ABOUT LEADS LEVELS

The M700E calibrator can be equipped with a version of firmware that includes support for LEADS, a data collection and analysis system LEADS specifically designed for handling meteorological and environmental data particularly when there is a need to integrate data and control instrumentation from several different manufacturers. When an M700E calibrator is equipped with the optional LEADS software used in conjunction with dataloggers located in the central data analysis facility it is possible to collect and buffer data between the various calibrators, analyzers and metrological equipment remotely located at an air monitoring station.

Because LEADS was originally developed for use with TNRCC using Dasibi 5008 calibrators, the LEADS version of the M700E includes support for Dasibi "Dot" serial data commands and operational "LEVEL's".

It also includes a method for driving external devices via contact closure control outputs in conjunction with an optional bolt-on valve driver assembly (see Section 5.8).

NOTE
For more information on the LEADS system, please go to http://www.meteostar.com/.

6.11.2. DOT COMMANDS

The Dasibi "Dot" commands form a text-based (ASCII) data protocol that is transmitted between a control computer (XENO data logger in this case) and a calibrator or ambient gas analyzer over an RS-232 connection. The details of the protocol are beyond the scope of this document, but in its simplest form the protocol is based on a two or three digit integer preceded by a control-A and a period (.) and then followed by a "!" and a two digit checksum.

EXAMPLE:

^A.xxx!nn

For further information on dot commands, please contact Teledyne API'S Customer Service.

An M700E equipped with LEADS software can be simultaneously operated over the same COMM port using standard Teledyne API's serial data commands and is compatible with APICOM versions 3.7.3 and later which include an added feature that allows a user to edit, upload and download level tables.

6.11.3. LEVELS

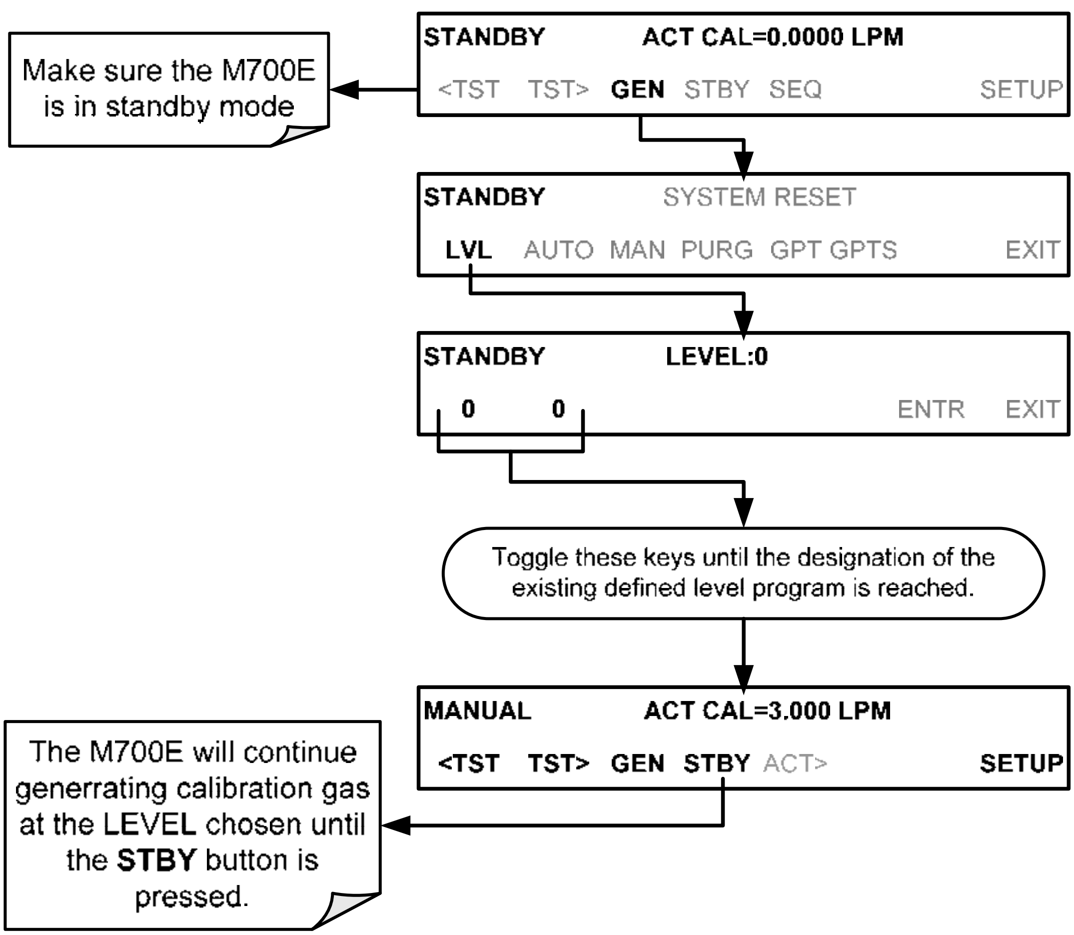
A **LEVEL** is a combination of several parameters:

- An ID number for the LEVEL
- An action, (e.g. GENERATE, GPT, GPTPS & MANUAL)
  - A target concentration value
  - An output flow rate (if applicable)
  - Configuration for one or both of two status output blocks.

Up to twenty levels can be defined and used with the M700E using a range of ID numbers from 0-98. Level 99 is reserved for standby. The levels are not time based and do not include characteristics such as start time or duration, therefore a single LEVEL can not switch between different concentration levels and flow rates. Separate flow and concentration outputs must be programmed into separate LEVELs which are then individually started and stopped either by an operator at the calibrator's front panel or through a serial data operation over the RS-232 or Ethernet ports.

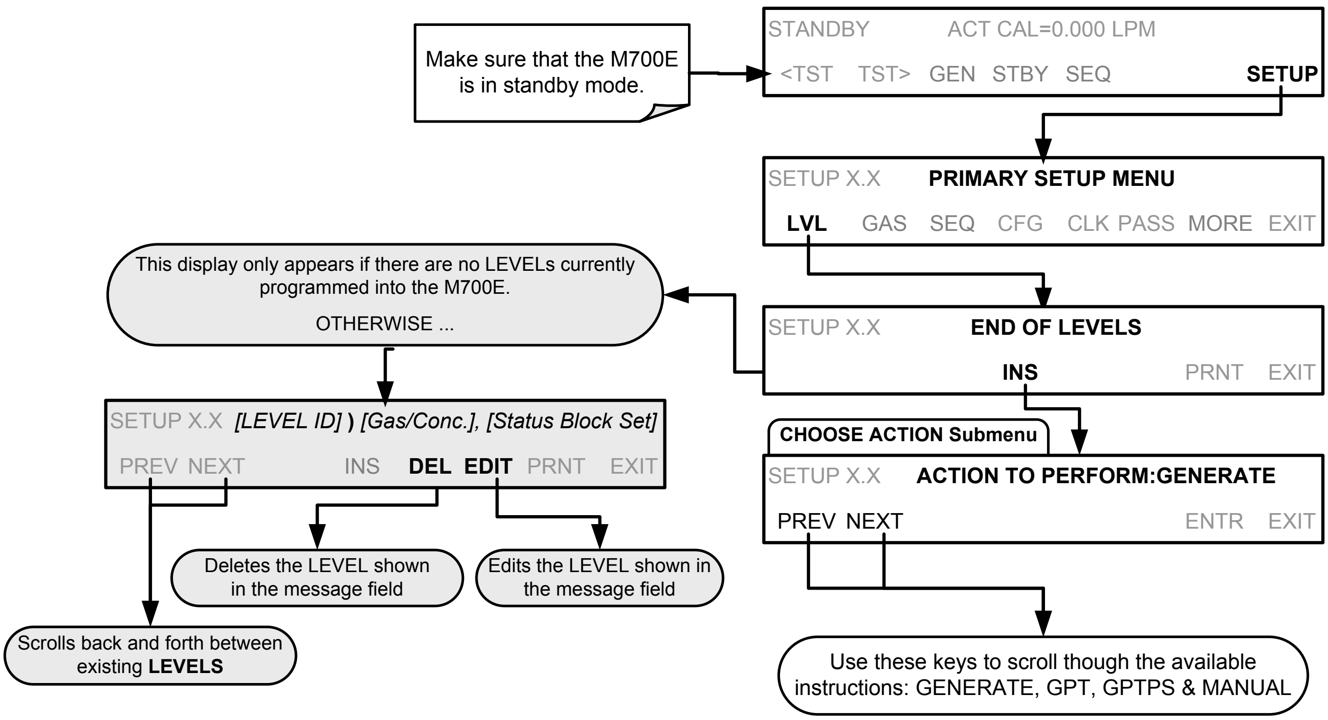
6.11.4. ACTIVATING AN EXISTING LEVEL

To activate an existing defined **LEVEL**, press:



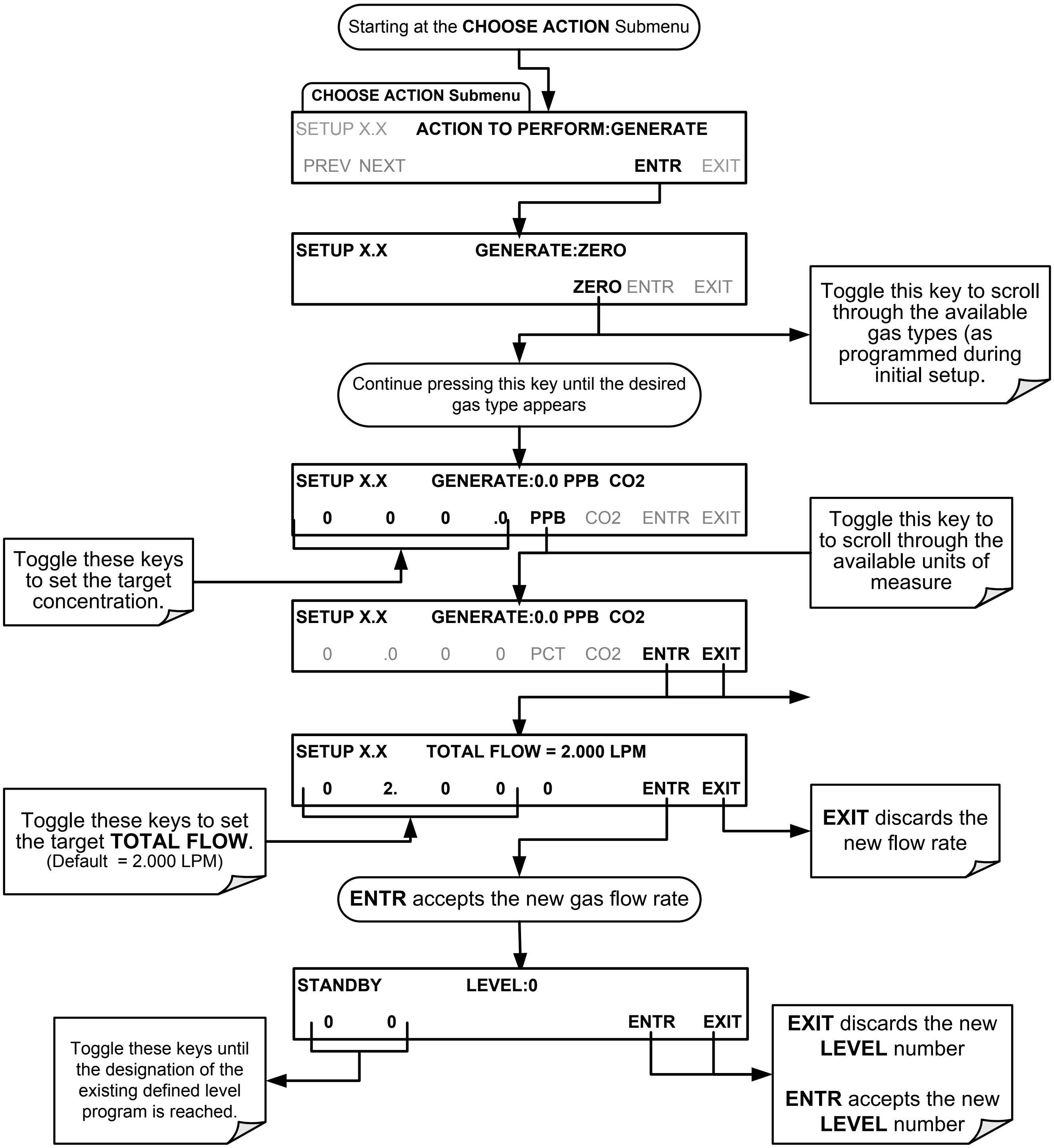
6.11.5. PROGRAMMING NEW LEVELS

To begin programming a new **LEVEL** find the **LVL** submenu by pressing:



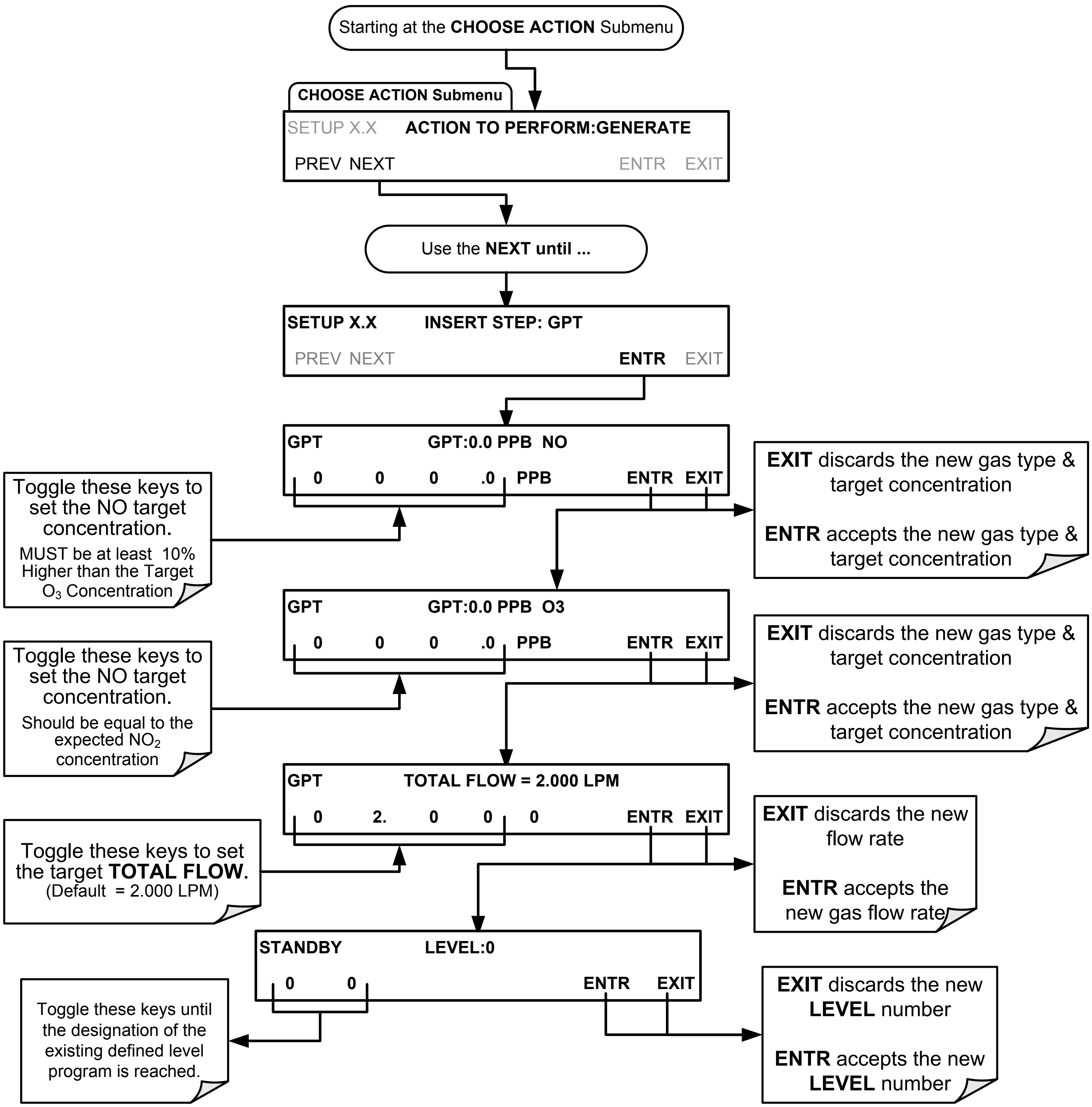
6.11.5.1. Creating a GENERATE LEVEL

To create a **LEVEL** using the M700E's **AUTO** generation function, press:



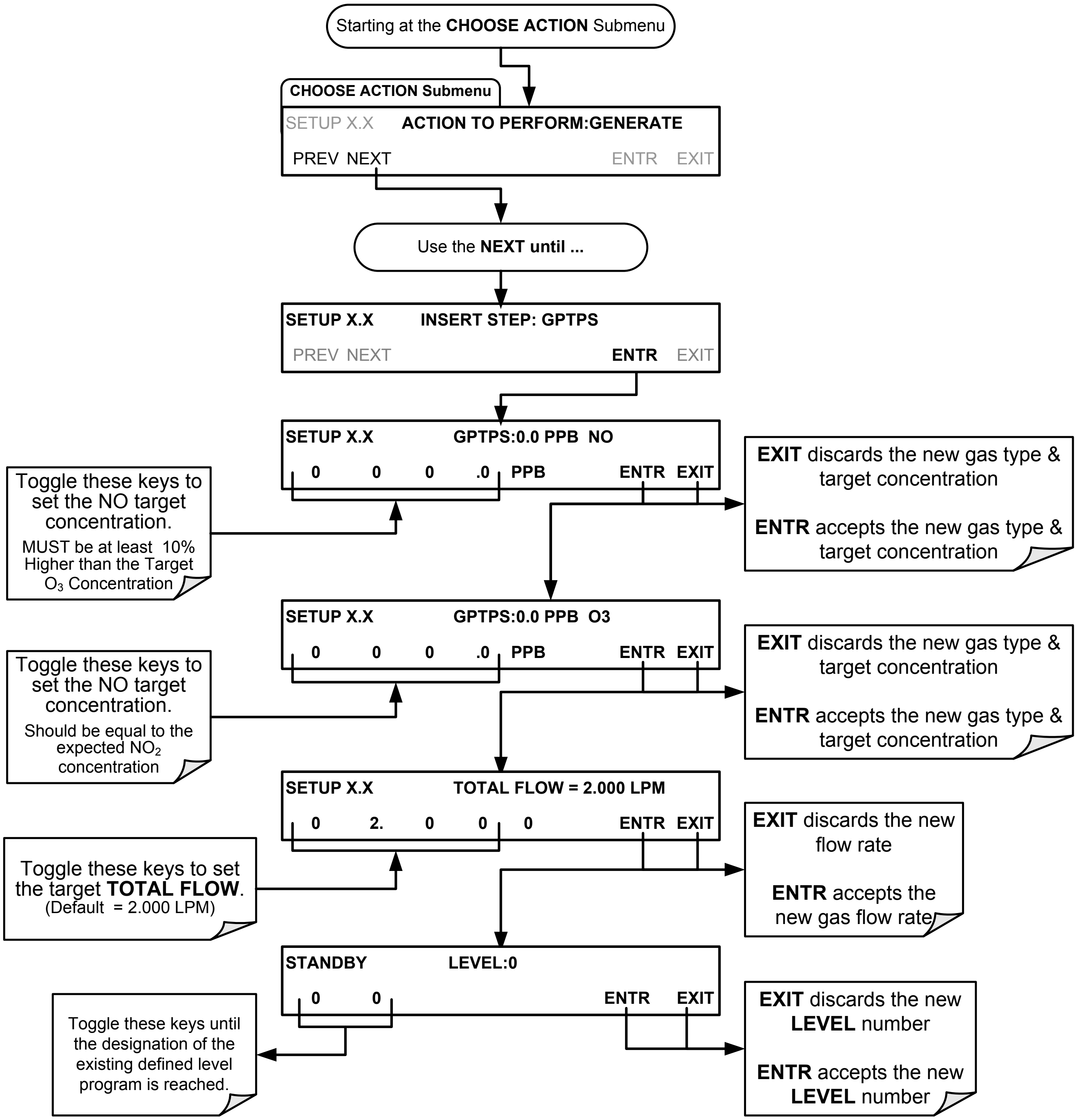
6.11.5.2. Creating a GPT LEVEL

To create a **LEVEL** using the M700E's **GPT** function, press:



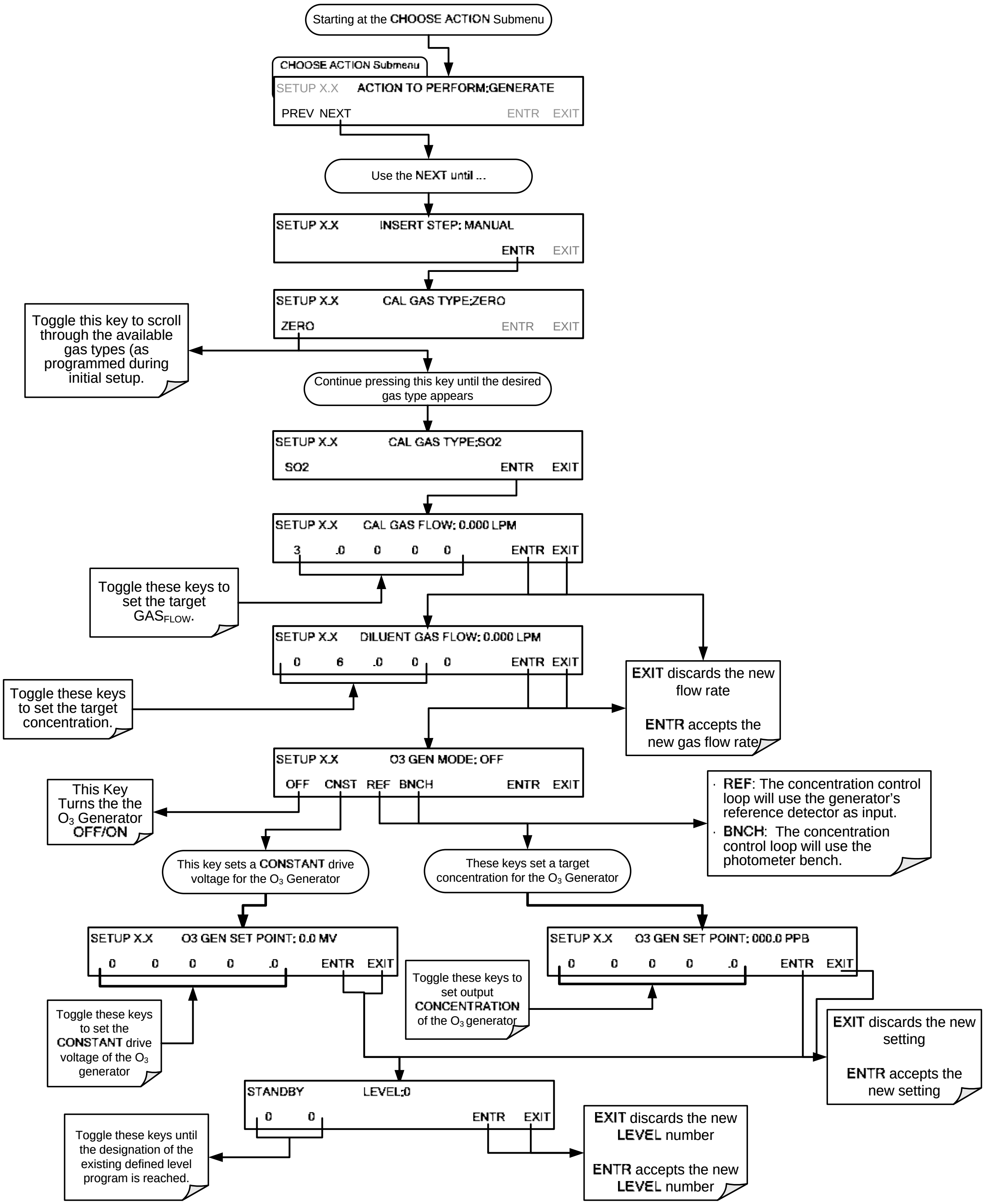
6.11.5.3. Creating a GPTPS LEVEL

To create a **LEVEL** using the M700E's **GPTPS** function, press:



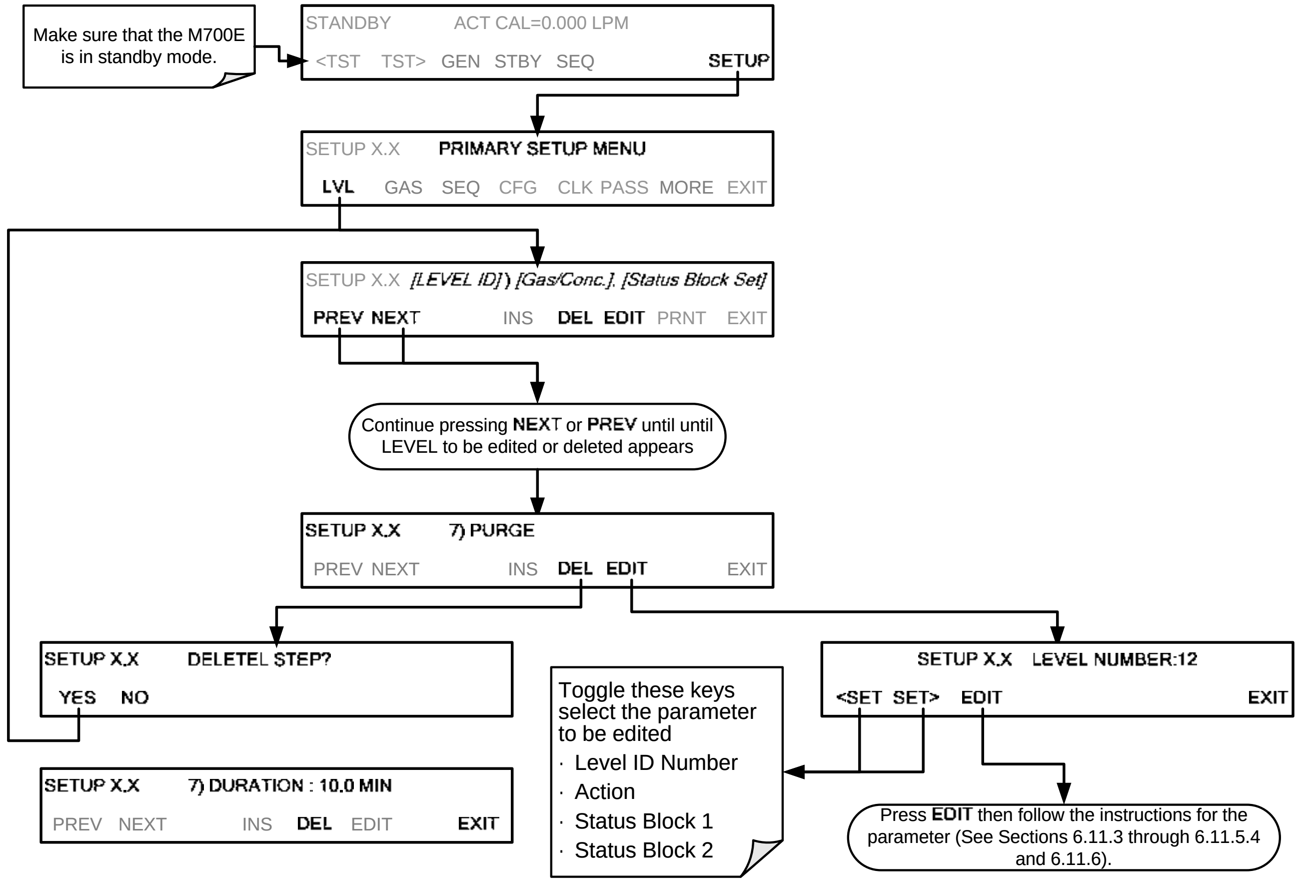
6.11.5.4. Creating a MANUAL LEVEL

To create a level using the M700E's **MANUAL** generation function, press:



6.11.5.5. Editing or Deleting a LEVEL

To edit or delete an existing **LEVEL**, press:

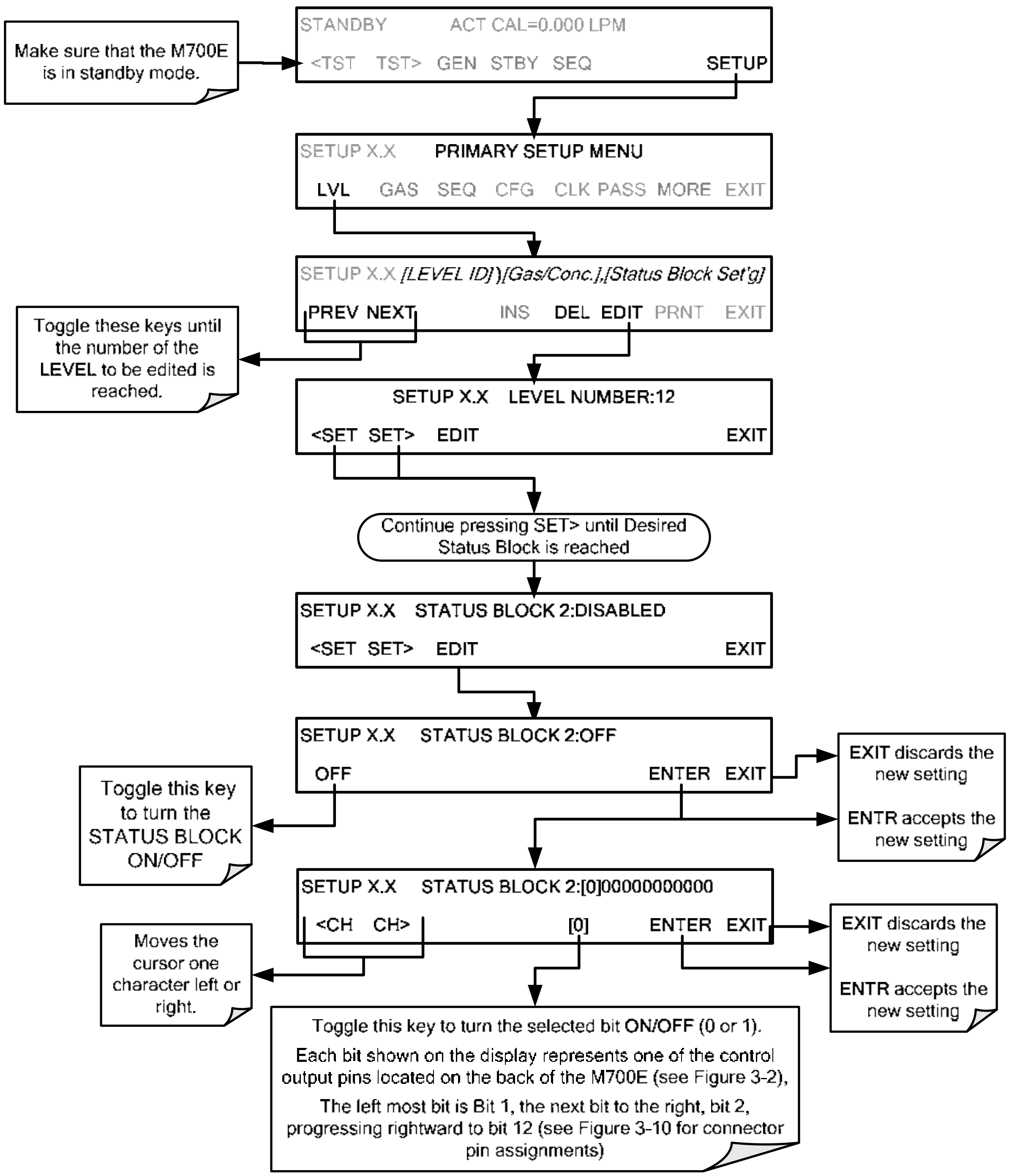


6.11.6. CONFIGURING LEVEL STATUS BLOCKS

There are two **STATUS BLOCKS** associated with **LEADS LEVELS**.

- **BLOCK 1:** This block corresponds to the physical CONTROL OUTPUT connections located on the back panel of the M700E (see Figure 3-2 and Section 3.1.2.5).
- **BLOCK 2**: The second status block does not correspond to any physical output but is used to communicate status over the serial data port.

To configure the either of the **STATUS BLOCKS**, press:



7. REMOTE OPERATION OF THE M700E

7.1. USING THE ANALYZER'S COMMUNICATION PORTS

The M700E is equipped with two serial communication ports located on the rear panel accessible via two DB-9 connectors on the back panel of the instrument (See Figure 3-2). The COM1 connector is a male DB-9 connector and the COM2 is a female DB9 connector.

Both ports operate similarly and give the user the ability to communicate with, issue commands to, and receive data from the calibrator through an external computer system or terminal.

- The RS-232 port (COM1) can also be configured to operate in single or RS-232 multi-drop mode (option 62; See Section 5.6.3 and 7.2.1).
- The COM2 port can be configured for standard RS-232 operation, half-duplex RS-485 communication or for access via an LAN by installing the Teledyne API's Ethernet interface card (See Section 5.6.4 and 7.4).

7.1.1. RS-232 DTE AND DCE COMMUNICATION

RS-232 was developed for allowing communications between data terminal equipment (DTE) and data communication equipment (DCE). Basic data terminals always fall into the DTE category whereas modems are always considered DCE devices.

Electronically, the difference between the DCE and DTE is the pin assignment of the Data Receive and Data Transmit functions.

- DTE devices receive data on pin 2 and transmit data on pin 3.
- DCE devices receive data on pin 3 and transmit data on pin 2.

A switch located below the serial ports on the rear panel allows the user to switch between DTE (for use with data terminals) or DCE (for use with modems). Since computers can be either DTE or DCE, check your computer to determine which mode to use.

7.1.2. COMM PORT DEFAULT SETTINGS AND CONNECTOR PIN ASSIGNMENTS

Received from the factory, the calibrator is set up to emulate an RS-232 DCE device.

- **RS-232 (COM1)**: RS-232 (fixed), DB-9 male connector.
  - **Baud rate**: 19200 bits per second (baud).
  - **Data Bits**: 8 data bits with 1 stop bit.
  - **Parity**: None.
- **COM2**: RS-232 (configurable to RS 485), DB-9 female connector.
  - **Baud rate**: 115000 bits per second (baud).
  - **Data Bits**: 8 data bits with 1 stop bit.
  - **Parity**: None.

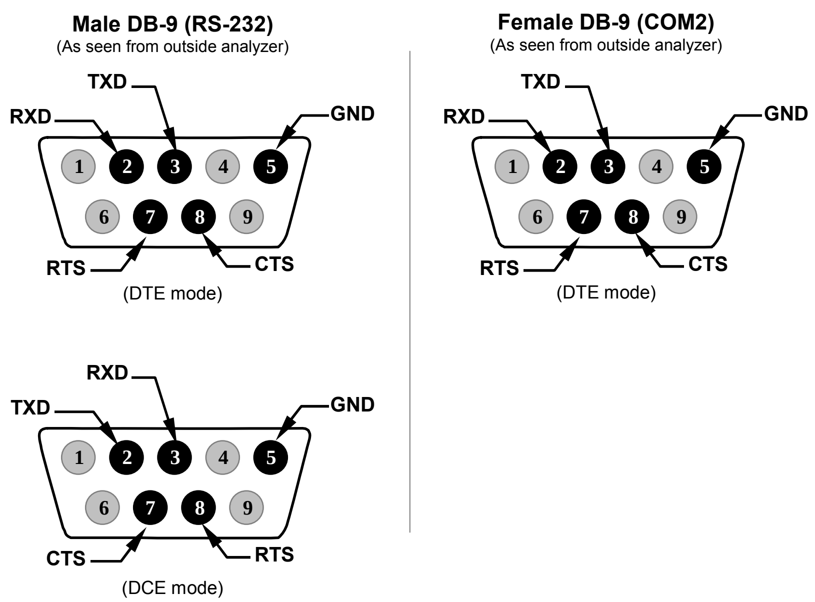


Figure 7-1: Default Pin Assignments for Back Panel COMM Port Connectors (RS-232 DCE & DTE)

The signals from these two connectors are routed from the motherboard via a wiring harness to two 10-pin connectors on the CPU card, CN3 (COM1) and CN4 (COM2).

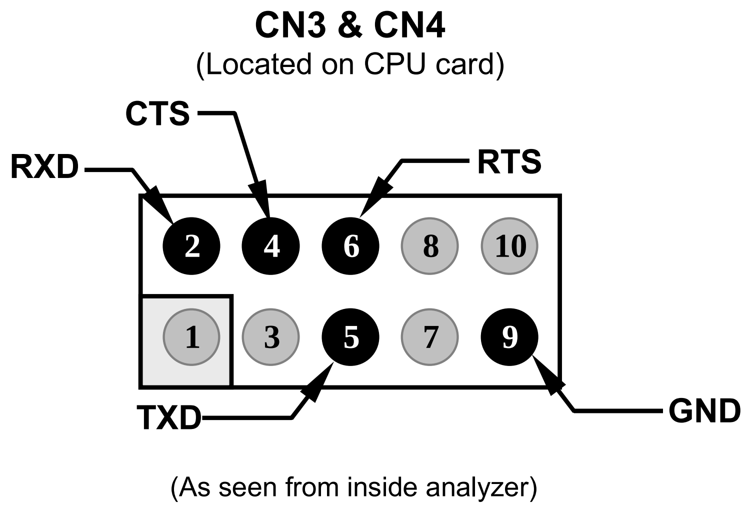


Figure 7-2: Default Pin Assignments for CPU COMM Port Connector (RS-232).

Teledyne API offers two mating cables, one of which should be applicable for your use.

- P/N WR000077, a DB-9 female to DB-9 female cable, 6 feet long. Allows connection of the serial ports of most personal computers. Also available as Option 60B (see Section 5.6.1).
- P/N WR000024, a DB-9 female to DB-25 male cable. Allows connection to the most common styles of modems (e.g. Hayes-compatible) and code activated switches. Also available as Option 60A (see Section 5.6.1).

Both cables are configured with straight-through wiring and should require no additional adapters.

NOTE

Cables that appear to be compatible because of matching connectors may incorporate internal wiring that makes the link inoperable. Check cables acquired from sources other than Teledyne API for pin assignments before using.

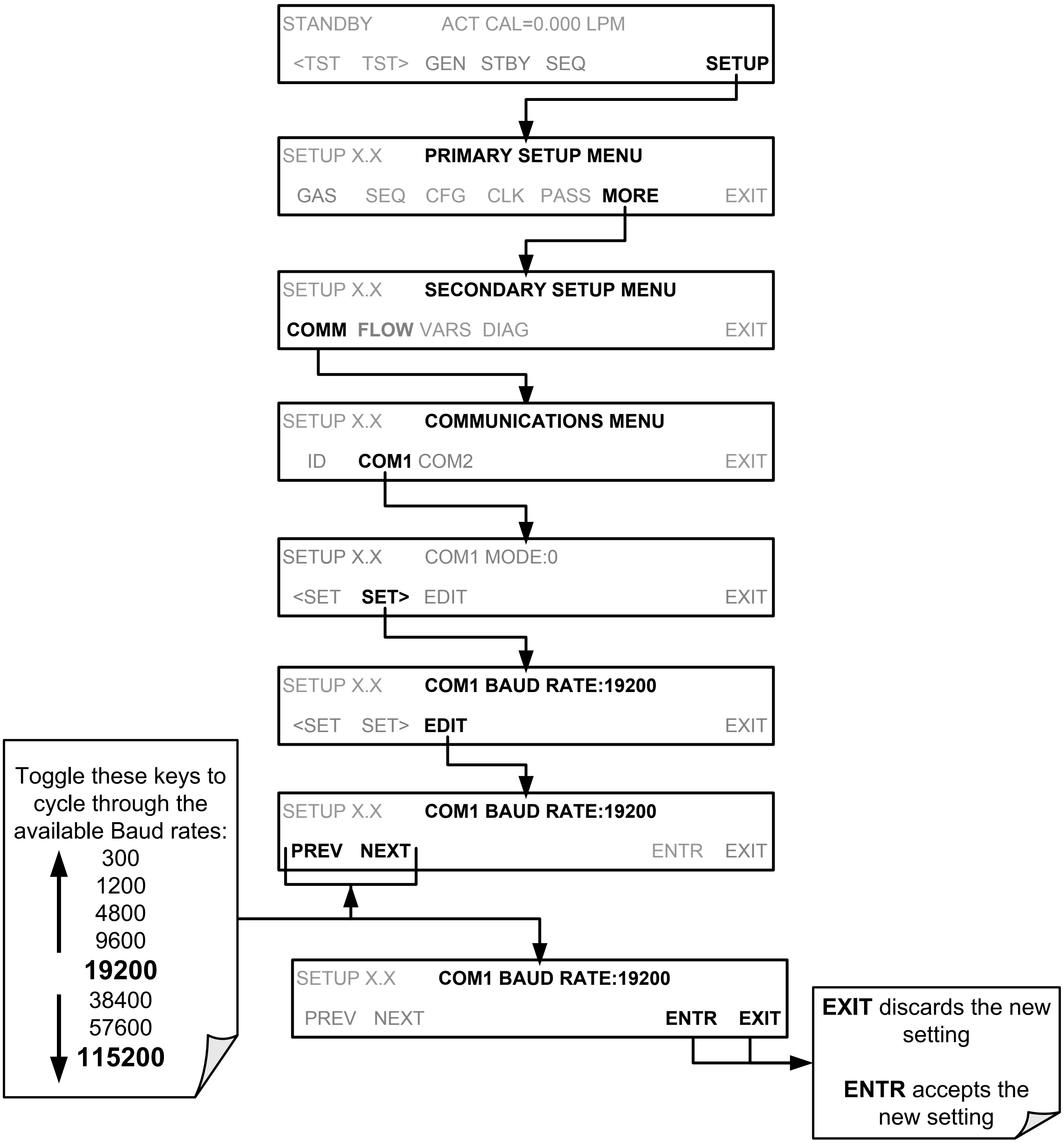
To assist in properly connecting the serial ports to either a computer or a modem, there are activity indicators just above the RS-232 port. Once a cable is connected between the calibrator and a computer or modem, both the red and green LEDs should be on.

If the lights are not lit, use small switch on the rear panel to switch it between DTE and DCE modes.

If both LEDs are still not illuminated, ensure the cable properly connected.

7.1.3. COMM PORT BAUD RATE

To select the baud rate of either one of the COMM Ports, press:



7.1.4. COMM PORT COMMUNICATION MODES

Each of the calibrator's serial ports can be configured to operate in a number of different modes, listed in Table 7-1. As modes are selected, the calibrator sums the Mode ID numbers and displays this combined number on the front panel display. For example, if quiet mode (01), computer mode (02) and Multi-Drop-enabled mode (32) are selected, the Calibrator would display a combined **MODE ID** of **35**.

Table 7-1: COMM Port Communication Modes

MODE[1]	ID	DESCRIPTION
QUIET	**1**	Quiet mode suppresses any feedback from the calibrator (such as warning messages) to the remote device and is typically used when the port is communicating with a computer program where such intermittent messages might cause communication problems. Such feedback is still available but a command must be issued to receive them.
COMPUTER	**2**	Computer mode inhibits echoing of typed characters and is used when the port is communicating with a computer operated control program.
SECURITY	**4**	When enabled, the serial port requires a password before it will respond. The only command that is active is the help screen (? CR).
E, 7, 1	**2048**	When turned on this mode switches the **COMM** port settings from No parity; 8 data bits; 1 stop bit to Even parity; 7 data bits; 1 stop bit
RS-485	**1024**	Configures the **COM2** Port for RS-485 communication. RS-485 mode has precedence over multi-drop mode if both are enabled.
MULTI-DROP PROTOCOL	**32**	Multi-drop protocol allows a multi-instrument configuration on a single communications channel. Multi-drop requires the use of instrument IDs.
ENABLE MODEM	**64**	Enables to send a modem initialization string at power-up. Asserts certain lines in the RS-232 port to enable the modem to communicate.
ERROR CHECKING[2]	**128**	Fixes certain types of parity errors at certain Hessen protocol installations.
XON/XOFF HANDSHAKE[2]	**256**	Disables XON/XOFF data flow control also known as software handshaking.
HARDWARE HANDSHAKE	**8**	Enables CTS/RTS style hardwired transmission handshaking. This style of data transmission handshaking is commonly used with modems or terminal emulation protocols as well as by Teledyne Instrument's APICOM software.
HARDWARE FIFO[2]	**512**	Disables the **HARDWARE FIFO** (First In – First Out), When FIFO is enabled it improves data transfer rate for that COMM port.
COMMAND PROMPT	**4096**	Enables a command prompt when in terminal mode.

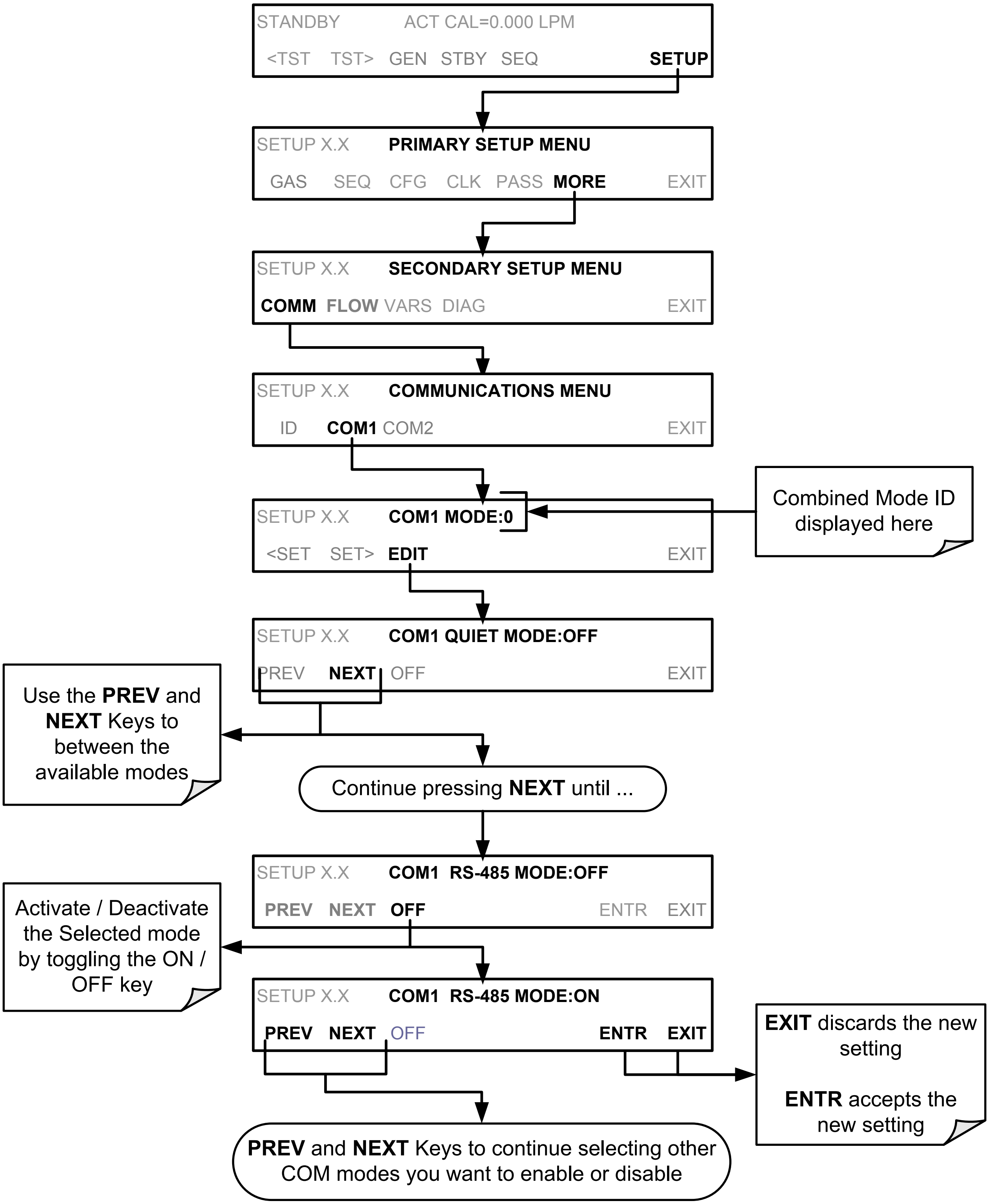
[1] Modes are listed in the order in which they appear in the **SETUP → MORE → COMM → COM[1 OR 2] → MODE** menu

[2] The default setting for this feature is **ON.** Do not disable unless instructed to by Teledyne API's Customer Service personnel.

Note

Communication Modes for each COMM port must be configured independently.

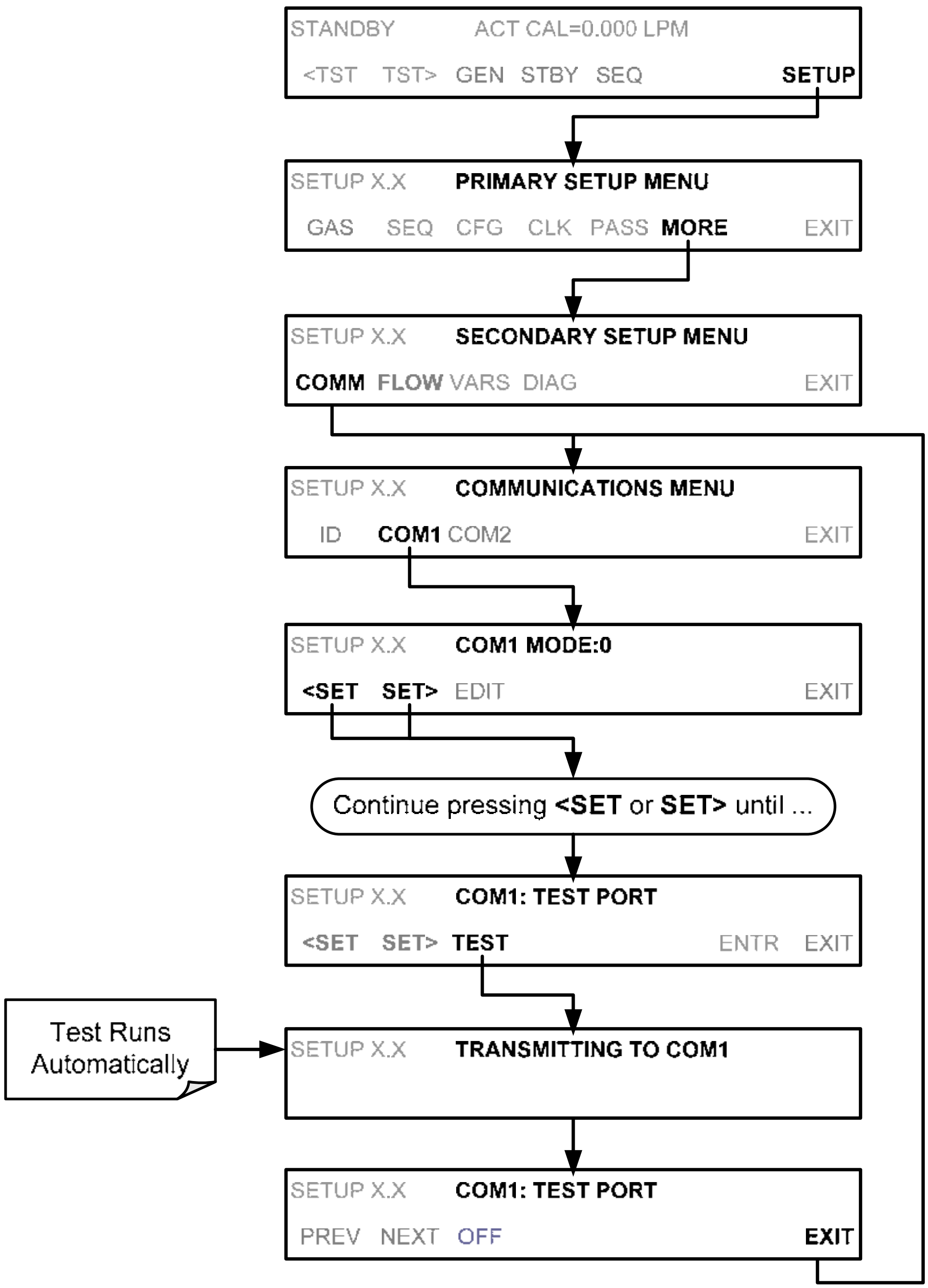
Press the following keys to select communication modes for a one of the COMM Ports, such as the following example where **RS-485** mode is enabled:



7.1.5. COMM PORT TESTING

The serial ports can be tested for correct connection and output in the **COMM** menu. This test sends a string of 256 'w' characters to the selected COMM port. While the test is running, the red LED on the rear panel of the calibrator should flicker.

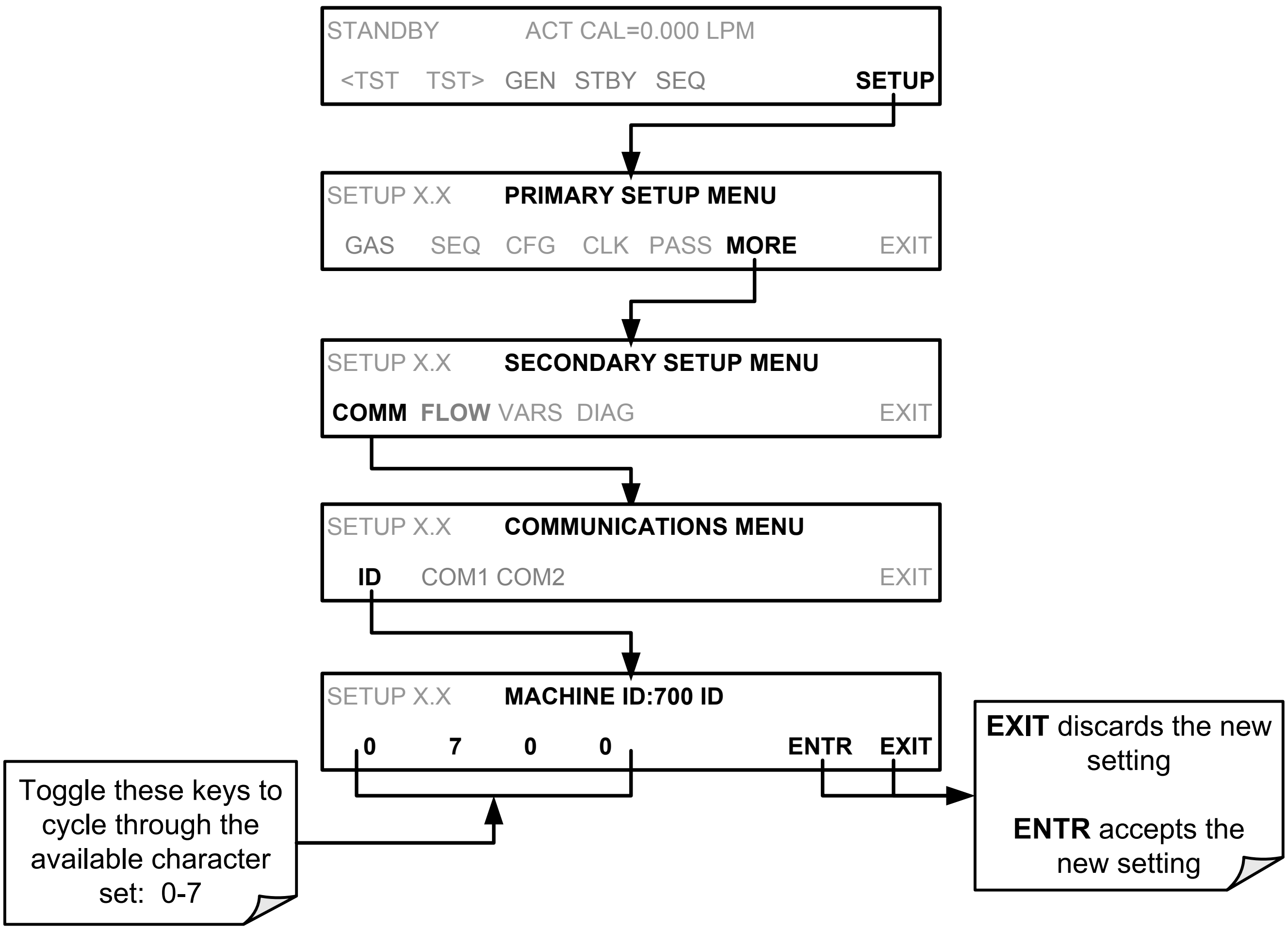
To initiate the test, press the following key sequence:



7.1.6. MACHINE ID

Each type of Teledyne API's calibrator is configured with a default ID code. The default ID code for all M700E calibrators is **700**. The ID number is only important if more than one calibrator is connected to the same communications channel such as when several calibrators are on the same Ethernet LAN (See Section 7.4); in an RS-232 multi-drop chain (See Section 7.2.1) or operating over a RS-485 network (See Section 7.3). If two calibrators of the same model type are used on one channel, the ID codes of one or both of the instruments need to be changed.

To edit the instrument's ID code, press:



The ID number is only important if more than one calibrator is connected to the same communications channel (e.g., a multi-drop setup). Different models of Teledyne API's calibrators have different default ID numbers, but if two calibrators of the same model type are used on one channel (for example, two M700E's), the ID of one instrument needs to be changed.

The ID can also be used for to identify any one of several calibrators attached to the same network but situated in different physical locations.

7.1.7. TERMINAL OPERATING MODES

The M700E can be remotely configured, calibrated or queried for stored data through the serial ports. As terminals and computers use different communication schemes, the calibrator supports two communicate modes specifically designed to interface with these two types of devices.

- **Computer mode** is used when the calibrator is connected to a computer with a dedicated interface program.

- **Interactive mode** is used with a terminal emulation programs such as HyperTerminal or a "dumb" computer terminal. The commands that are used to operate the calibrator in this mode are listed in Table 7-2.

7.1.7.1. Help Commands in Terminal Mode

Table 7-2: Terminal Mode Software Commands

COMMAND	Function
Control-T	Switches the calibrator to terminal mode (echo, edit). If mode flags 1 & 2 are OFF, the interface can be used in interactive mode with a terminal emulation program.
Control-C	Switches the calibrator to computer mode (no echo, no edit).
CR (carriage return)	A carriage return is required after each command line is typed into the terminal/computer. The command will not be sent to the calibrator to be executed until this is done. On personal computers, this is achieved by pressing the ENTER key.
BS (backspace)	Erases one character to the left of the cursor location.
ESC (escape)	Erases the entire command line.
? [ID] CR	This command prints a complete list of available commands along with the definitions of their functionality to the display device of the terminal or computer being used. The ID number of the calibrator is only necessary if multiple calibrators are on the same communications line, such as the multi-drop setup.
Control-C	Pauses the listing of commands.
Control-P	Restarts the listing of commands.

7.1.7.2. Command Syntax

Commands are not case-sensitive and all arguments within one command (i.e. ID numbers, keywords, data values, etc.) must be separated with a space character.

All Commands follow the syntax:

X [ID] COMMAND <CR>

Where

X is the command type (one letter) that defines the type of command. Allowed designators are listed in Table 7-3 and Appendix A-6.

[ID] is the machine identification number (Section 7.1.6). Example: the Command "? 700" followed by a carriage return would print the list of available commands for the revision of software currently installed in the instrument assigned ID Number 700.

COMMAND is the command designator: This string is the name of the command being issued (LIST, ABORT, NAME, EXIT, etc.). Some commands may have additional arguments that define how the command is to be executed. Press ? <CR> or refer to Appendix A-6 for a list of available command designators.

<CR> is a carriage return. All commands must be terminated by a carriage return (usually achieved by pressing the ENTER key on a computer).

Table 7-3: Teledyne API Serial I/O Command Types

COMMAND	COMMAND TYPE
C	Calibration
D	Diagnostic
L	Logon
T	Test measurement
V	Variable
W	Warning

7.1.7.3. Data Types

Data types consist of integers, hexadecimal integers, floating-point numbers, Boolean expressions and text strings.

- Integer data are used to indicate integral quantities such as a number of records, a filter length, etc. They consist of an optional plus or minus sign, followed by one or more digits. For example, *+1*, *-12*, *123* are all valid integers.

- Hexadecimal integer data are used for the same purposes as integers. They consist of the two characters "0x," followed by one or more hexadecimal digits (0-9, A-F, a-f), which is the 'C' programming language convention. No plus or minus sign is permitted. For example, *0x1*, *0x12*, *0x1234abcd* are all valid hexadecimal integers.

- Floating-point numbers are used to specify continuously variable values such as temperature set points, time intervals, warning limits, voltages, etc. They consist of an optional plus or minus sign, followed by zero or more digits, an optional decimal point and zero or more digits. (At least one digit must appear before or after the decimal point.) Scientific notation is not permitted. For example, *+1.0*, *1234.5678*, *-0.1*, *1* are all valid floating-point numbers.

- Boolean expressions are used to specify the value of variables or I/O signals that may assume only two values. They are denoted by the keywords *ON* and *OFF*.

- Text strings are used to represent data that cannot be easily represented by other data types, such as data channel names, which may contain letters and numbers. They consist of a quotation mark, followed by one or more printable characters, including spaces, letters, numbers, and symbols, and a final quotation mark. For example, *"a"*, *"1"*, *"123abc"*, and *"()[]<>"* are all valid text strings. It is not possible to include a quotation mark character within a text string.

- Some commands allow you to access variables, messages, and other items. When using these commands, you must type the entire name of the item; you cannot abbreviate any names.

7.1.7.4. Status Reporting

Reporting of status messages as an audit trail is one of the three principal uses for the RS-232 interface (the other two being the command line interface for controlling the instrument and the download of data in electronic format). You can effectively disable the reporting feature by setting the interface to quiet mode (Section 7.1.4, Table 7-1).

Status reports include warning messages, calibration and diagnostic status messages. Refer to Appendix A-3 for a list of the possible messages, and this for information on controlling the instrument through the RS-232 interface.

General Message Format

All messages from the instrument (including those in response to a command line request) are in the format:

X DDD:HH:MM [Id] MESSAGE<CRLF>

Where:

X	is a command type designator, a single character indicating the message type, as shown in the Table 7-3.
DDD:HH:MM	is the time stamp, the date and time when the message was issued. It consists of the Day-of-year (DDD) as a number from 1 to 366, the hour of the day (HH) as a number from 00 to 23, and the minute (MM) as a number from 00 to 59.
[ID]	is the calibrator ID, a number with 1 to 4 digits.
MESSAGE	is the message content that may contain warning messages, test measurements, variable values, etc.
<CRLF>	is a carriage return / line feed pair, which terminates the message.

The uniform nature of the output messages makes it easy for a host computer to parse them into an easy structure. Keep in mind that the front panel display does not give any information on the time a message was issued, hence it is useful to log such messages for trouble-shooting and reference purposes. Terminal emulation programs such as HyperTerminal can capture these messages to text files for later review.

7.1.7.5. COMM Port Password Security

In order to provide security for remote access of the M700E, a LOGON feature can be enabled to require a password before the instrument will accept commands. This is done by turning on the **SECURITY MODE** (Mode 4, Section 7.1.4). Once the **SECURITY MODE** is enabled, the following items apply.

- A password is required before the port will respond or pass on commands.
- If the port is inactive for one hour, it will automatically logoff, which can also be achieved with the LOGOFF command.
- Three unsuccessful attempts to log on with an incorrect password will cause subsequent logins to be disabled for 1 hour, even if the correct password is used.
- If not logged on, the only active command is the '?' request for the help screen.
- The following messages will be returned at logon:
    - LOGON SUCCESSFUL - Correct password given
    - LOGON FAILED - Password not given or incorrect
    - LOGOFF SUCCESSFUL - Connection terminated successfully

To log on to the M700E calibrator with **SECURITY MODE** feature enabled, type:

LOGON 940331

940331 is the default password. To change the default password, use the variable RS232_PASS issued as follows:

V RS232_PASS=NNNNNN

Where N is any numeral between 0 and 9.

7.2. REMOTE ACCESS BY MODEM

The M700E can be connected to a modem for remote access. This requires a cable between the calibrator's COMM port and the modem, typically a DB-9F to DB-25M cable (available from Teledyne API with P/N WR0000024).

Once the cable has been connected, check to ensure that:

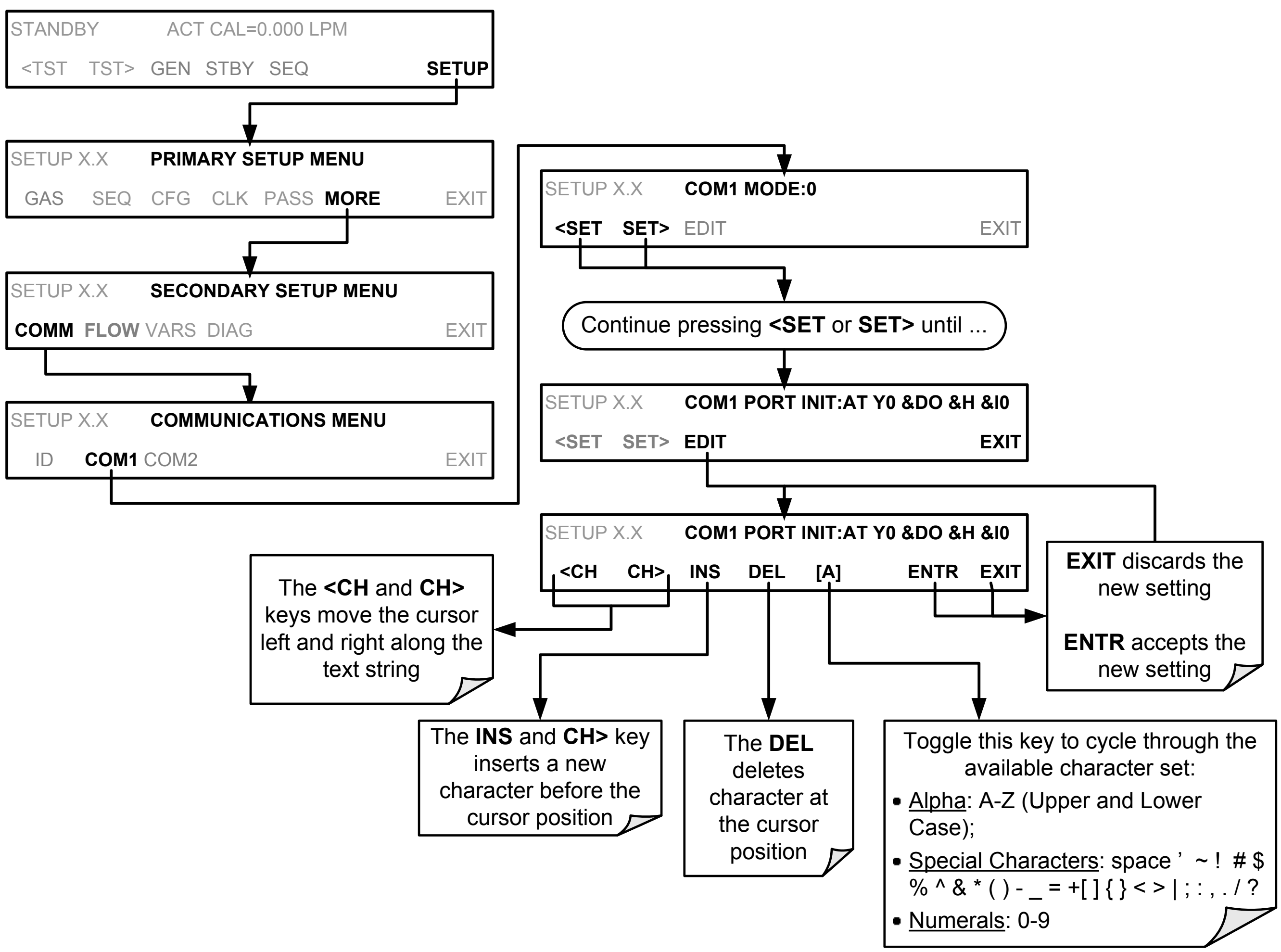
- The DTE-DCE is in the DCE position.
- The M700E COMM port is set for a baud rate that is compatible with the modem.
- The Modem is designed to operate with an 8-bit word length with one stop bit.
- The **MODEM ENABLE** communication mode is turned **ON** (Mode 64, see Section 7.1.4).

Once this is completed, the appropriate setup command line for your modem can be entered into the calibrator. The default setting for this feature is:

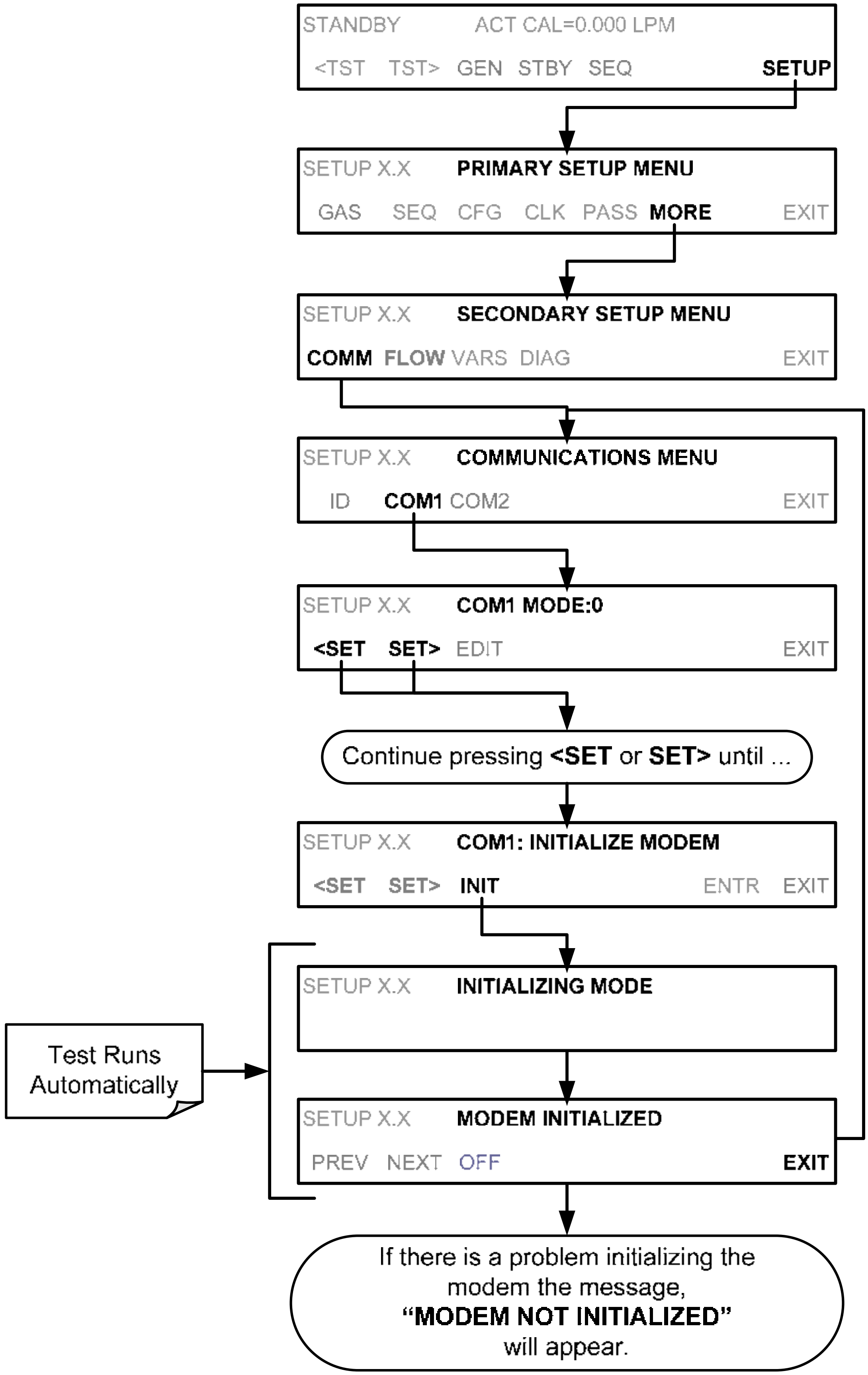
AT Y0 &D0 &H0 &I0 S0=2 &B0 &N6 &M0 E0 Q1 &W0

This string can be altered to match your modem's initialization and can be up to 100 characters long.

To change this setting, press:



To initialize the modem, press:



7.2.1. MULTI-DROP RS-232 SET UP

The RS-232 multi-drop consists of a Printed Circuit Assembly (PCA) that plugs onto the CN3, CN4 and CN5 connectors of the CPU card and the cabling to connect it to the calibrator's motherboard. This PCA includes all circuitry required to enable your calibrator for multi-drop operation. It converts the instrument's COM1 port to multi-drop configuration allowing up to eight Teledyne API's E-Series calibrators or E-Series analyzers to be connected the same I/O port of the host computer.

Because both of the DB9 connectors on the calibrator's back panel are needed to construct the multi-drop chain, COM2 is no longer available for separate RS-232 or RS-485 operation; however, with the addition of an Ethernet Option (option 63, See Section 5.6.4 and 7.4) the COM2 port is available for communication over a 10BaseT LAN.

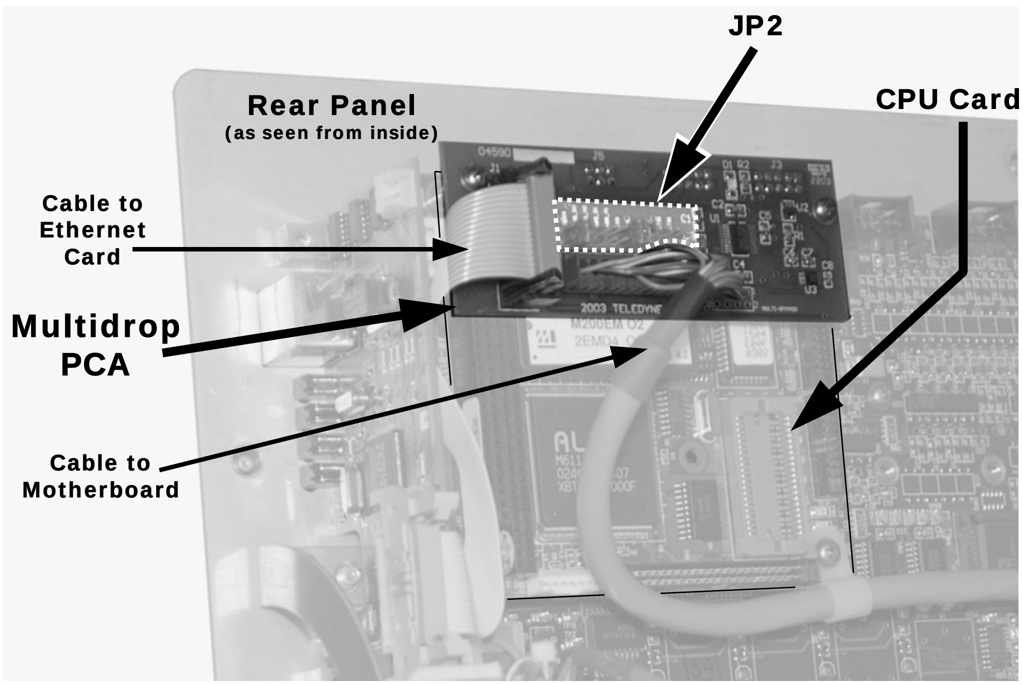


Figure 7-3: Location of JP2 on RS232-Multi-drop PCA (Option 62)

Each calibrator or analyzer in the multi-drop chain must have:

- One Teledyne API's Option 62 installed.
- One 6' straight-through, DB9 male → DB9 Female cable (Teledyne API's P/N WR0000101) is required for each calibrator.

To set up the network, for each instrument:

1. Turn the instrument on and change its MACHINE ID code to a unique 4-digit number.
2. Remove the top cover of the instrument and locate JP2 on the multi-drop PCA (7-4).
3. Ensure that the jumpers are in place; connecting pins 9 ↔ 10 and 11 ↔ 12.
4. If the instrument is to be the last instrument on the chain, ensure that a jumper is in place; connecting pins 21 ↔ 22.

5. If you are adding an instrument to the end of an already existing chain, do not forget to remove JP2, pins 21 ↔ 22 on the multi-drop PCA on the instrument that was previously the last instrument in the chain.
6. Close the instrument.
7. Using straight-through, DB9 male → DB9 Female cables interconnect the host and the calibrators as shown in Figure 7-4.

NOTE:

Teledyne API recommends setting up the first link, between the Host and the first instrument and testing it before setting up the rest of the chain.

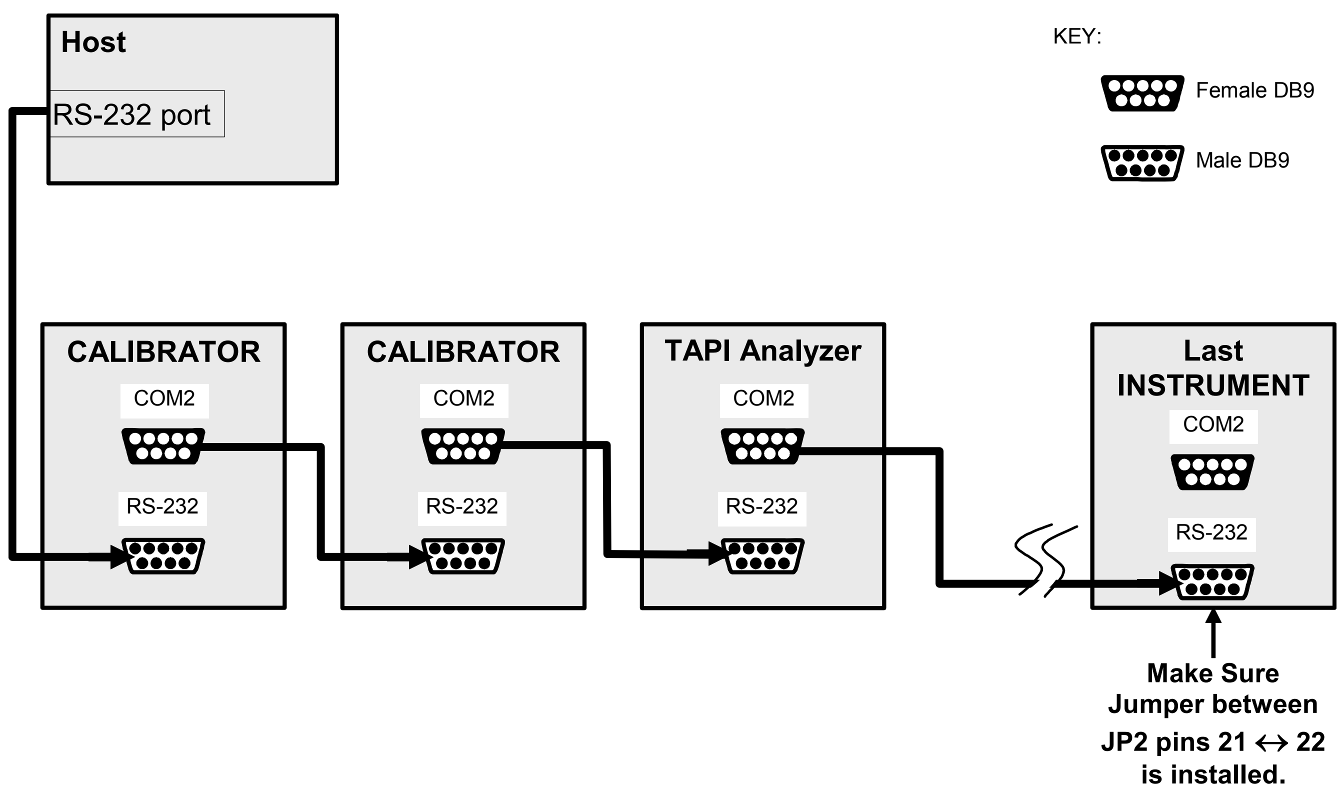


Figure 7-4: RS-232 Multi-drop PCA Host/Calibrator Interconnect Diagram

7.3. RS-485 CONFIGURATION OF COM2

As delivered from the factory, COM2 is configured for RS-232 communications. This port can be reconfigured for operation as a non-isolated, half-duplex RS-485 port capable of supporting up to 32 instruments with a maximum distance between the host and the furthest instrument being 4000 feet. If you require full duplex or isolated operation, please contact Teledyne API's Customer Service.

- To reconfigure COM2 as an RS-285 port set switch 6 of SW1 to the ON position (see Figure 7-7).
- The RS-485 port can be configured with or without a 150 Ω termination resistor. To include the resistor, install jumper at position JP3 on the CPU board (see Figure 7-7). To configure COM2 as an un-terminated RS-485 port leave JP3 open.

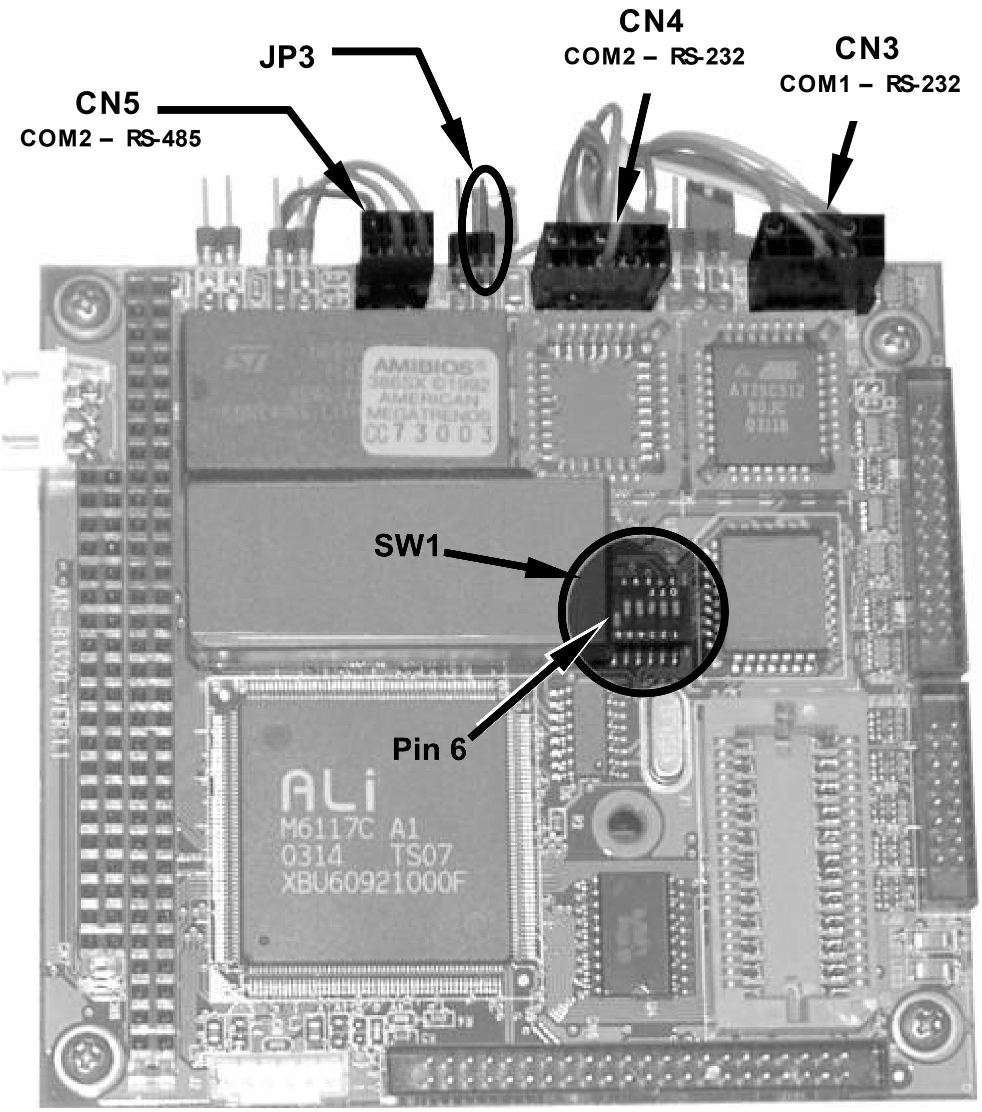


Figure 7-5: CPU Card Locations of RS-232/485 Switches, Connectors and Jumpers

When COM2 is configured for RS-485 operation the port uses the same female DB-9 connector on the back of the instrument as when COM2 is configured for RS-232 operation, however, the pin assignments are different.

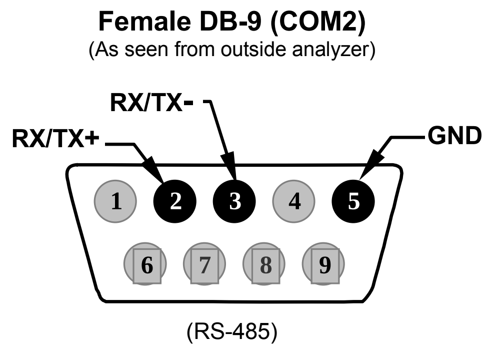


Figure 7-6: Back Panel connector Pin-Outs for COM2 in RS-485 Mode

The signal from this connector is routed from the motherboard via a wiring harness to a 6-pin connector on the CPU card, CN5.

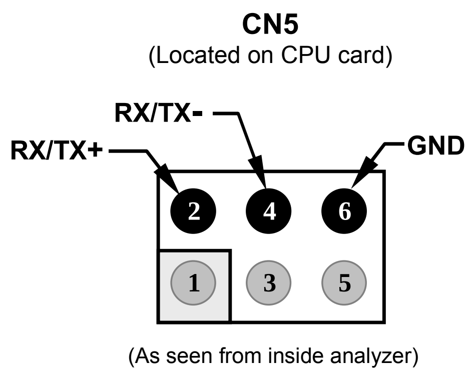


Figure 7-7: CPU Connector Pin-Outs for COM2 in RS-485 Mode

7.4. REMOTE ACCESS VIA THE ETHERNET

When equipped with the optional Ethernet interface, the calibrator can be connected to any standard 10BaseT Ethernet network via low-cost network hubs, switches or routers. The interface operates as a standard TCP/IP device on port 3000. This allows a remote computer to connect through the internet to the calibrator using APICOM, terminal emulators or other programs.

The firmware on board the Ethernet card automatically sets the communication modes and baud rate (115,200 kBaud) for the COM2 port. Once the Ethernet option is installed and activated, the COM2 submenu is replaced by a new submenu, **INET**. This submenu is used to manage and configure the Ethernet interface with your LAN or Internet Server(s).

The card has four LEDs that are visible on the rear panel of the calibrator, indicating its current operating status.

Table 7-4: Ethernet Status Indicators

LED	FUNCTION
LNK (green)	ON when connection to the LAN is valid.
ACT (yellow)	Flickers on any activity on the LAN.
TxD (green)	Flickers when the RS-232 port is transmitting data.
RxD (yellow)	Flickers when the RS-232 port is receiving data.

7.4.1. ETHERNET CARD COM2 COMMUNICATION MODES AND BAUD RATE

The firmware on board the Ethernet card automatically sets the communication modes for the COM2 port. The baud rate is also automatically set at 115,200 kBaud.

7.4.2. CONFIGURING THE ETHERNET INTERFACE OPTION USING DHCP

The Ethernet option for you M700E uses Dynamic Host Configuration Protocol (DHCP) to configure its interface with your LAN automatically. This requires your network servers also be running DHCP. The calibrator will do this the first time you turn the instrument on after it has been physically connected to your network. Once the instrument is connected and turned on, it will appear as an active device on your network without any extra set up steps or lengthy procedures.

NOTE

It is a good idea to check the INET settings the first time you power up your calibrator after it has been physically connected to the LAN/Internet to ensure that the DHCP has successfully downloaded the appropriate information from you network server(s).

The Ethernet configuration properties are viewable via the calibrator's front panel.

Table 7-5: LAN/Internet Configuration Properties

PROPERTY	DEFAULT STATE		DESCRIPTION
DHCP STATUS	On	Editable	This displays whether the DHCP is turned ON or OFF.
INSTRUMENT IP ADDRESS	Configured by DHCP	**EDIT** key disabled when DHCP is **ON**	This string of four packets of 1 to 3 numbers each (e.g. 192.168.76.55.) is the address of the calibrator itself.
GATEWAY IP ADDRESS	Configured by DHCP	**EDIT** key disabled when DHCP is **ON**	A string of numbers very similar to the Instrument IP address (e.g. 192.168.76.1.) that is the address of the computer used by your LAN to access the Internet.
SUBNET MASK	Configured by DHCP	**EDIT** key disabled when DHCP is **ON**	Also, a string of four packets of 1 to 3 numbers each (e.g. 255.255.252.0) that defines that identifies the LAN to which the device is connected. All addressable devices and computers on a LAN must have the same subnet mask. Any transmissions sent devices with different subnet masks are assumed to be outside of the LAN and are routed through a different gateway computer onto the Internet.
TCP PORT[1]	**3000**	Editable, but **DO NOT CHANGE**	This number defines the terminal control port by which the instrument is addressed by terminal emulation software, such as Internet or Teledyne API's APICOM.
HOST NAME	**M700E**	Editable	The name by which your calibrator will appear when addressed from other computers on the LAN or via the Internet. While the default setting for all Teledyne API's M700E calibrators is "M700E", the host name may be changed to fit customer needs.

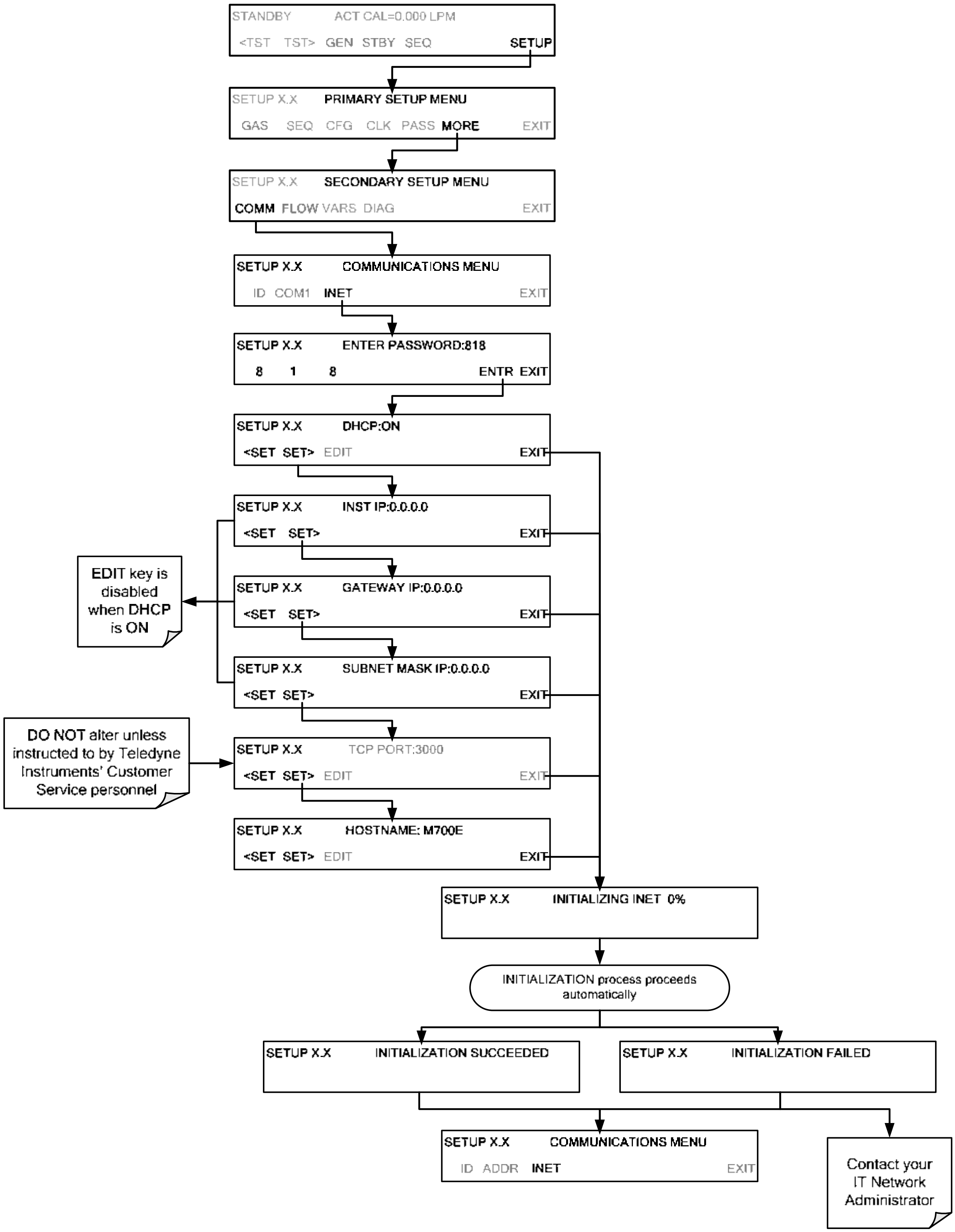
[1] Do not change the setting for this property unless instructed to by Teledyne API's Customer Service personnel.

NOTE

If the gateway IP, instrument IP and the subnet mask are all zeroes (e.g. "0.0.0.0"), the DCHP was not successful in which case you may have to configure the calibrator's Ethernet properties manually.

See your network administrator.

To view the above properties listed in Table 7-5, press:



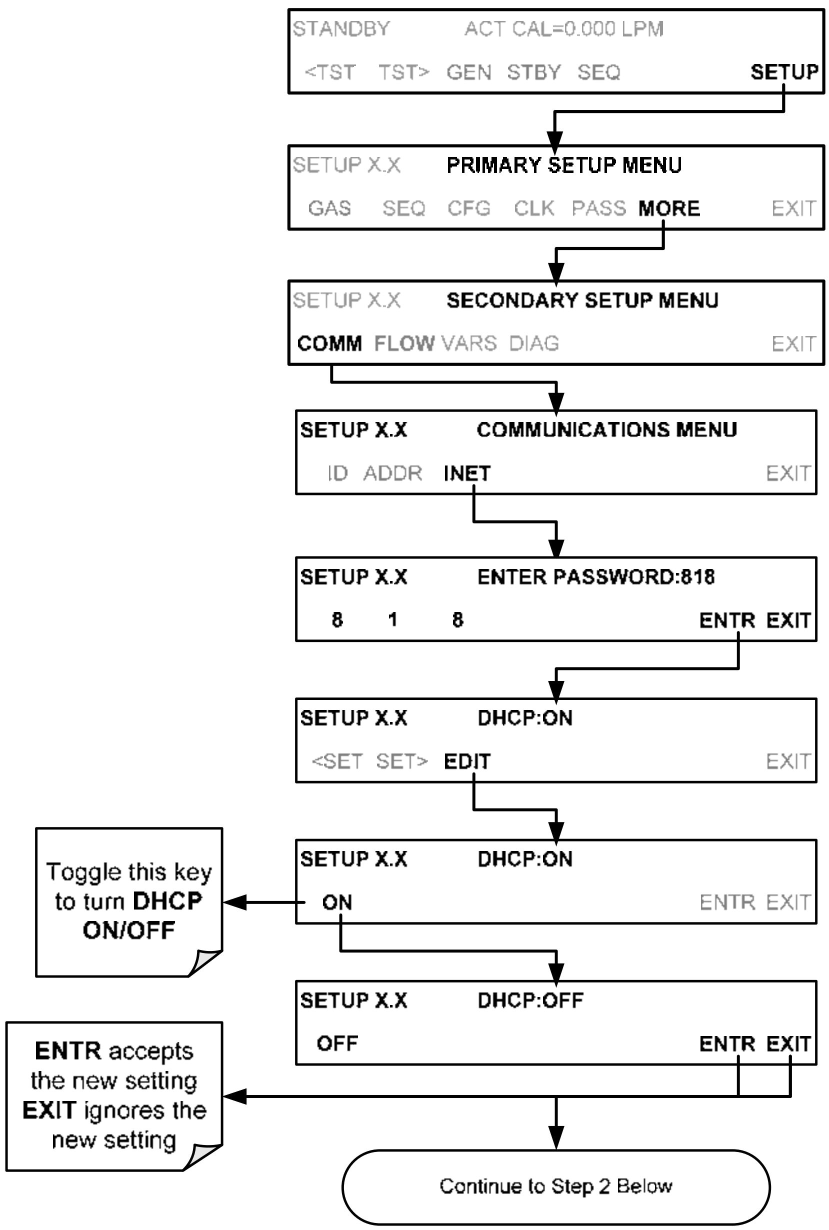
7.4.2.1. Manually Configuring the Network IP Addresses

There are several circumstances when you may need to configure the interface settings of the calibrator's Ethernet card manually. The **INET** sub-menu may also be used to edit the Ethernet card's configuration properties.

- Your LAN is not running a DHCP software package,
- The DHCP software is unable to initialize the calibrator's interface;
- You wish to program the interface with a specific set of IP addresses that may not be the ones automatically chosen by DHCP.

Editing the Ethernet Interface properties is a two-step process.

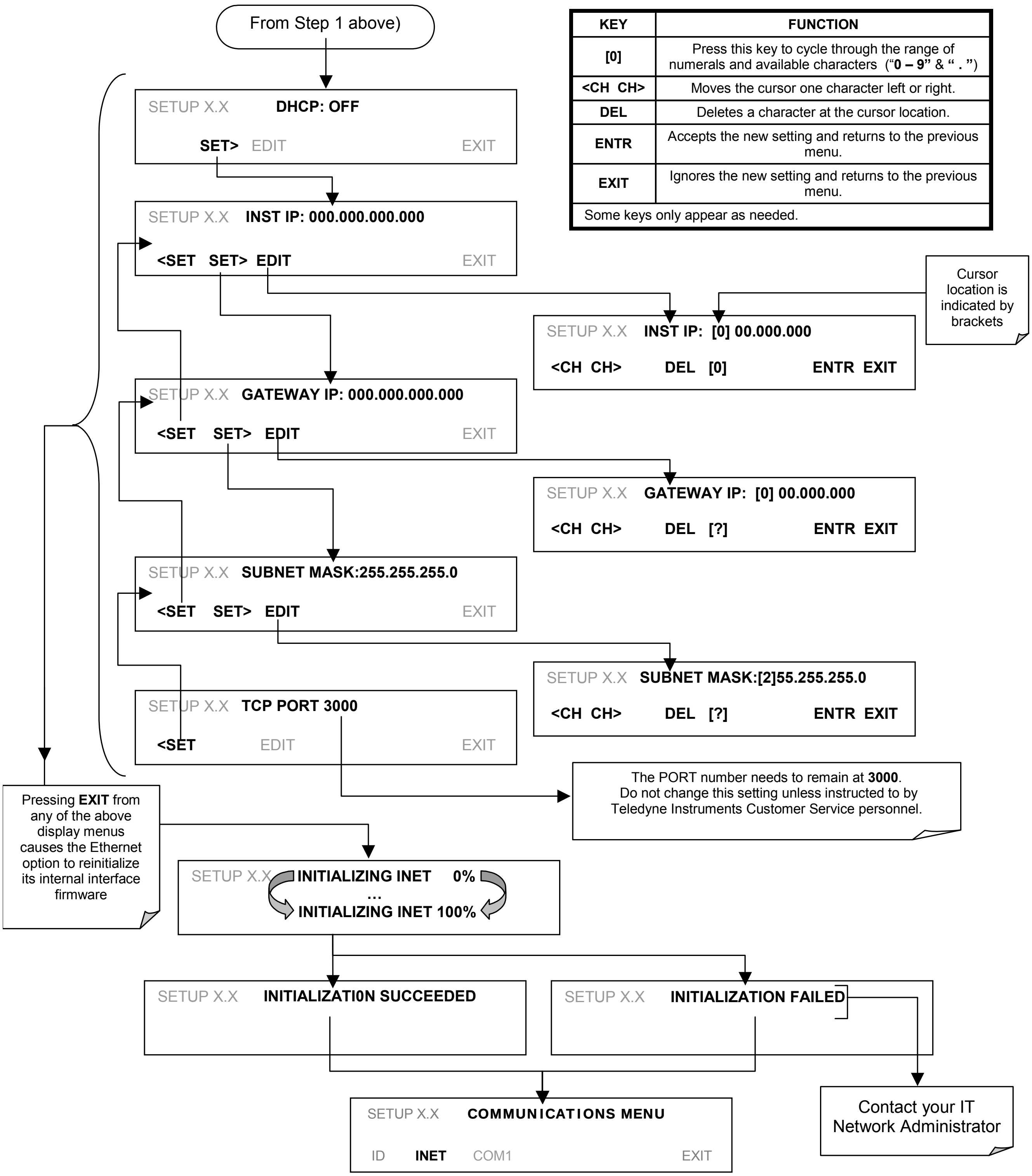
STEP 1: Turn **DHCP OFF**. While DHCP is turned **ON**, the ability to set the **INSTRUMENT IP**, **GATEWAY IP** and **SUBNET MASK** manually is disabled.



STEP 2: Configure the **INSTRUMENT IP**, **GATEWAY IP** and **SUBNET MASK** addresses by pressing:

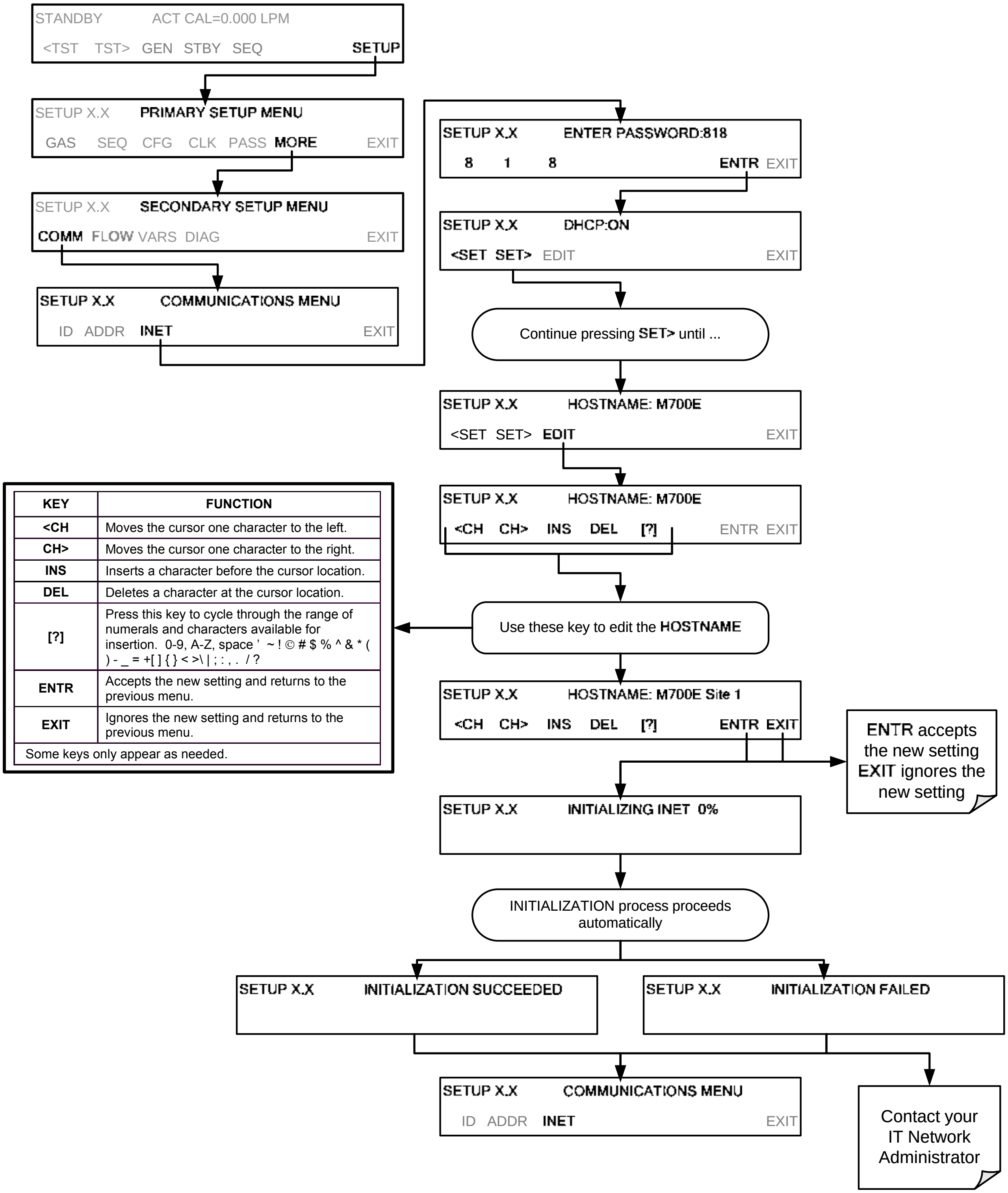
Internet Configuration Keypad Functions

KEY	FUNCTION
[0]	Press this key to cycle through the range of numerals and available characters (“**0 – 9**” & “ **.** ”)
<CH CH>	Moves the cursor one character left or right.
DEL	Deletes a character at the cursor location.
ENTR	Accepts the new setting and returns to the previous menu.
EXIT	Ignores the new setting and returns to the previous menu.
Some keys only appear as needed.	



7.4.3. CHANGING THE CALIBRATOR'S HOSTNAME

The **HOSTNAME** is the name by which the calibrator appears on your network. The default name for all Teledyne API's M700E calibrators is **M700E**. To change this name (particularly if you have more than one M700E calibrator on your network), press.



KEY	FUNCTION
<CH	Moves the cursor one character to the left.
CH>	Moves the cursor one character to the right.
INS	Inserts a character before the cursor location.
DEL	Deletes a character at the cursor location.
[?]	Press this key to cycle through the range of numerals and characters available for insertion. 0-9, A-Z, space ' ~ ! © # $ % ^ & * ( ) - _ = +[ ] { } < >\ | ; : , . / ?
ENTR	Accepts the new setting and returns to the previous menu.
EXIT	Ignores the new setting and returns to the previous menu.
Some keys only appear as needed.	

7.5. APICOM REMOTE CONTROL PROGRAM

APICOM is an easy-to-use, yet powerful interface program that allows the user to access and control any of Teledyne API's main line of ambient and stack-gas instruments from a remote connection through direct cable, modem or Ethernet. Running APICOM, a user can:

- Establish a link from a remote location to the M700E through direct cable connection via RS-232 modem or Ethernet.
- View the instrument's front panel and remotely access all functions that could be accessed when standing in front of the instrument.
- Remotely edit system parameters and set points.
- Download, view, graph and save data for predictive diagnostics or data analysis.
- Check on system parameters for trouble-shooting and quality control.

APICOM is very helpful for initial setup, data analysis, maintenance and trouble-shooting. Figure 7-8 shows an example of APICOM's main interface, which emulates the look and functionality of the instruments actual front panel.

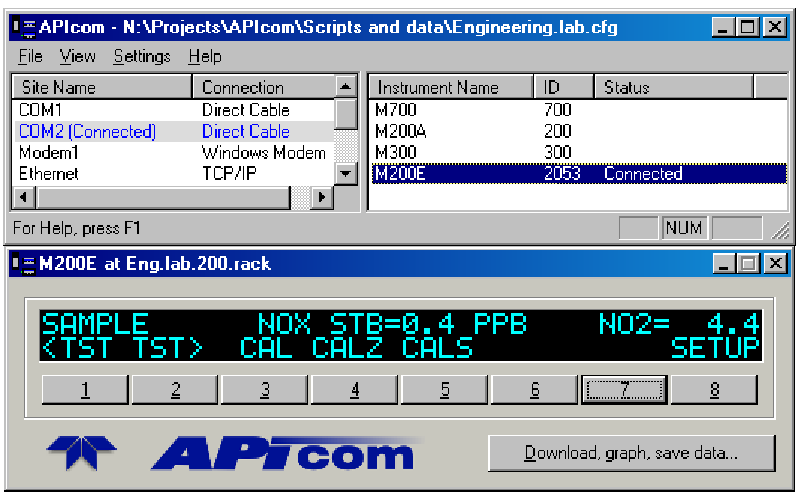


Figure 7-8: APICOM Remote Control Program Interface

NOTE

APICOM is included free of cost with the calibrator and the latest versions can also be downloaded for free at http://www.teledyne-api.com/software/apicom/.

The M700E calibrator is fully supported by APICOM revision 3.9.4 and later.

Instruments with the LEADS support option must run APICOM revision 4.0 and later.

USER NOTES:

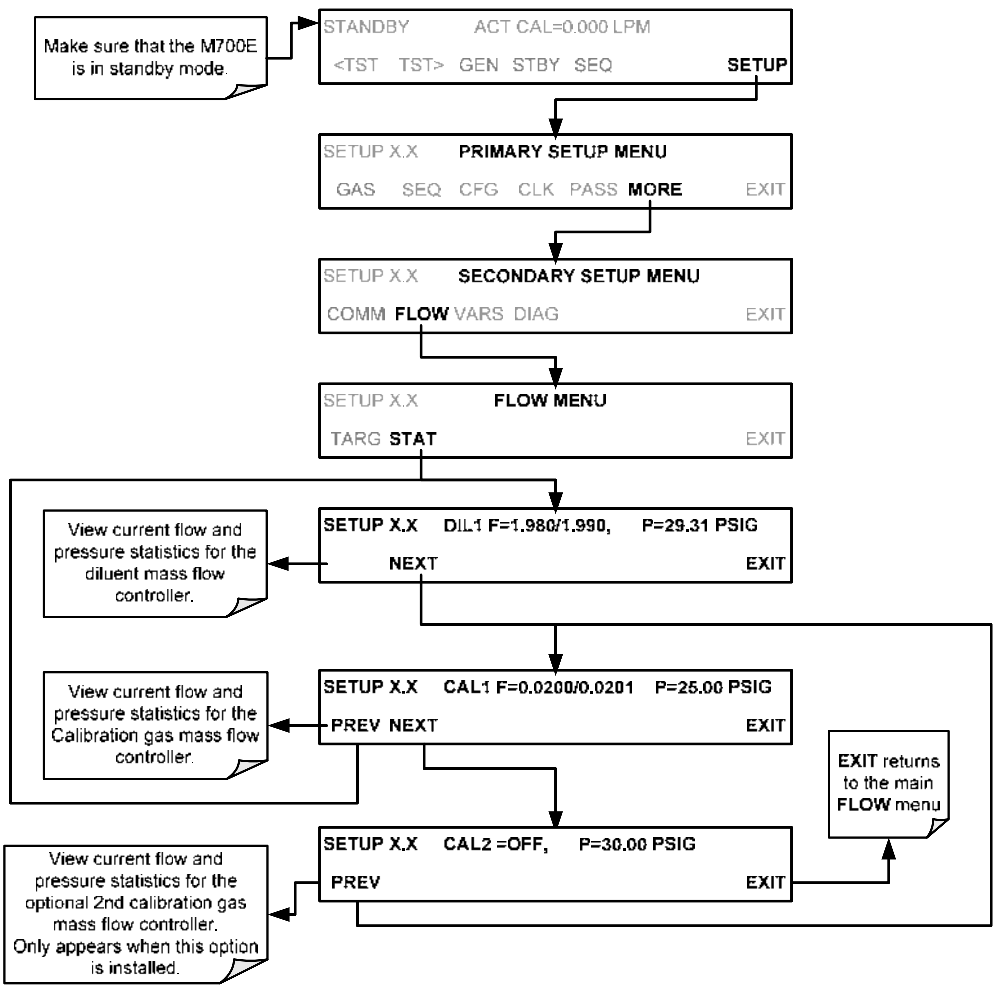
8. M700E CALIBRATION AND VERIFICATION

Basic electronic calibration of the M700E Dynamic Dilution Calibrator is performed at the factory. Normally there is no need to perform this factory calibration in the field however, the performance of several of the instrument's key subsystems should be verified periodically and if necessary adjusted. These subsystems are:

- Mass Flow Controllers: The accuracy of the mass flow controller outputs is intrinsic to achieving the correct calibration mixture concentrations, therefore the accuracy of their output should be checked and if necessary adjusted every 6 months (see Sections 8.1 and 8.2).
- O_3 Photometer: If your M700E is equipped with the optional O_3 photometer its performance should be periodically verified against and external transfer standard (see Section 8.3).
- O_3 Generator: If your M700E is equipped with the optional O_3 generator, it should be periodically calibrated (see Section 8.4).

8.1. VIEWING THE PERFORMANCE STATISTICS FOR THE M700E'S MFC'S

It is possible to view the target flow rate, actual flow rate and actual gas pressure for each MFC via the **FLOW** submenu in the M700E calibrator (in real time). To access this information, press:



In the displays associated with the **FLOW → STAT** submenu:

- The numbers after "F=" are the flow.
  - The first number is the target flow.
  - The second is the actual flow.
- The number after "P=" is pressure in PSIG.
- If an MFC is off, its flows are displayed as OFF.

8.2. CALIBRATING THE OUTPUT OF THE M700E'S MFC'S

A table exists in the memory of the M700E's for each MFC that sets the output of the MFC at each of 20 equally spaced control points along its entire performance range. This table may be accesses via the **DIAG → MFC CONFIGURATION** submenu (see Section 8.2.2).

For each calibration point, the following is displayed:

- The drive voltage in 20 equal, incremental steps from 0 mVDC to 5000 mVDC;
- The expected flow rate corresponding to each drive voltage point (each equal to1/20th of the full scale for the selected mass flow controller).

This table can also be used to calibrate the output of the MFC's by adjusting either the control voltage of a point or its associated flow output value (see Section 8.2.2).

Table 8-1: Examples of MFC Calibration Points

CAL POINT	DRIVE VOLTAGE	MFC FULL SCALE			
		1.0 LPM	3.0 LPM	5.0 LPM	10.0 LPM
		MFC TARGET OUTPUT			
0	000 mV	0.000	0.000	0.000	0.000
1	250 mV	0.050	0.150	0.250	0.500
2	500 mV	0.100	0.300	0.500	1.000
3	750 mV	0.150	0.450	0.750	1.500
4	1000 mV	0.200	0.600	1.000	2.000
5	1250 mV	0.250	0.750	1.250	2.500
6	1500 mV	0.300	0.900	1.500	3.000
7	1750 mV	0.350	1.050	1.750	3.500
8	2000 mV	0.400	1.200	2.000	4.000
9	2250 mV	0.450	1.350	2.250	4.500
10	2500 mV	0.500	1.500	2.500	5.000
11	2750 mV	0.550	1.650	2.750	5.500
12	3000 mV	0.600	1.800	3.000	6.000
13	3250 mV	0.650	1.950	3.250	6.500
14	3500 mV	0.700	2.100	3.500	7.000
15	3150 mV	0.750	2.250	3.750	7.500
16	4000 mV	0.800	2.400	4.000	8.000
17	4250 mV	0.850	2.550	4.250	8.500
18	4500 mV	0.900	2.700	4.500	9.000
19	4750 mV	0.950	2.850	4.750	9.500
20	5000 mV	1.000	3.000	5.000	10.000

8.2.1. SETUP FOR VERIFICATION AND CALIBRATION OF THE M700E'S MFC'S

NOTE

A separate flow meter is required for the procedure.

1. Turn off the M700E Dynamic Dilution Calibrator.
2. Open the front panel to the M700E calibrator. This is the easiest access to the MFC output ports.
   - A locking screw located at the top center of the front panel (See Figure 3-1) must be removed before the panel can be opened.
3. Attach the flow meter directly to the output port of the MFC to be checked/tested.

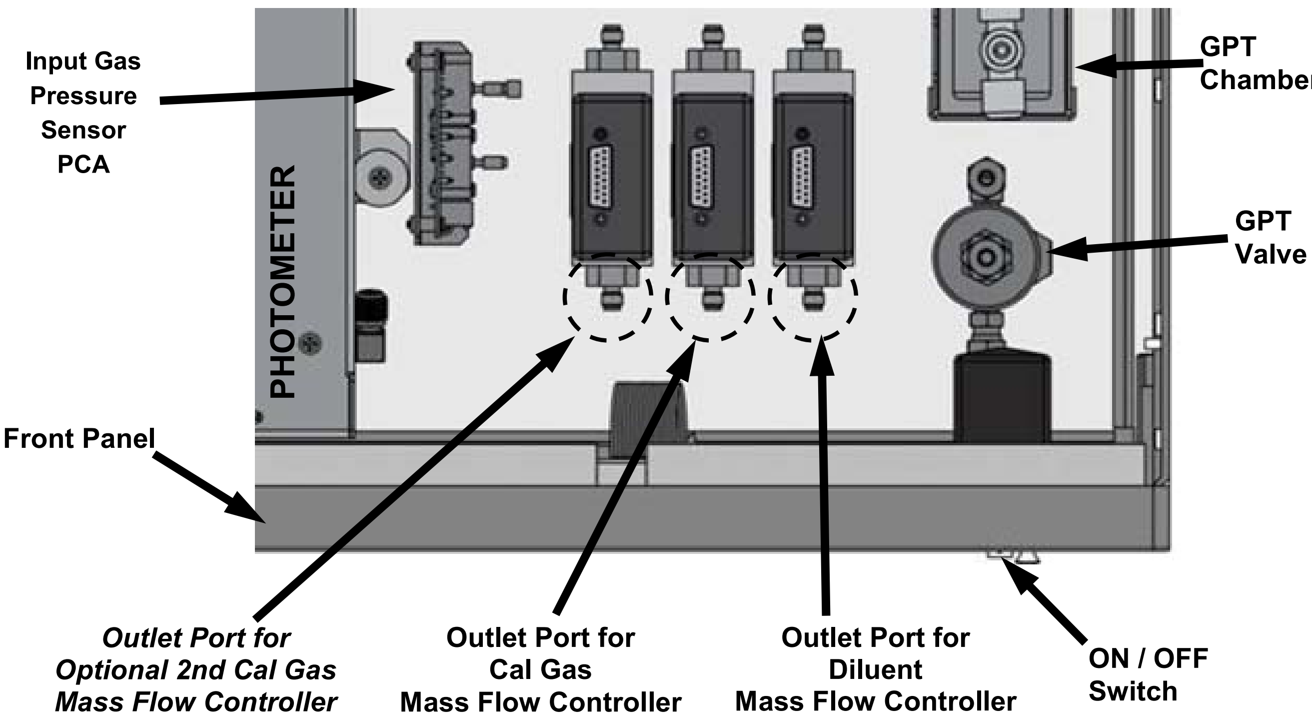
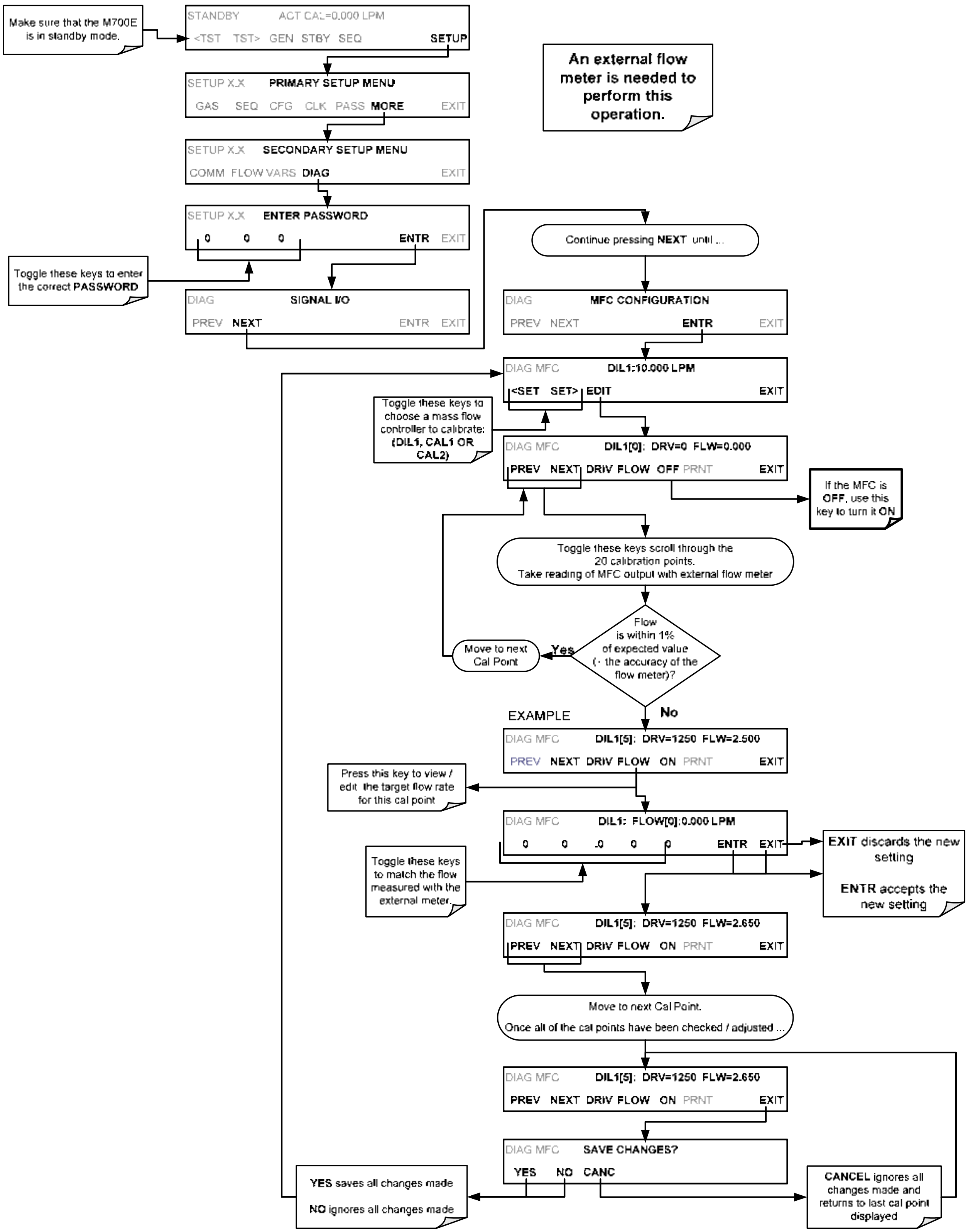


Figure 8-1: Location of MFC Outlet Ports

4. Turn the M700E Dynamic Dilution Calibrator ON.

8.2.2. VERIFYING AND CALIBRATING THE M700E'S MFC'S

Once the external flow meter is connected to the output of the MFC being verified/calibrated, perform the following steps:



8.3. VERIFYING AND CALIBRATING THE M700E'S OPTIONAL O_3 PHOTOMETER

For calibrators equipped with the O_3 photometer, the accuracy of calibration mixtures involving O_3 produced by the M700E depends entirely on the accuracy of the photometer, therefore it is very important that the photometer is operating properly and accurately. Setup for Verifying O_3 Photometer Performance is shown in Section 8.3.1.

8.3.1. SETUP FOR VERIFYING O_3 PHOTOMETER PERFORMANCE

NOTE

This operation requires an external reference photometer.

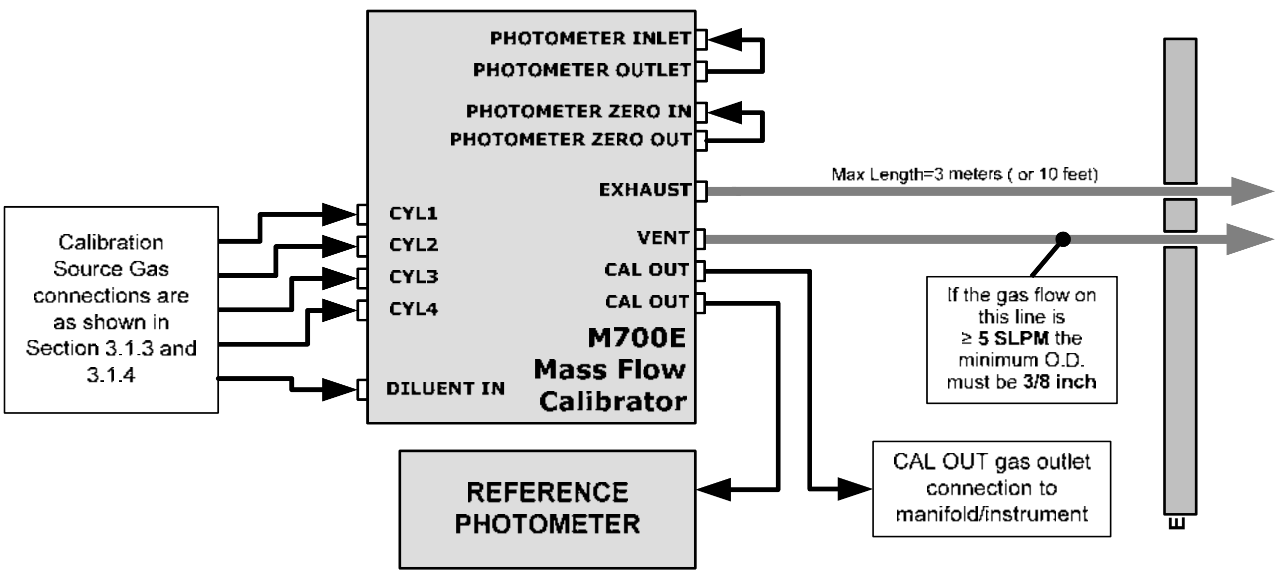
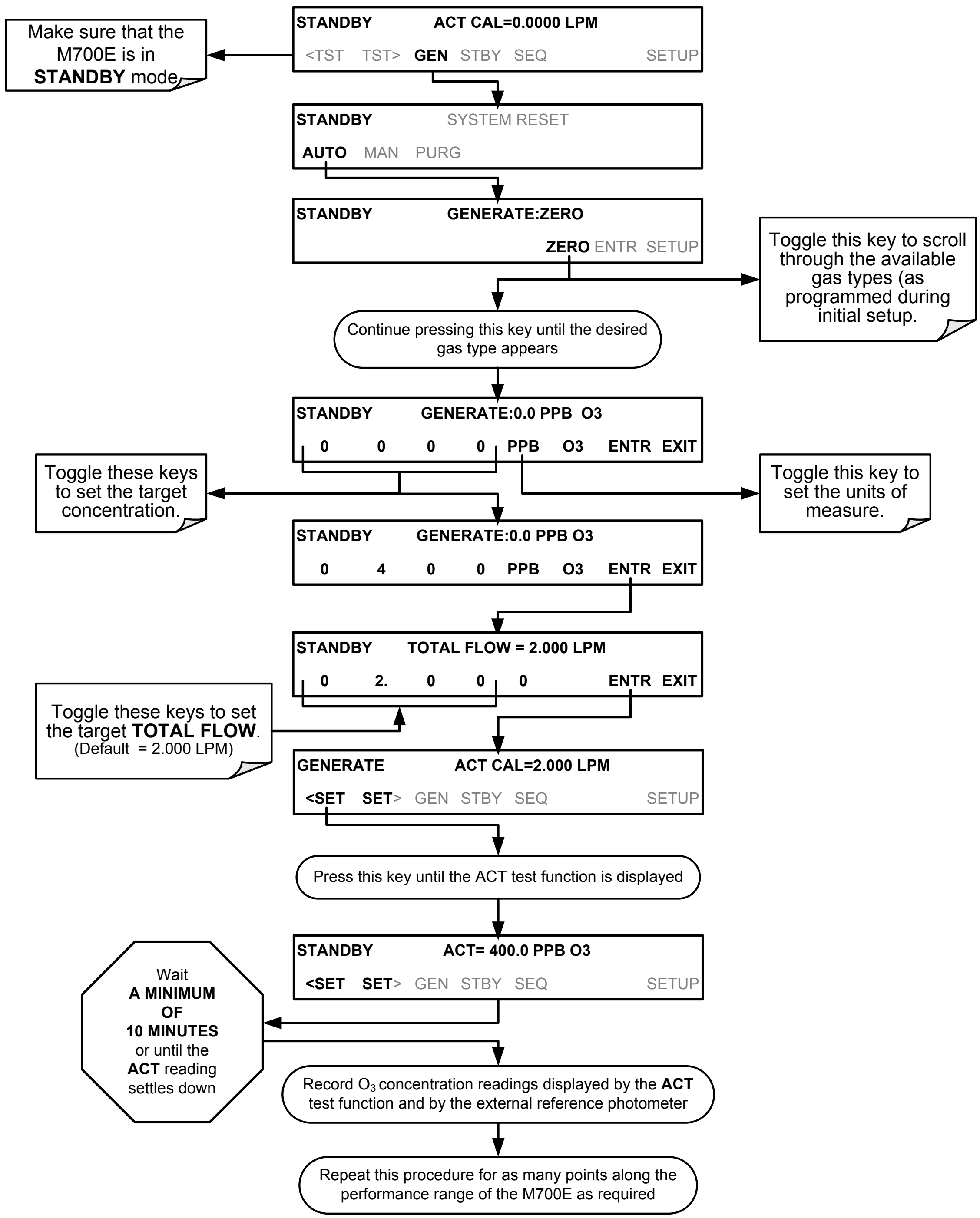


Figure 8-2: Set up for Verifying Optional O_3 Photometer

8.3.2. VERIFYING O_3 PHOTOMETER PERFORMANCE

To verify the performance of the M700E's optional internal photometer perform the following steps:



NOTE

The readings recorded from the M700E's ACT test function and the reference photometer should be within 1% of each other.

8.3.3. SETUP FOR CALIBRATION OF THE O_3 PHOTOMETER

NOTE

This procedure requires external sources for zero air and O_3 as an external reference photometer.

Calibrating the M700E calibrator's optional internal photometer requires a different set up than that used during the normal operation of the calibrator. There are two ways to make the connections between these instruments and the M700E calibrator.

8.3.3.1. Setup Using Direct Connections

Figure 8-3 shows the external zero air and O_3 sources as well as the reference photometer connected directly to the fixtures on the back of the M700E Calibrator.

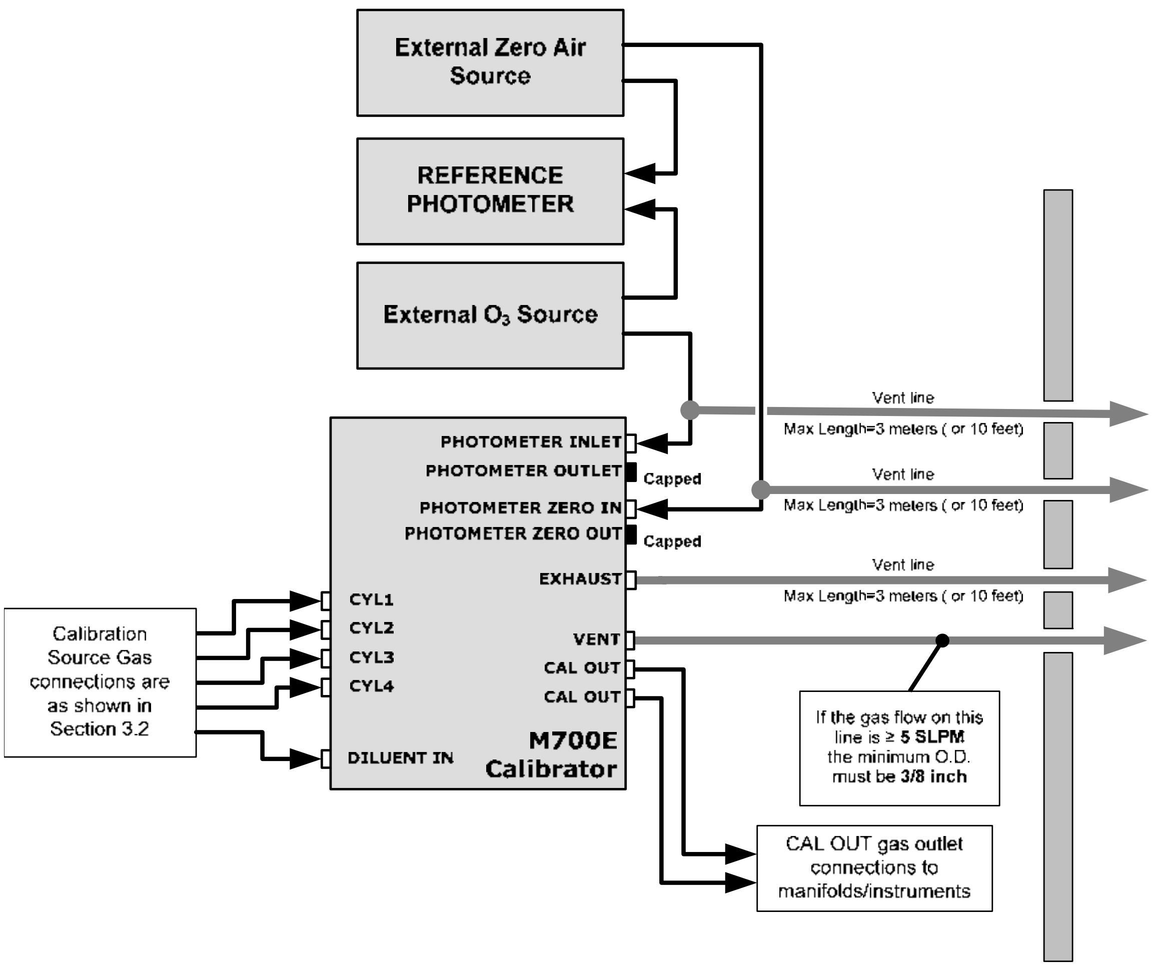


Figure 8-3: External Photometer Validation Setup – Direct Connections

NOTE

A Minimum of 1.1 LPM is required for the external zero air source.

8.3.3.2. Setup Using a Calibration Manifold

Figure 8-4 shows the external zero air and O_3 sources as well as the reference photometer connected to the M700E Calibrator via calibration manifolds for both zero air and O_3.

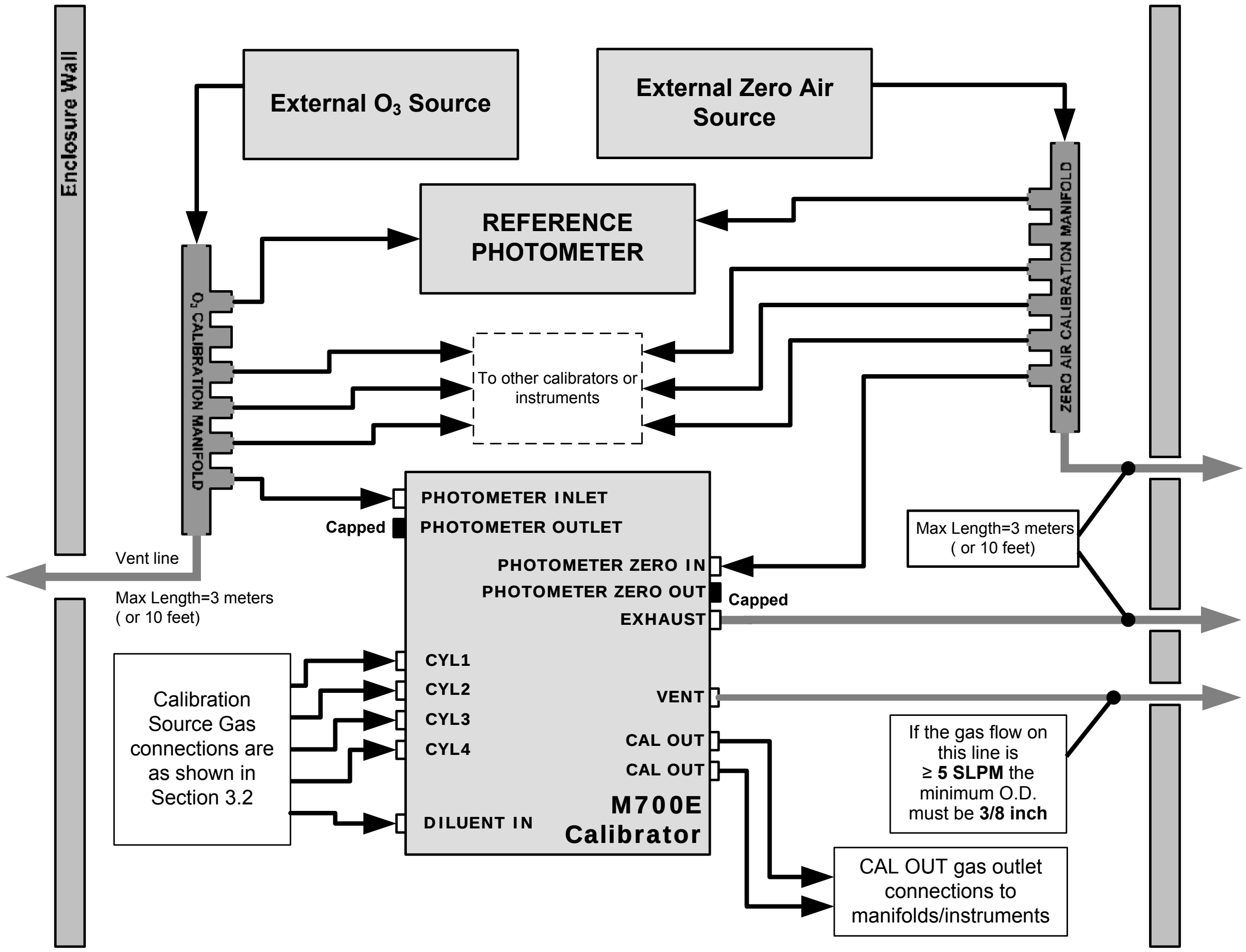


Figure 8-4: External Photometer Validation Setup with Calibration Manifolds

NOTE

The manifolds as shown in the above drawing are oriented to simplify the drawing.

The actual orientation in your setup is with the ports facing upward. All unused ports should be capped.

A Minimum of 1.1 LPM is required for the external zero air source.

8.3.3.3. Calibration Manifold Exhaust/Vent Line

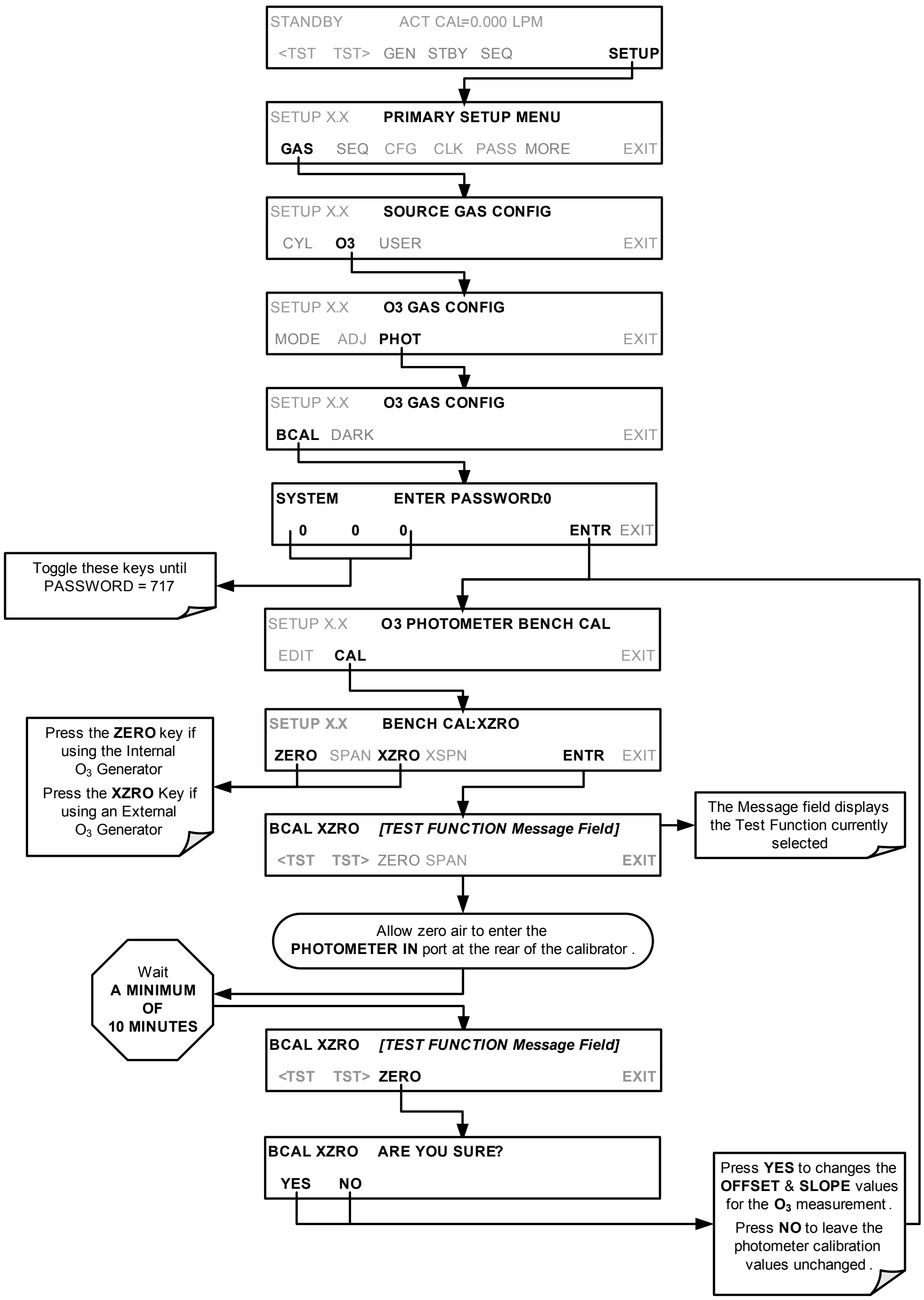
The manifold's excess gas should be vented to a suitable vent outside of the room. The internal diameter of this vent should be large enough to avoid any appreciable pressure drop, and it must be located sufficiently downstream of the output ports to ensure that no ambient air enters the manifold due to eddy currents or back diffusion.

8.3.4. PERFORMING AN EXTERNAL CALIBRATION OF THE O_3 PHOTOMETER

The following procedure sets values held in the calibrator's memory for zero point **OFFSET** and **SLOPE.**

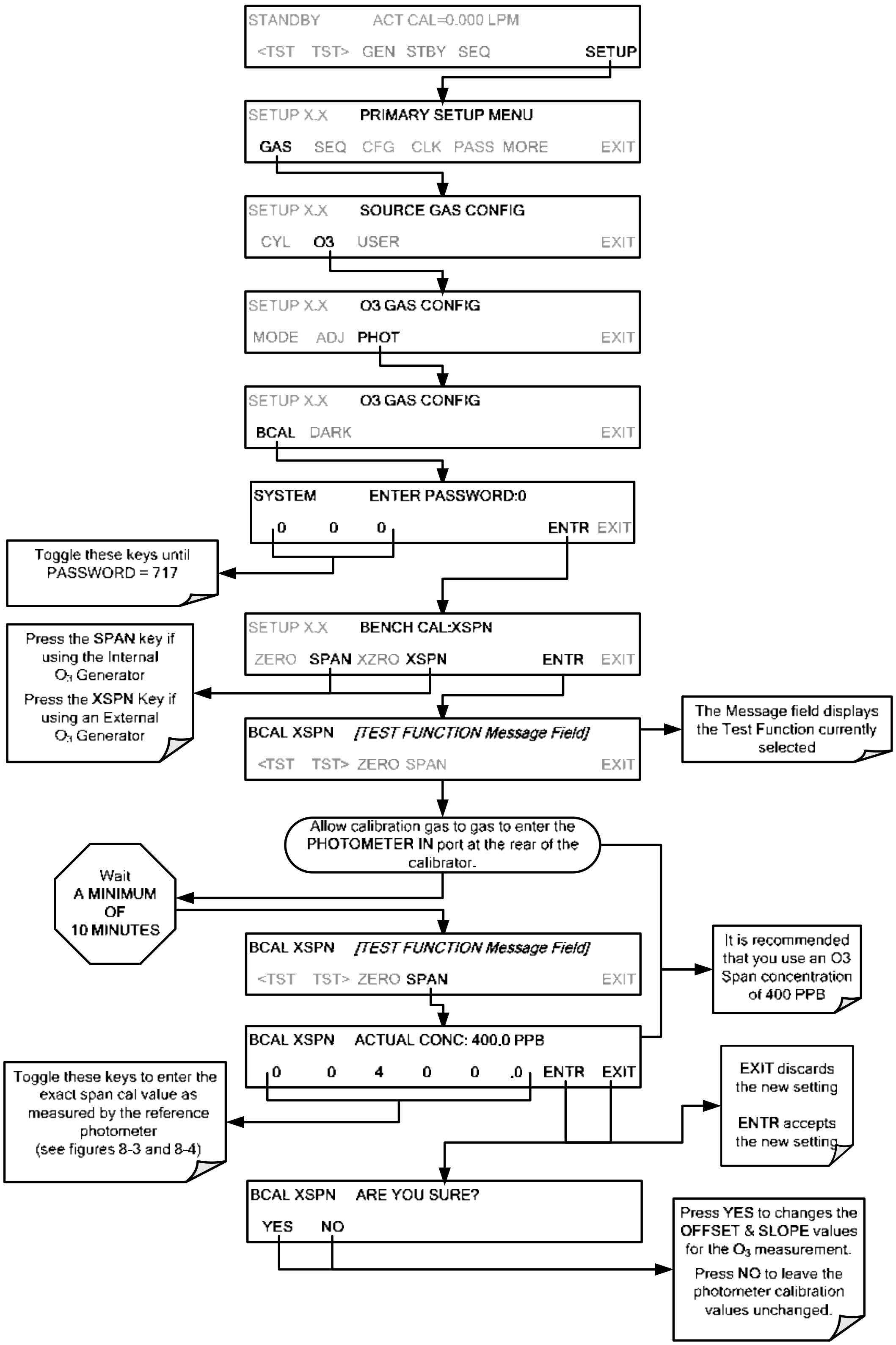
8.3.4.1. Photometer Zero Calibration

To set the zero point offset for the M700E Dynamic Dilution Calibrator's photometer, press:



8.3.4.2. Photometer Span Calibration

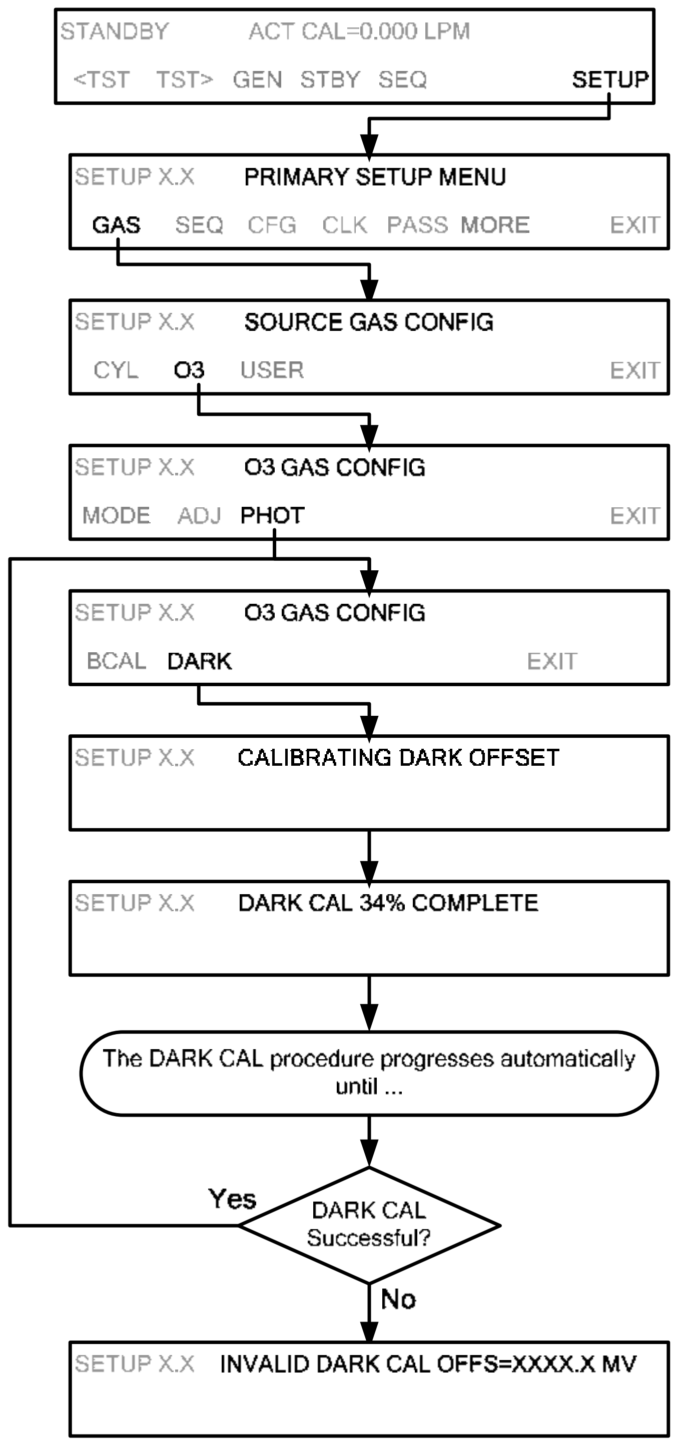
To set the response SLOPE for the M700E Dynamic Dilution Calibrator's photometer, press:



8.3.5. O_3 PHOTOMETER DARK CALIBRATION

The Dark Calibration Test turns off the Photometer UV Lamp and records any offset signal level of the UV Detector-Preamp-Voltage to Frequency Converter circuitry. This allows the instrument to compensate for any voltage levels inherent in the Photometer detection circuit that might affect the output of the detector circuitry and therefore the calculation of O_3 concentration.

To activate the Dark Calibration feature:



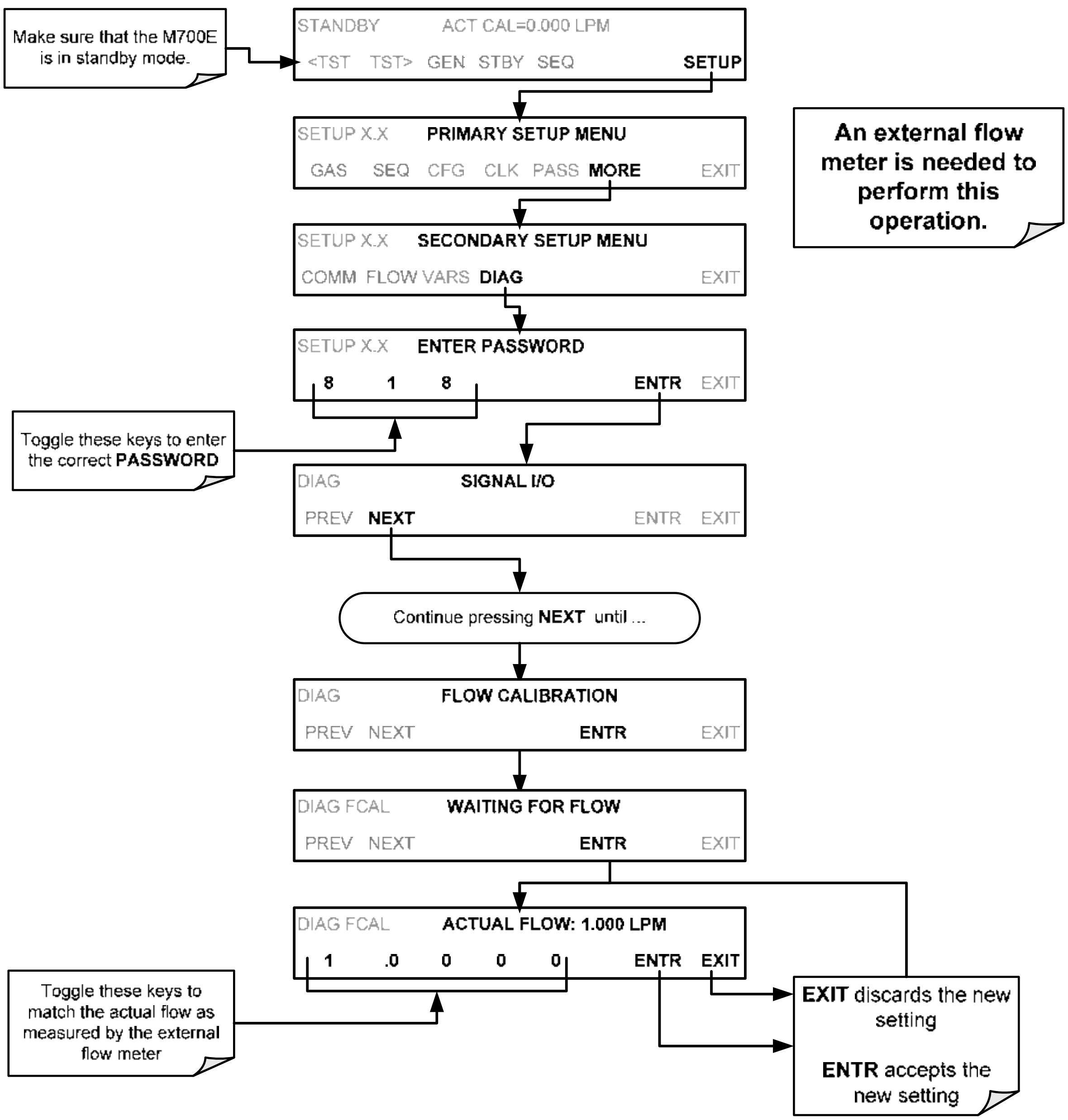
8.3.6. O_3 PHOTOMETER GAS FLOW CALIBRATION

NOTE

A separate flow meter is required for the procedure.

To calibrate the flow of gas through the M700E calibrator's optional photometer bench.

1. Turn OFF the M700E Dynamic Dilution Calibrator.
2. Attach the flow meter directly to the EXHAUST port of the M700E calibrator.
3. Turn the M700E Dynamic Dilution Calibrator ON.
4. Perform the following steps:



8.4. CALIBRATING THE O_3 GENERATOR

8.4.1. SETUP FOR VERIFICATION AND CALIBRATION THE O_3 GENERATOR

> **NOTE**
>
> **An external reference photometer is required for the procedure.**

8.4.1.1. Setup Using Direct Connections

Figure 8-5 shows the reference photometer connected directly to the fixtures on the back of the M700E Calibrator.

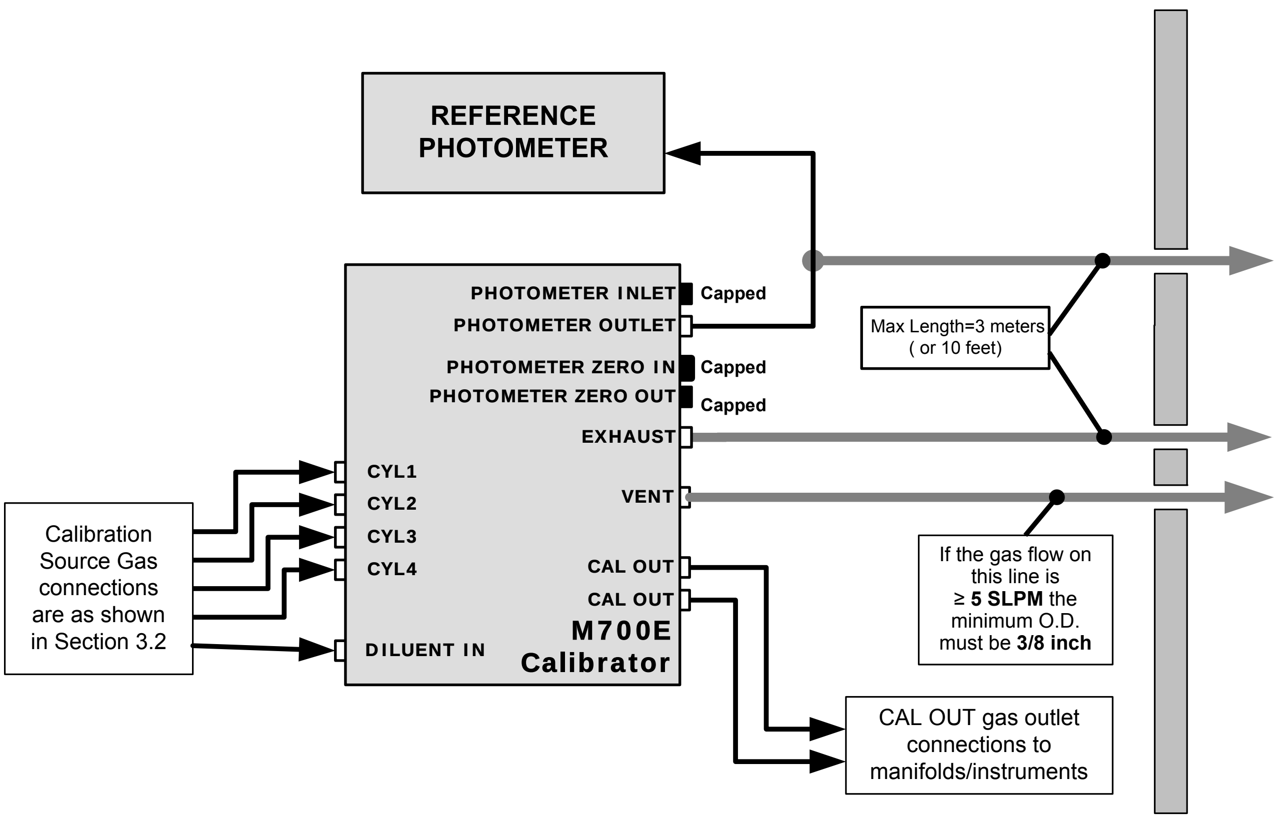
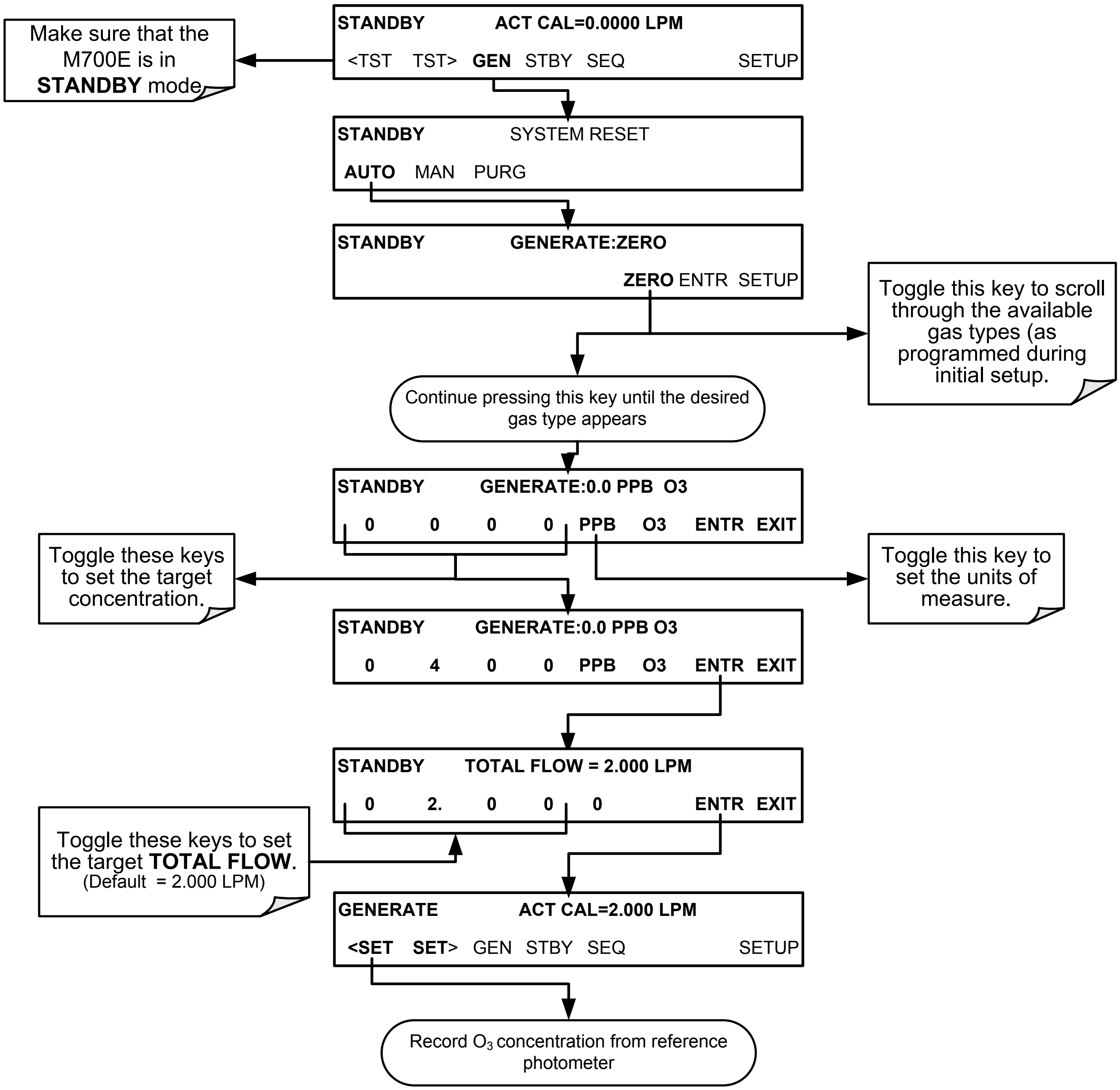


Figure 8-5: O_3 Generator Calibration Setup – Direct Connections

8.4.2. VERIFYING O_3 GENERATOR PERFORMANCE

Using the set up shown in Figure 8-4, perform the following steps:



NOTE

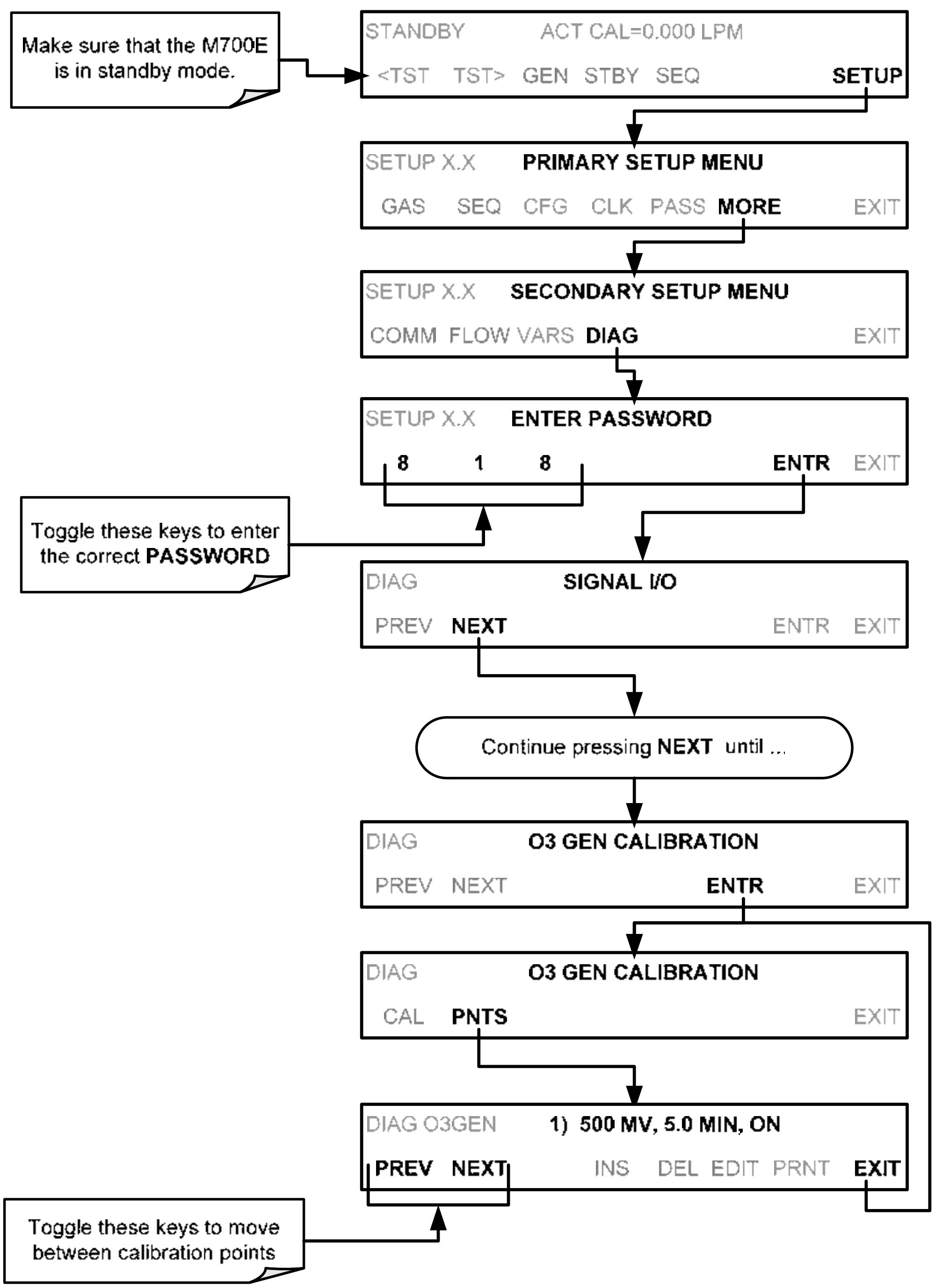
The readings recorded from the M700E's ACT test function and the reference photometer should be within 1% of each other.

8.4.3. O_3 GENERATOR CALIBRATION PROCEDURE

The M700E calibrator's software includes a routine for automatically calibration the O_3 generator. A table of drive voltages stored in the M700E's memory is the basis for this calibration. For each point included in the table used by the M700E to calibrate the optional O_3 generator the user can set a drive voltage and a dwell time for that point. Each point can also be individually turned OFF or ON.

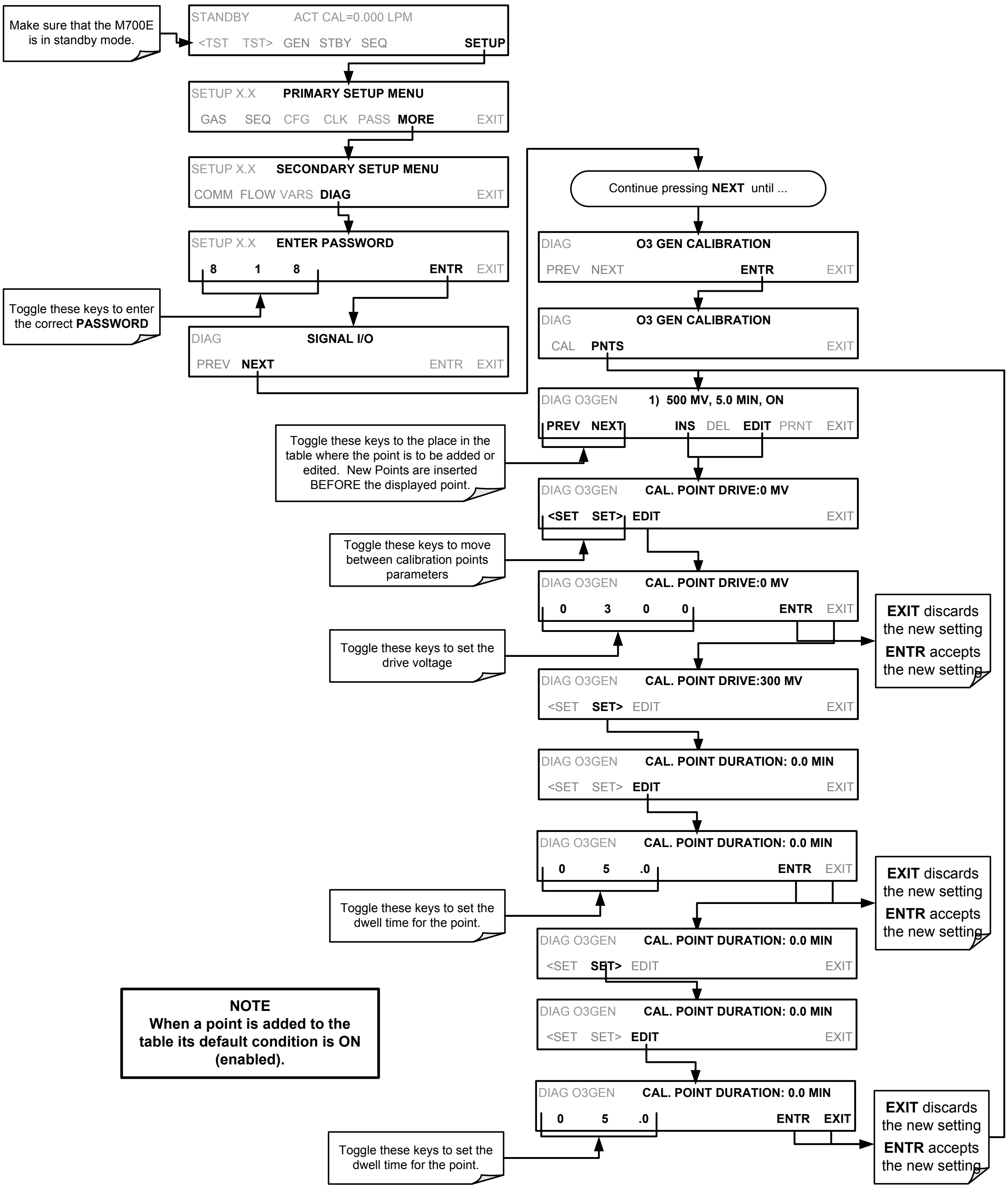
8.4.3.1. Viewing O_3 Generator Calibration Points

To view these calibration points, press:



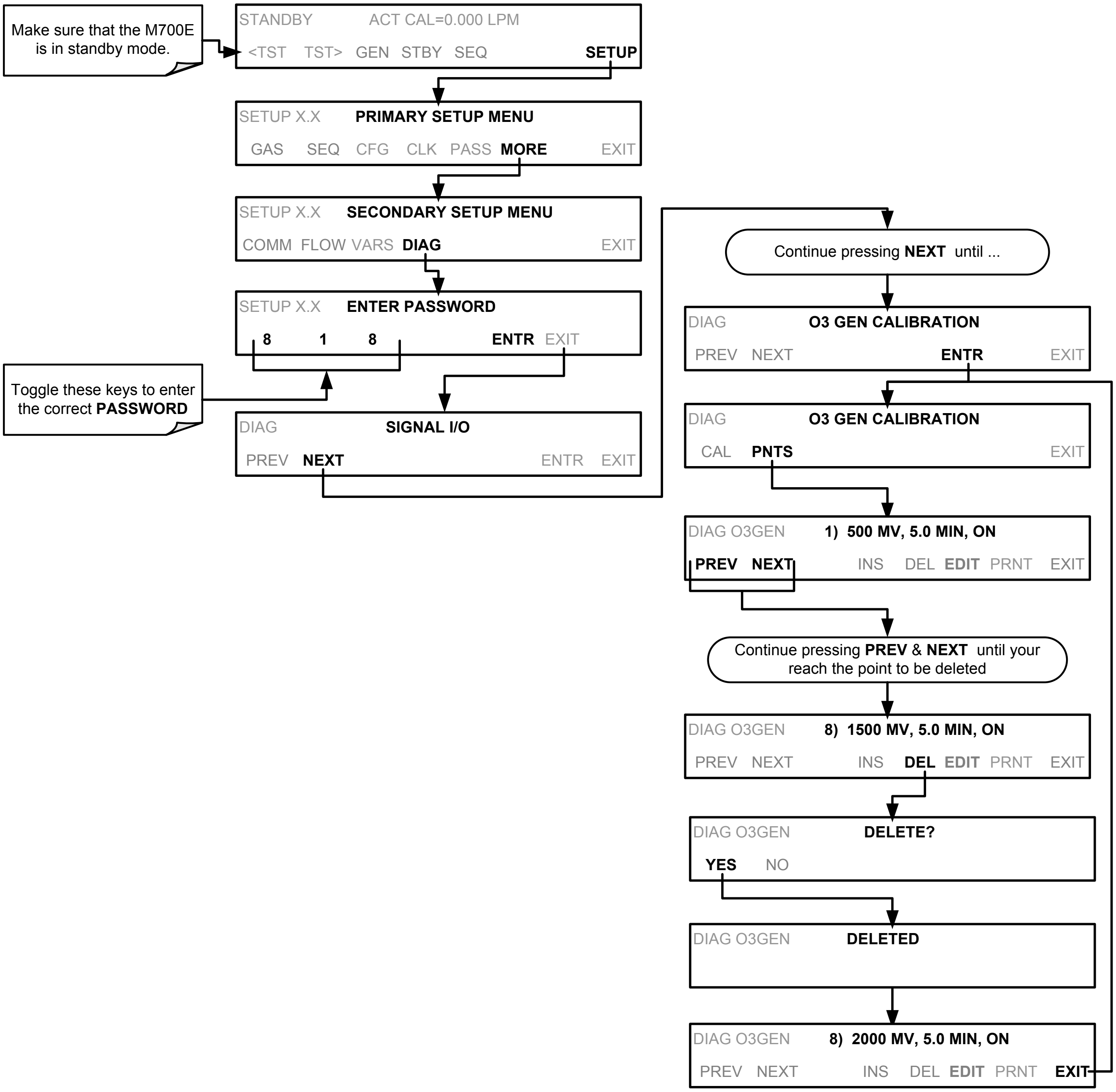
8.4.3.2. Adding or Editing O_3 Generator Calibration Points

To add a calibration point to the table or edit an existing point, press:



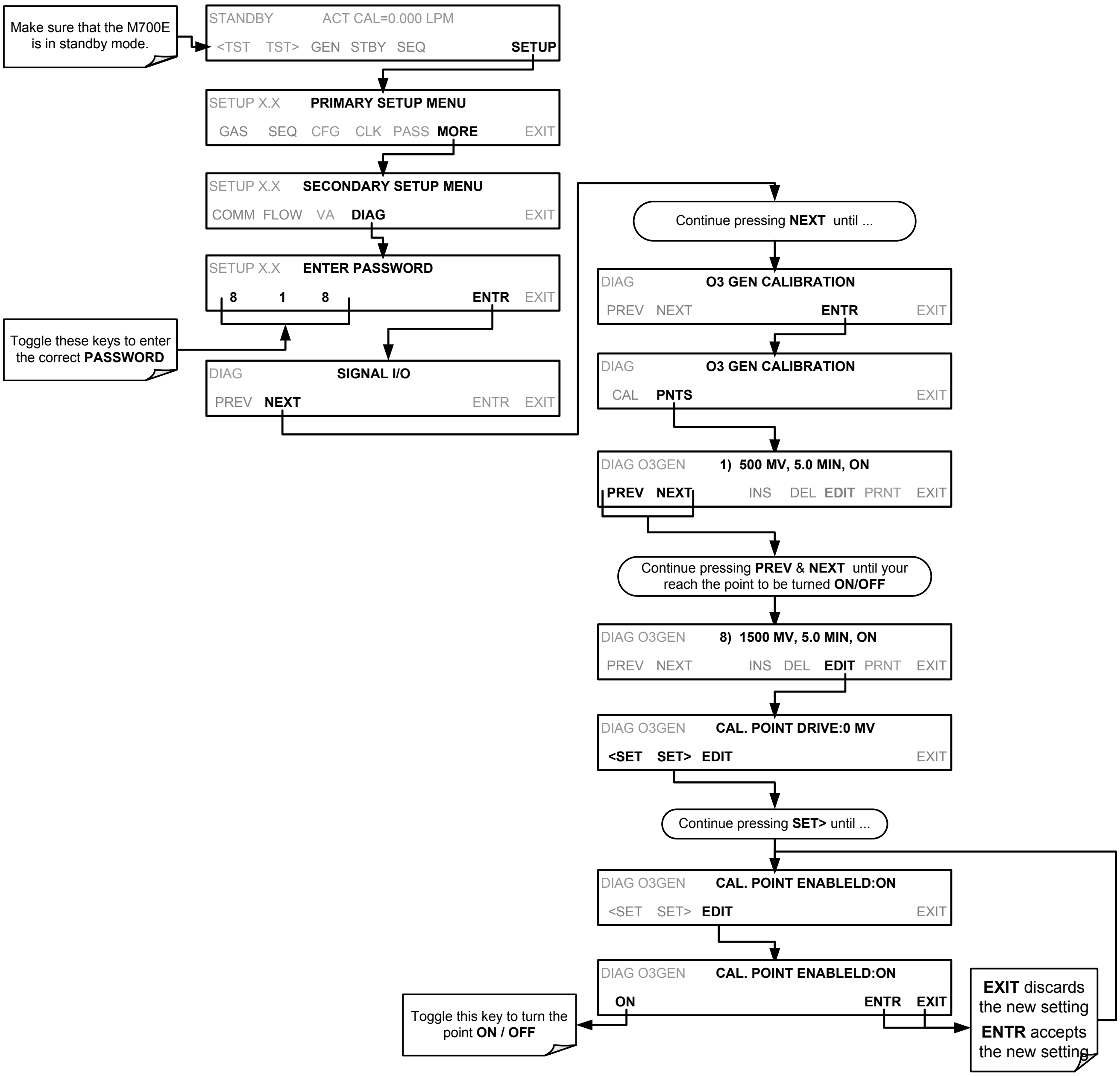
8.4.3.3. Deleting O_3 Generator Calibration Points

To delete an existing calibration point, press:



8.4.3.4. Turning O_3 Generator Calibration Points ON / OFF

To enable or disable an existing calibration point, press:

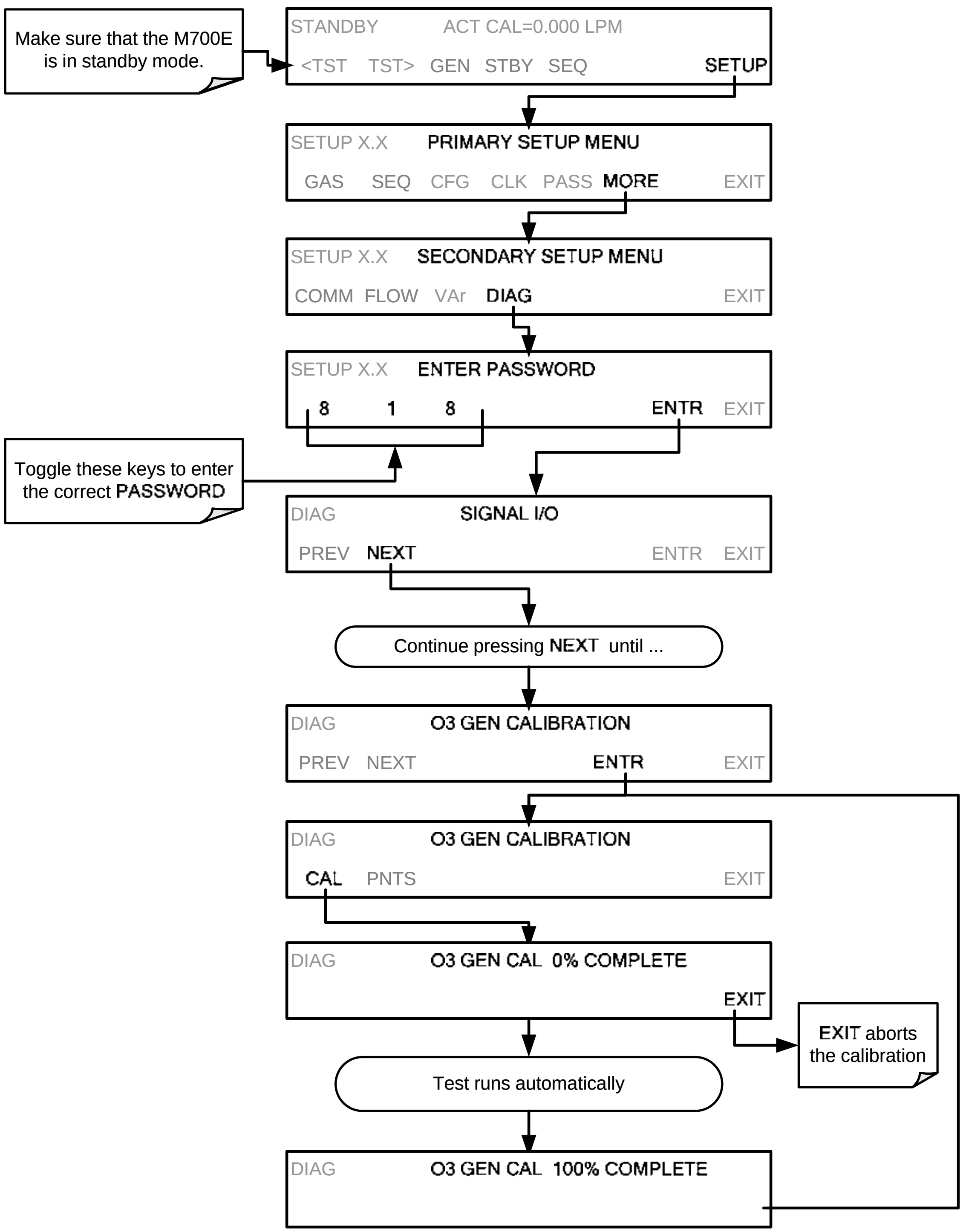


8.4.3.5. Performing an Automatic Calibration of the Optional O_3 Generator

NOTE

This procedure requires that the M700E calibrator have an optional photometer installed.

To run the automatic O_3 generator calibration program, press:



8.5. M700E GAS PRESSURE SENSOR CALIBRATION

NOTE

The procedures described in this section require a separate pressure meter/monitor.

The M700E Dynamic Dilution Calibrator has several sensors that monitor the pressure of the gases flowing through the instrument. The data collected by these sensors is used to compensate the final concentration calculations for changes in atmospheric pressure and is stored in the CPU's memory as various test functions:

Table 8-2: M700E Pressure Sensor Calibration Setup

SENSOR	ASSOCIATED TEST FUNCTION	UNITS	PRESSURE MONITOR MEASUREMENT POINT
Diluent Pressure Sensor	**DIL PRESSURE**	**PSIG**	Insert monitor just before the inlet port of the diluent MFC
Cal Gas Pressure Sensor	**CAL PRESSURE**	**PSIG**	Insert monitor just before the inlet port of the cal gas MFC
O_3 Regulator Pressure Sensor (Optional O_3 Generator)	**REG PRESSURE**	**PSIG**	Insert monitor in line between the regulator and the O_3 gas pressure sensor located on the O_3 generator / photometer pressure / flow sensor PCA
Sample Gas Pressure Sensor (Optional O_3 Photometer)	**PHOTO SPRESS**	**IN-HG-A**	Use monitor to measure ambient atmospheric pressure at the calibrator's location.

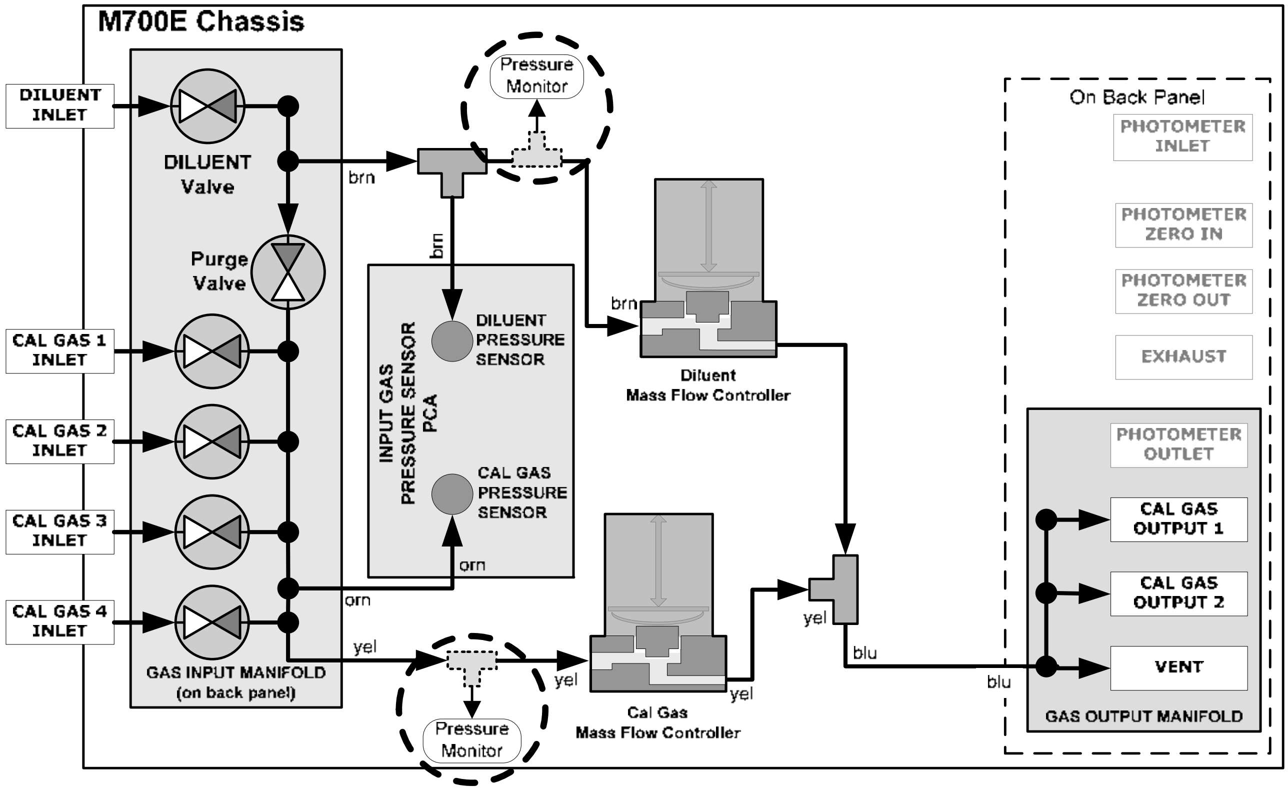


Figure 8-6: Pressure Monitor Points – M700E – Basic Unit

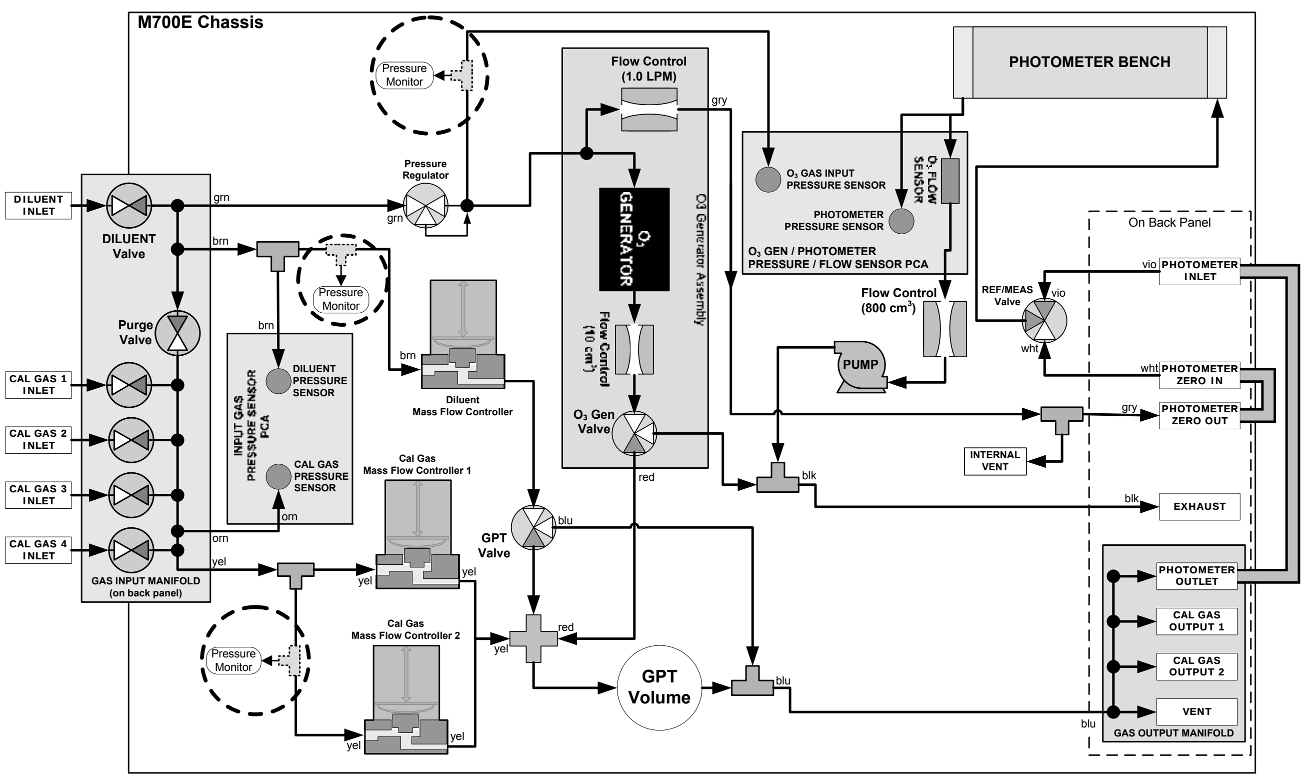
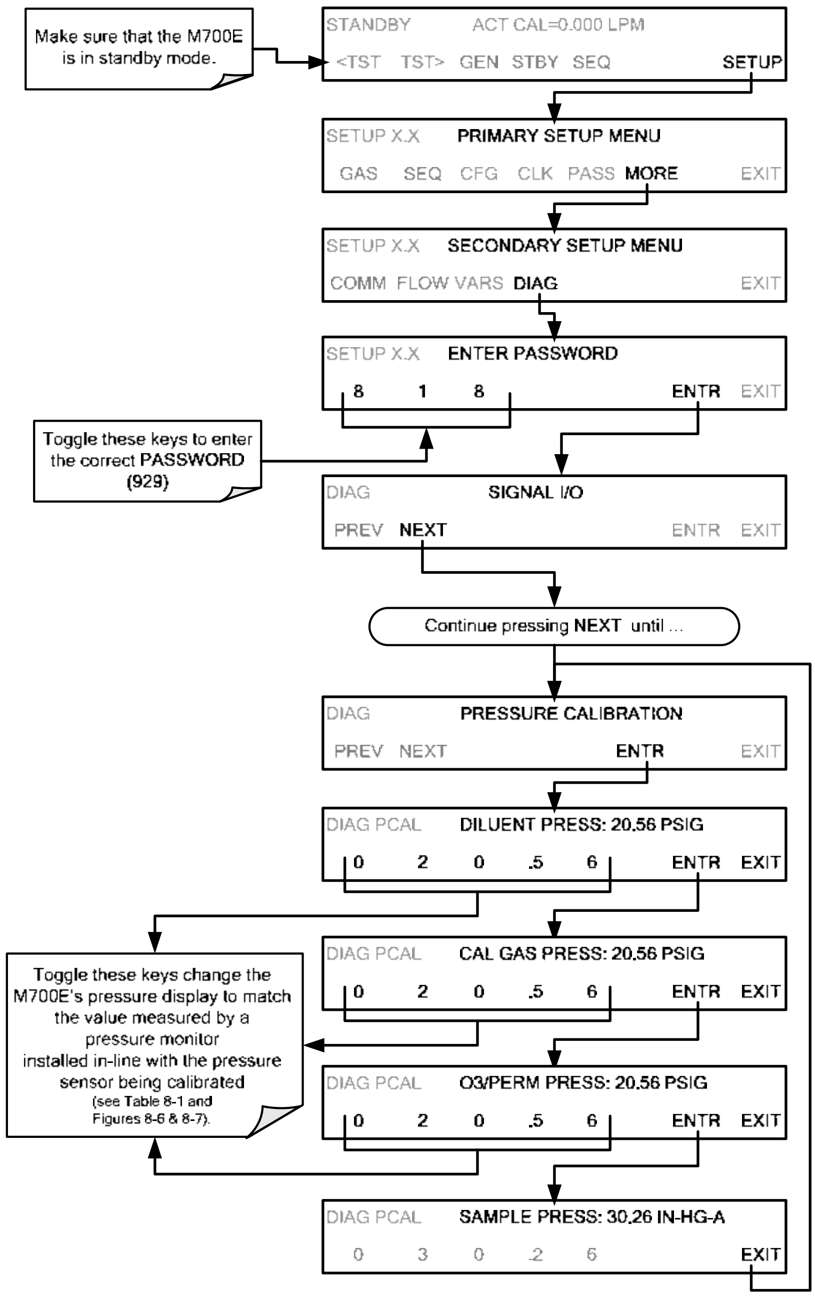


Figure 8-7: Pressure Monitor Points – M700E with O_3 Options and Multiple Cal MFC's Installed

8.5.1.1. Calibrating the Diluent, Cal Gas Optional O_3 Generator Pressure Sensors

1. Turn off the calibrator and open the top cover.
2. For the sensor being calibrated, insert a "T" pneumatic connector at the location described in Table 8-2 and shown in Figure 8-6 and Figure 8-7.
3. Turn on the calibrator and perform the following steps:



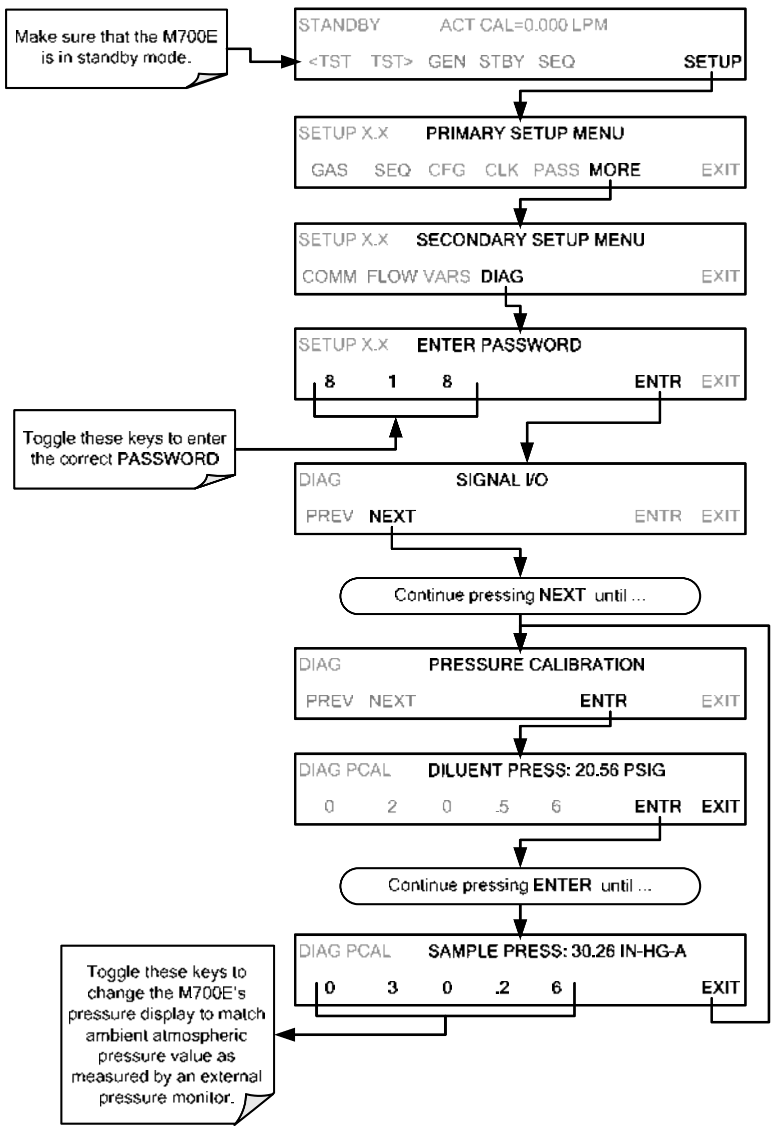
4. Turn OFF the M700E.
5. Remove the pressure monitor.
6. Restore the pneumatic lines to their proper connections.
7. Close the calibrator's cover.

8.5.1.2. Calibrating the Optional O_3 Photometer Sample Gas Pressure Sensors

NOTE

This calibration must be performed when the pressure of the photometer sample gas is equal to ambient atmospheric pressure.

1. Turn off the calibrator and open the top cover.
2. Disconnect power to the photometer's internal pump.
3. Measure the ambient atmospheric pressure of M700E's location in In-Hg-A.
4. Turn on the calibrator and perform the following steps:



5. Turn OFF the M700E.
6. Reconnect the internal pump.
7. Close the calibrator's cover.

USER NOTES:

USER NOTES:

SECTION III
–
TECHNICAL INFORMATION

USER NOTES:

9. THEORY OF OPERATION

9.1. BASIC PRINCIPLES OF DYNAMIC DILUTION CALIBRATION

The M700E Dynamic Dilution Calibrator generates calibration gas mixtures by mixing bottled source gases of known concentrations with a diluent gas (zero air). Using several Mass Flow Controllers (MFC's) the M700E calibrator creates exact ratios of diluent and source gas by controlling the relative rates of flow of the various gases, under conditions where the temperature and pressure of the gasses being mixed is known (and therefore the density of the gases).

The CPU calculates both the required source gas and diluent gas flow rates and controls the corresponding mass flow controllers by the following equation.

Equation 9-1

$$C_f = C_i \times \frac{GAS_{flow}}{Totalflow}$$

WHERE:

C_f = final concentration of diluted gas

C_i = source gas concentration

GAS_{flow} = source gas flow rate

Totalflow = the total gas flow through the calibrator

Totalflow is determined as:

Equation 9-2a

$$\mathbf{TOTALFLOW =} GAS_{flow} + Diluent_{flow}$$

WHERE:

GAS_{flow} = source gas flow rate

$Diluent_{flow}$ = zero air flow rate

For instrument with multiple source gas MFC total Flow is:

Equation 9-2b

$$\mathbf{TOTALFLOW} = GAS_{flow\ MFC1} + GAS_{flow\ MFC2} \ldots + GAS_{flow\ MFCn} + Diluent_{flow\ rate}$$

This dilution process is dynamic. The M700E's CPU not only keeps track of the temperature and pressure of the various gases, but also receives data on actual flow rates of the various MFC's in real time so the flow rate control can be constantly adjusted to maintain a stable output concentration.

The M700E calibrator's level of control is so precise that bottles of mixed gases can be used as source gas. Once the exact concentrations of all of the gases in the bottle are programmed into the M700E, it will create an exact output concentration of any of the gases in the bottle.

9.1.1. GAS PHASE TITRATION MIXTURES FOR O_3 AND NO_2

Because ozone is a very reactive and therefore under normal ambient conditions a short-lived gas, it cannot be reliably bottled, however, an optional O_3 generator can be included in the M700E calibrator that allows the instrument to be use to create calibration mixtures that include O_3.

This ability to generate O_3 internally also allows the M700E Dynamic Dilution Calibrator to be used to create calibration mixture containing NO_2 using a gas phase titration process (GPT) by precisely mixing bottled NO of a known concentration with O_3 of a known n concentration and diluent gas (zero air).

The principle of GPT is based on the rapid gas phase reaction between NO and O_3 that produces quantities of NO_2 as according to the following equation:

Equation 9-3

$$NO + O_3 \rightarrow NO_2 + O_2 + h\nu_{(light)}$$

Under controlled circumstances, the NO-O_3 reaction is very efficient (<1% residual O_3), therefore the concentration of NO_2 resulting from the mixing of NO and O_3 can be accurately predicted and controlled as long as the following conditions are met:

e) The amount of O_3 used in the mixture is known.

f) The amount of NO used in the mixture is **AT LEAST** 10% greater than the amount O_3 in the mixture.

g) The volume of the mixing chamber is known.

h) The NO and O_3 flow rates (from which the time the two gases are in the mixing chamber) are low enough to give a residence time of the reactants in the mixing chamber of >2.75 ppm min.

Given the above conditions, the amount of NO_2 being output by the M700E will be equal to (at a 1:1 ratio) to the amount of O_3 added.

Since:

- The O_3 flow rate of the M700E's O_3 generator is a fixed value (typically about 0.105 LPM);
- The GPT chamber's volume is known,
- The source concentration of NO is a fixed value,

Once the **TOTALFLOW** is determined and entered into the M700E's memory and target concentration for the O_3 generator are entered into the calibrator's software, the M700E adjusts the NO flow rate and diluent (zero air) flow rate to precisely create the appropriate NO_2 concentration at the output.

In this case, ***Totalflow*** is calculated as:

Equation 9-4

$$DIL_{flow} = Totalflow - NOGAS_{flow} - O_{3flow}$$

WHERE:

$NOGAS_{flow}$ = NO source gas flow rate (For calibrator's with multiple source gas MFC, $NOGAS_{flow}$ is the sum of the flow rate for all of the active cal gas MFC's)

Totalflow = total gas flow requirements of the system.

$O_{3\,flow}$ = the flow rate set for the O_3 generator.

DIL_{flow} = required diluent gas flow

Again, this is a dynamic process. An optional photometer can be added the M700E calibrator that allows the CPU to tracks the chemiluminescent reaction created when the NO and O_3 interact to measure the decrease in

NO concentration as NO_2 is produced. This information, along with the other data (gas temperature and pressure, actual flow rates, etc.) is used by the CPU to establish a very accurate NO_2 calibration mixture.

9.2. PNEUMATIC OPERATION

The M700E calibrator pneumatic system consists of the precision dilution system and valve manifold consisting of four gas port valves and one diluent air valve. When bottles of source gas containing different, gases are connected to the four source-gas inlet-ports, these valves are used to select the gas type to be used by opening and closing off gas flow from the various bottles upstream of the MFC's.

NOTE

Each valve is rated for up to 40 PSI zero air pressure and the source gas pressure should be between 25 to 30 PSI and never more than 35 PSI. Exceeding 35 PSI may cause leakage that could cause unwanted gases to be included in the calibration mixture.

By closing all of the four source gas input valves so that only zero air is allowed into the calibrator, the entire pneumatic system can be purges with zero air without having to manipulate the MFC's.

For instrument in which the O_3 generator and GPT pneumatics are installed, a glass volume, carefully selected per the U.S. E.P.A. guidelines is used to optimize NO_2 creation.

See Figure 3-5 and Figure 3-6 for descriptions of the internal pneumatics for the M700E calibrator.

9.2.1. GAS FLOW CONTROL

The precision of gas flow through the M700E Dynamic Dilution Calibrator is centrally critical to its ability to mix calibration gases accurately. This control is established in several ways.

9.2.1.1. Diluent and Source Gas Flow Control

Diluent and source gas flow in the M700E calibrator is a directly and dynamically controlled buy using highly accurate Mass Flow Controller. These MFC's include internal sensors that determine the actual flow of gas though each and feedback control circuitry that uses this data to adjust the flow as required. The MFC's consist of a shunt, a sensor, a solenoid valve and the electronic circuitry required to operate them.

The shunt divides the gas flow such that the flow through the sensor is a precise percentage of the flow through the valve. The flow through the sensor is always laminar.

The MFC's internal sensor operates on a unique thermal-electric principle. A metallic capillary tube is heated uniformly by a resistance winding attached to the midpoint of the capillary. Thermocouples are welded at equal distances from the midpoint of the tube. At zero air flow the temperature of both thermocouples will be the same. When flow occurs through the tubing, heat is transferred from the tube to the gas on the inlet side and from the gas back to the tube on the outlet side creating an asymmetrical temperature distribution. The thermocouples sense this decrease and increase of temperature in the capillary tube and produces a mVDC output signal proportional to that change that is proportional to the rate of flow through the MFC's valve.

The electronic circuitry reads the signal output by the thermal flow sensor measured through a capillary tube. This signal is amplified so that it is varies between 0.00 VDC and 5.00 VDC. A separate 0 to 5 VDC command voltage is also generated that is proportional to the target flow rate requested by the M700E's CPU. The 0-5VDC command signal is electronically subtracted from the 0-5VDC flow signal. The amount and direction of the movement is dependent upon the value and the sign of the differential signal.

The MFC's valve is an automatic metering solenoid type; its height off the seat is controlled by the voltage in its coil. The controller's circuitry amplifies and the differential signal obtained by comparing the control voltage to the flow sensor output and uses it to drive the solenoid valve.

The entire control loop is set up so that as solenoid valve opens and closes to vary the flow of gas through the shunt, valve and sensor in an attempt to minimize the differential between the control voltage for the target flow rate and the flow sensor output voltage generated by the actual flow rate of gas through the controller.

This process is heavily dependant on the capacity of the gas to heat and cool. Since the heat capacity of many gases is relatively constant over wide ranges of temperature and pressure, the flowmeter is calibrated directly in molar mass units for known gases (see Section **Error! Reference source not found.**). Changes in gas composition usually only require application of a simple multiplier to the air calibration to account for the difference in heat capacity and thus the flowmeter is capable of measuring a wide variety of gases.

9.2.1.2. Flow Control Assemblies for Optional O_3 Components

Whereas the gas flow rates for the final mixing of gases is controlled directly by the calibrator's MFC, under direction of the CPU, gas flow through is controlled n on dynamically by various flow control assemblies located in the gas stream(s). These orifices are not adjusted but maintain precise volumetric control as long as the a critical pressure ratio is maintained between the upstream and the downstream orifice.

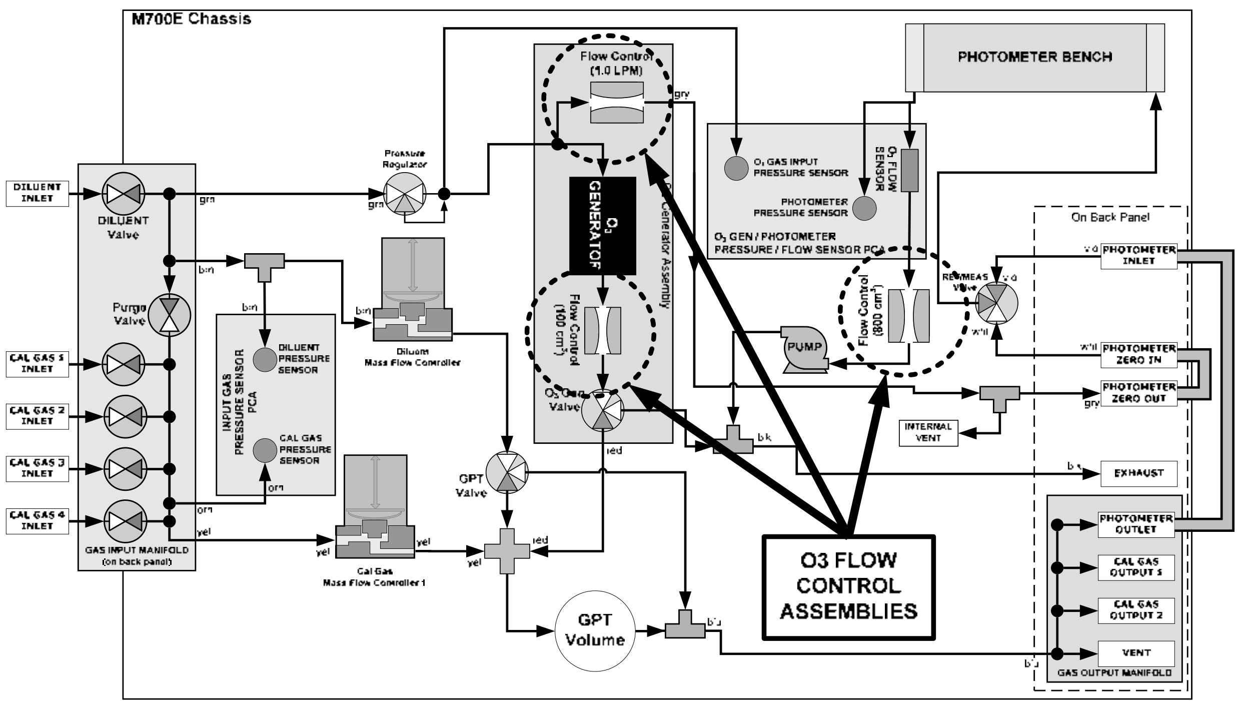


Figure 9-1: Location of Gas Flow Control Assemblies for M700E's with O_3 Options Installed

The flow orifice assemblies consist of:

- A critical flow orifice.
- Two o-rings: Located just before and after the critical flow orifice, the o-rings seal the gap between the walls of assembly housing and the critical flow orifice.
- A spring: Applies mechanical force needed to form the seal between the o-rings, the critical flow orifice and the assembly housing.

9.2.1.3. Critical Flow Orifices

The most important component of the flow control assemblies is the critical flow orifice.

Critical flow orifices are a remarkably simple way to regulate stable gas flow rates. They operate without moving parts by taking advantage of the laws of fluid dynamics. By restricting the flow of gas though the orifice, a pressure differential is created. This pressure differential combined with the action of the calibrator's pump draws the gas through the orifice.

As the pressure on the downstream side of the orifice (the pump side) continues to drop, the speed that the gas flows though the orifice continues to rise. Once the ratio of upstream pressure to downstream pressure is greater than 2:1, the velocity of the gas through the orifice reaches the speed of sound. As long as that ratio stays at least 2:1 the gas flow rate is unaffected by any fluctuations, surges, or changes in downstream pressure because such variations only travel at the speed of sound themselves and are therefore cancelled out by the sonic shockwave at the downstream exit of the critical flow orifice.

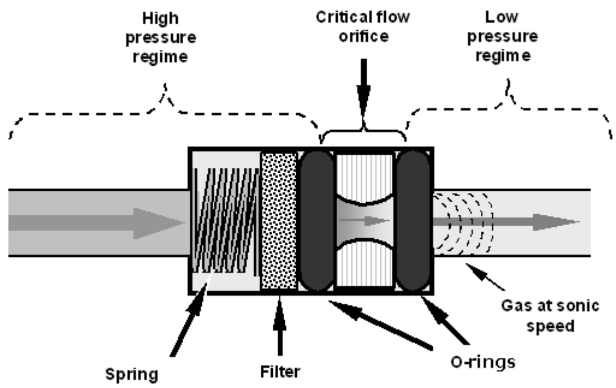


Figure 9-2: Flow Control Assembly & Critical Flow Orifice

The actual flow rate of gas through the orifice (volume of gas per unit of time), depends on the size and shape of the aperture in the orifice. The larger the hole, the more gas molecules (moving at the speed of sound) pass through the orifice.

With a nominal pressure of 10 in-Hg-A in the sample/reaction cell, the necessary ratio of reaction cell pressure to pump vacuum pressure of 2:1 is exceeded and accommodating a wide range of variability in atmospheric pressure and accounting for pump degradation. This extends the useful life of the pump. Once the pump degrades to the point where the sample and vacuum pressures is less than 2:1, a critical flow rate can no longer be maintained.

9.2.2. INTERNAL GAS PRESSURE SENSORS

The M700E includes a single pressure regulator. Depending upon how many and which options are installed in the M700E calibrator, there are between two and four pressure sensors installed as well.

In the basic unit a printed circuit, assembly located near the front of the calibrator near the MFC's includes sensors that measure the pressure of the diluent gas and the source gas currently selected to flow into the calibrator. The calibrator monitors these sensors.

- Should the pressure of one of them fall below 15 PSIG or rise above 36 PSIG a warning is issued.

In units with the optional O_3 generator installed a second PCA located at the rear of the calibrator just behind the generator assembly includes a sensor that measures the gas pressure of the zero air flowing into the generator. A regulator is also located on the gas input to the O_3 generator that maintains the pressure differential needed for the critical flow orifice to operate correctly.

- Should the pressure of one of this sensor fall below 15 PSIG or rise above 25 PSIG a warning is issued.

In calibrators with O_3 photometers installed, a second pressure located on the rear PCA measures the pressure of gas in the photometer's absorption tube. This data is used by the CPU when calculating the O_3 concentration inside the absorption tube.

9.3. ELECTRONIC OPERATION

9.3.1. OVERVIEW

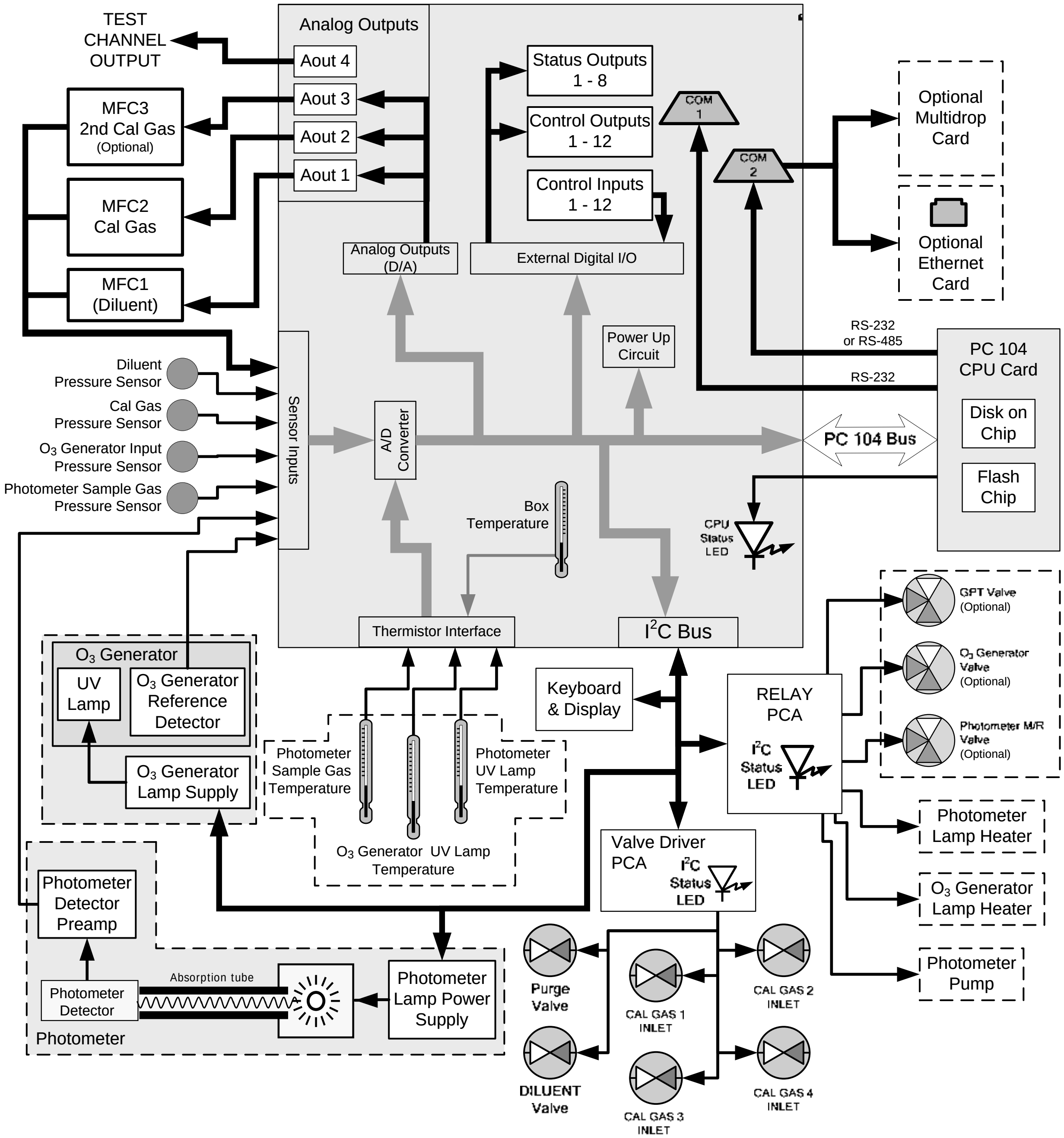


Figure 9-3: M700E Electronic Block Diagram

At its heart, the calibrator is a microcomputer (CPU) that controls various internal processes, interprets data, makes calculations, and reports results using specialized firmware developed by Teledyne API. It communicates with the user as well as receives data from and issues commands to a variety of peripheral devices via a separate printed circuit assembly called the Mother Board.

The motherboard collects data, performs signal conditioning duties and routes incoming and outgoing signals between the CPU and the calibrator's other major components.

Data is generated by the various sub components of the M700E (e.g. flow data from the MFC's, O_3 concentration from the optional photometer). Analog signals are converted into digital data by a unipolar, analog-to-digital converter, located on the motherboard.

A variety of sensors report the physical and operational status of the calibrator's major components, again through the signal processing capabilities of the motherboard. These status reports are used as data for the concentration calculations and as trigger events for certain control commands issued by the CPU. They are stored in memory by the CPU and in most cases can be viewed but the user via the front panel display.

The CPU communicates with the user and the outside world in a variety of manners:

- Through the calibrator's keyboard and vacuum florescent display over a clocked, digital, serial I/O bus (using a protocol called I^2C);
- RS 232 and RS485 serial I/O channels;
- Via an optional Ethernet communications card:
- Various digital and analog outputs, and
- A set of digital control input channels.

Finally, the CPU issues commands via a series of relays and switches (also over the I^2C bus) located on a separate printed circuit assembly to control the function of key electromechanical devices such as heaters, motors and valves.

9.3.2. CPU

The CPU is a low power (5 VDC, 0.8A max), high performance, 386-based microcomputer running a version of the DOS operating system. Its operation and assembly conform to the PC-104 specification, version 2.3 for embedded PC and PC/AT applications. It has 2 MB of DRAM memory on board and operates at 40 MHz clock rate over an internal, 32-bit data and address bus. Chip to chip data handling is performed by two 4-channel, direct memory access (DMA) devices over data busses of either 8-bit or 16-bit bandwidth. The CPU supports both RS-232 and RS-485 serial protocols. Figure 9-4 shows the CPU board.

The CPU communicates with the user and the outside world in a variety of ways:

- Through the calibrator's keyboard and vacuum fluorescence display over a clocked, digital, serial I/O bus using the I^2C protocol (read *I-square-C bus*)
- RS-232 and/or RS-485 serial ports (one of which can be connected to an Ethernet converter)
- Various analog voltage and current outputs
- Several digital I/O channels

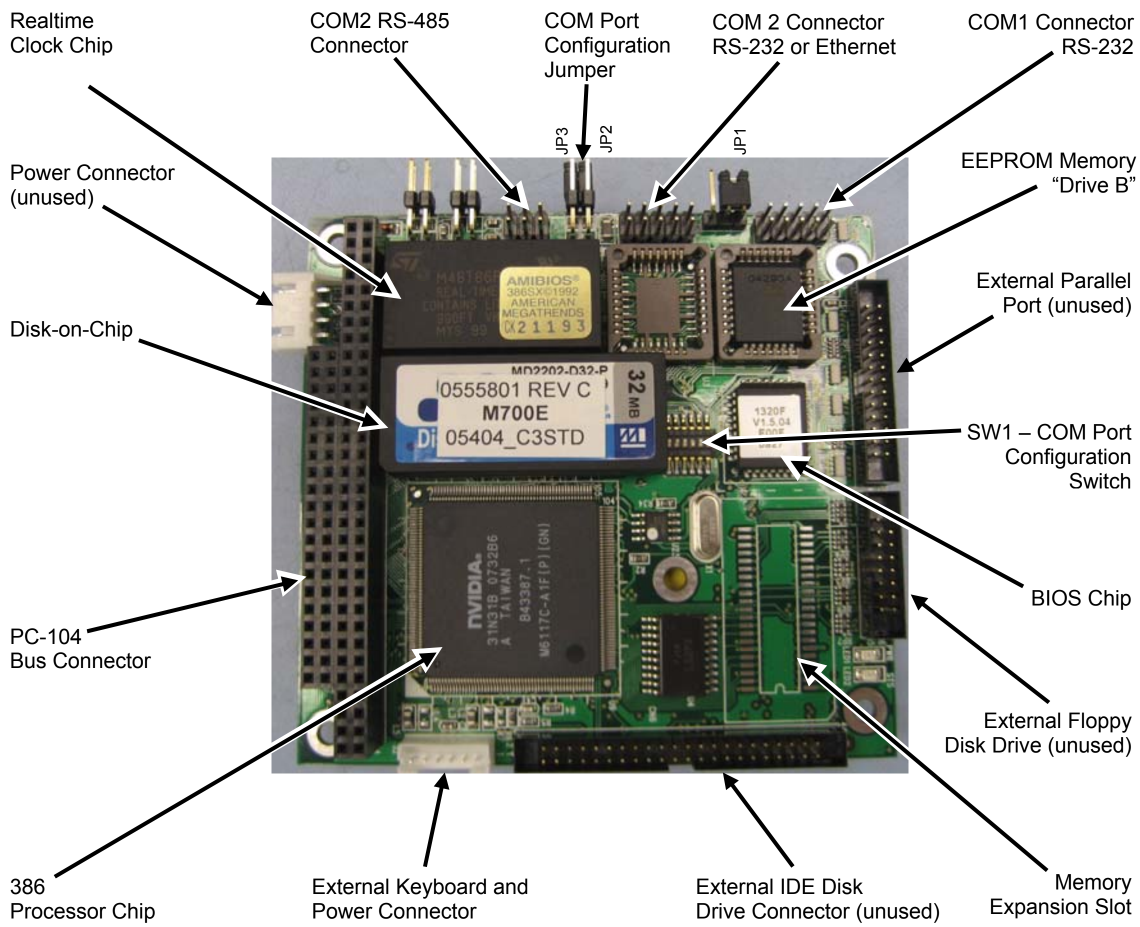


Figure 9-4: M700E CPU Board Annotated

Finally, the CPU issues commands (also over the I^2C bus) to a series of relays and switches located on a separate PCA (the relay PCA located in the right rear of the chassis on its own mounting bracket) to control the function of heaters and valves. The CPU includes two types of non-volatile data storage, one disk-on-chip and one or two flash chips.

9.3.2.1. Disk-on-Chip

Technically, the disk-on-chip is an EEPROM, but appears to the CPU as, behaves as, and performs the same functions in the system as an 8 mb disk drive, internally labeled as DOS drive C:\. It is used to store the computer's operating system files, the Teledyne API firmware and peripheral files.

9.3.2.2. Flash Chip

The flash chip is another, smaller EEPROM with about 64 kb of space, internally labeled as DOS drive B:\. The M700E CPU board can accommodate up to two EEPROM flash chips. The M700E standard configuration is one chip with 64 kb of storage capacity, which is used to store the calibrator configuration as created during final checkout at the factory. Separating these data onto a less frequently accessed chip significantly decreases the chance of data corruption through drive failure.

In the unlikely event that the flash chip should fail, the calibrator will continue to operate with just the DOC. However, all configuration information will be lost, requiring the unit to be recalibrated.

9.3.3. RELAY PCA

The relay PCA is one of the central switching and power distribution units of the calibrator. It contains power relays, valve drivers and status LEDs for all heated zones and valves, as well as thermocouple amplifiers, power distribution connectors and the two switching power supplies of the calibrator. The relay PCA communicates with the motherboard over the I^{2}C bus and can be used for detailed trouble-shooting of power problems and valve or heater functionality.

Generally, the relay PCA is located in the right-rear quadrant of the calibrator and is mounted vertically on the back of the same bracket as the instrument's DC power supplies, however the exact location of the relay PCA may differ from model to model (see Figure 3-3 or Figure 3-4).

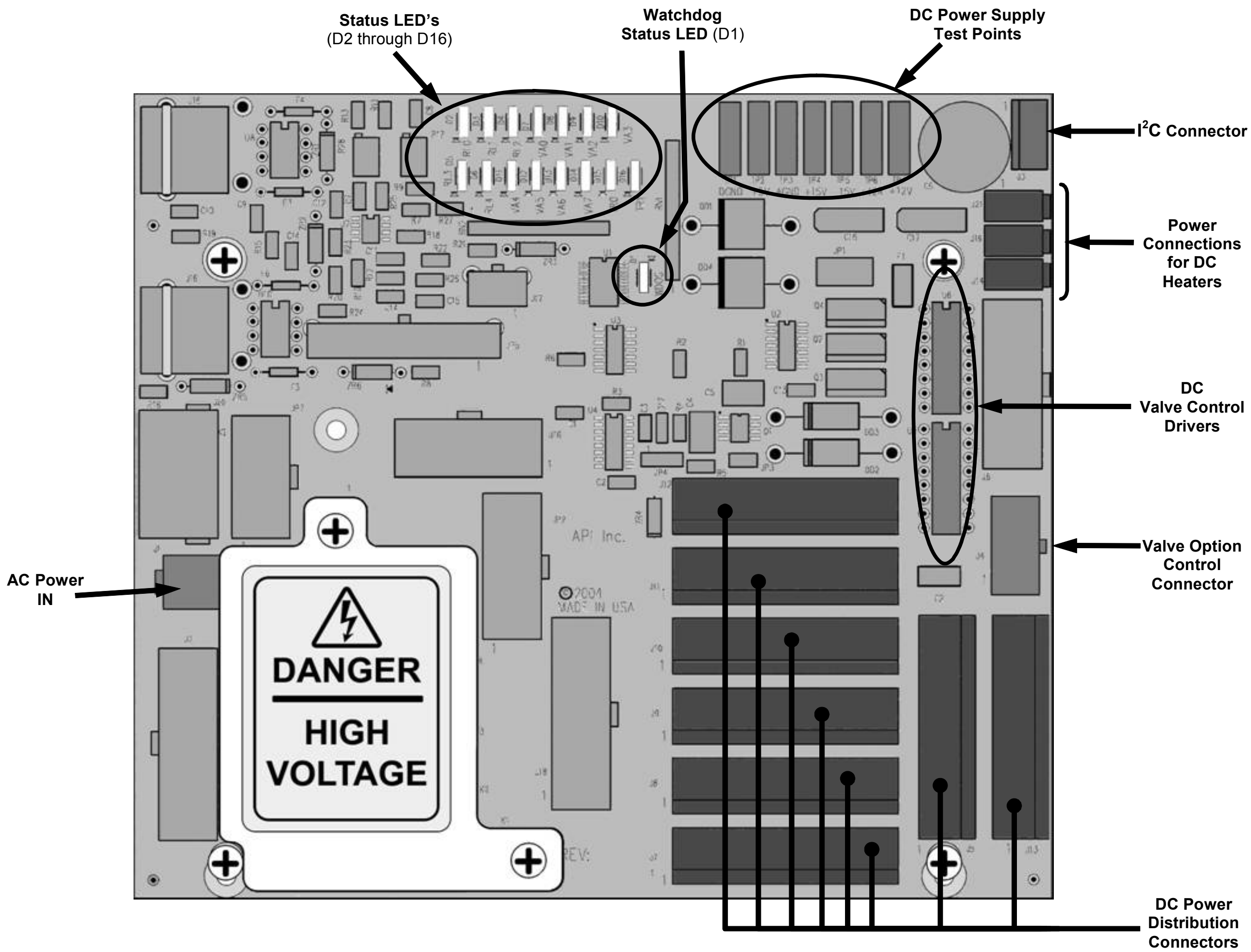


Figure 9-5: Relay PCA

This is the base version of the Relay PCA. It does not include the AC relays and is used in instruments where there are no AC powered components requiring control. A plastic insulating safety shield covers the empty AC Relay sockets.

CAUTION

NEVER REMOVE THIS SAFETY SHIELD WHILE THE INSTRUMENT IS PLUGGED IN AND TURNED ON. THE CONTACTS OF THE AC RELAY SOCKETS BENEATH THE SHIELD CARRY HIGH AC VOLTAGES EVEN WHEN NO RELAYS ARE PRESENT

9.3.3.1. Valve Control

The relay PCA also hosts two valve driver chips, each of which can drive up four valves. In the M700E, the relay PCA controls only those valves associated with the O_3 generator and photometer options. All valves related to source gas and diluent gas flow are controlled by a separate valve driver PCA (see Section 9.3.4).

9.3.3.2. Heater Control

The relay PCA controls the various DC heaters related to the O_3 generator and photometer options.

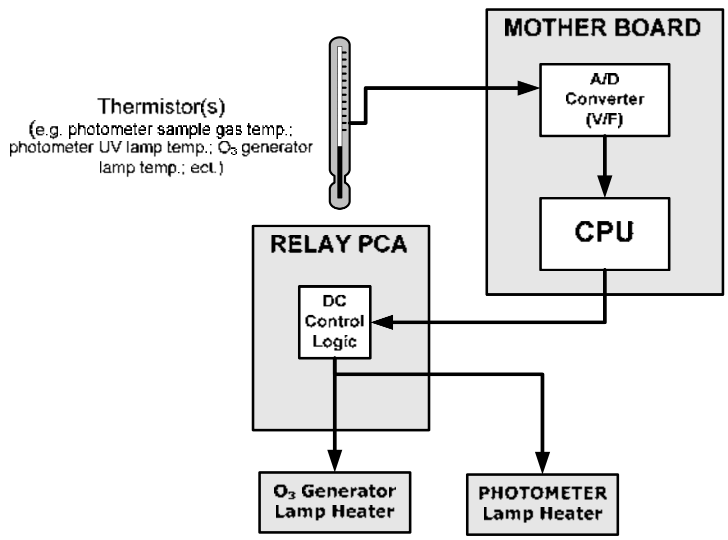


Figure 9-6: Heater Control Loop Block Diagram.

9.3.3.3. Relay PCA Status LEDs & Watch Dog Circuitry

Thirteen LEDs are located on the calibrator's relay PCA to indicate the status of the calibrator's heating zones and some of its valves as well as a general operating watchdog indicator.

Table 9-1 shows the status of these LEDs and their respective functionality.

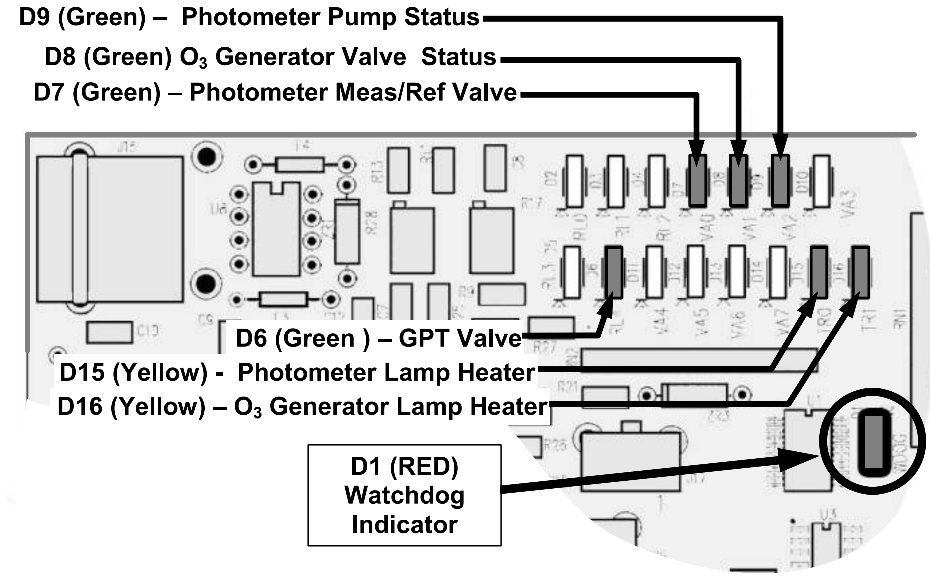


Figure 9-7: Status LED Locations – Relay PCA

Table 9-1: Relay PCA Status LEDs

LED	COLOR	DESCRIPTION	FUNCTION
D1	Red	Watchdog Circuit; I^2C bus operation.	Blinks when I^2C bus is operating properly
D2-6	SPARE		
D7[1]	Green	Photometer Meas/Ref Valve	When lit the valve open to REFERENCE gas path
D8[2]	Green	O_3 generator Valve status	When lit the valve open to O_3 generator gas path
D9	Green	Photometer Pump status	When lit the pump is turner on.
D6[1,2]	Yellow	GPT Valve status	When lit the valve open to GT Chamber
D10 - 14	SPARE		
D15[1]	Yellow	Photometer Heater Status	When lit the photometer UV lamp heater is on
D16[2]	Yellow	O_3 Generator Heater Status	When lit the O_3 generator UV lamp heater is on

[1] Only applies on calibrators with photometer options installed.
[2] Only applies on calibrators with O_3 generator options installed.

9.3.3.4. Relay PCA Watchdog Indicator (D1)

The most important of the status LEDs on the relay PCA is the red I^2C Bus watchdog LED. It is controlled directly by the calibrator's CPU over the I^2C bus. Special circuitry on the relay PCA watches the status of D1. Should this LED ever stay ON or OFF for 30 seconds (indicating that the CPU or I^2C bus has stopped functioning) this Watchdog Circuit automatically shuts all valves and turns off all heaters and lamps.

9.3.4. VALVE DRIVER PCA

The valves that operate the M700E calibrator's main source gas and diluent gas inputs are controlled by a PCA that is attached directly to the input valve manifold (see Figure 3-3 or Figure 3-4). Like the relay PCA, the valve driver PCA communicates with M700E's CPU through the motherboard over the I^{2}C bus.

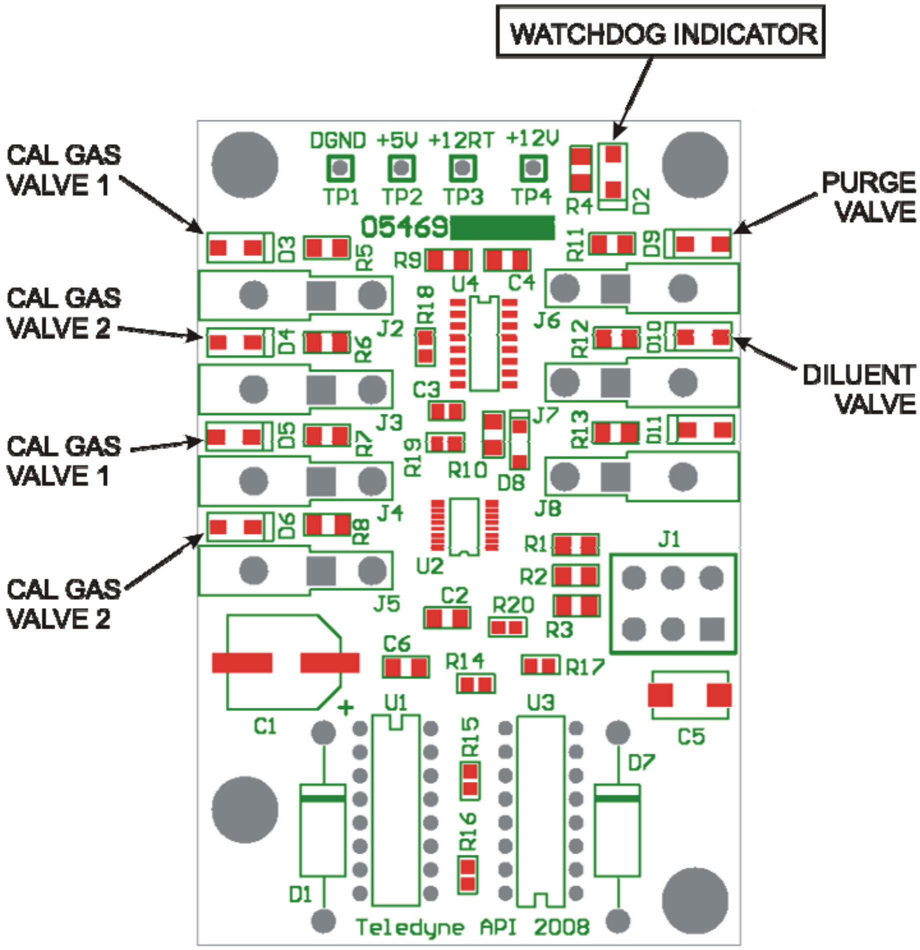


Figure 9-8: Status LED Locations – Valve Driver PCA

9.3.4.1. Valve Driver PCA Watchdog Indicator

The most important of the status LEDs on the relay PCA is the red I^{2}C Bus watchdog LED. It is controlled directly by the calibrator's CPU over the I^{2}C bus. Like the watchdog LED on the relay PCA, should this LED ever stay ON or OFF for 30 seconds if the CPU or I^{2}C bus has stopped functioning, this Watchdog Circuit automatically shuts all valves and turns off all heaters and lamps.

9.3.5. MOTHERBOARD

This is the largest electronic assembly in the calibrator and is mounted to the rear panel as the base for the CPU board and all I/O connectors. This printed circuit assembly provides a multitude of functions including A/D conversion, digital input/output, PC-104 to I^2C translation, temperature sensor signal processing and is a pass through for the RS-232 and RS-485 signals.

9.3.5.1. A to D Conversion

Analog signals, such as the voltages received from the calibrator's various sensors, are converted into digital signals that the CPU can understand and manipulate by the analog to digital converter (A/D). Under the control of the CPU, this functional block selects a particular signal input and then coverts the selected voltage into a digital word.

The A/D consists of a voltage-to-frequency (V-F) converter, a programmable logic device (PLD), three multiplexers, several amplifiers and some other associated devices. The V-F converter produces a frequency proportional to its input voltage. The PLD counts the output of the V-F during a specified time period, and sends the result of that count, in the form of a binary number, to the CPU.

The A/D can be configured for several different input modes and ranges but in uni-polar mode with a +5V full scale. The converter includes a 1% over and under-range. This allows signals from -0.05V to +5.05V to be fully converted.

For calibration purposes, two reference voltages are supplied to the A/D converter: Reference ground and +4.096 VDC. During calibration, the device measures these two voltages and outputs their digital equivalent to the CPU. The CPU uses these values to compute the converter's offset and slope, then uses these factors for subsequent calculations.

9.3.5.2. Sensor Inputs

The key analog sensor signals are coupled to the A/D converter through the master multiplexer from two connectors on the motherboard. Terminating resistors (100 kΩ) on each of the inputs prevent crosstalk between the sensor signals.

The key analog sensor signals are coupled to the A/D through the master multiplexer from two connectors on the motherboard. 100K terminating resistors on each of the inputs prevent cross talk from appearing on the sensor signals.

9.3.5.3. Thermistor Interface

This circuit provides excitation, termination and signal selection for several negative-coefficient, thermistor temperature sensors located inside the calibrator.

9.3.5.4. Analog Outputs

The M700E calibrator comes equipped with one analog output. It can be set by the user to output a signal level representing any one of the test parameters (see Table 6-13) and will output an analog VDC signal that rises and falls in relationship with the value of the chosen parameter.

9.3.5.5. External Digital I/O

The external digital I/O performs two functions.

The **STATUS** outputs carry logic-level (5V) signals through an optically isolated 8-pin connector on the rear panel of the calibrator. These outputs convey on/off information about certain calibrator conditions such as **CONC VALID**. They can be used to interface with certain types of programmable devices.

The **CONTROL** outputs can be used to initiate actions by external peripheral devices in conjunction with individual steps of a calibration sequence (see Section 6.5.2.8).

The **CONTROL** inputs can be initiated by applying 5V DC power from an external source such as a PLC or data logger (Section 6.5.1.5). Zero and span calibrations can be initiated by contact closures on the rear panel.

9.3.5.6. I^{2}C Data Bus

I^{2}C is a two-wire, clocked, digital serial I/O bus that is used widely in commercial and consumer electronic systems. A transceiver on the motherboard converts data and control signals from the PC-104 bus to I^{2}C. The data are then fed to the keyboard/display interface and finally onto the relay PCA.

Interface circuits on the keyboard/display interface and relay PCA convert the I^{2}C data to parallel inputs and outputs. An additional interrupt line from the keyboard to the motherboard allows the CPU to recognize and service key strokes on the keyboard.

9.3.5.7. Power-up Circuit

This circuit monitors the +5V power supply during calibrator start-up and sets the analog outputs, external digital I/O ports, and I^{2}C circuitry to specific values until the CPU boots and the instrument software can establish control.

9.3.6. INPUT GAS PRESSURE SENSOR PCA

This PCA, physically located to the just to the left of the MFC's, houses two pressure sensors that measure the pressure of the incoming diluent gas (zero air) and calibration gases relative to ambient pressure. Pneumatically, both sensors measure their respective gases just upstream from the associated MFC.

This data is used in calculating the concentration of calibration mixtures.

The following TEST functions are viewable from the instrument's front panel:

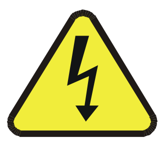
- **CALPRESS** - the pressure of the selected calibration gas input reported in **PSIG.**
- **DILPRESS** - the pressure of the diluent gas (zero air) input also reported in **PSIG.**

9.3.7. POWER SUPPLY AND CIRCUIT BREAKER

The M700E calibrator operates in two main AC power ranges: 100-120 VAC and 220-240 VAC (both ± 10%) between 47 and 63 Hz. A 5-ampere circuit breaker is built into the ON/OFF switch. In case of a wiring fault or incorrect supply power, the circuit breaker will automatically turn off the calibrator.

NOTE

The M700E calibrator is equipped with a universal power supply that allows it to accept any AC power configuration, within the limits specified in Table 2-2.



CAUTION
Should the power circuit breaker trip correct the condition causing this situation before turning the calibrator back on.

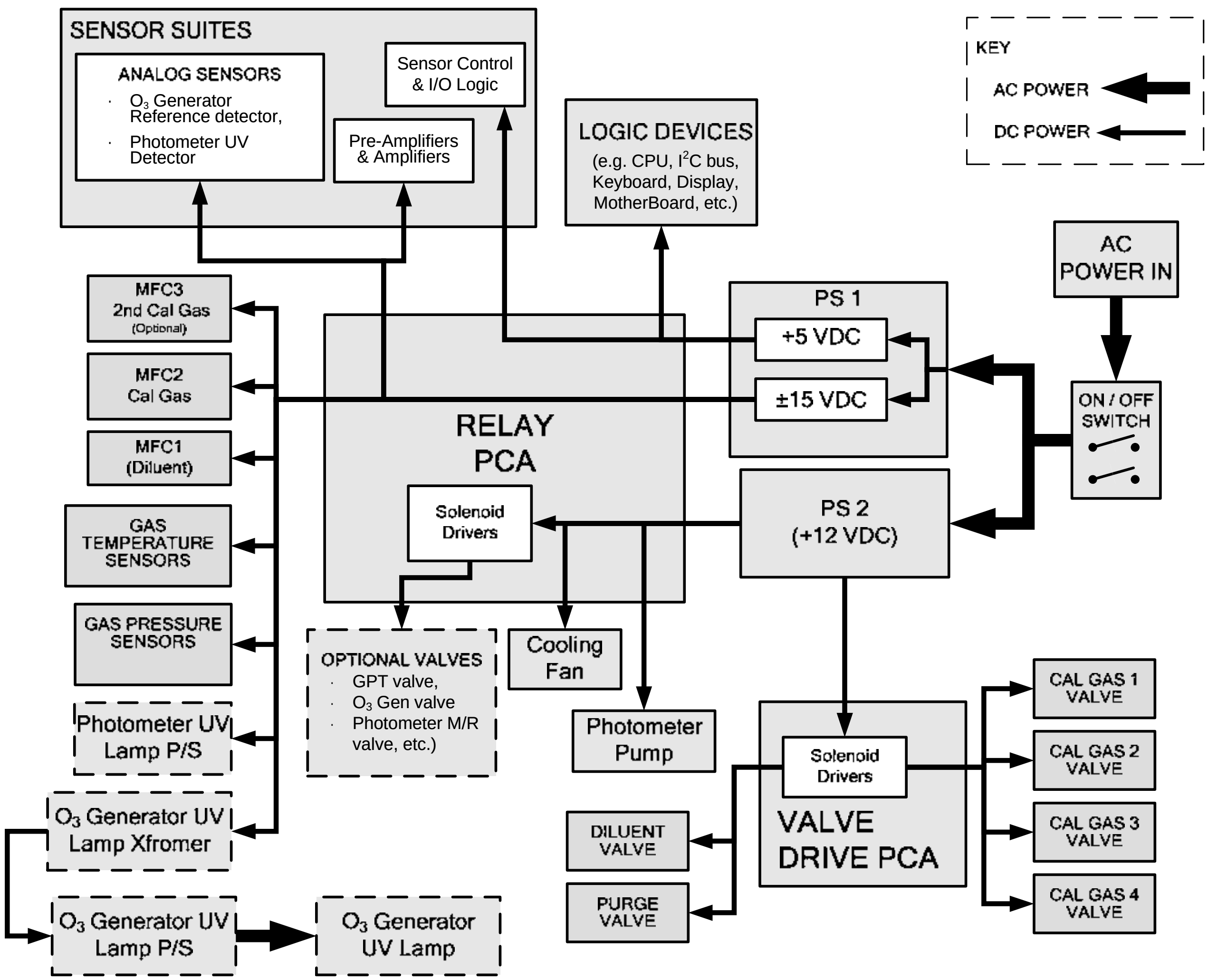


Figure 9-9: M700E Power Distribution Block diagram

9.4. FRONT PANEL INTERFACE

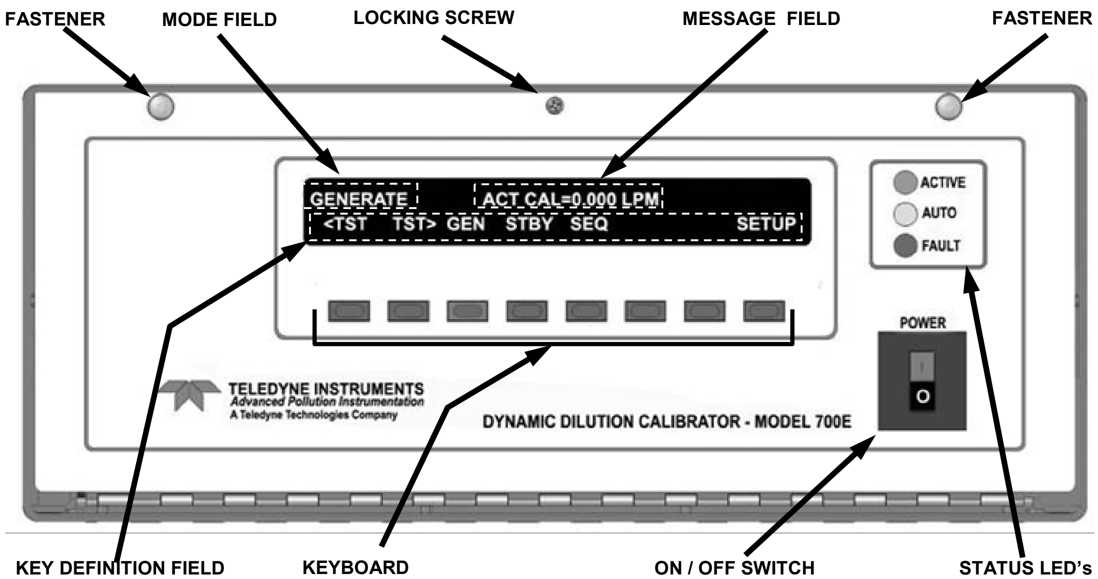


Figure 9-10: M700E Front Panel Layout

The most commonly used method for communicating with the M700E Dynamic Dilution Calibrator is via the instrument's front panel, which includes a set of three status LEDs, a vacuum florescent display and a keyboard with 8 context sensitive keys.

9.4.1.1. Calibrator Status LEDs

Three LEDS are used to inform the user of the instruments basic operating status.

Table 9-2: Front Panel Status LEDs

Name	Color	Behavior	Significance
Main Message Field	N/A	Displays Warning messages and Test Function values	At initial start up, the various warning messages will appear here.
Mode Field	N/A	Displays "STANDBY"	Instrument is in **STANDBY** mode.
STATUS LEDs			
Active	Green	OFF	Unit is operating in **STANDBY** mode. This LED glows green when the instrument is actively producing calibration gas.
Auto	Yellow	OFF	This LED only glows when the calibrator is performing an automatic calibration sequence.
Fault	Red	BLINKING	The calibrator is warming up and therefore many of its subsystems are not yet operating within their optimum ranges. Various warning messages will appear.

9.4.1.2. Keyboard

A row of eight keys just below the vacuum florescent display (see Figure 9-10) is the main method by which the user interacts with the calibrator. As the software is operated, labels appear on the bottom row of the display directly above each active key, defining the function of that key as it is relevant for the operation being performed. Pressing a key causes the associated instruction to be performed by the calibrator.

Note that the keys do not auto-repeat. In circumstances where the same key must be activated for two consecutive operations, it must be released and repressed.

9.4.1.3. Display

The main display of the calibrator is a vacuum florescent display with two lines of 40 text characters each. Information is organized in the following manner (see Figure 9-10):

- MODE FIELD: Displays the name of the calibrator's current operating mode.
- MESSAGE FIELD: Displays a variety of informational messages such as warning messages, operation data and response messages during interactive tasks.
- KEY DEFINITION FIELD: Displays the definitions for the row of keys just below the display. These definitions are dynamic, context sensitive and software driven.

9.4.1.4. Keyboard/Display Interface Electronics

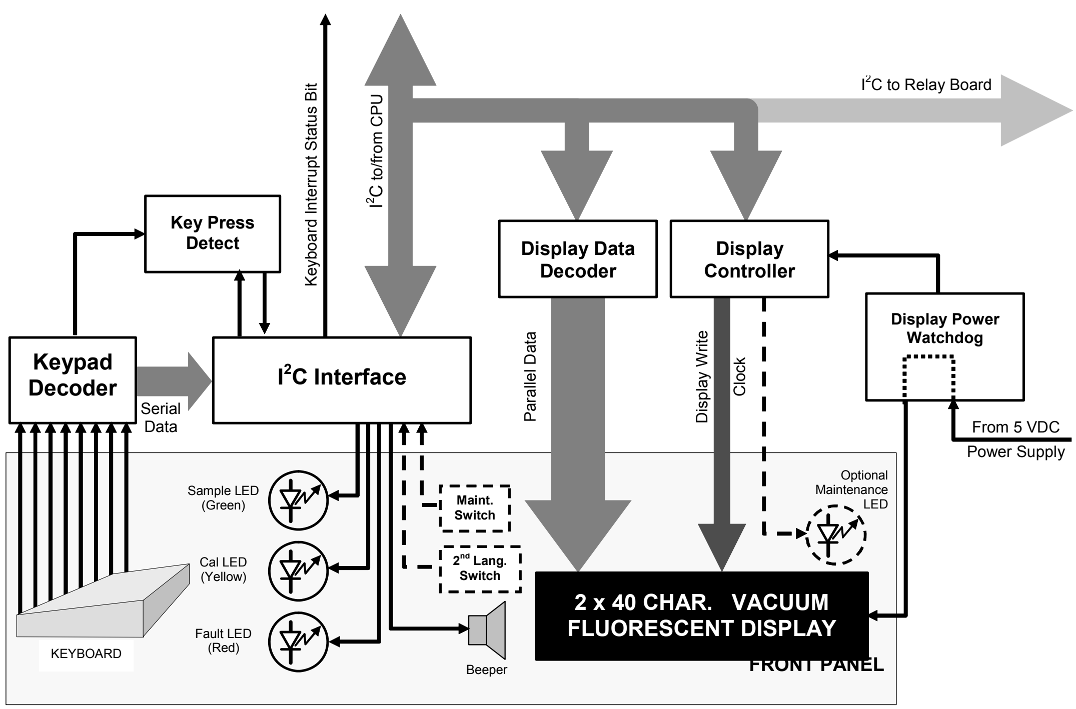


Figure 9-11: Keyboard and Display Interface Block Diagram

The keyboard/display interface electronics of the M700E Calibrator watches the status of the eight front panel keys, alerts the CPU when keys are depressed, translates data from parallel to serial and back and manages communications between the keyboard, the CPU and the front panel display. Except for the Keyboard interrupt status bit, all communication between the CPU and the keyboard/display is handled by way of the instrument's I^2C bus. The CPU controls the clock signal and determines when the various devices on the bus are allowed to talk or required to listen. Data packets are labeled with addresses that identify for which device the information is intended.

KEYPAD DECODER

Each key on the front panel communicates with a decoder IC via a separate analog line. When a key is depressed the decoder chip notices the change of state of the associated signal; latches and holds the state of all eight lines (in effect creating an 8-bit data word); alerts the key-depress-detect circuit (a flip-flop IC); translates the 8-bit word into serial data and; sends this to the I^2C interface chip.

KEY-DEPRESS-DETECT CIRCUIT

This circuit flips the state of one of the inputs to the I^2C interface chip causing it to send an interrupt signal to the CPU.

I^2C INTERFACE CHIP

- This IC performs several functions:
- Using a dedicated digital status bit, it sends an interrupt signal alerting the CPU that new data from the keyboard is ready to send.
- Upon acknowledgement by the CPU, that it has received the new keyboard data, the I^2C interface chip resets the key-depress-detect flip-flop.
- In response to commands from the CPU, it turns the front panel status LEDs on and off and activates the beeper.
- Informs the CPU when the optional maintenance and second language switches have been opened or closed (see Chapter 5 for information on these options).

DISPLAY DATA DECODER

This decoder translates the serial data sent by the CPU (in TTY format) into a bitmapped image, which is sent over a parallel data bus to the display.

DISPLAY CONTROLLER

This circuit manages the interactions between the display data decoder and the display itself. It generates a clock pulse that keeps the two devices synchronized. It can also, in response to commands from the CPU turn off and/or reset the display.

DISPLAY POWER WATCHDOG

The M700E calibrator's display can begin to show garbled information or lock-up if the DC voltage supplied to it falls too low, even momentarily. To alleviate this, a brownout Watchdog Circuit monitors the level of the power supply and in the event that the voltage level falls below a certain level resets the display by turning it off, then back on.

9.5. SOFTWARE OPERATION

The M700E calibrator's core module is a high performance, 386-based microcomputer running a version of DOS. On top of the DOS shell, special software developed by Teledyne API interprets user commands from various interfaces, performs procedures and tasks and stores data in the CPU's memory devices. Figure 9-12 shows a block diagram of this software functionality.

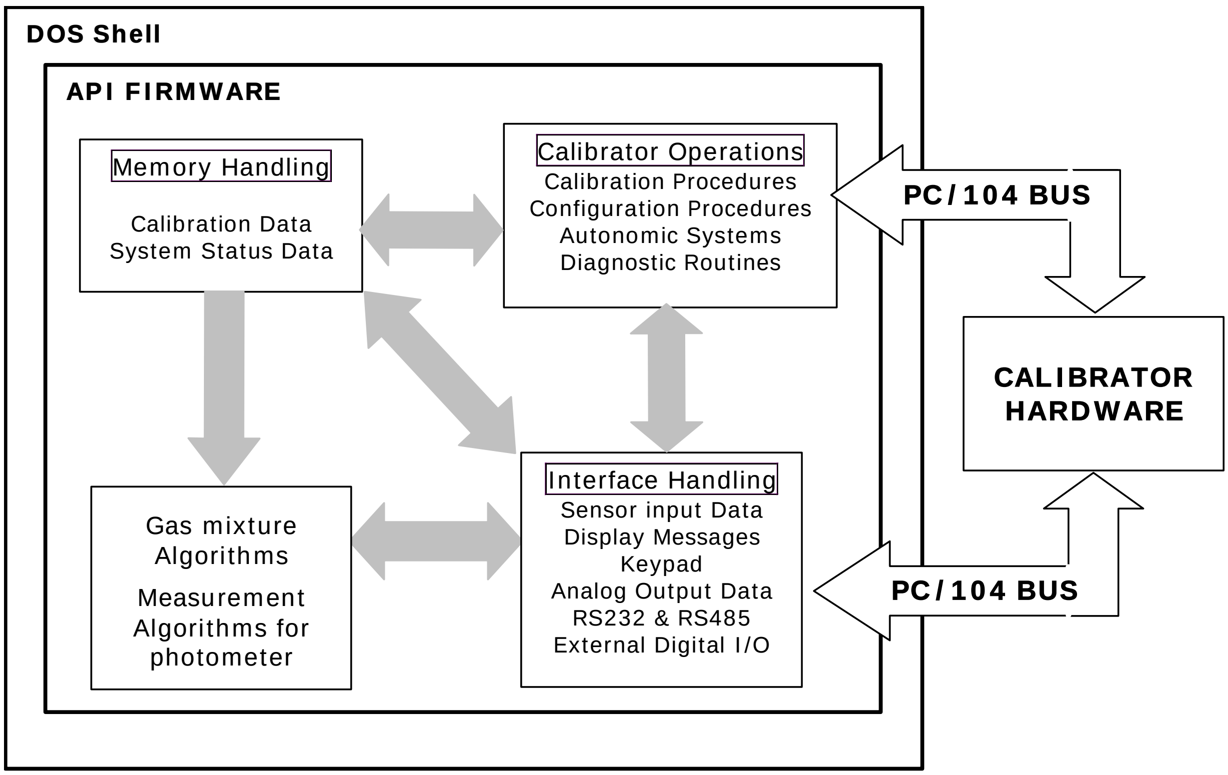


Figure 9-12: Schematic of Basic Software Operation

9.6. O_3 GENERATOR OPERATION

9.6.1. PRINCIPLE OF PHOTOLITIC O_3 GENERATION

Ozone is a naturally occurring substance that is sometimes called "activated oxygen". It contains three atoms of oxygen (O_3) instead of the usual two found in normal oxygen (O_2) that is essential for life. Because of its relatively short half-life, ozone cannot be bottled and stored for later use and there fore must always be generated on-site by an ozone generator. The two main principles of ozone generation are UV-light and corona-discharge. While the corona-discharge method is most common because of its ability to generate very high concentrations (up to 50%), it is inappropriate for calibration needs since the level of fine control over the O_3 concentration is poor. Also, the corona-discharge method produces a small amount of NO_2 as a byproduct, which also may be undesirable in a calibration application.

The UV-light method is most feasible in calibration applications where production of low, accurate concentrations of ozone desired. This method mimics the radiation method that occurs naturally from the sun in the upper atmosphere producing the ozone layer. An ultra-violet lamp inside the generator emits a precise wavelength of UV Light (185 nm). Ambient air is passed over an ultraviolet lamp, which splits some of the molecular oxygen (O_2) in the gas into individual oxygen atoms that attach to other existing oxygen molecules (O_2), forming ozone (O_3).

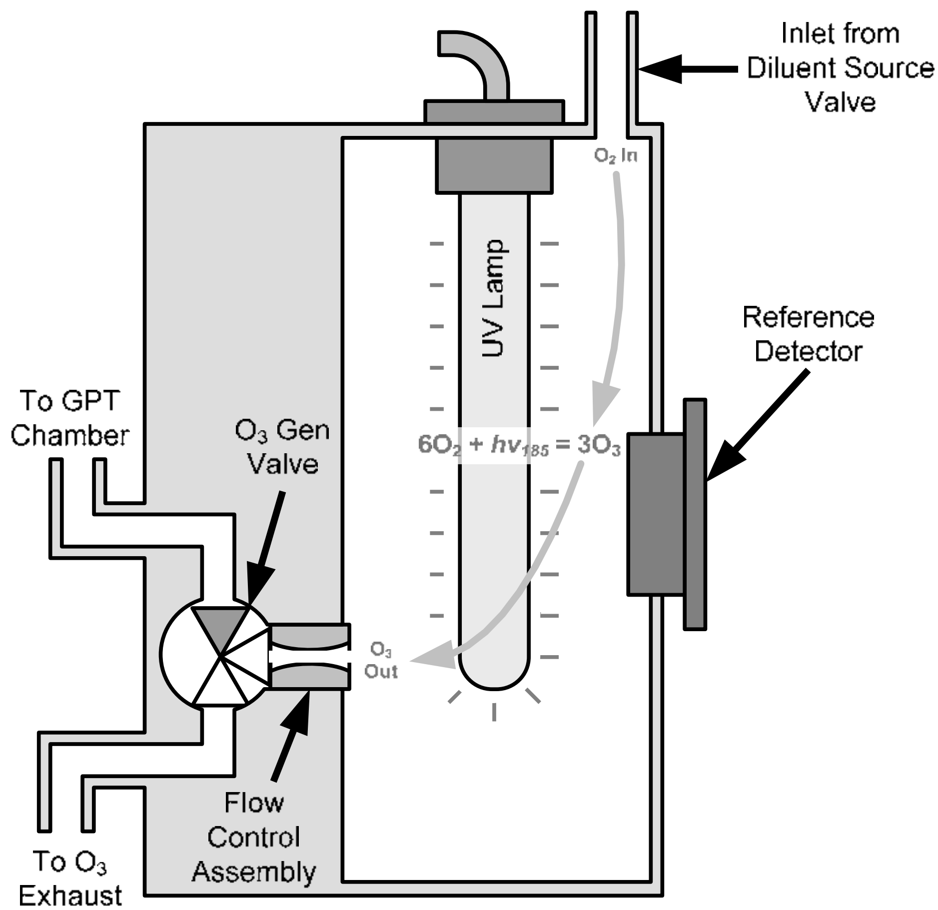


Figure 9-13: O_3 Generator Internal Pneumatics

9.6.2. O_3 GENERATOR – PNEUMATIC OPERATION

Pneumatic flow through the O_3 generator is created by supplying zero air (diluent) to it under pressure. The zero air source must be capable of maintaining a continuous flow rate of at least 100 cm^3/min unless the optional photometer is also installed, in which case the minimum continuous flow rate must be at least 1.1 LPM.

Input and output gas flow is directed by two valves, both of which must be open:

- The diluent inlet valve: This valve is located on the back panel and allows diluent / zero air into the calibrator.
- The O_3 generation valve: This valve is located on the body of the O_3 generator is downstream from the generator chamber itself and directs the output of the generator to either the GPT mixing chamber or the exhaust vent at the back of the calibrator.

The rate of flow through the O_3 generator is controlled by a 100 cm^3/min flow control assembly positioned between the O_3 generation chamber and the O_3 generation valve. A self adjusting pressure regulator on the zero air (diluent) supply gas line maintains the required 2:1 pressure ration across the critical flow orifice of the flow control assembly (see Section 9.2.1.3).

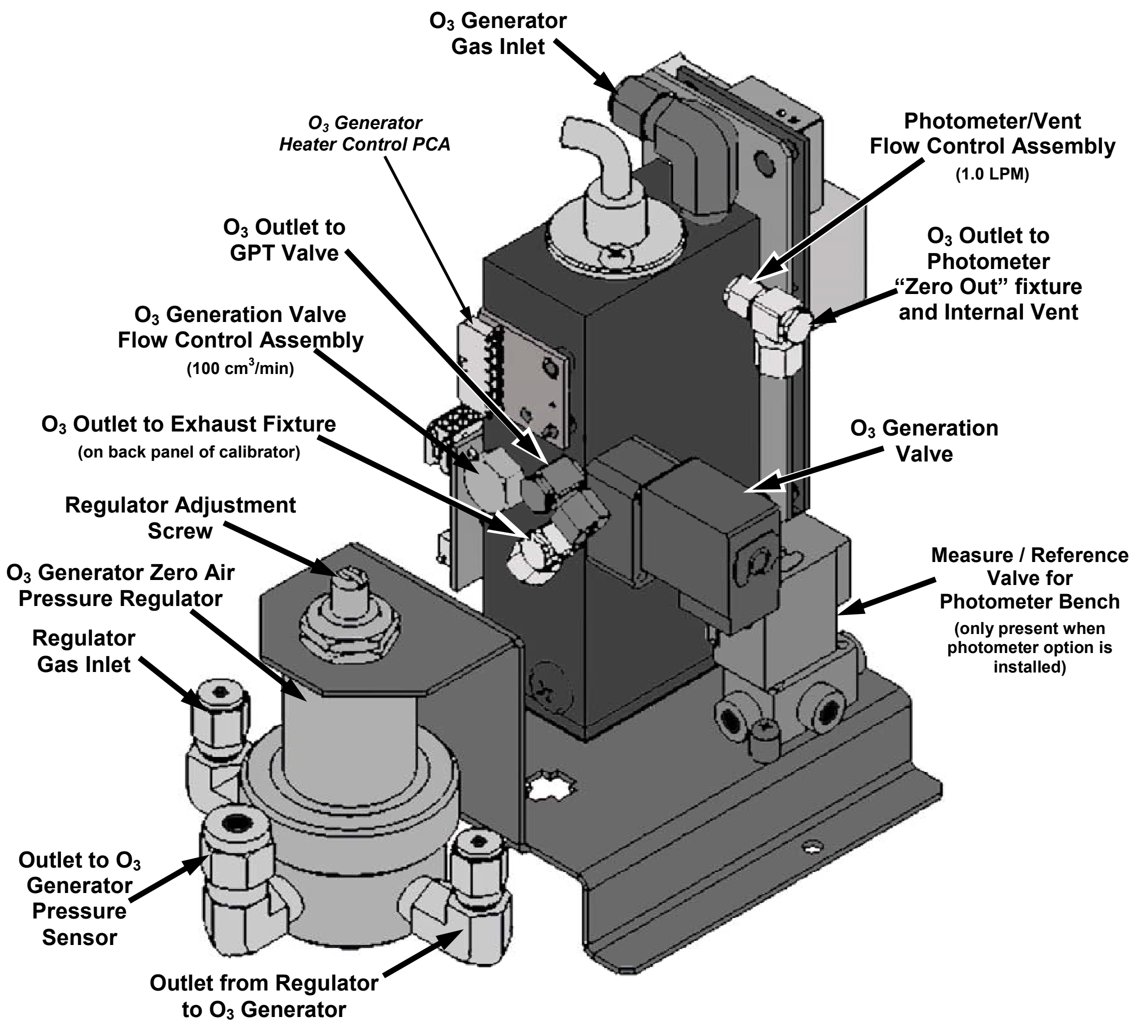


Figure 9-14: O_3 Generator Valve and Gas Fixture Locations

9.6.3. O_3 GENERATOR – ELECTRONIC OPERATION

Electronically the O_3 generator and its subcomponents act as peripheral devices operated by the CPU via the motherboard. Sensors, such as the UV lamp thermistor send analog data to the motherboard, where it is digitized. Digital data is sent by the motherboard to the calibrator's CPU and where required stored in either flash memory or on the CPU's Disk-on-Chip. Commands from the CPU are sent to the motherboard and forwarded to the various devices via the calibrators I^2C bus.

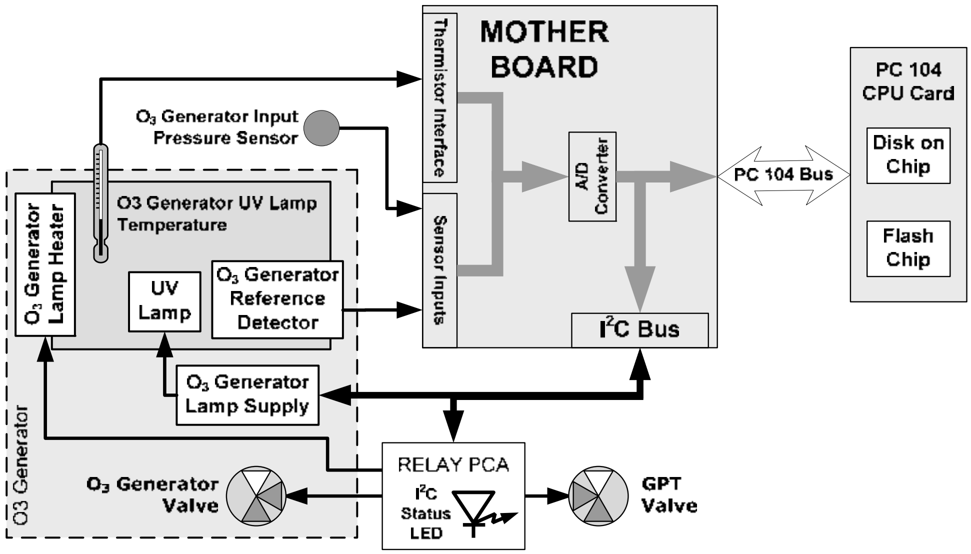


Figure 9-15: O_3 Generator – Electronic Block Diagram

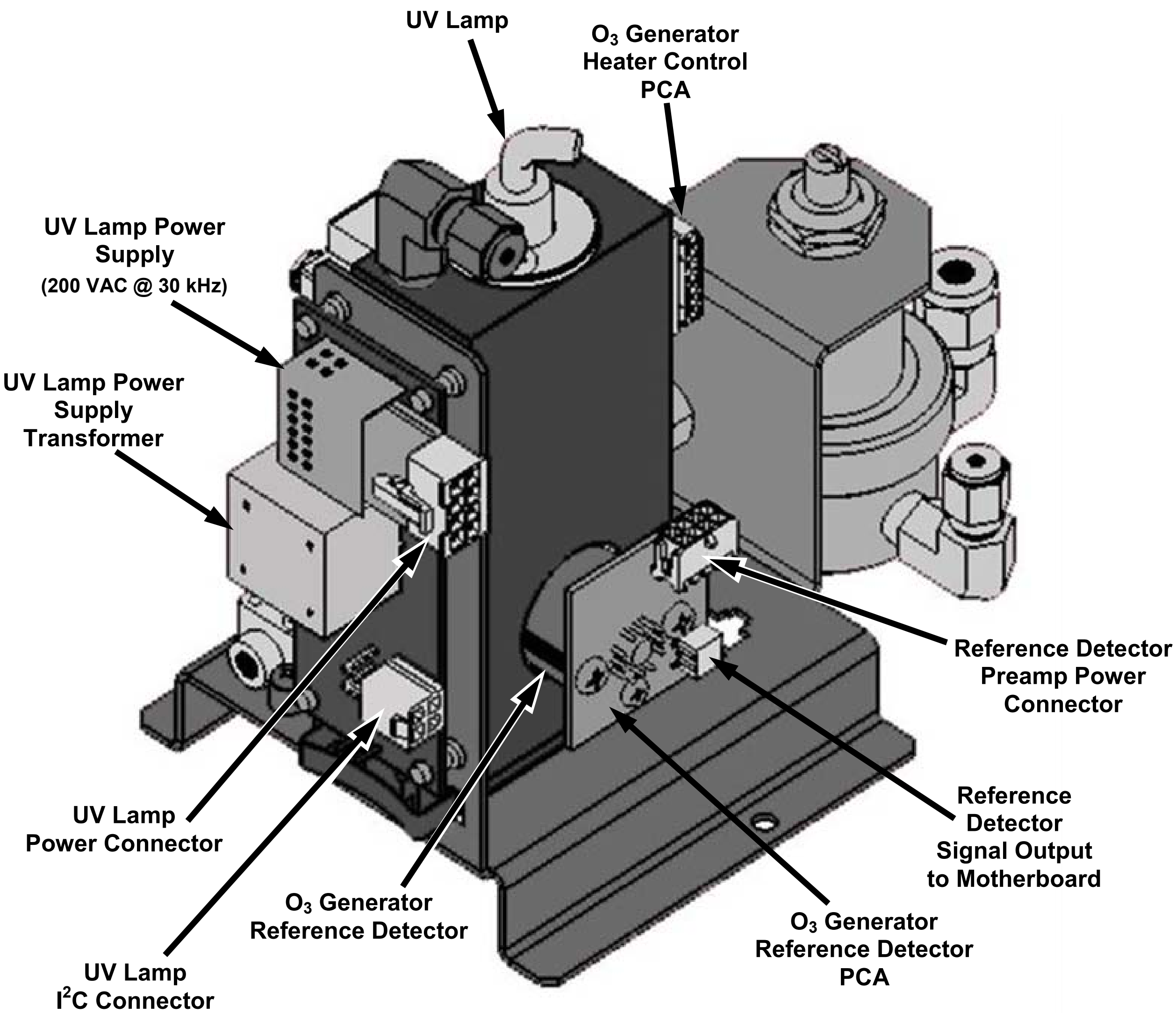


Figure 9-16: O_3 Generator Electronic Components Location

9.6.3.1. O_3 Generator Temperature Control

In order to operate at peak efficiency the UV lamp of the M700E's O_3 generator is maintained at a constant 48ºC. If the lamp temperature falls below 43ºC or rises above 53ºC a warning is issued by the calibrators CPU.

This temperature is controlled as described in the section on the relay PCA (Section 9.3.3). The location of the thermistor and heater associated with the O_3 generator is shown in Figure 9-17:

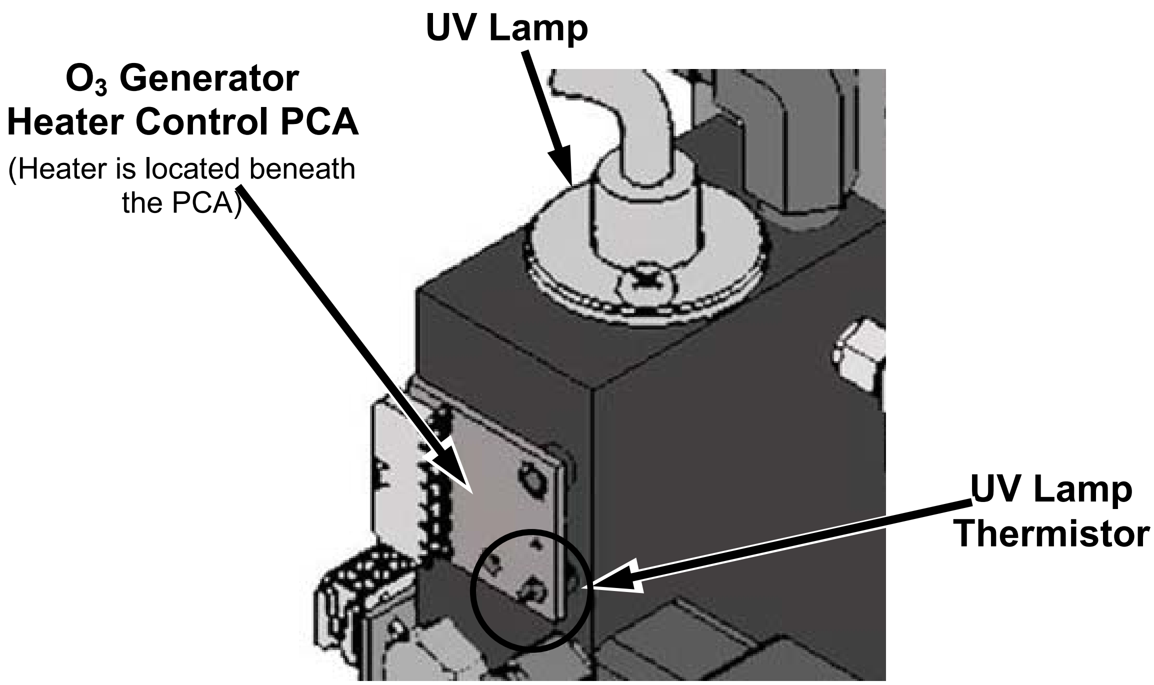


Figure 9-17: O_3 Generator Temperature Thermistor and DC Heater Locations

9.6.3.2. Pneumatic Sensor for the O_3 Generator

A pressure sensor, located on the O_3 generator and photometer, pressure/flow sensor PCA (see Figure 3-4), monitors the output gas pressure of the regulator on the O_3 generator's zero air supply. The regulator is adjusted at the factory to maintain a pressure of 20 PSIG on this line. If the pressure drops below 15 PSIG or rises above 25 PSIG a warning is issued.

9.7. PHOTOMETER OPERATION

The Model M700E calibrator's optional photometer determines the concentration of Ozone (O_3) in a sample gas drawn through it. Sample and calibration gasses must be supplied at ambient atmospheric pressure in order to establish a stable gas flow through the absorption tube where the gas' ability to absorb ultraviolet (UV) radiation of a certain wavelength (in this case 254 nm) is measured.

Gas bearing O_3 and zero air are alternately routed through the photometer's absorption tube. Measurements of the UV light passing through the sample gas with and without O_3 present are made and recorded.

Calibration of the photometer is performed in software and does not require physical adjustment. During calibration, the CPU's microprocessor measures the current state of the UV Sensor output and various other physical parameters of the calibrator and stores them in memory.

The CPU uses these calibration values, the UV absorption measurements made on the sample gas in the absorption tube along with data regarding the current temperature and pressure of the gas to calculate a final O_3 concentration.

9.7.1. MEASUREMENT METHOD

9.7.1.1. Calculating O_3 Concentration

The basic principle by which photometer works is called Beer's Law (also referred to as the Beer-Lambert equation). It defines the how light of a specific wavelength is absorbed by a particular gas molecule over a certain distance at a given temperature and pressure. The mathematical relationship between these three parameters for gasses at Standard Temperature and Pressure (STP) is:

Equation 9-5

$$I = I_0 e^{-\alpha LC} \qquad \text{at STP}$$

Where:

I_o is the intensity of the light if there was no absorption.

I is the intensity with absorption.

L is the absorption path, or the distance the light travels as it is being absorbed.

C is the concentration of the absorbing gas. In the case of the M700E, Ozone (O_3).

α is the absorption coefficient that tells how well O_3 absorbs light at the specific wavelength of interest.

To solve this equation for **C**, the concentration of the absorbing Gas (in this case O_3), the application of algebra is required to rearrange the equation as follows:

Equation 9-6

$$C = \ln \frac{I_o}{I} \times \frac{1}{\alpha L} \qquad \text{at STP}$$

Unfortunately, both ambient temperature and pressure influence the density of the sample gas and therefore the number of ozone molecules present in the absorption tube thus changing the amount of light absorbed.

In order to account for this effect the following addition is made to the equation:

Equation 9-7

$$C = \ln \frac{I_o}{I} \times \frac{1}{\alpha L} \times \frac{T}{273^{o} K} \times \frac{29.92 \, inHg}{P}$$

Where:

T = sample ambient temperature in degrees Kelvin

P = ambient pressure in inches of mercury

Finally, to convert the result into Parts per Billion (PPB), the following change is made:

Equation 9-8

$$C = \ln\frac{I_o}{I} \times \frac{10^{9}}{\alpha L} \times \frac{T}{273^{o}K} \times \frac{29.92\,inHg}{P}$$

The M700E photometer:

- Measures each of the above variables: ambient temperature; ambient gas pressure; the intensity of the UV light beam with and without O_3 present;
- Inserts know values for the length of the absorption path and the absorption coefficient, and:
- Calculates the concentration of O_3 present in the sample gas.

9.7.1.2. The Measurement / Reference Cycle

In order to solve the Beer-Lambert equation, it is necessary to know the intensity of the light passing through the absorption path both when O_3 is present and when it is not. A valve called the measure/reference valve, physically located on front-left corner of the O_3 generator assembly (see Figure 3-4 and Figure 9-14) alternates the gas stream flowing to the photometer between zero air (diluent gas) and the O_3 output from the O_3 generator. This cycle takes about 6 seconds.

Table 9-3: M700E Photometer Measurement / Reference Cycle

TIME INDEX	STATUS
0 sec.	Measure/Reference Valve Opens to the Measure Path.
0 – 2 sec.	Wait Period. Ensures that the absorption tube has been adequately flushed of any previously present gasses.
2 – 3 Seconds	Calibrator measures the average UV light intensity of O_3 bearing Sample Gas (**I**) during this period.
3 sec.	Measure/Reference Valve Opens to the Reference Path.
3 – 5 sec.	Wait Period. Ensures that the absorption tube has been adequately flushed of O_3 bearing gas.
5 – 6 Seconds	Calibrator measures the average UV light intensity of Non-O_3 bearing Sample Gas (**I_0**) during this period.
CYCLE REPEAT EVERY 6 SECONDS	

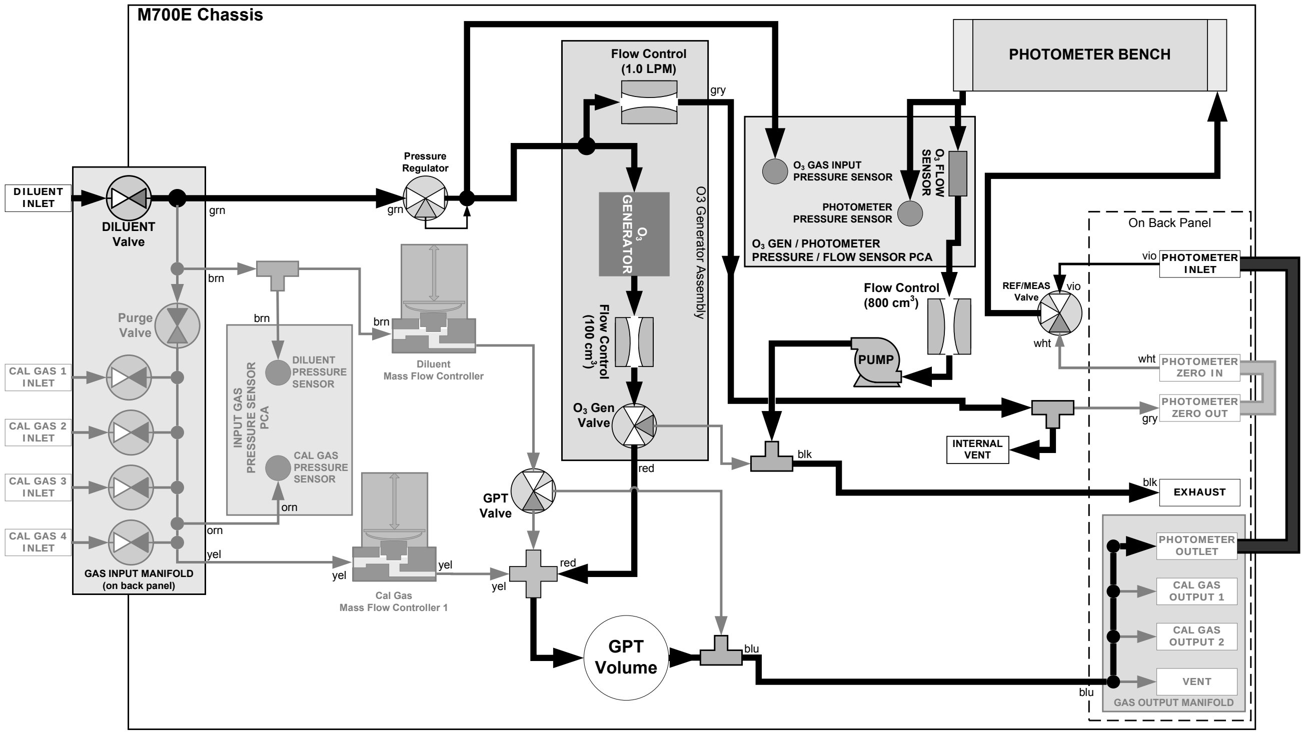


Figure 9-18: O_3 Photometer Gas Flow – Measure Cycle

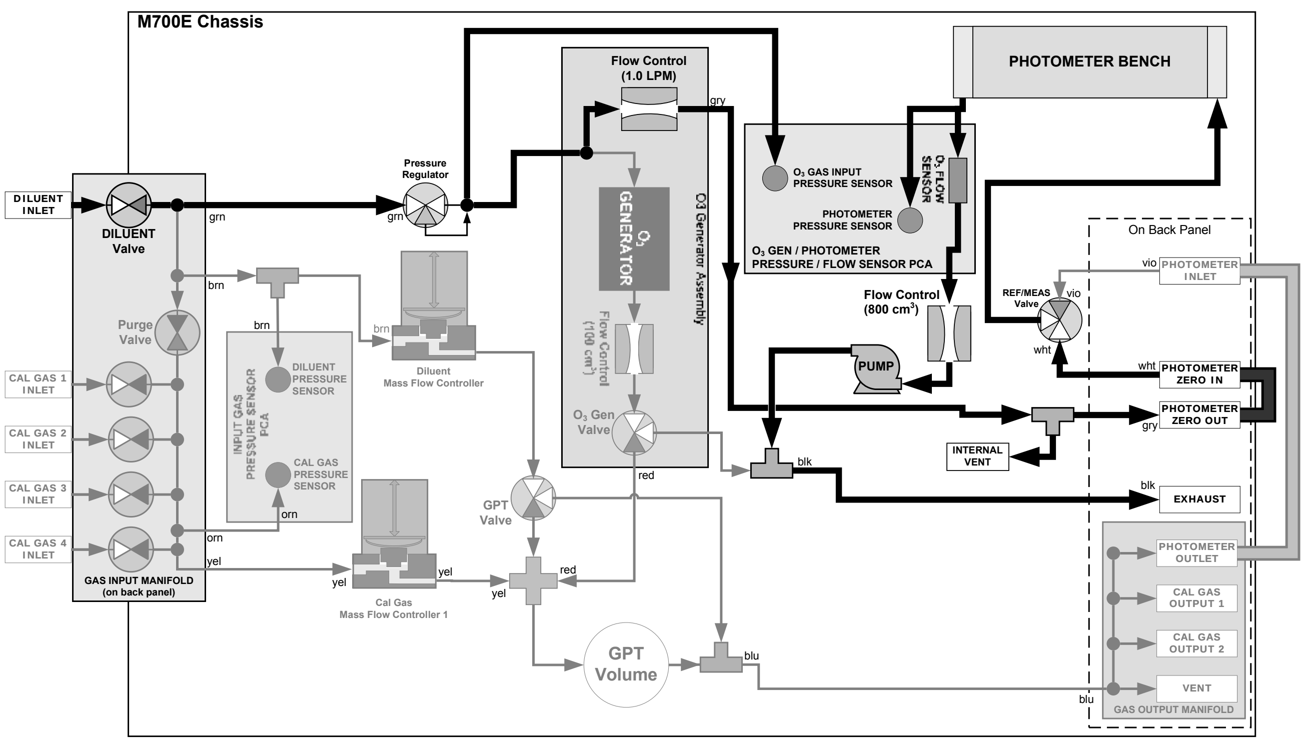


Figure 9-19: O_3 Photometer Gas Flow – Reference Cycle

9.7.1.3. The Absorption Path

In the most basic terms, the M700E photometer uses a high energy, mercury vapor lamp to generate a beam of UV light. This beam passes through a window of material specifically chosen to be both non-reactive to O_3 and transparent to UV radiation at 254nm and into an absorption tube filled with sample gas.

Because ozone is a very efficient absorber of UV radiation the absorption path length required to create a measurable decrease in UV intensity is short enough (approximately 42 cm) that the light beam is only required to make one pass through the Absorption Tube. Therefore, no complex mirror system is needed to lengthen the effective path by bouncing the beam back and forth.

Finally, the UV passes through a similar window at the other end of the absorption tube and is detected by a specially designed vacuum diode that only detects radiation at or very near a wavelength of 254nm. The specificity of the detector is high enough that no extra optical filtering of the UV light is needed.

The detector reacts to the UV light and outputs a current signal that varies in direct relationship with the intensity of the light shining on it. This current signal is amplified and converted to a 0 to 5 VDC voltage analog signal voltage sent to the instrument's motherboard where it is digitized. The CPU to be uses this digital data in computing the concentration of O_3 in the absorption tube.

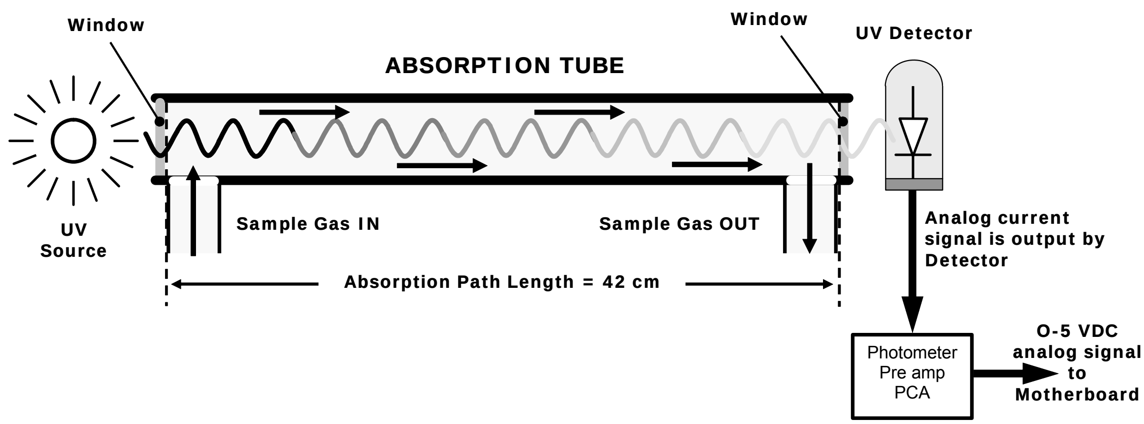


Figure 9-20: O_3 Photometer Absorption Path

9.7.1.4. Interferent Rejection

It should be noted that the UV absorption method for detecting ozone is subject to interference from a number of sources. The M700E's photometer has been successfully tested for its ability to reject interference from sulfur dioxide, nitrogen dioxide, nitric oxide, water, and meta-xylene.

While the photometer rejects interference from the aromatic hydrocarbon meta-xylene, it should be noted that there are a very large number of volatile aromatic hydrocarbons that could potentially interfere with ozone detection. If the M700E calibrator is installed in an environment where high aromatic hydrocarbon concentrations are suspected, specific tests should be conducted to reveal the amount of interference these compounds may be causing.

9.7.2. PHOTOMETER LAYOUT

The photometer is where the absorption of UV light by ozone is measured and converted into a voltage. It consists of several sub-assemblies:

- A mercury-vapor UV lamp. This lamp is coated in a material that optically screens the UV radiation output to remove the O_3 producing 185nm radiation. Only light at 254nm is emitted.
- An AC power supply to supply the current for starting and maintaining the plasma arc of the mercury vapor lamp.
- A thermistor and DC heater attached to the UV Lamp to maintain the Lamp at an optimum operating temperature.
- 42 cm long quartz absorption tube.
- A thermistor attached to the quartz tube for measuring sample gas temperature.
- Gas inlet and outlet mounting blocks that route sample gas into and out of the photometer.
- The vacuum diode, UV detector that converts UV light to a DC current.
- A preamplifier assembly, which convert the Detector's current output into a DC Voltage then amplifies it to a level readable by the A-to-D converter circuitry of the instrument's motherboard.

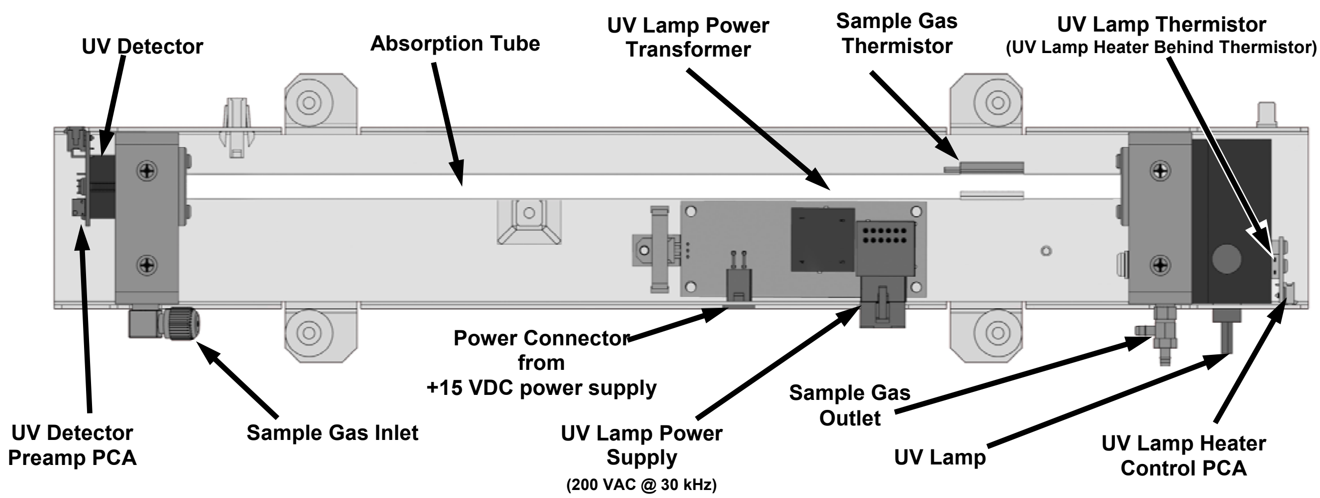


Figure 9-21: O_3 Photometer Layout – Top Cover Removed

9.7.3. PHOTOMETER PNEUMATIC OPERATION

The flow of gas through the photometer is created by a small internal pump that pulls air though the instrument. There are several advantages to this "pull through" configuration. Placing the pump down stream from the absorption tube avoids problems caused by the pumping process heating and compressing the sample.

In order to measure the presence of low concentrations of O_3 in the sample air, it is necessary to establish and maintain a relatively constant and stable volumetric flow of sample gas through the photometer. The simplest way to accomplish this is by placing a flow control assembly containing a critical flow orifice directly upstream of the pump but down stream from the absorption tube.

The critical flow orifice installed in the pump supply line is tuned to create a flow of 800 cm^3/min. A pressure sensor and a flow sensor, located on the O_3 generator/photometer pressure flow sensor PCA, monitor the pressure and flow rate of the gas passing through the photometers absorption tube.

See Figure 9-18 and Figure 9-19 for depictions of the airflow related to the photometer.

9.7.4. PHOTOMETER ELECTRONIC OPERATION

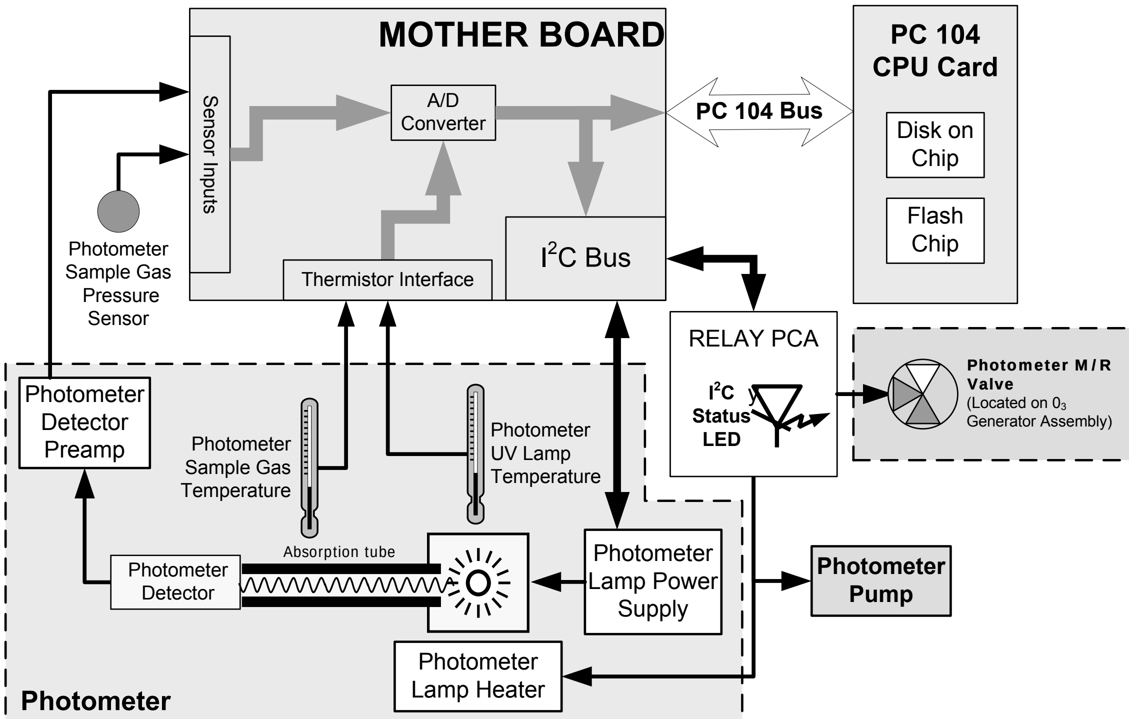


Figure 9-22: O_3 Photometer Electronic Block Diagram

Like the O_3 generator, the O_3 photometer and its subcomponents act as peripheral devices operated by the CPU via the motherboard. Communications to and from the CPU are handled by the motherboard.

Outgoing commands for the various devices such as the photometer pump, the UV lamp power supply, or the UV Lamp heater are issued via the I^2C bus to circuitry on the relay PCA which turns them ON/OFF. The CPU also issues commands over the I^2C bus that cause the relay PCA to cycle the measure/reference valve back and forth.

Incoming data from the UV light detector is amplified locally then converted to digital information by the motherboard. Output from the photometers temperature sensors is also amplified and converted to digital data by the motherboard. The O_3 concentration of the sample gas is computed by the CPU using this data (along with gas pressure and flow data received from the M700E's pressure sensors.

9.7.4.1. O_3 Photometer Temperature Control

In order to operate at peak efficiency the UV lamp of the M700E's O_3 photometer is maintained at a constant 58ºC. This is intentionally set at a temperature higher than the ambient temperature of the M700E's operating environment to ensure that local changes in temperature do not affect the UV Lamp. If the lamp temperature falls below 56ºC or rises above 61ºC a warning is issued by the calibrators CPU.

This temperature is controlled as described in the section on the relay PCA (Section 9.3.3.2).

The following TEST functions report these temperatures and are viewable from the instrument's front panel:

- **PHOTOLTEMP** - The temperature of the UV Lamp reported in ºC.
- **PHOTOSTEMP** - The temperature of the Sample gas in the absorption tube reported in ºC.

9.7.4.2. Pneumatic Sensors for the O_3 Photometer

The sensors located on the pneumatic sensor just to the left rear of the O_3 generator assembly measure the absolute pressure and the flow rate of gas inside the photometer's absorption tube. This information is used by the CPU to calculate the O_3 concentration of the sample gas (See Equation 9-7). Both of these measurements are made downstream from the absorption tube but upstream of the pump. A critical flow orifice located between the flow sensor and the pump maintains the gas flow through the photometer at 800 cm^3/min.

The following TEST functions are viewable from the instrument's front panel:

- **PHOTOFLOW** - The flow rate of gas through the photometer measured in LPM.
- **PHOTOSPRESS** – the pressure of the gas inside the absorption tube. This pressure is reported in inches of mercury-absolute (**in-Hg-A**), i.e. referenced to a vacuum (zero absolute pressure). This is not the same as **PSIG.**

USER NOTES:

10. MAINTENANCE SCHEDULE & PROCEDURES

Predictive diagnostic functions including failure warnings and alarms built into the calibrator's firmware allow the user to determine when repairs are necessary without performing painstaking preventative maintenance procedures.

For the most part, the M700E calibrator is maintenance free, there are, however, a minimal number of simple procedures that when performed regularly will ensure that the M700E photometer continues to operate accurately and reliably over its lifetime.

Repairs and troubleshooting are covered in Chapter 11 of this manual.

10.1. MAINTENANCE SCHEDULE

Table 10-1 shows a typical maintenance schedule for the M700E. Please note that in certain environments (i.e. dusty, very high ambient pollutant levels) some maintenance procedures may need to be performed more often than shown.

NOTE

If the instrument has the optional O_3 photometer installed, a Span and Zero Calibration Check must be performed on the photometer following some of the maintenance procedure listed below.

See Section 8.3 for instructions on performing checks.

	**CAUTION** **RISK OF ELECTRICAL SHOCK. DISCONNECT POWER BEFORE PERFORMING ANY OF THE FOLLOWING OPERATIONS THAT REQUIRE ENTRY INTO THE INTERIOR OF THE CALIBRATOR.**

	**CAUTION** **THE OPERATIONS OUTLINED IN THIS CHAPTER ARE TO BE PERFORMED BY QUALIFIED MAINTENANCE PERSONNEL ONLY.**

Table 10-1: M700E Maintenance Schedule

Item	Action	Freq	Cal Check Req'd.[1]	Manual Section	Date Performed									
Verify Test Functions	Record and analyze	Weekly or after any Maintenance or Repair	No											
Pump Diaphragm[1]	**No Replacement Required. Under Normal Circumstances this Pump Will Last the Lifetime of the Instrument.**													
Absorption Tube[1]	Inspect - - - Clean	As Needed	Yes after cleaning	10.2.2	**Cleaning of the Photometer Absorption Tube Should Not Be Required as long as ONLY CLEAN, DRY, PARTICULATE FREE Zero Air (Diluent Gas) is used with the M700E Calibrator**									
Perform Flow Check	Verify Flow of MFC's	Annually or any time the M700E's internal DAC is recalibrated	No	8.1 & 8.2										
Perform Leak Check	Verify Leak Tight	Annually or after any Maintenance or Repair	Yes	10.2.1										
Pneumatic lines	Examine and clean	As needed	Yes if cleaned	- - -										

[1] Only applies to M700E Calibrator's with O_3 photometer options installed.

10.2. MAINTENANCE PROCEDURES

The following procedures are to be performed periodically as part of the standard maintenance of the M700E calibrator.

10.2.1. AUTO LEAK CHECK

10.2.1.1. Equipment Required

- Four (4) 1/4" Pneumatic caps.
- One (1) 1/8" Pneumatic Cap
- One (1) # 6 hexagonal Driver/Wrench
- One (1) Pneumatic "T" fitting

10.2.1.2. Setup Auto Leak Check

To perform a leak-check on the M700E calibrator:

1. Remove the cover from the calibrator.
2. On Instruments with the optional O_3 photometer installed, the photometer flow sensor PCA and pump must be bypassed:
   - Using a #6 nut driver, remove the hexagonal nut located at the top of the gas outlet of the photometer (see Figure 10-1).
   - Using a #6 nut driver, remove the hexagonal nut located on the fitting on the back side of the Flow/Pressure sensor board (see Figure 10-1).
   - Connect the end of the line removed from the Sensor PCA in Step 3 to the Photometer Outlet Fitting.

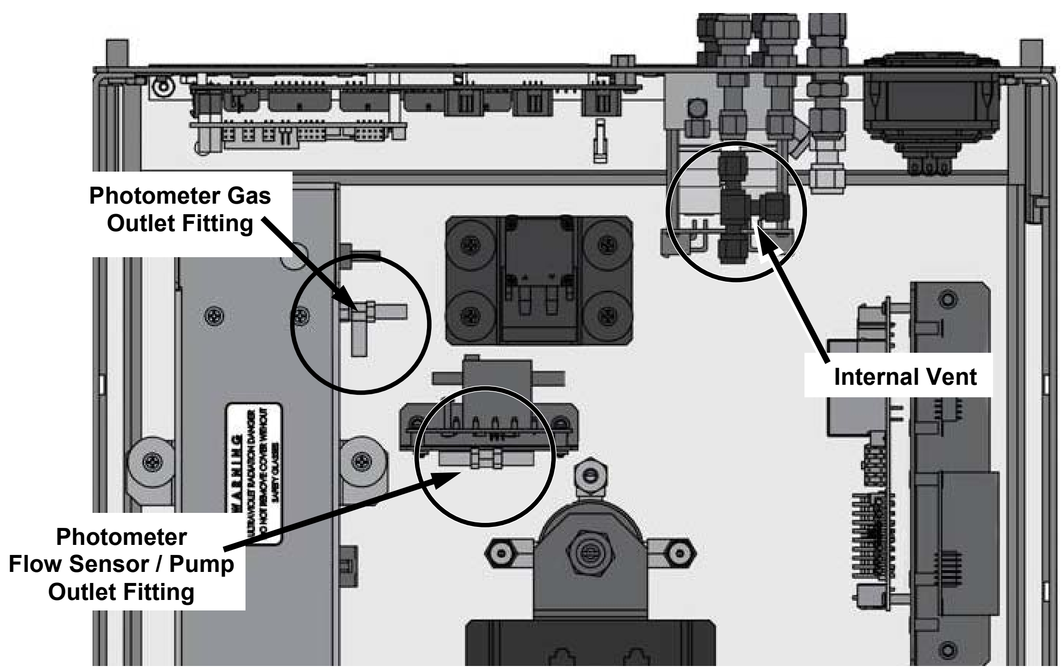


Figure 10-1: Bypassing the Photometer Sensor PCA and Pump

3. Using the 1/8" cap, securely cover the outlet of the internal vent located just behind the valve relay PCA (see Figure 10-1).
4. Use the 1/4" caps to cover the following gas outlet ports on the back of the M700E (see Figure 10-2).
   - Exhaust (Only required for calibrators with O_3 generators install).
   - Both Cal Gas 1 outlet ports.
   - The Vent port.

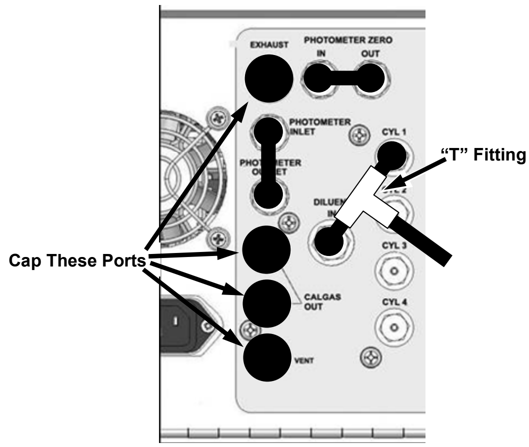


Figure 10-2: Gas Port Setup for Auto-Leak Check Procedure

5. If a bottle of source gas is connected to the CYL 1 port, remove it.

NOTE

Ensure that the gas outlet of the bottle is CLOSED before disconnecting the gas line from the CYL 1 port.

6. Connect a gas line from the zero air gas source to the DILUENT IN and to the CYL 1 port using a "T" type pneumatic fitting (see Figure 10-2).

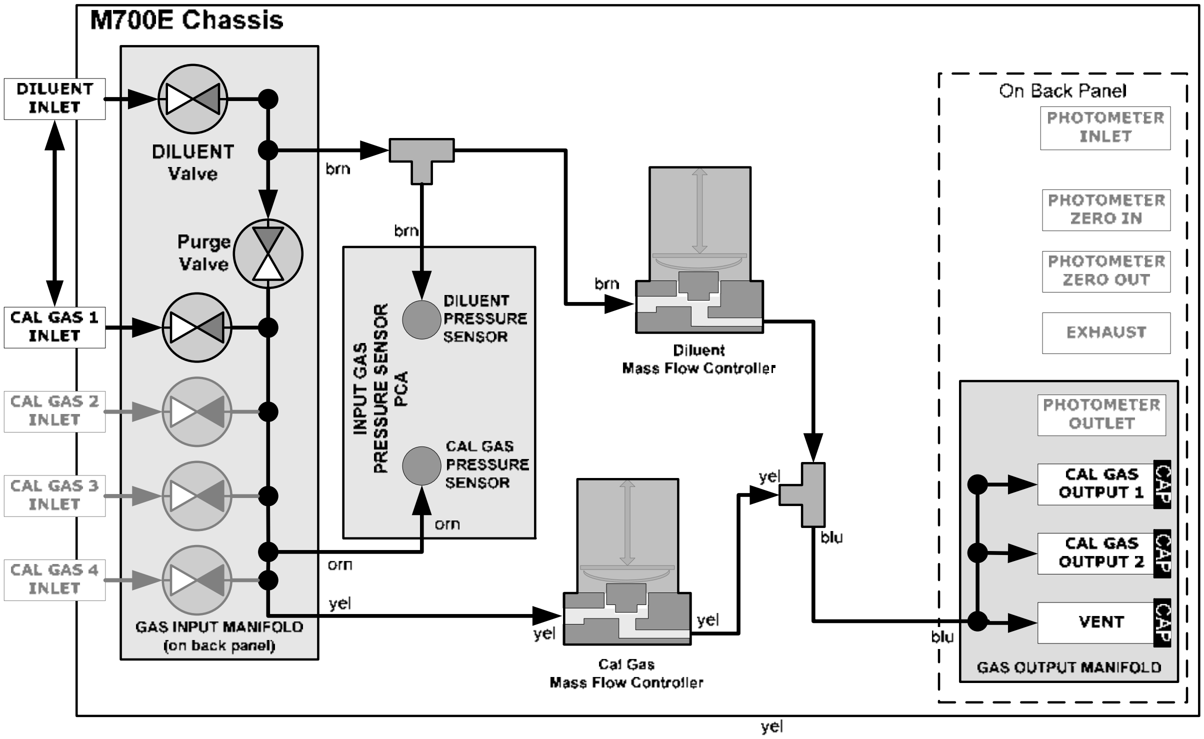


Figure 10-3: Gas Flow for Auto-Leak Check Procedure of Base Model M700E's

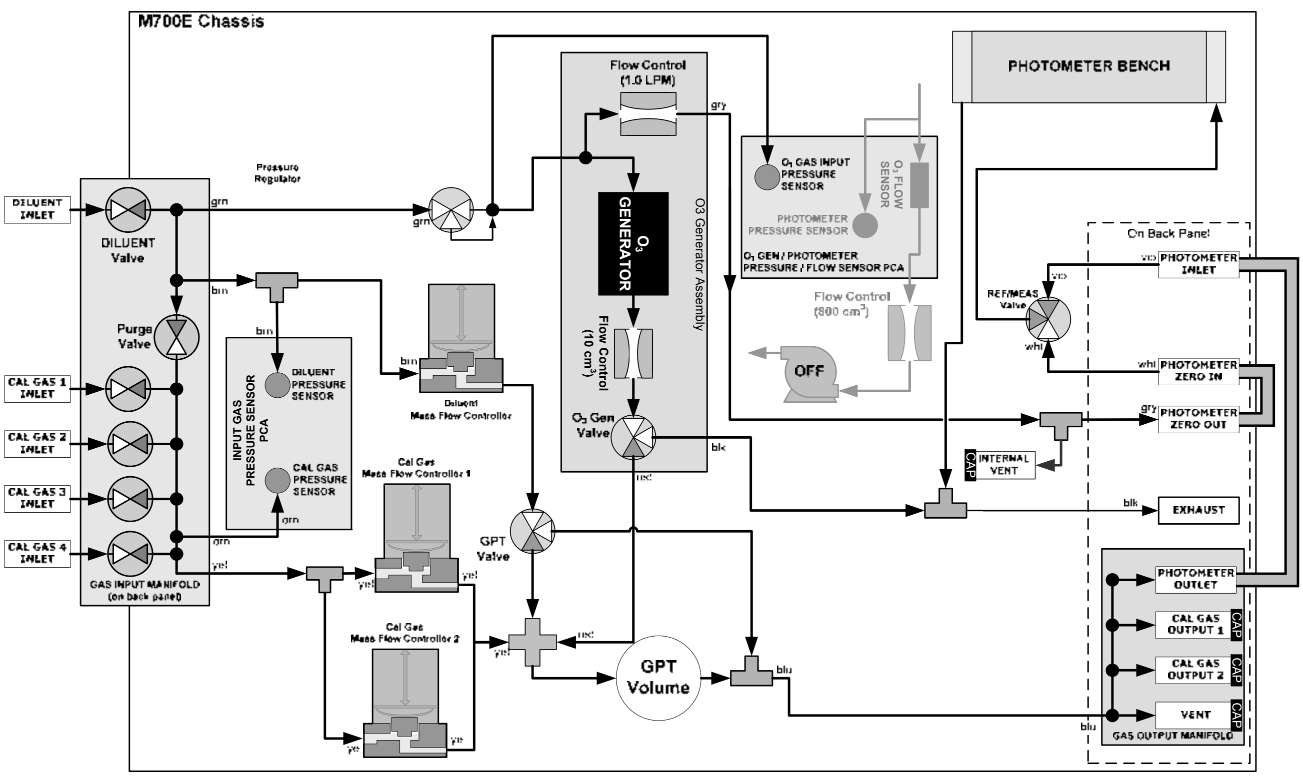
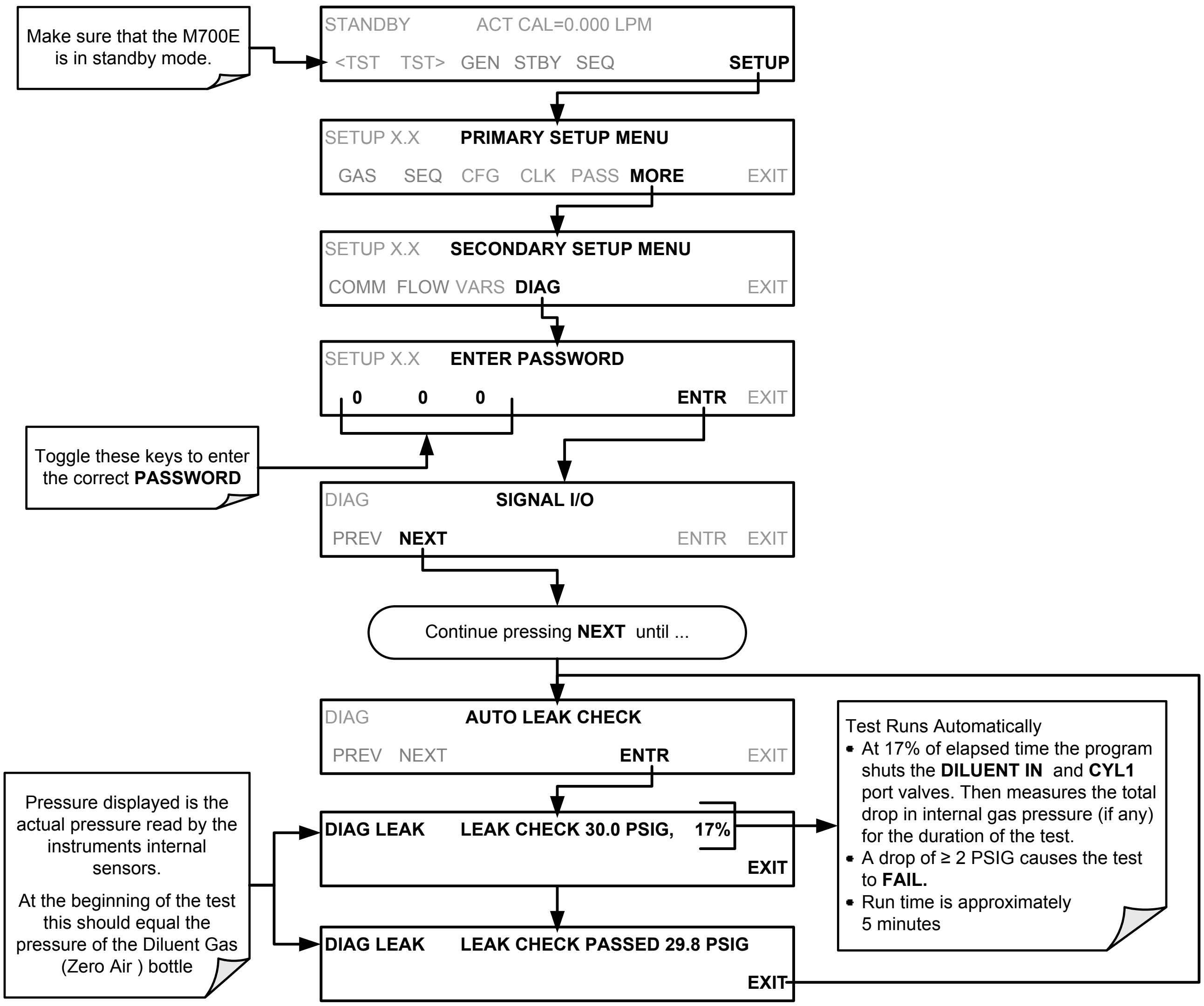


Figure 10-4: Gas Flow for Auto-Leak Check Procedure of M700E's with Optional Photometer

10.2.1.3. Performing the Auto Leak Check Procedure

To perform an **AUTO LEAK CHECK**, press:



10.2.1.4. Returning the M700E to Service after Performing an Auto Leak Check

1. Remove all of the caps from the EXHAUST, CAL GAS OUTPUTS (2) and the VENT port and from the internal vent.
2. On instruments with an optional O_3 photometer, reconnect the internal gas lines so that the Sensor PCA and pump are functional.
3. Remove the tee from the DILUENT IN and CYL 1.
4. Reconnect the ZERO AIR SOURCE to the DILUENT IN.
5. Reconnect Cal Gas bottle to CYL 1 and open the bottles outlet port.
6. Replace the calibrator's top cover.
7. The calibrator is now ready to be used.

10.2.2. CLEANING OR REPLACING THE ABSORPTION TUBE

NOTE

Although this procedure should never be needed as long as the user is careful to supply the photometer with clean, dry and particulate free zero air only, it is included here for those rare occasions when cleaning or replacing the absorption tube may be required.

1. Remove the center cover from the optical bench.
2. Unclip the sample thermistor from the tube.
3. Loosen the two screws on the round tube retainers at either end of the tube.
4. Using both hands, carefully rotate the tube to free it.
5. Slide the tube towards the lamp housing.
   - The front of the tube can now be slid past the detector block and out of the instrument.

CAUTION

**DO NOT CAUSE THE TUBE TO BIND AGAINST THE METAL HOUSINGS.
THE TUBE MAY BREAK AND CAUSE SERIOUS INJURY.**

6. Clean the tube by rinsing with de-ionized water.
7. Air dry the tube.
8. Check the cleaning job by looking down the bore of the tube.
   - It should be free from dirt and lint.
9. Inspect the o-rings that seal the ends of the optical tube (these o-rings may stay seated in the manifolds when the tube is removed).
   - If there is any noticeable damage to these o-rings, they should be replaced.
10. Re-assemble the tube into the lamp housing and perform an **AUTO LEAK CHECK** on the instrument.

NOTE

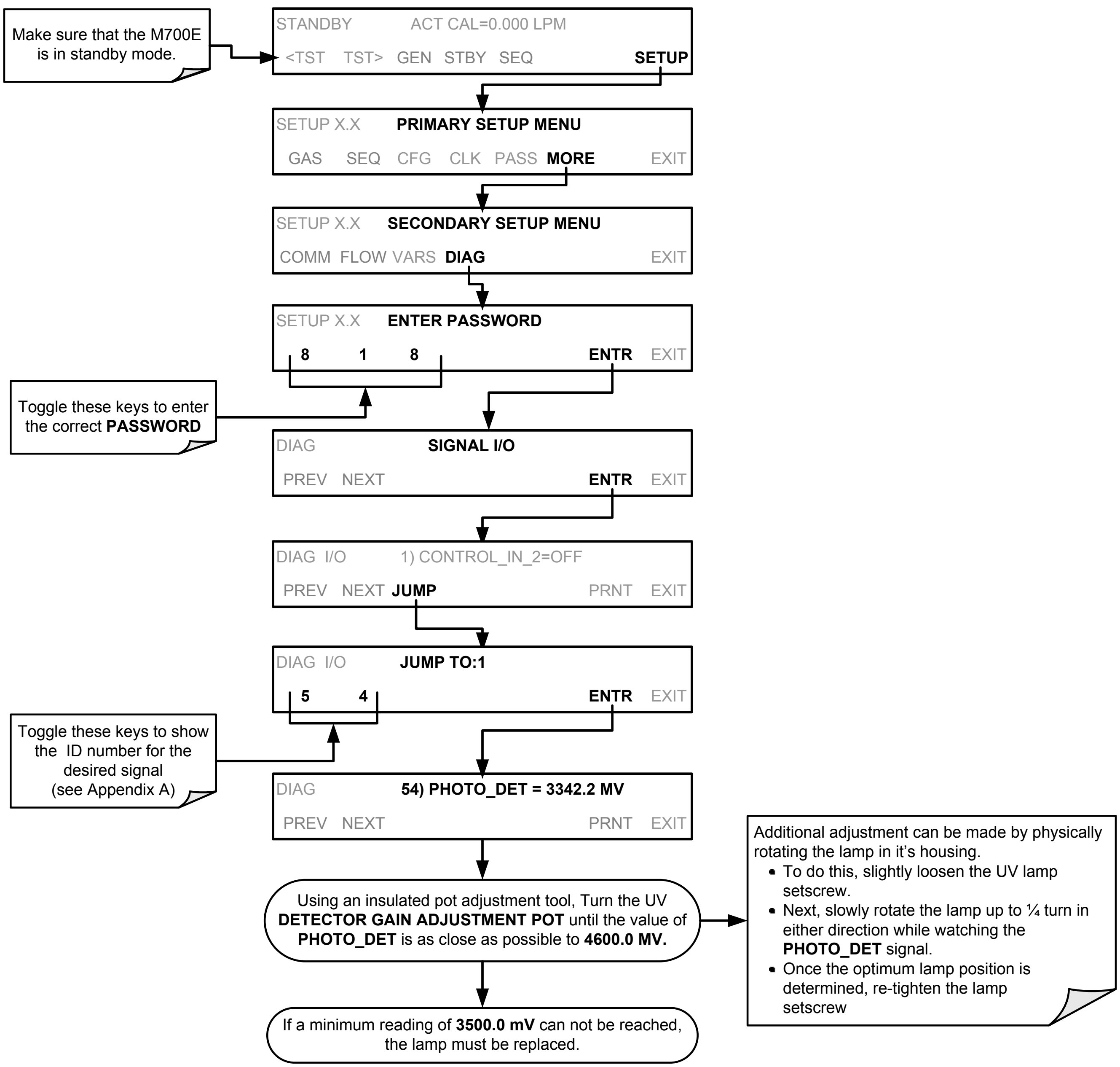
It is important for proper optical alignment that the tube be pushed all the way towards the front of the optical bench when it is reassembled prior to gently retightening the tube retainer screws.

This will ensure that the tube is assembled with the forward end against the stop inside the detector manifold.

10.2.3. UV SOURCE LAMP ADJUSTMENT

This procedure provides in detail the steps for adjustment of the UV source lamp in the optical bench assembly. This procedure should be done whenever the **PHOTO REFERENCE** test function value drops below 3000 mV.

1. Ensure that the calibrator is warmed-up and has been running for at least 30 minutes before proceeding.
2. Remove the cover from the calibrator.
3. Locate the optional Photometer (see Figure 3-4).
4. Locate the **UV DETECTOR GAIN ADJUST POT** on the photometer assembly (see Figure 10-5).
5. Perform the following procedure:



6. Replace the cover on the calibrator.

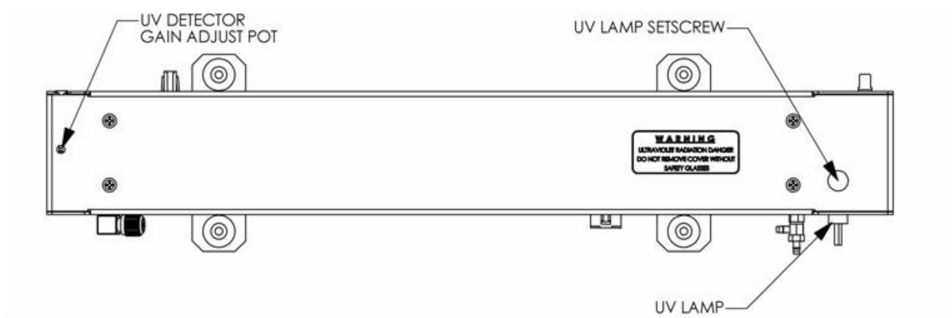


Figure 10-5: Photometer Assembly – Lamp Adjustment / Installation

10.2.4. UV SOURCE LAMP REPLACEMENT

This procedure details the steps for replacement of the UV source lamp in the optical bench assembly. This procedure should be done whenever the lamp can no longer be adjusted as described in Section 10.2.3.

1. Turn the calibrator off.
2. Remove the cover from the calibrator.
3. Locate the Optical Bench Assembly (see Figure 3-4).
4. Locate the UV lamp at the front of the optical bench assembly (see Figure 10-5).
5. Unplug the lamp cable from the power supply connector on the side of the optical bench.
6. Slightly loosen (do not remove) the UV lamp setscrew and pull the lamp from its housing.
7. Install the new lamp in the housing, pushing it all the way in. Leave the UV lamp setscrew loose for now.
8. Turn the calibrator back on and allow it to warm up for at least 30 minutes.
9. Turn the UV detector gain adjustment pot (See Figure 10-5) clockwise to its minimum value. The pot may click softly when the limit is reached.
10. Perform the UV Lamp Adjustment procedure described in Section 10.2.3, with the following exceptions:
    a) Slowly rotate the lamp in its housing (up to ¼ turn in either direction) until a **MINIMUM** value is observed.
        - Ensure the lamp is pushed all the way into the housing while performing this rotation.
        - If the PHOTO_DET will not drop below 5000 mV while performing this rotation, contact Teledyne API'S Customer Service for assistance.

    b) Once a lamp position is found that corresponds to a minimum observed value for **PHOTO_DET**, tighten the lamp setscrew at the approximate minimum value observed.
    c) Adjust PHOTO_DET within the range of 4400 – 4600 mV.
11. Replace the cover on the calibrator.

NOTE

The UV lamp contains mercury (Hg), which is considered hazardous waste. The lamp should be disposed of in accordance with local regulations regarding waste containing mercury.

10.2.5. ADJUSTMENT OR REPLACEMENT OF OZONE GENERATOR UV LAMP

This procedure details the steps for replacement and initial adjustment of the ozone generator lamp. If you are adjusting an existing lamp, skip to Step 8.

1. Turn off the calibrator.
2. Remove the cover from the calibrator.
3. Locate the O_3 generator (see Figure 3-4).

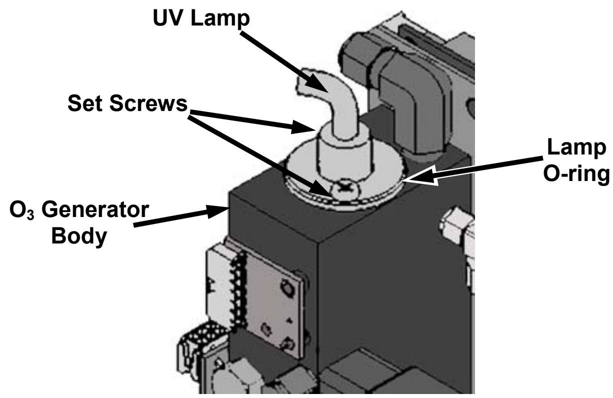


Figure 10-6: O_3 Generator Temperature Thermistor and DC Heater Locations

4. Remove the two setscrews on the top of the O_3 generator and gently pull out the old lamp.
5. Inspect the o-ring beneath the nut and replace if damaged.
6. Install the new lamp in O_3 generator housing.
   - Do not fully tighten the setscrews.
   - The lamp should be able to be rotated in the assembly by grasping the lamp cable.
7. Turn on calibrator and allow it to stabilize for at least 30 minutes.
8. Locate the potentiometer used to adjust the O_3 generator UV output.

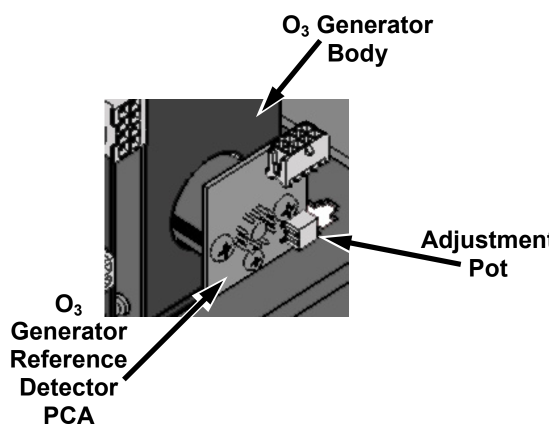
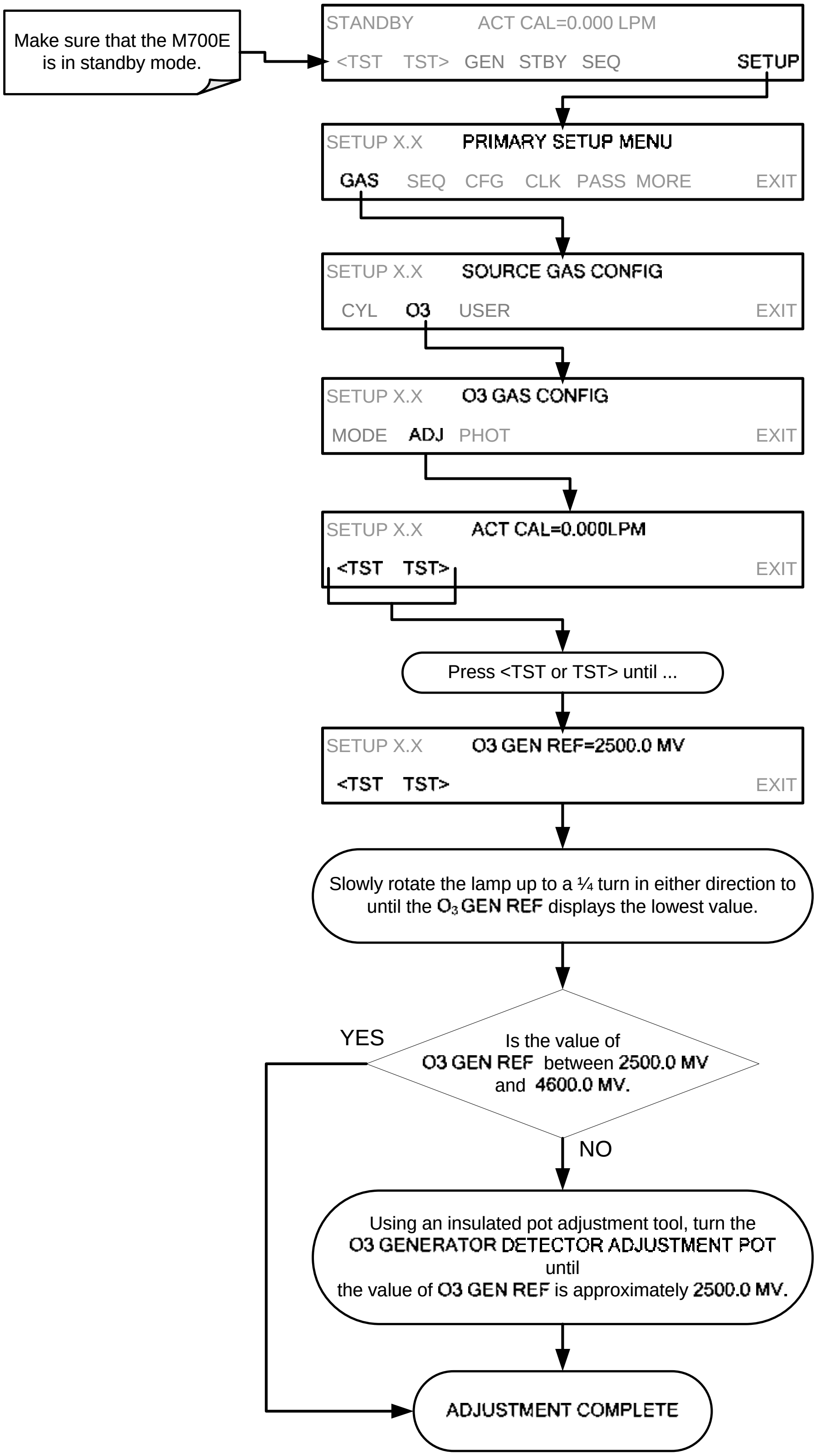


Figure 10-7: Location of O_3 Generator Reference Detector Adjustment Pot

9. Perform the following procedure:



10. Tighten the two setscrews.

11. Replace the calibrator's cover.
12. Perform an auto-leak check (See Section 10.2.1).
13. Perform an Ozone Generator calibration (see Section 8.4).

USER NOTES:

11. GENERAL TROUBLESHOOTING & REPAIR OF THE M700E CALIBRATOR

This section contains a variety of methods for identifying and solving performance problems with the calibrator.

NOTE

The operations outlined in this chapter must be performed by qualified maintenance personnel only.

CAUTION

- **Risk of electrical shock. Some operations need to be carried out with the instrument open and running.**
- **Exercise caution to avoid electrical shocks and electrostatic or mechanical damage to the calibrator.**
- **Do not drop tools into the calibrator or leave those after your procedures.**
- **Do not shorten or touch electric connections with metallic tools while operating inside the calibrator.**
- **Use common sense when operating inside a running calibrator.**

11.1. GENERAL TROUBLESHOOTING

The M700E Dynamic Dilution Calibrator has been designed so that problems can be rapidly detected, evaluated and repaired. During operation, it continuously performs diagnostic tests and provides the ability to evaluate its key operating parameters without disturbing monitoring operations.

A systematic approach to troubleshooting will generally consist of the following five steps:

1. Note any warning messages and take corrective action as necessary.
2. Examine the values of all TEST functions and compare them to factory values. Note any major deviations from the factory values and take corrective action.
3. Use the internal electronic status LEDs to determine whether the electronic communication channels are operating properly.
   - Verify that the DC power supplies are operating properly by checking the voltage test points on the relay PCA.
   - Note that the calibrator's DC power wiring is color-coded and these colors match the color of the corresponding test points on the relay PCA.
4. Follow the procedures defined in Section 3.3.4 to confirm that the calibrator's vital functions are working (power supplies, CPU, relay PCA, keyboard, etc.).
   - See Figure 3-3 and Figure 3-4 for general layout of components and sub-assemblies in the calibrator.
   - See the wiring interconnect diagram and interconnect list in Appendix D.

11.1.1. FAULT DIAGNOSIS WITH WARNING MESSAGES

The most common and/or serious instrument failures will result in a warning message being displayed on the front panel. Table 11-1 lists warning messages, along with their meaning and recommended corrective action.

It should be noted that if more than two or three warning messages occur at the same time, it is often an indication that some fundamental sub-system (power supply, relay PCA, motherboard) has failed rather than indication of the specific failures referenced by the warnings. In this case, it is recommended that proper operation of power supplies (See Section 11.4.3), the relay PCA (See Section 11.4.6), and the motherboard (See Section11.4.10) be confirmed before addressing the specific warning messages.

The M700E will alert the user that a Warning Message is active by displaying the keypad label MSG on the Front Panel. In this case, the Front panel display will look something like the following:

The calibrator will also alert the user via the Serial I/O COMM port(s) and cause the FAULT LED on the front panel to blink.

To view or clear the various warning messages press:

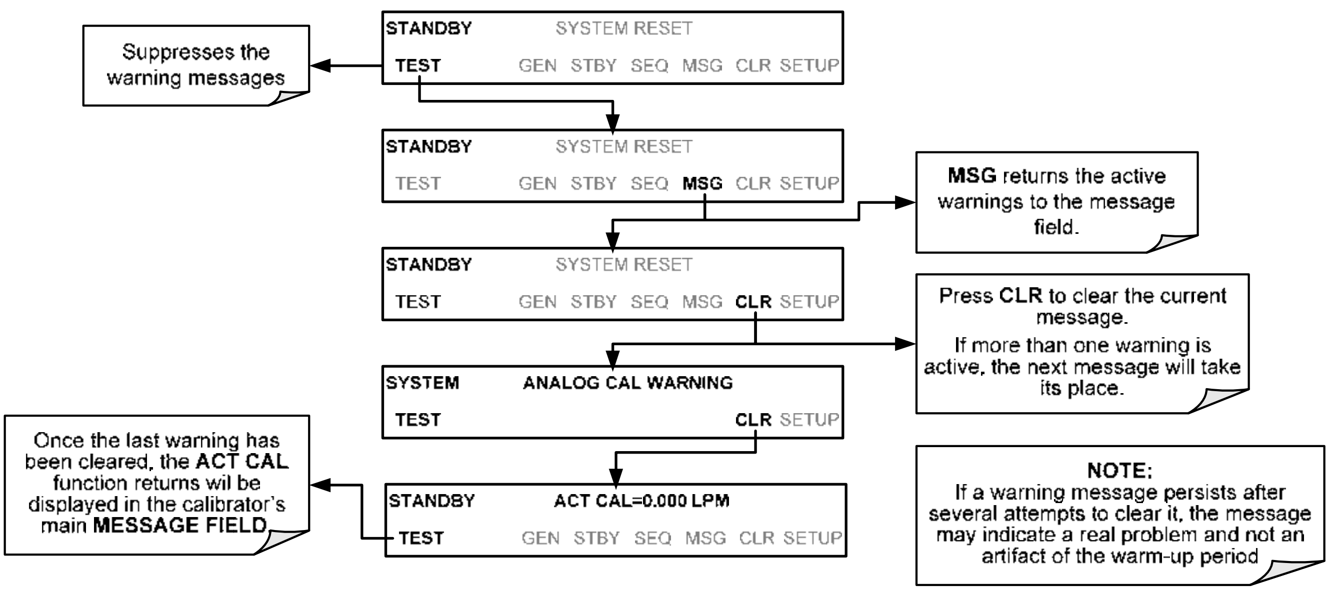


Table 11-1: Front Panel Warning Messages

WARNING	FAULT CONDITION	POSSIBLE CAUSES
CONFIG INITIALIZED	Configuration and Calibration data reset to original Factory state.	- Failed Disk-on-Chip - User has erased configuration data
DATA INITIALIZED	Data Storage in iDAS was erased.	- Failed Disk-on-Chip. - User cleared data.
FRONT PANEL WARN	The CPU is unable to Communicate with the Front Panel Display Keyboard	- *WARNING* only appears on Serial I/O COMM Port(s) - Front Panel Display will be frozen, blank or will not respond. - Failed Keyboard - I^2C Bus failure - Loose Connector/Wiring
LAMP DRIVER WARN[1, 2]	The CPU is unable to communicate with either the O_3 generator or photometer lamp I^2C driver chip.	- I^2C has failed
MFC COMMUNICATION WARNING	Firmware is unable to communicate with any MFC.	- I^2C has failed - One of the MFC's has failed - Cabling loose or broken between MFC and Motherboard
MFC PRESSURE WARNING	One of the calibrator's mass flow controllers internal gas pressure is <15 PSIG or > 36 PSIG	- Zero or source air supply is incorrectly set up or improperly vented. - Leak or blockage exists in the M700E's internal pneumatics - Failed CAL GAS or DUILUENT pressure sensor
O3 GEN LAMP TEMP WARNING[1]	IZS Ozone Generator Temp is outside of control range of 48°C ± 3°C.	- No IZS option installed, instrument improperly configured - O_3 generator heater - O_3 generator temperature sensor - Relay controlling the O_3 generator heater - Entire Relay PCA - I^2C Bus
O3 GEN REFERENCE WARNING[1]	The O_3 generator's reference detector output has dropped below 50 mV.[1]	Possible failure of: - O_3 generator UV Lamp - O_3 generator reference detector - O_3 generator lamp power supply - I^2C bus
O3 PUMP WARNING[1]	The photometer pump failed to turn on within the specified timeout period (default = 30 sec.).	- Failed Pump - Problem with Relay PCA - 12 VDC power supply problem
PHOTO LAMP TEMP WARNING[2]	The photometer lamp temp is < 51°C or >61°C.	Possible failure of: - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Relay PCA - I^2C Bus - Hot Lamp

(table continued)

Table 11-1: Front Panel Warning Messages (cont.)

WARNING	FAULT CONDITION	POSSIBLE CAUSES
PHOTO LAMP STABILITY WARNING	Value output during the Photometer's reference cycle changes from measurements to measurement more than 25% of the time.	- Faulty UV source lamp - Noisy UV detector - Faulty UV lamp power supply - Faulty ± 15 VDC power supply
PHOTO REFERENCE WARNING[2]	Occurs when Ref is <2500 mVDC or >4950 mVDC.	Possible failure of: - UV Lamp - UV Photo-Detector Preamp
REAR BOARD NOT DET	Mother Board not detected on power up.	- THIS WARNING only appears on Serial I/O COMM Port(s) Front Panel Display will be frozen, blank or will not respond. - Failure of Mother Board
REGULATOR PRESSURE WARNING	Regulator pressure is > 15 PSIG or > 25 PSIG.	- Zero or source air supply is incorrectly set up or improperly vented. - Incorrectly adjusted O_3 zero air pressure regulator - Leak or blockage exists in the M700E's internal pneumatics - Failed O_3 Generator Input pressure sensor
RELAY BOARD WARN	The CPU cannot communicate with the Relay PCA.	- I^2C Bus failure - Failed relay PCA - Loose connectors/wiring
SYSTEM RESET	The computer has rebooted.	- This message occurs at power on. - If it is confirmed that power has not been interrupted - Failed +5 VDC power - Fatal error caused software to restart - Loose connector/wiring
VALVE BOARD WARN	The CPU is unable to communicate with the valve board.	- I^2C Bus failure - Failed valve driver PCA - Loose connectors/wiring

[1] Only applicable for calibrators with the optional the O_3 generator installed.

[2] Only applicable for calibrators with the optional photometer installed.

[3] On instrument with multiple Cal Gas MFC's installed, the **MFC FLOW WARNING** occurs when the flow rate requested is <10% of the range of the lowest rated MFC (i.e. all of the cal gas MFC are turned off).

11.1.2. FAULT DIAGNOSIS WITH TEST FUNCTIONS

Besides being useful as predictive diagnostic tools, the test functions viewable from the calibrators front panel can be used to isolate and identify many operational problems when combined with a thorough understanding of the calibrators Theory of Operation (see Chapter 9).

The acceptable ranges for these test functions are listed in the "Nominal Range" column of the calibrator Final Test and Validation Data Sheet shipped with the instrument. Values outside these acceptable ranges indicate a failure of one or more of the calibrator's subsystems. Functions whose values are still within acceptable ranges but have significantly changed from the measurement recorded on the factory data sheet may also indicate a failure.

A worksheet has been provided in Appendix C to assist in recording the value of these Test Functions.

Table 11-2 contains some of the more common causes for these values to be out of range.

Table 11-2: Test Functions – Indicated Failures

TEST FUNCTION	DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS.
O3 GEN REF[1]	Particularly important in calibrators without the optional O_3 photometer since the reference detector is the primary input for controlling O_3 concentration. Possible causes of faults are the same as **O3 GEN REFERENCE WARNING** from Table 11-1.
O3 FLOW[1]	Gas flow problems directly affect the concentration accuracy of the M700E's calibration gas mixtures. - Check for Gas Flow problems.
O3 GEN DRIVE[1]	Check the O_3 generator heater and temperature sensors. Possible causes of faults are the same as **O3 GEN LAMP TEMP WARNING** from Table 11-1.
O3 LAMP TEMP[1]	Incorrect Lamp temperature can affect the efficiency and durability of the O_3 generators UV lamp. Possible causes of faults are the same as **O3 GEN LAMP TEMP WARNING** from Table 11-1.
CAL PRESSURE	Affects proper flow rate of Cal gas MFC's. Possible causes of faults are the same as **MFC PRESSURE WARNING** from Table 11-1.
DIL PRESSURE	Affects proper flow rate of Diluent gas MFC's. Possible causes of faults are the same as **MFC PRESSURE WARNING** from Table 11-1.
REG PRESSURE[2]	Same as **REGULATOR PRESSURE WARNING** from Table 11-1.
BOX TEMP	If the Box Temperature is out of range, ensure that the: Box Temperature typically runs ~7°C warmer than ambient temperature. - The Exhaust-Fan is running. - Ensure there is sufficient ventilation area to the side and rear of instrument to allow adequate ventilation.
PHOTO MEASURE[2] **&** **PHOTO REFERENCE**[2]	If the value displayed is too high the UV Source has become brighter. Adjust the variable gain potentiometer on the UV Preamp Board in the optical bench. If the value displayed is too low: - < 200mV – Bad UV lamp or UV lamp power supply. - < 2500mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. If the value displayed is constantly changing: - Bad UV lamp. - Defective UV lamp power supply. - Failed I^2C Bus. If the PHOTO REFERENCE value changes by more than 10mV between zero and span gas: - Defective/leaking switching valve.
PHOTO FLOW[2]	Gas flow problems directly affect the accuracy of the photometer measurements and therefore the concentration accuracy of cal gas mixtures involving O_3 and GPT mixtures. - Check for Gas Flow problems.
PHOTO LAMP TEMP[2]	Poor photometer temp control can cause instrument noise, stability and drift. Temperatures outside of the specified range or oscillating temperatures are cause for concern. Possible causes of faults are the same as **PHOTO LAMP TEMP WARNING from** Table 11-1.
PHOTO SPRESS[2]	The pressure of the gas in the photometer's sample chamber is used to calculate the concentration of O_3 in the gas stream. Incorrect sample pressure can cause inaccurate readings. - Check for Gas Flow problems. See Section Table 11-1.

(table continued)

Table 11-2: Test Functions - Indicated Failures (cont.)

TEST FUNCTION	DIAGNOSTIC RELEVANCE AND CAUSES OF FAULT CONDITIONS.
PHOTO STEMP[2]	The temperature of the gas in the photometer's sample chamber is used to calculate the concentration of O_3 in the gas stream. Incorrect sample temperature can cause inaccurate readings. Possible causes of faults are: - Bad bench lamp heater - Failed sample temperature sensor - Failed relay controlling the bench heater - Failed Relay PCA - I^2C Bus malfunction - Hot Lamp
PHOTO SLOPE[2]	Values outside range indicate: ▪ Contamination of the Zero Air or Span Gas supply. ▪ Instrument is miss-calibrated. ▪ Blocked Gas Flow. ▪ Faulty Sample Pressure Sensor or circuitry. ▪ Bad/incorrect Span Gas concentration.
PHOTO OFFSET[2]	Values outside range indicate: ▪ Contamination of the Zero Air supply.
TIME	Time of Day clock is too fast or slow. ▪ To adjust see Section 6.7. ▪ Battery in clock chip on CPU board may be dead.

[1] Only appears when the optional O_3 generator is installed.
[2] Only appears when the optional O_3 photometer is installed

11.1.3. USING THE DIAGNOSTIC SIGNAL I/O FUNCTION

The Signal I/O parameters found under the DIAG Menu combined with a thorough understanding of the instruments Theory of Operation (found in Chapter 9) are useful for troubleshooting in three ways:

- The technician can view the raw, unprocessed signal level of the calibrator's critical inputs and outputs.
- Many of the components and functions that are normally under algorithmic control of the CPU can be manually exercised.
- The technician can directly control the signal level Analog and Digital Output signals.

This allows the technician to observe systematically the effect of directly controlling these signals on the operation of the calibrator. Figure 11-1 is an example of how to use the Signal I/O menu to view the raw voltage of an input signal or to control the state of an output voltage or control signal. The specific parameter will vary depending on the situation.

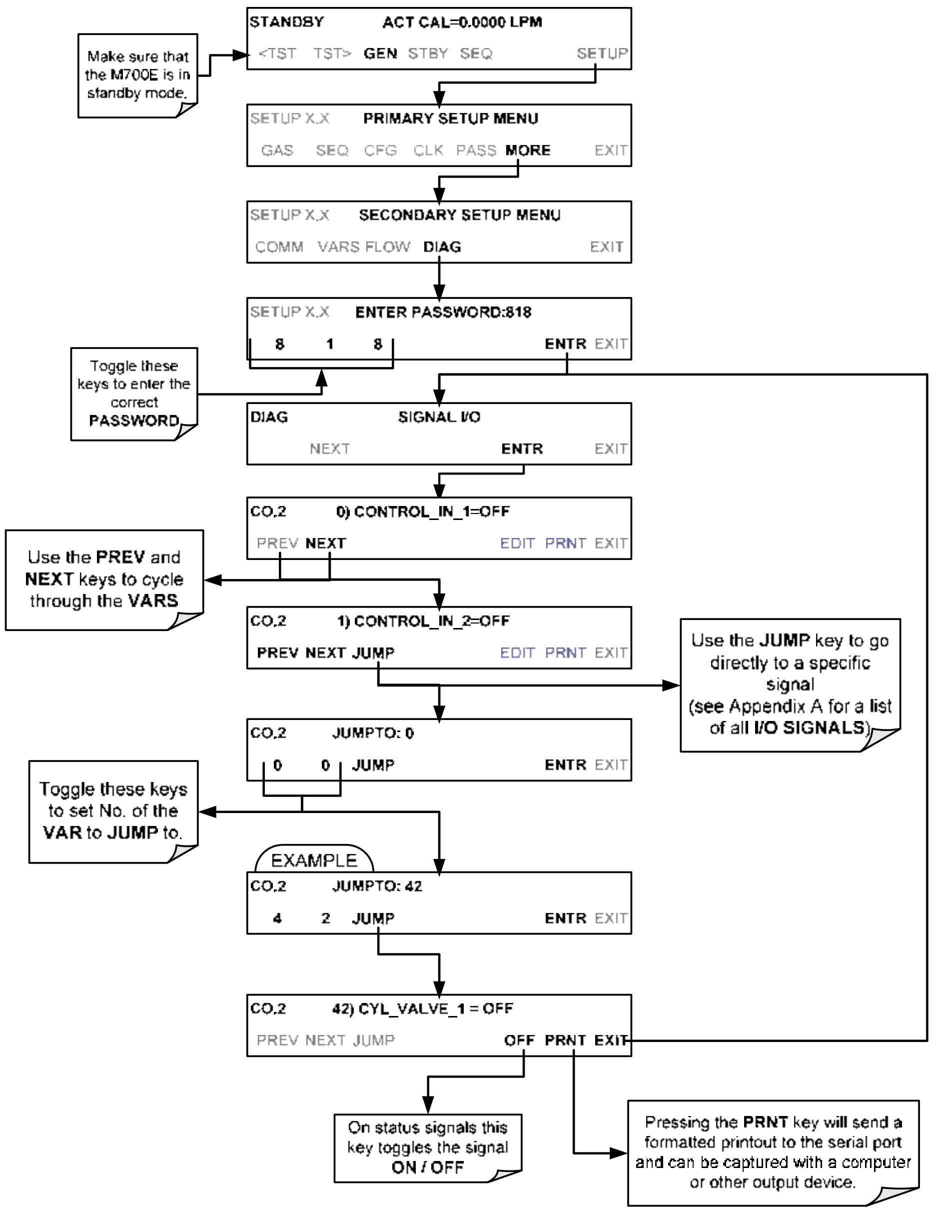


Figure 11-1: Example of Signal I/O Function

11.2. USING THE ANALOG OUTPUT TEST CHANNEL

The signals available for output over the M700E's analog output channel can also be used as diagnostic tools. See Section 6.9 for instruction on activating the analog output and selecting a function.

Table 11-3: Test Channel Outputs as Diagnostic Tools

TEST CHANNEL	DESCRIPTION	ZERO	FULL SCALE	CAUSES OF EXTREMELY HIGH / LOW READINGS
NONE	**TEST CHANNEL IS TURNED OFF**			
O3 PHOTO MEAS	The raw output of the photometer during its measure cycle	0 mV	5000 mV*	If the value displayed is: - >5000 mV: The UV source has become brighter; adjust the UV Detector Gain potentiometer. - < 100mV – Bad UV lamp or UV lamp power supply. - < 2000mV – Lamp output has dropped, adjust UV Preamp Board or replace lamp. If the value displayed is constantly changing: - Bad UV lamp. - Defective UV lamp power supply. - Failed I^2C Bus. If the PHOTO REFERENCE value changes by more than 10mV between zero and span gas: - Defective/leaking M/R switching valve.
O3 PHOTO REF	The raw output of the photometer during its reference cycle	0 mV	5000 mV	
O3 GEN REF	The raw output of the O_3 generator's reference detector	0 mV	5000 mV	Possible causes of faults are the same as **O3 GEN REFERENCE WARNING** from Table 11-1.
SAMPLE PRESSURE	The pressure of gas in the photometer absorption tube	0 "Hg	40 "Hg-In-A	Check for Gas Flow problems.
SAMPLE FLOW	The gas flow rate through the photometer	0 cm^3/min	1000 cm^3/m	Check for Gas Flow problems.
SAMPLE TEMP	The temperature of gas in the photometer absorption tube	0 C°	70 C°	Possible causes of faults are the same as **PHOTO STEMP** from Table 11-2.
PHOTO LAMP TEMP	The temperature of the photometer UV lamp	0 C°	70 C°	Possible failure of: - Bench lamp heater - Bench lamp temperature sensor - Relay controlling the bench heater - Entire Relay PCA - I^2C Bus - Hot Lamp
O3 LAMP TEMP	The temperature of the O_3 generator's UV lamp	0 mV	5000 mV	Same as **PHOTO LAMP TEMP WARNING from** Table 11-1.
CHASSIS TEMP	The temperature inside the M700E's chassis (same as **BOX TEMP**)	0 C°	70 C°	Possible causes of faults are the same as **BOX TEMP** from Table 11-2.
O3 PHOTO CONC	The current concentration of O_3 being measured by the photometer.	- - -		- I^2C Bus malfunction - Gas flow problem through the photometer. - Electronic failure of the photometer subsystems. - Failure or pressure / temperature sensors associated with the photometer. - Bad/incorrect Span Gas concentration. - Contamination of the Zero Air supply. - Malfunction of the O_3 generator. - Internal A/D converter problem.

11.3. USING THE INTERNAL ELECTRONIC STATUS LEDS

Several LEDs are located inside the instrument to assist in determining if the calibrators CPU, I^2C bus and Relay PCA are functioning properly.

11.3.1. CPU STATUS INDICATOR

DS5, a red LED, that is located on upper portion of the motherboard, just to the right of the CPU board, flashes when the CPU is running the main program loop. After power-up, approximately 30 – 60 seconds, DS5 should flash on and off. If characters are written to the front panel display but DS5 does not flash then the program files have become corrupted, contact customer service because it may be possible to recover operation of the calibrator. If after 30 – 60 seconds, neither DS5 is flashing nor have any characters been written to the front panel display then the CPU is bad and must be replaced.

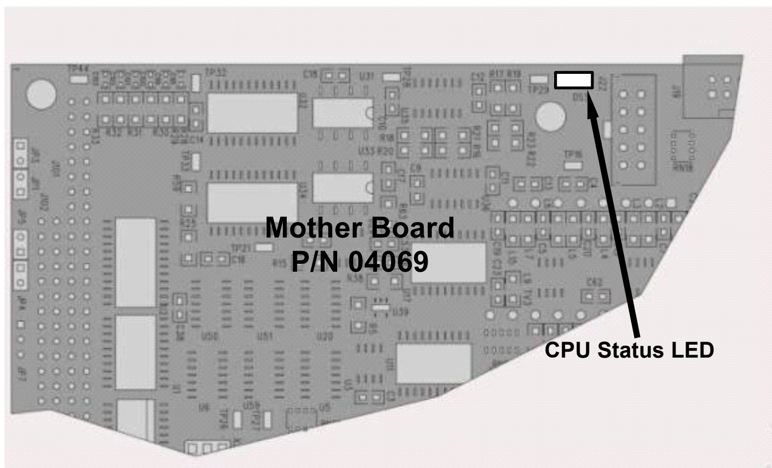


Figure 11-2: CPU Status Indicator

11.3.2. RELAY PCA STATUS LEDS

There are seven LEDs located on the Relay PCA. Some are not used on this model.

11.3.2.1. I^2C Bus Watchdog Status LEDs

The most important is D1 (see Table 11-4, which indicates the health of the I^2C bus).

Table 11-4: Relay PCA Watchdog LED Failure Indications

LED	Function	Fault Status	Indicated Failure(s)
D1 (Red)	I^2C bus Health (Watchdog Circuit)	Continuously ON or Continuously OFF	Failed/Halted CPU Faulty Mother Board, Keyboard or Relay PCA Faulty Connectors/Wiring between Mother Board, Keyboard or Relay PCA Failed/Faulty +5 VDC Power Supply (PS1)

If D1 is blinking, then the other LEDs can be used in conjunction with **DIAG** Menu Signal I/O to identify hardware failures of the relays and switches on the Relay.

11.3.2.2. O_3 Option Status LEDs

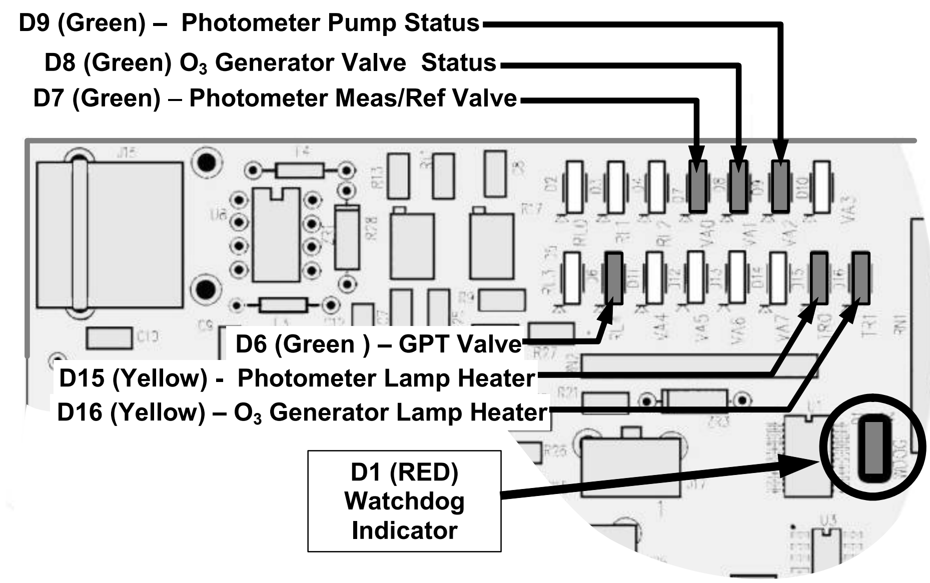


Figure 11-3: Relay PCA Status LEDS Used for Troubleshooting

Table 11-5: Relay PCA Status LED Failure Indications

LED	FUNCTION	SIGNAL I/O PARAMETER		DIAGNOSTIC TECHNIQUE
		ACTIVATED BY	VIEW RESULT	
D7[1] Green	Photometer Meas/Ref Valve	**PHOTO_REF_VALVE**	N/A	Valve should audibly change states. If not: • Failed Valve • Failed Relay Drive IC on Relay PCA • Failed Relay PCA • Faulty +12 VDC Supply (PS2) • Faulty Connectors/Wiring
D8[2] Green	O_3 Generator Valve Status	**O3_GEN_VALVE**	N/A	
D9[1] Green	Photometer Pump Status	**O3-PUMP-ON**	N/A	
D6[1,2] Yellow	GPT Valve Status	**GPT_VALVE**	N/A	
D15[1] Yellow	Photometer Heater Status	**PHOTO_LAMP_HEATER**	**PHOTO_LAMP_TEMP**	Voltage displayed should change. If not: • Failed Heater • Faulty Temperature Sensor • Failed AC Relay • Faulty Connectors/Wiring
D16[2] Green	O_3 Generator Heater Status	**O3_GEN_HEATER**	**O3_GEN_TEMP**	

[1] Only applies on calibrators with photometer options installed.
[2] Only applies on calibrators with O_3 generator options installed.

11.3.3. VALVE DRIVER PCA STATUS LEDS

The Signal I/O submenu also includes VARS that can be used to turn the various input gas valves on and off as part of a diagnostic investigation.

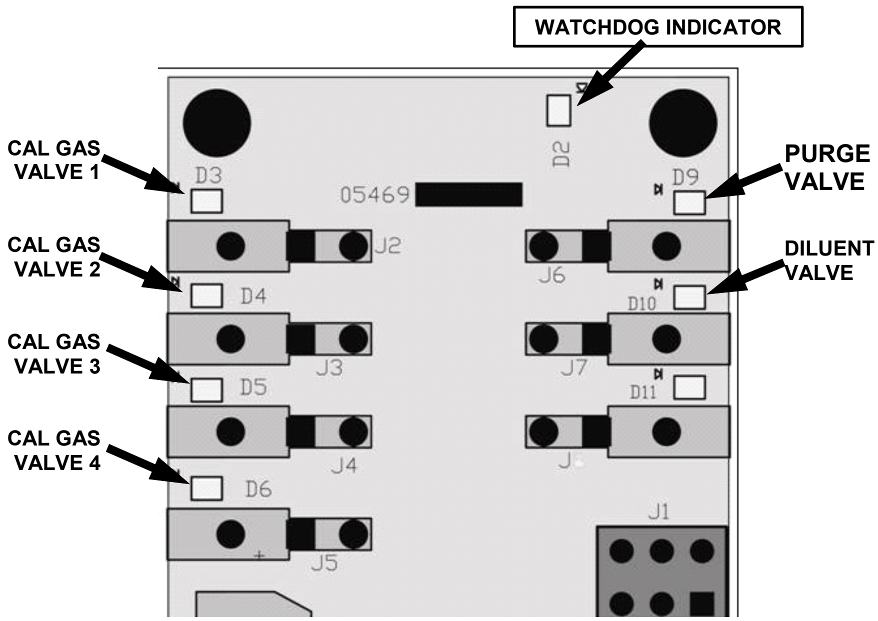


Figure 11-4: Valve Driver PCA Status LEDS Used for Troubleshooting

Table 11-6: Valve Driver Board Watchdog LED Failure Indications

LED	Function	Fault Status	Indicated Failure(s)
D1 (Red)	I^2C bus Health (Watchdog Circuit)	Continuously ON or Continuously OFF	• Failed/Halted CPU • Faulty Mother Board, Keyboard or Relay PCA • Faulty Connectors/Wiring between Mother Board, Keyboard or Relay PCA • Failed/Faulty +5 VDC Power Supply (PS1)

Table 11-7: Relay PCA Status LED Failure Indications

LED	FUNCTION	ACTIVATED BY SIGNAL I/O PARAMETER	DIAGNOSTIC TECHNIQUE
D3	**Cal Gas CYL1**	**CYL_VALVE_1**	Valve should audibly change states and LED should glow. If not: • Failed Valve • Failed Valve Driver IC on Relay PCA • Failed Valve Driver Board • Faulty +12 VDC Supply (PS2) • Faulty Connectors/Wiring
D4	**Cal Gas CYL2**	**CYL_VALVE_2**	
D5	**Cal Gas CYL3**	**CYL_VALVE_3**	
D6	**Cal Gas CYL4**	**CYL_VALVE_4**	
D9	**Purge Valve Status**	**PURGE_VALVE**	
D10	**Diluent Valve Status**	**INPUT_VALVE**	

11.4. SUBSYSTEM CHECKOUT

The preceding sections of this manual discussed a variety of methods for identifying possible sources of failures or performance problems within the M700E calibrator. In most cases, this included a list of possible components or subsystems that might be the source of the problem. This section describes how to check individual components or subsystems to determine if which is actually the cause of the problem being investigated.

11.4.1. VERIFY SUBSYSTEM CALIBRATION

A good first step when troubleshooting the operation of the M700E calibrator is to verify that its major subsystems are properly calibrated. These are:

- The mass flow controllers (see Section 8.2).
- Test Channel D → A conversion (see Section 6.9.2).
- Gas pressure calibration (see Section 8.5).

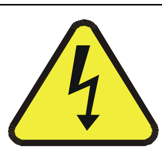
When optional O_3 components are installed, you should also check:

- Photometer calibration (see Section 8.3).
- O_3 generator calibration (see Section 8.4).

11.4.2. AC MAIN POWER

The M700E calibrator's electronic systems will operate with any of the specified power regimes. As long as system is connected to 100-120 VAC or 220-240 VAC at either 50 or 60 Hz it will turn on and after about 30 seconds show a front panel display.

- Internally, the status LEDs located on the Relay PCA, Motherboard and CPU should turn on as soon as the power is supplied.
- If they do not, check the circuit breaker built into the ON/OFF switch on the instruments front panel.

	**CAUTION** **SHOULD THE AC POWER CIRCUIT BREAKER TRIP, INVESTIGATE AND CORRECT THE CONDITION CAUSING THIS SITUATION BEFORE TURNING THE CALIBRATOR BACK ON.**

11.4.3. DC POWER SUPPLY

If you have determined that the calibrator's AC mains power is working, but the unit is still not operating properly, there may be a problem with one of the instrument's switching power supplies. The supplies can have two faults, namely no DC output, and noisy output.

To assist tracing DC Power Supply problems, the wiring used to connect the various printed circuit assemblies and DC Powered components and the associated test points on the relay PCA follow a standard color-coding scheme as defined in Figure 11-5 and Table 11-8.

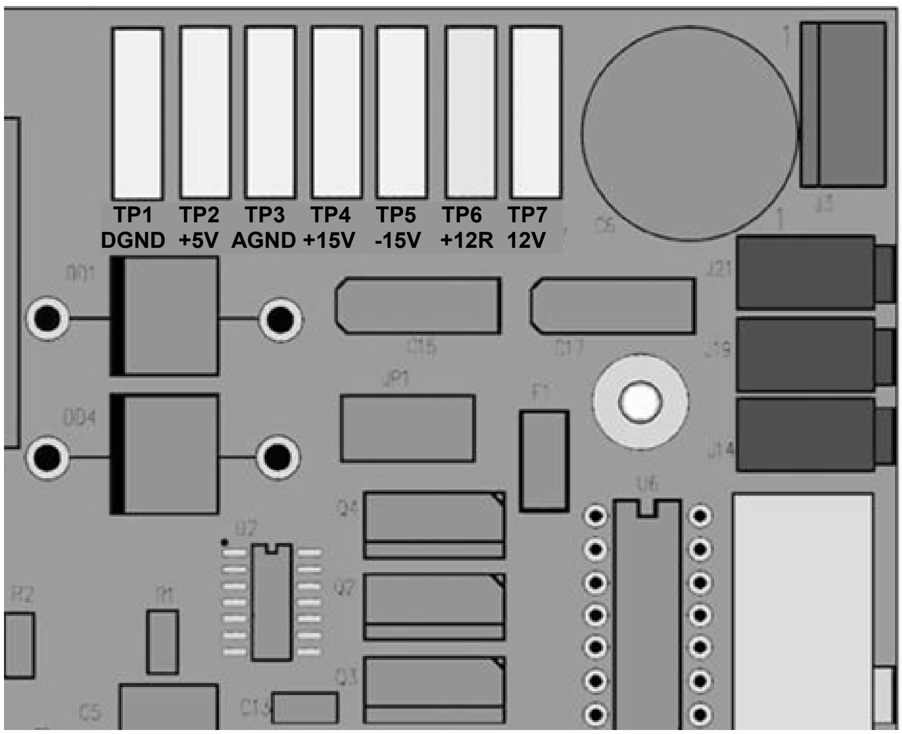


Figure 11-5: Location of DC Power Test Points on Relay PCA

Table 11-8: DC Power Test Point and Wiring Color Codes

NAME	TEST POINT#	TP AND WIRE COLOR
Dgnd	**1**	Black
+5V	**2**	Red
Agnd	**3**	Green
+15V	**4**	Blue
-15V	**5**	Yellow
+12R	**6**	Purple
+12V	**7**	Orange

A voltmeter should be used to verify that the DC voltages are correct per the values in Table 11-9, and an oscilloscope, in AC mode, with band limiting turned on, can be used to evaluate if the supplies are producing excessive noise (> 100 mV p-p).

Table 11-9: DC Power Supply Acceptable Levels

POWER SUPPLY ASSY	VOLTAGE	CHECK RELAY PCA TEST POINTS				MIN V	MAX V
		FROM TEST POINT		TO TEST POINT			
		NAME	#	NAME	#		
PS1	+5	Dgnd	1	+5	2	4.8	5.25
PS1	+15	Agnd	3	+15	4	13.5	16V
PS1	-15	Agnd	3	-15V	5	-14V	-16V
PS1	Agnd	Agnd	3	Dgnd	1	-0.05	0.05
PS1	Chassis	Dgnd	1	Chassis	N/A	-0.05	0.05
PS2	+12	+12V Ret	6	+12V	7	11.75	12.5
PS2	Dgnd	+12V Ret	6	Dgnd	1	-0.05	0.05

11.4.4. I^2C BUS

Operation of the I^2C bus can be verified by observing the behavior of D1 on the relay PCA & D2 on the Valve Driver PCA in conjunction with the performance of the front panel display.

Assuming that the DC power supplies are operating properly the I^2C bus is operating properly if:

- D1 on the relay PCA and D2 of the Valve Driver PCA is flashing, or
- Pressing a key on the front panel results in a change to the display.

There is a problem with the I^2C bus if:

- Both D1 on the relay PCA and D2 of the Valve Driver PCA are ON/OFF Constantly and pressing a key on the front panel DOES NOT result in a change to the display.

If the keyboard interface is working but either of the two Watchdog LEDs is not flashing, the problem may be a wiring issue between the board and the motherboard.

11.4.5. KEYBOARD/DISPLAY INTERFACE

The front panel keyboard, display and Keyboard Display Interface PCA can be verified by observing the operation of the display when power is applied to the instrument and when a key is pressed on the front panel. Assuming that there are no wiring problems and that the DC power supplies are operating properly:

- The vacuum fluorescent display is good if a "-" character is visible on the upper left hand corner of the display at power-up .
- If there is no "-" character on the display at power-up and D1 on the Relay PCA or D2 on the Valve Driver PCA is flashing; then the Keyboard/Display Interface PCA is bad.
- The CPU Status LED, DS5, is flashing, but there is no "-" character on the display at power-up.

- If the calibrator starts operation with a normal display but pressing a key on the front panel does not change the display, then there are three possible problems.
  1. One or more of the keys is bad,
  2. The interrupt signal between the Keyboard Display Interface PCA and the motherboard is broken, or
  3. The Keyboard Display Interface PCA is bad.

11.4.6. RELAY PCA

The Relay PCA can be most easily checked by observing the condition of the status LEDs on the Relay PCA (see Section 11.3.2), and using the **SIGNAL I/O** submenu under the **DIAG** menu (see Section 11.1.3) to toggle each LED **ON** or **OFF.**

If D1 on the Relay PCA is flashing and the status indicator for the output in question (Heater power, Valve Drive, etc.) toggles properly using the Signal I/O function, then the associated control device on the Relay PCA is bad. Several of the control devices are in sockets and can be easily replaced. Table 11-10 lists the control device associated with a particular function.

Table 11-10: Relay PCA Control Devices

FUNCTION	CONTROL DEVICE	IN SOCKET
UV Lamp Heater	Q2	No
O_3 Gen Heater	Q3	No
All Valves	U5	Yes

11.4.7. VALVE DRIVER PCA

Like the Relay PCA the valve driver PCA is checked by observing the condition of the its status LEDs on the Relay Board (see Section 11.3.2), and using the **SIGNAL I/O** submenu under the **DIAG** menu (see Section 11.1.3) to toggle each LED **ON** or **OFF.**

If D2 on the valve driver board is flashing and the status indicator for the output in question (Gas Cyl 1, Purge Valve, etc.) toggles properly using the Signal I/O function, then the control IC is bad.

11.4.8. INPUT GAS PRESSURE / FLOW SENSOR ASSEMBLY

The input gas pressure/flow sensor PCA, located at the front of the instrument to the left of the MFC's (see Figure 3-4) can be checked with a Voltmeter. The following procedure assumes that the wiring is intact and that the motherboard as well as the power supplies is operating properly:

BASIC PCA OPERATION:

- Measure the voltage across C1 it should be 5 VDC ± 0.25 VDC. If not then the board is bad

CAL GAS PRESSURE SENSOR:

1. Measure the pressure on the inlet side of S1 with an external pressure meter.
2. Measure the voltage across TP4 and TP1.
   - The expected value for this signal should be:

$$\text{Expected mVDC} = \left(\frac{\text{Pressure}}{34.18_{\text{psig}}} \times 4250_{\text{mvDC}}\right) + 750_{\text{mvDC}} \qquad \pm 10\%_{\text{rdg}}$$

     EXAMPLE: If the measured pressure is 25 PSIG, the expected voltage level between TP4 and TP1 would be between 3470 mVDC and 4245 mVDC.

     EXAMPLE: If the measured pressure is 30 PSIG, the expected voltage level between TP4 and TP1 would be between 4030 mVDC and 4930 mVDC.

   - If this voltage is out of range, then either pressure transducer S1 is bad, the board is bad, or there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.

DILUENT PRESSURE SENSOR:

1. Measure the pressure on the inlet side of S2 with an external pressure meter.
2. Measure the voltage across TP5 and TP1.
   - Evaluate the reading in the same manner as for the cal gas pressure sensor.

11.4.9. PHOTOMETER O_3 GENERATOR PRESSURE/FLOW SENSOR ASSEMBLY

This assembly is only present in calibrators with O_3 generator and/or photometer options installed. The pressure/flow sensor PCA, located at the rear of the instrument between the O_3 generator and the photometer pump (see Figure 3-4) can be checked with a Voltmeter. The following procedure assumes that the wiring is intact and that the motherboard as well as the power supplies are operating properly:

BASIC PCA OPERATION

- Measure the voltage across C1 it should be 5 VDC ± 0.25 VDC. If not then the board is bad
- Measure the voltage between TP2 and TP1 C1 it should be 1o VDC ± 0.25 VDC. If not then the board is bad.

PHOTOMETER PRESSURE SENSOR

1. Measure the pressure on the inlet side of S1 with an external pressure meter.
2. Measure the voltage across TP4 and TP1.
   - The expected value for this signal should be:

$$\text{Expected mVDC} = \left(\frac{\text{Pressure}}{30.0_{\text{In-Hg-A}}} \times 4660_{\text{mvDC}}\right) + 250_{\text{mvDC}} \qquad \pm 10\%_{\text{rdg}}$$

   EXAMPLE: If the measured pressure is 20 In-Hg-A, the expected voltage level between TP4 and TP1 would be between 2870 mVDC and 3510 mVDC.

   EXAMPLE: If the measured pressure is 25 In-Hg-A, the expected voltage level between TP4 and TP1 would be between 3533 mVDC and 4318 mVDC.

   - If this voltage is out of range, then either pressure transducer S1 is bad, the board is bad or there is a pneumatic failure preventing the pressure transducer from sensing the absorption cell pressure properly.

O_3 GENERATOR PRESSURE SENSOR

1. Measure the pressure on the inlet side of S2 with an external pressure meter.
2. Measure the voltage across TP5 and TP1.
   - Evaluate the reading in the same manner as for the cal gas pressure sensor (see Section 11.4.8).

PHOTOMETER FLOW SENSOR

- Measure the voltage across TP3 and TP1.
  - With proper flow (800 cm^3/min through the photometer), this should be approximately 4.5V (this voltage will vary with altitude).
  - With flow stopped (photometer inlet disconnected or pump turned OFF) the voltage should be approximately 1V.
  - If the voltage is incorrect, the flow sensor S3 is bad, the board is bad or there is a leak upstream of the sensor.

11.4.10. MOTHERBOARD

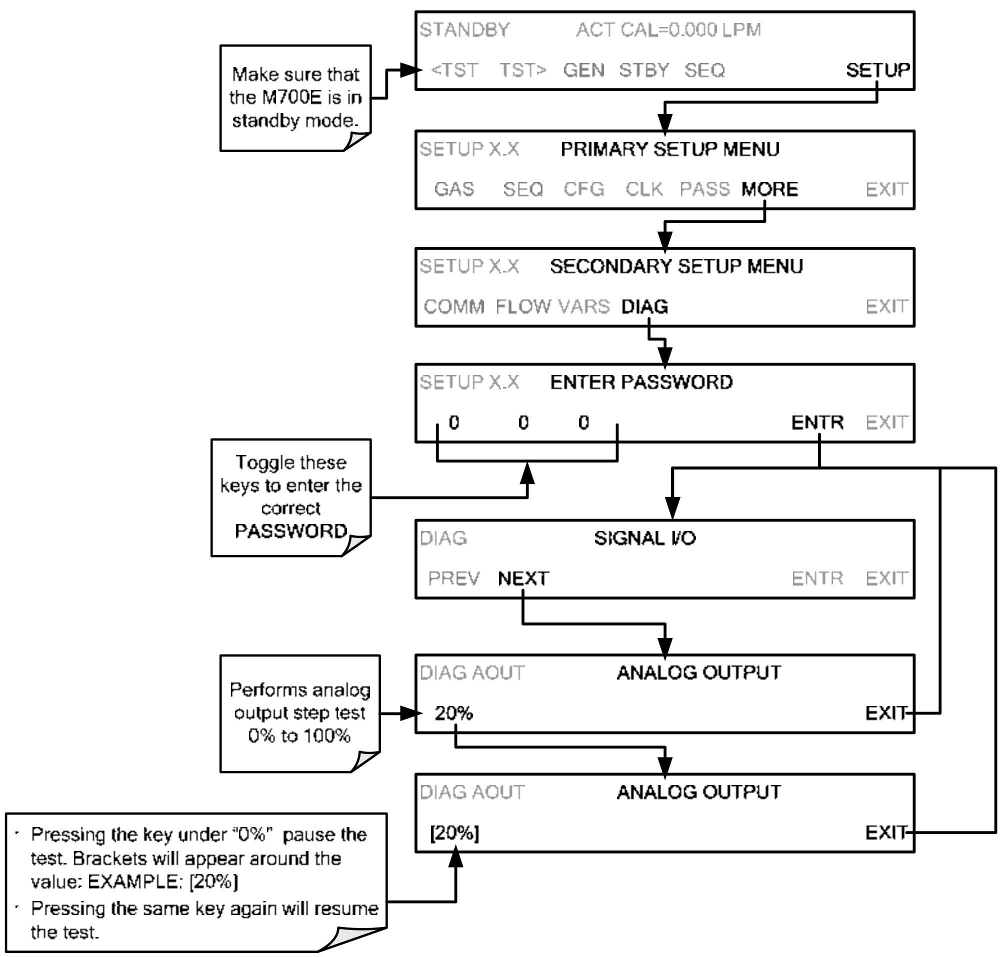
11.4.10.1. A/D Functions

The simplest method to check the operation of the A-to-D converter on the motherboard is to use the Signal I/O function under the DIAG menu to check the two A/D reference voltages and input signals that can be easily measured with a voltmeter.

1. Use the Signal I/O function (See Section 11.1.3 and Appendix A) to view the value of **REF_4096_MV** and **REF_GND**. If both are within 3 mV of nominal (4096 and 0), and are stable, ±0.5 mV then the basic A/D is functioning properly. If not then the motherboard is bad.
2. Choose a parameter in the Signal I/O function such as **DIL_PRESS, MFC_FLOW_1** or **SAMPLE_FLOW**.
   - Compare these voltages at their origin (see the interconnect drawing and interconnect list in Appendix D) with the voltage displayed through the signal I/O function.
   - If the wiring is intact but there is a large difference between the measured and displayed voltage (±10 mV) then the motherboard is bad.

11.4.10.2. Test Channel / Analog Outputs Voltage

To verify that the analog output is working properly, connect a voltmeter to the output in question and perform an analog output step test as follows:



For each of the steps the output should be within 1% of the nominal value listed in the table below except for the 0% step, which should be within 0mV ±2 to 3 mV. Ensure you take into account any offset that may have been programmed into channel (See Section 6.9.1.5).

Table 11-11: Analog Output Test Function – Nominal Values Voltage Outputs

		FULL SCALE OUTPUT OF VOLTAGE RANGE (see Section 6.9.1.3)			
		100MV	**1V**	**5V**	**10V**
STEP	**%**	**NOMINAL OUTPUT VOLTAGE**			
1	0	0	0	0	0
2	20	20 mV	0.2	1	2
3	40	40 mV	0.4	2	4
4	60	60 mV	0.6	3	6
5	80	80 mV	0.8	4	8
6	100	100 mV	1.0	5	10

If one or more of the steps fails to be within these ranges, it is likely that there has been a failure of the either or both of the DACs and their associated circuitry on the motherboard.

11.4.10.3. Status Outputs

To test the status output electronics:

1. Connect a jumper between the "D"pin and the "▽" pin on the status output connector.
2. Connect a 1000 ohm resistor between the "+" pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the "▽" pin and the pin of the output being tested (see table below).
4. Under the **DIAG→ SIGNAL I/O** menu (See Section11.1.3), scroll through the inputs and outputs until you get to the output in question.
5. Alternately, turn on and off the output noting the voltage on the voltmeter.
   - It should vary between 0 volts for ON and 5 volts for OFF.

Table 11-12: Status Outputs Check

PIN (LEFT TO RIGHT)	STATUS
1	ST_SYSTEM_OK
2	SPARE
3	ST_CAL_ACTIVE
4	ST_DIAG_MODE
5	ST_TEMP_ALARM
6	ST_PRESS_ALARM
7	PERM_VALVE_1
8	PERM_VALVE_2

11.4.10.4. Control Inputs

Table 11-13: M700E Control Input Pin Assignments and Corresponding Signal I/O Functions

CONNECTOR	INPUT	CORRESPONDING I/O SIGNAL
Top	A	CONTROL_IN_1
Top	B	CONTROL_IN_2
Top	C	CONTROL_IN_3
Top	D	CONTROL_IN_4
Top	E	CONTROL_IN_5
Top	F	CONTROL_IN_6
Bottom	G	CONTROL_IN_7
Bottom	H	CONTROL_IN_8
Bottom	I	CONTROL_IN_9
Bottom	J	CONTROL_IN_10
Bottom	K	CONTROL_IN_11
Bottom	L	CONTROL_IN_12

The control input bits can be tested by applying a trigger voltage to an input and watching changes in the status of the associated function under the SIGNAL I/O submenu:

EXAMPLE: to test the "**A**" control input:

1. Under the **DIAG→ SIGNAL I/O** menu (See Section 11.1.3), scroll through the inputs and outputs until you get to the output named **0) CONTROL_IN_1**.
2. Connect a jumper from the "**+**" pin on the appropriate connector to the "**U**" on the same connector.
3. Connect a second jumper from the "▽" pin on the connector to the "**A**" pin.
4. The status of **0) CONTROL_IN_1** should change to read "**ON**".

11.4.10.5. Control Outputs

To test the Control Output electronics:

1. Connect a jumper between the "E"pin and the "▽" pin on the status output connector.
2. Connect a 1000 ohm resistor between the "+" pin and the pin for the status output that is being tested.
3. Connect a voltmeter between the "▽" pin and the pin of the output being tested (see Table 11-14).
4. Under the **DIAG→ SIGNAL I/O** menu (See Section 11.1.3), scroll through the inputs and outputs until you get to the output in question.
5. Alternately, turn on and off the output noting the voltage on the voltmeter.
   - It should vary between 0 volts for ON and 5 volts for OFF.

Table 11-14: Control Outputs Pin Assignments and Corresponding Signal I/O Functions Check

PIN (LEFT TO RIGHT)	STATUS
1	**CONTROL_OUT_1**
2	**CONTROL_OUT_2**
3	**CONTROL_OUT_3**
4	**CONTROL_OUT_4**
5	**CONTROL_OUT_5**
6	**CONTROL_OUT_6**
7	**CONTROL_OUT_7**
8	**CONTROL_OUT_8**
9	**CONTROL_OUT_9**
10	**CONTROL_OUT_10**
11	**CONTROL_OUT_11**
12	**CONTROL_OUT_12**

11.4.11. CPU

There are two major types of failures associated with the CPU board: complete failure and a failure associated with the Disk-On-Chip on the CPU board. If either of these failures occur, contact the factory.

For complete failures, assuming that the power supplies are operating properly and the wiring is intact, the CPU is bad if on the following occurs while powering up the instrument:

- The vacuum fluorescent display shows a dash in the upper left hand corner.
- The CPU Status LED, DS5, is not flashing. (See Section 11.3.1).
- There is no activity from the primary RS-232 port on the rear panel even if “? <ret>” is pressed.
- In some rare circumstances this failure may be caused by a bad IC on the motherboard, specifically U57 the large, 44 pin device on the lower right hand side of the board. If this is true, removing U57 from its socket will allow the instrument to startup but the measurements will be incorrect.
- If the calibrator stops part way through initialization (there are words on the vacuum fluorescent display) then it is likely that the DOC has been corrupted.

11.4.12. RS-232 COMMUNICATIONS

11.4.12.1. General RS-232 Troubleshooting

Teledyne API calibrators use the RS-232 communications protocol to allow the instrument to be connected to a variety of computer-based equipment. RS-232 has been used for many years and as equipment has become more advanced, connections between various types of hardware have become increasingly difficult. Generally, every manufacturer observes the signal and timing requirements of the protocol very carefully.

Problems with RS-232 connections usually center around 4 general areas:

- Incorrect cabling and connectors. See Section 7.1.2 for connector and pin-out information.
- The BAUD rate and protocol are incorrectly configured. See Section 7.1.3.
- If a modem is being used, additional configuration and wiring rules must be observed. See Section 7.2.
- Incorrect setting of the DTE-DCE Switch is set correctly. See Section 7.1.1.
- Verify that the cable (P/N 03596) that connects the serial COMM ports of the CPU to J12 of the motherboard is properly seated.

11.4.12.2. Troubleshooting Calibrator/Modem or Terminal Operation

These are the general steps for troubleshooting problems with a modem connected to a Teledyne API calibrator.

1. Check cables for proper connection to the modem, terminal or computer.
2. Check to ensure the DTE-DCE is in the correct position as described in Section 7.1.1.
3. Check to ensure the set up command is correct. See Section 7.2.1.
4. Verify that the Ready to Send (RTS) signal is at logic high. The M700E sets pin 7 (RTS) to greater than 3 volts to enable modem transmission.
5. Ensure the BAUD rate, word length, and stop bit settings between modem and calibrator match. See Section 7.1.3.
6. Use the RS-232 test function to send "w" characters to the modem, terminal or computer. See Section 7.1.5.
7. Get your terminal, modem or computer to transmit data to the calibrator (holding down the space bar is one way); the green LED should flicker as the instrument is receiving data.
8. Ensure that the communications software or terminal emulation software is functioning properly.

NOTE

Further help with serial communications is available in a separate manual "RS-232 Programming Notes" Teledyne API's P/N 013500000.

11.4.13. TEMPERATURE PROBLEMS

Individual control loops are used to maintain the set point of the Photometer UV Lamp (optional), and the Ozone Generator Lamp (optional). If any of these temperatures are out of range or are poorly controlled, the M700E will perform poorly.

11.4.13.1. Box / Chassis Temperature

The box temperature sensor is mounted to the Motherboard and cannot be disconnected to check its resistance. Rather check the **BOX TEMP** signal using the **SIGNAL I/O** function under the **DIAG** Menu (see Section 11.1.3). This parameter will vary with ambient temperature, but at ~30°C (6-7° above room temperature) the signal should be ~1450 mV.

11.4.13.2. Photometer Sample Chamber Temperature

The temperature of the gas in the photometer sample chamber should read approximately 5.0°C higher than the box temperature.

11.4.13.3. UV Lamp Temperature

There are three possible causes for the UV Lamp temperature to have failed.

- The UV Lamp heater has failed. Check the resistance between pins 5 and 6 on the six-pin connector adjacent to the UV Lamp on the Optical Bench.
  - It should be approximately 30 Ohms.
- Assuming that the I^2C bus is working and that there is no other failure with the Relay board, the FET Driver on the Relay Board may have failed.
  - Using the **PHOTO_LAMP HEATER** parameter under the **SIGNAL I/O** function of the **DIAG** menu, as described above, turn on and off the UV Lamp Heater (D15 on the relay board should illuminate as the heater is turned on).
  - Check the DC voltage present between pin 1 and 2 on J13 of the Relay Board.
  - If the FET Driver has failed, there will be no change in the voltage across pins 1 and 2.
- If the FET Driver Q2 checks out OK, the thermistor temperature sensor in the lamp assembly may have failed.
  - Unplug the connector to the UV Lamp Heater/Thermistor PCB, and measure the resistance of the thermistor between pins 5 and 6 of the 6-pin connector.
  - The resistance near the 58°C set point is ~8.1k ohms.

11.4.13.4. Ozone Generator Temperature

There are three possible causes for the Ozone Generator temperature to have failed.

- The O_3 Gen heater has failed. Check the resistance between pins 5 and 6 on the six-pin connector adjacent to the UV Lamp on the O_3 Generator. It should be approximately 5 Ohms.
- Assuming that the I^2C bus is working and that there is no other failure with the Relay board, the FET Driver on the Relay Board may have failed. Using the **O3_GEN_HEATER** parameter under the **SIGNAL I/O** submenu of the **DIAG** menu as described above, turn the UV Lamp Heater on and off. Check the DC voltage present between pin 1 and 2 on J14 of the Relay Board.

  If the FET Driver has failed, there should be no change in the voltage across pins 1 and 2.
- If the FET Driver checks out OK, the thermistor temperature sensor in the lamp assembly may have failed. Unplug the connector to the Ozone Generator Heater/Thermistor PCB, and measure the resistance of the thermistor between pins 5 and 6 of the 6-pin connector.

11.5. TROUBLE SHOOTING THE OPTIONAL O_3 PHOTOMETER

11.5.1. DYNAMIC PROBLEMS WITH THE OPTIONAL O_3 PHOTOMETER

Dynamic problems are problems that only manifest themselves when the photometer is measuring O_3 concentration gas mixtures. These can be the most difficult and time consuming to isolate and resolve.

Since many photometer behaviors that appear to be a dynamic in nature are often a symptom of a seemingly unrelated static problems, it is recommended that dynamic problems not be addressed until all static problems, warning conditions and subsystems have been checked and any problems found are resolved.

Once this has been accomplished, the following most common dynamic problems should be checked.

11.5.1.1. Noisy or Unstable O_3 Readings at Zero

- Check for leaks in the pneumatic system as described in Section 10.2.1.
- Confirm that the Zero gas is free of Ozone.
- Confirm that the Source Lamp is fully inserted and that the lamp hold-down thumb-screw is tight.
- Check for a dirty Absorption Cell and/or pneumatic lines. Clean as necessary as described in Section 10.2.2.
- Disconnect the exhaust line from the optical bench (the pneumatic line at the lamp end of the bench) and plug the port in the bench. If readings remain noisy, the problem is in one of the electronic sections of the instrument. If readings become quiet, the problem is in the instrument's pneumatics.

11.5.1.2. Noisy, Unstable, or Non-Linear Span O_3 Readings

- Check for leaks in the pneumatic systems as described in Section 10.2.1.
- Check for proper operation of the meas/ref switching valve as described in Section 11.5.2.
- Check for dirty absorption cell and clean or replace as necessary as described in Section 10.2.2.
- Check for operation of the A/D circuitry on the motherboard. See Section 11.4.10.1.
- Confirm the Sample Temperature, Sample Pressure and Sample Flow readings are correct. Check and adjust as required.

11.5.1.3. Slow Response to Changes in Concentration

- Check for dirty absorption cell and clean or replace as necessary as described in Section 10.2.2.
- Check for pneumatic leaks as described in Section 10.2.1.
- The photometer needs 800 cm^3/min of gas flow. Ensure that this is accounted for when calculating total required output flow for the calibrator (see Section 3.3.10).

11.5.1.4. The Analog Output Signal Level Does Not Agree With Front Panel Readings

- Confirm that the recorder offset (see Section 6.9.1.5) is set to zero.
- Perform an AIO calibration (see Section 6.9.2) and photometer dark calibration (see Section 8.3.5).

11.5.1.5. Cannot Zero

- Check for leaks in the pneumatic system as described in Section 10.2.1.
- Confirm that the Zero gas is free of Ozone.
- The photometer needs 800 cm^3/min of gas flow. Ensure that this is accounted for when calculating total required output flow for the calibrator (see Section 3.3.10).

11.5.1.6. Cannot Span

- Check for leaks in the pneumatic systems as described in Section 10.2.1.
- Check for proper operation of the meas/ref switching valve as described in Section11.5.2.
- Check for dirty absorption cell and clean or replace as necessary as described in Section 10.2.2.
- Check for operation of the A/D circuitry on the motherboard. See Section 11.4.10.1.
- Confirm the Sample Temperature, Sample Pressure and Sample Flow readings are correct. Check and adjust as required.
- The photometer needs 800 cm^3/min of gas flow. Ensure that this is accounted for when calculating total required output flow for the calibrator (see Section 3.3.10).

11.5.2. CHECKING MEASURE / REFERENCE VALVE

To check the function of the photometer's measure / reference valve:

1. Set the calibrator's front panel display to show the **PHOTO REFERENC**E test function (see Section 6.1).
2. Follow the instruction in Sections 8.3.3 and 8.3.4.1 for performing a zero point calibration of the photometer.
   - Press X**ZRO** and allow the calibrator to stabilize.
3. Before completing the calibration by pressing the **ZERO** key, note of the displayed value.
4. Press the final Zero key then press "**NO**" when asked, "**ARE YOU SURE**".
5. Follow the instruction in Sections 8.3.4.2 for performing a span point calibration of the photometer.
   - Press **XSPN** and allow the calibrator to stabilize.
6. Before completing the calibration by pressing the **SPAN** key, note of the displayed value of **PHOTO REFERENCE**.
   - If the O_3 REF value has decreased by more than 2 mV from its value with Zero-gas, then there is a "cross-port" leak in the M/R valve.
7. Press the final Zero key then press "**NO**" when asked, "**ARE YOU SURE**".

11.5.3. CHECKING THE UV LAMP POWER SUPPLY

NOTE

A schematic and physical diagram of the Lamp Power Supply can be found in Appendix D.

WARNING
Hazardous voltage present - use caution.

It is not always possible to determine with certainty whether a problem is the result of the UV Lamp or the Lamp Power Supply. However, the following steps will provide a reasonable confidence test of the Lamp Power Supply.

1. Unplug the cable connector at P1 on the Lamp Power Supply and confirm that +15VDC is present between Pins 1 and 2 on the cable connector.

2. If this voltage is incorrect, check the DC test points on the relay PCA as described in Section 11.4.3.

3. Remove the cover of the photometer and check for the presence of the following voltages on the UV lamp power supply PCA (see Figure 9-21):

   - +4500 mVDC ±10 mVDC between TP1 and TP4 (grnd)
     - If this voltage is incorrect, either the UV lamp power supply PCA is faulty or the I^{2}C bus is not communicating with the UV lamp power supply PCA.
   - +5VDC between TP3 and TP4 (grnd)
     - If this voltages is less than 4.8 or greater than 5.25 either the 5 VDC power supply or the UV lamp power supply PCA are faulty.
   - If the above voltages check out, it is more likely that a problem is due to the UV Lamp than due to the Lamp Power Supply.
     - Replace the Lamp and if the problem persists, replace the Lamp Power Supply.

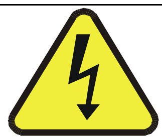
11.6. TROUBLE SHOOTING THE OPTIONAL O_3 GENERATOR

The only significant components of the O_3 generator that might reasonable malfunction is the power supply assembly for the UV source lamp and the lamp itself.

11.6.1. CHECKING THE UV SOURCE LAMP POWER SUPPLY

NOTE

A schematic and physical diagram of the Lamp Power Supply can be found in Appendix D.



WARNING
Hazardous voltage present - use caution.

It is not always possible to determine with certainty whether a problem is the result of the UV Lamp or the Lamp Power Supply, however, the following steps will provide a reasonable confidence test of the Lamp Power Supply.

1. Ensure that the calibrator is in **STANDBY** mode.
2. Unplug the cable connector at P1 on the Lamp Power Supply and confirm that +15VDC is present between Pins 1 and 2 on the cable connector.
3. If this voltage is incorrect, check the DC test points on the relay PCA as described in Section 11.4.3.
4. Remove the cover of the photometer and check for the presence of the following voltages on the UV lamp power supply PCA (see Figure 9-21):
   - +800 mVDC ±10 mVDC between TP1 and TP4 (grnd)
     - If this voltage is incorrect, either the UV lamp power supply PCA is faulty or the I^2C bus is not communicating with the UV lamp power supply PCA.
   - +5VDC between TP3 and TP4 (grnd)
     - If this voltages is less than 4.8 or greater than 5.25 either the 5 VDC power supply or the UV lamp power supply PCA are faulty.
   - If the above voltages check out, it is more likely that a problem is due to the UV Lamp than due to the Lamp Power Supply.
     - Replace the Lamp and if the problem persists, replace the Lamp Power Supply.

11.7. REPAIR PROCEDURES

11.7.1. DISK-ON-CHIP REPLACEMENT PROCEDURE

Replacing the DOC, may be necessary in certain rare circumstances when a chip fails or when loading new instrument software. This will cause all of the instrument configuration parameters to be lost. However, a backup copy of the operating parameters are stored in a second non-volatile memory and will be loaded into the new the DOC on power-up. To change the DOC, perform the following procedure:

1. Turn off power to the instrument.
2. Fold down the rear panel by loosening the thumbscrews on each side
3. Locate the Disk-on-Chip in the rightmost socket near the right hand side of the CPU assembly. Remove the IC by gently prying it up from the socket.
4. Reinstall the new Disk-on-Chip, making sure the notch in the end of the chip is facing upward.
5. Close the rear panel and turn on power to the machine.

11.8. TECHNICAL ASSISTANCE

If this manual and its troubleshooting & repair sections do not solve your problems, technical assistance may be obtained from "

TELEDYNE API, CUSTOMER SERVICE,
9480 CARROLL PARK DRIVE
SAN DIEGO, CALIFORNIA 92121-5201
USA

Toll-free Phone:	**800-324-5190**
Phone:	**858-657-9800**
Fax:	**858-657-9816**
Email:	**api-sales@teledyne.com**
Website:	**http://www.teledyne-api.com/**

Before you contact customer service, fill out the problem report form in Appendix C, which is also available online for electronic submission at http://www.teledyne-api.com/forms/.

USER NOTES:

USER NOTES:

12. A PRIMER ON ELECTRO-STATIC DISCHARGE

Teledyne API considers the prevention of damage caused by the discharge of static electricity to be extremely important part of making sure that your analyzer continues to provide reliable service for a long time. This section describes how static electricity occurs, why it is so dangerous to electronic components and assemblies as well as how to prevent that damage from occurring.

12.1. HOW STATIC CHARGES ARE CREATED

Modern electronic devices such as the types used in the various electronic assemblies of your analyzer, are very small, require very little power and operate very quickly. Unfortunately, the same characteristics that allow them to do these things also make them very susceptible to damage from the discharge of static electricity. Controlling electrostatic discharge begins with understanding how electro-static charges occur in the first place.

Static electricity is the result of something called triboelectric charging which happens whenever the atoms of the surface layers of two materials rub against each other. As the atoms of the two surfaces move together and separate, some electrons from one surface are retained by the other.

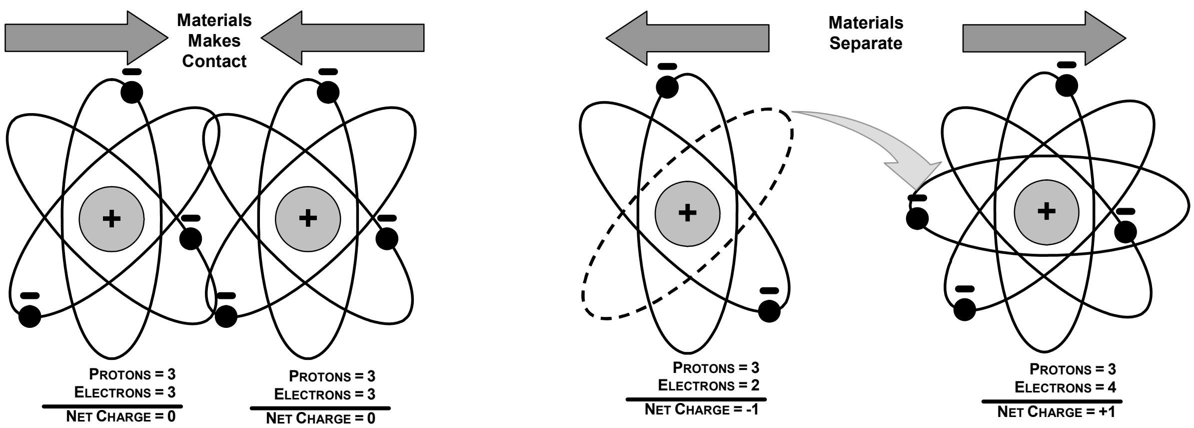


Figure 12-1: Triboelectric Charging

If one of the surfaces is a poor conductor or even a good conductor that is not grounded, the resulting positive or negative charge cannot bleed off and becomes trapped in place, or static. The most common example of triboelectric charging happens when someone wearing leather or rubber soled shoes walks across a nylon carpet or linoleum tiled floor. With each step, electrons change places and the resulting electro-static charge builds up, quickly reaching significant levels. Pushing an epoxy printed circuit board across a workbench, using a plastic handled screwdriver or even the constant jostling of Styrofoam™ pellets during shipment can also build hefty static charges

Table 12-1: Static Generation Voltages for Typical Activities

MEANS OF GENERATION	65-90% RH	10-25% RH
Walking across nylon carpet	1,500V	35,000V
Walking across vinyl tile	250V	12,000V
Worker at bench	100V	6,000V
Poly bag picked up from bench	1,200V	20,000V
Moving around in a chair padded with urethane foam	1,500V	18,000V

12.2. HOW ELECTRO-STATIC CHARGES CAUSE DAMAGE

Damage to components occurs when these static charges come into contact with an electronic device. Current flows as the charge moves along the conductive circuitry of the device and the typically very high voltage levels of the charge overheat the delicate traces of the integrated circuits, melting them or even vaporizing parts of them. When examined by microscope the damage caused by electro-static discharge looks a lot like tiny bomb craters littered across the landscape of the component's circuitry.

A quick comparison of the values in Table 12-1 with the those shown in the Table 12-2, listing device susceptibility levels, shows why *Semiconductor Reliability News* estimates that approximately 60% of device failures are the result of damage due to electro-static discharge.

Table 12-2: Sensitivity of Electronic Devices to Damage by ESD

DEVICE	DAMAGE SUSCEPTIBILITY VOLTAGE RANGE	
	DAMAGE BEGINS OCCURRING AT	CATASTROPHIC DAMAGE AT
MOSFET	10	100
VMOS	30	1800
NMOS	60	100
GaAsFET	60	2000
EPROM	100	100
JFET	140	7000
SAW	150	500
Op-AMP	190	2500
CMOS	200	3000
Schottky Diodes	300	2500
Film Resistors	300	3000
This Film Resistors	300	7000
ECL	500	500
SCR	500	1000
Schottky TTL	500	2500

Potentially damaging electro-static discharges can occur:

- Any time a charged surface (including the human body) discharges to a device. Even simple contact of a finger to the leads of a sensitive device or assembly can allow enough discharge to cause damage. A similar discharge can occur from a charged conductive object, such as a metallic tool or fixture.
- When static charges accumulated on a sensitive device discharges from the device to another surface such as packaging materials, work surfaces, machine surfaces or other device. In some cases, charged device discharges can be the most destructive.
- A typical example of this is the simple act of installing an electronic assembly into the connector or wiring harness of the equipment in which it is to function. If the assembly is carrying a static charge, as it is connected to ground a discharge will occur.
- Whenever a sensitive device is moved into the field of an existing electro-static field, a charge may be induced on the device in effect discharging the field onto the device. If the device is then momentarily grounded while within the electrostatic field or removed from the region of the electrostatic field and grounded somewhere else, a second discharge will occur as the charge is transferred from the device to ground.

12.3. COMMON MYTHS ABOUT ESD DAMAGE

I didn't feel a shock so there was no electro-static discharge: The human nervous system isn't able to feel a static discharge of less than 3500 volts. Most devices are damaged by discharge levels much lower than that.

I didn't touch it so there was no electro-static discharge: Electro Static charges are fields whose lines of force can extend several inches or sometimes even feet away from the surface bearing the charge.

It still works so there was no damage: Sometimes the damaged caused by electro-static discharge can completely sever a circuit trace causing the device to fail immediately. More likely, the trace will be only partially occluded by the damage causing degraded performance of the device or worse, weakening the trace. This weakened circuit may seem to function fine for a short time, but even the very low voltage and current levels of the device's normal operating levels will eat away at the defect over time causing the device to fail well before its designed lifetime is reached.

These latent failures are often the most costly since the failure of the equipment in which the damaged device is installed causes down time, lost data, lost productivity, as well as possible failure and damage to other pieces of equipment or property.

Static Charges can't build up on a conductive surface: There are two errors in this statement.

Conductive devices can build static charges if they are not grounded. The charge will be equalized across the entire device, but without access to earth ground, they are still trapped and can still build to high enough levels to cause damage when they are discharged.

A charge can be induced onto the conductive surface and/or discharge triggered in the presence of a charged field such as a large static charge clinging to the surface of a nylon jacket of someone walking up to a workbench.

As long as my analyzer is properly installed, it is safe from damage caused by static discharges: It is true that when properly installed the chassis ground of your analyzer is tied to earth ground and its electronic components are prevented from building static electric charges themselves. This does not prevent discharges from static fields built up on other things, like you and your clothing, from discharging through the instrument and damaging it.

12.4. BASIC PRINCIPLES OF STATIC CONTROL

It is impossible to stop the creation of instantaneous static electric charges. It is not, however difficult to prevent those charges from building to dangerous levels or prevent damage due to electro-static discharge from occurring.

12.4.1. GENERAL RULES

Only handle or work on all electronic assemblies at a properly set up ESD station. Setting up an ESD safe workstation need not be complicated. A protective mat properly tied to ground and a wrist strap are all that is needed to create a basic anti-ESD workstation.

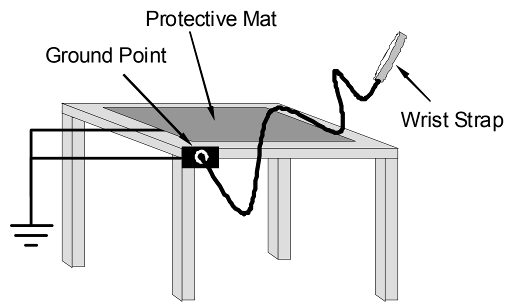


Figure 12-2: Basic Anti-ESD Work Station

For technicians that work in the field, special lightweight and portable anti-ESD kits are available from most suppliers of ESD protection gear. These include everything needed to create a temporary anti-ESD work area anywhere.

Always wear an Anti-ESD wrist strap when working on the electronic assemblies of your analyzer. An anti-ESD wrist strap keeps the person wearing it at or near the same potential as other grounded objects in the work area and allows static charges to dissipate before they can build to dangerous levels. Anti-ESD wrist straps terminated with alligator clips are available for use in work areas where there is no available grounded plug.

Also, anti-ESD wrist straps include a current limiting resistor (usually around one meg-ohm) that protects you should you accidentally short yourself to the instrument's power supply.

Simply touching a grounded piece of metal is insufficient. While this may temporarily bleed off static charges present at the time, once you stop touching the grounded metal new static charges will immediately begin to re-build. In some conditions, a charge large enough to damage a component can rebuild in just a few seconds.

Always store sensitive components and assemblies in anti-ESD storage bags or bins: Even when you are not working on them, store all devices and assemblies in a closed anti-Static bag or bin. This will prevent induced charges from building up on the device or assembly and nearby static fields from discharging through it.

Use metallic anti-ESD bags for storing and shipping ESD sensitive components and assemblies rather than pink-poly bags. The famous, pink-poly bags are made of a plastic that is impregnated with a liquid (similar to liquid laundry detergent) which very slowly sweats onto the surface of the plastic creating a slightly conductive layer over the surface of the bag.

While this layer may equalizes any charges that occur across the whole bag, it does not prevent the build up of static charges. If laying on a conductive, grounded surface, these bags will allow charges to bleed away but the very charges that build up on the surface of the bag itself can be transferred through the bag by induction onto the circuits of your ESD sensitive device. Also, the liquid impregnating the plastic is eventually used up after which the bag is as useless for preventing damage from ESD as any ordinary plastic bag.

Anti-Static bags made of plastic impregnated with metal (usually silvery in color) provide all of the charge equalizing abilities of the pink-poly bags but also, when properly sealed, create a Faraday cage that completely isolates the contents from discharges and the inductive transfer of static charges.

Storage bins made of plastic impregnated with carbon (usually black in color) are also excellent at dissipating static charges and isolating their contents from field effects and discharges.

Never use ordinary plastic adhesive tape near an ESD sensitive device or to close an anti-ESD bag. The act of pulling a piece of standard plastic adhesive tape, such as Scotch® tape, from its roll will generate a static charge of several thousand or even tens of thousands of volts on the tape itself and an associated field effect that can discharge through or be induced upon items up to a foot away.

12.4.2. BASIC ANTI-ESD PROCEDURES FOR ANALYZER REPAIR AND MAINTENANCE

12.4.2.1. Working at the Instrument Rack

When working on the analyzer while it is in the instrument rack and plugged into a properly grounded power supply

1. Attach your anti-ESD wrist strap to ground before doing anything else.
   - Use a wrist strap terminated with an alligator clip and attach it to a bare metal portion of the instrument chassis.
   - This will safely connect you to the same ground level to which the instrument and all of its components are connected.
2. Pause for a second or two to allow any static charges to bleed away.
3. Open the casing of the analyzer and begin work. Up to this point, the closed metal casing of your analyzer has isolated the components and assemblies inside from any conducted or induced static charges.
4. If you must remove a component from the instrument, do not lay it down on a non-ESD preventative surface where static charges may lie in wait.
5. Only disconnect your wrist strap after you have finished work and closed the case of the analyzer.

12.4.2.2. Working at an Anti-ESD Work Bench

When working on an instrument of an electronic assembly while it is resting on a anti-ESD work bench

1. Plug you anti-ESD wrist strap into the grounded receptacle of the work station before touching any items on the work station and while standing at least a foot or so away. This will allow any charges you are carrying to bleed away through the ground connection of the workstation and prevent discharges due to field effects and induction from occurring.
2. Pause for a second or two to allow any static charges to bleed away.
3. Only open any anti-ESD storage bins or bags containing sensitive devices or assemblies after you have plugged your wrist strap into the workstation.
   - Lay the bag or bin on the workbench surface.
   - Before opening the container, wait several seconds for any static charges on the outside surface of the container to be bled away by the workstation's grounded protective mat.
4. Do not pick up tools that may be carrying static charges while also touching or holding an ESD Sensitive Device.
   - Only lay tools or ESD-sensitive devices and assemblies on the conductive surface of your workstation. Never lay them down on any non-ESD preventative surface.
5. Place any static sensitive devices or assemblies in anti-static storage bags or bins and close the bag or bin before unplugging your wrist strap.
6. Disconnecting your wrist strap is always the last action taken before leaving the workbench.

12.4.2.3. Transferring Components from Rack to Bench and Back

When transferring a sensitive device from an installed Teledyne API analyzer to an anti-ESD workbench or back:

1. Follow the instructions listed above for working at the instrument rack and workstation.
2. Never carry the component or assembly without placing it in an anti-ESD bag or bin.
3. Before using the bag or container allow any surface charges on it to dissipate:
   - If you are at the instrument rack, hold the bag in one hand while your wrist strap is connected to a ground point.
   - If you are at an anti-ESD workbench, lay the container down on the conductive work surface.
   - In either case wait several seconds.
4. Place the item in the container.
5. Seal the container. If using a bag, fold the end over and fastening it with anti-ESD tape.
   - Folding the open end over isolates the component(s) inside from the effects of static fields.
   - Leaving the bag open or simply stapling it shut without folding it closed prevents the bag from forming a complete protective envelope around the device.
6. Once you have arrived at your destination, allow any surface charges that may have built up on the bag or bin during travel to dissipate:
   - Connect your wrist strap to ground.
   - If you are at the instrument rack, hold the bag in one hand while your wrist strap is connected to a ground point.
   - If you are at a anti-ESD work bench, lay the container down on the conductive work surface.
   - In either case wait several seconds.
7. Open the container.

12.4.2.4. Opening Shipments from Teledyne API's Customer Service

Packing materials such as bubble pack and Styrofoam pellets are extremely efficient generators of static electric charges. To prevent damage from ESD, Teledyne API ships all electronic components and assemblies in properly sealed anti-ESD containers.

Static charges will build up on the outer surface of the anti-ESD container during shipping as the packing materials vibrate and rub against each other. To prevent these static charges from damaging the components or assemblies being shipped ensure that you:

Always unpack shipments from Teledyne API's Customer Service by:

1. Opening the outer shipping box away from the anti-ESD work area.
2. Carry the still sealed ant-ESD bag, tube or bin to the anti-ESD work area.
3. Follow steps 6 and 7 of Section 12.4.2.3 above when opening the anti-ESD container at the work station.
4. Reserve the anti-ESD container or bag to use when packing electronic components or assemblies to be returned to Teledyne API.

12.4.2.5. Packing Components for Return to Teledyne API's Customer Service

Always pack electronic components and assemblies to be sent to Teledyne API's Customer Service in anti-ESD bins, tubes or bags.

WARNING

- **DO NOT use pink-poly bags.**
- **NEVER allow any standard plastic packaging materials to touch the electronic component/assembly directly**
  - **This includes, but is not limited to, plastic bubble-pack, Styrofoam peanuts, open cell foam, closed cell foam, and adhesive tape**
- **DO NOT use standard adhesive tape as a sealer. Use ONLY anti-ESD tape**

1. Never carry the component or assembly without placing it in an anti-ESD bag or bin.
2. Before using the bag or container allow any surface charges on it to dissipate:
   - If you are at the instrument rack, hold the bag in one hand while your wrist strap is connected to a ground point.
   - If you are at an anti-ESD workbench, lay the container down on the conductive work surface.
   - In either case wait several seconds.
3. Place the item in the container.
4. Seal the container. If using a bag, fold the end over and fastening it with anti-ESD tape.
   - Folding the open end over isolates the component(s) inside from the effects of static fields.
   - Leaving the bag open or simply stapling it shut without folding it closed prevents the bag from forming a complete protective envelope around the device.

NOTE

If you do not already have an adequate supply of anti-ESD bags or containers available, Teledyne API's Customer Service department will supply them (see Section 11.8 for contact information).

Follow the instructions listed above for working at the instrument rack and workstation.

USER NOTES:

USER NOTES:

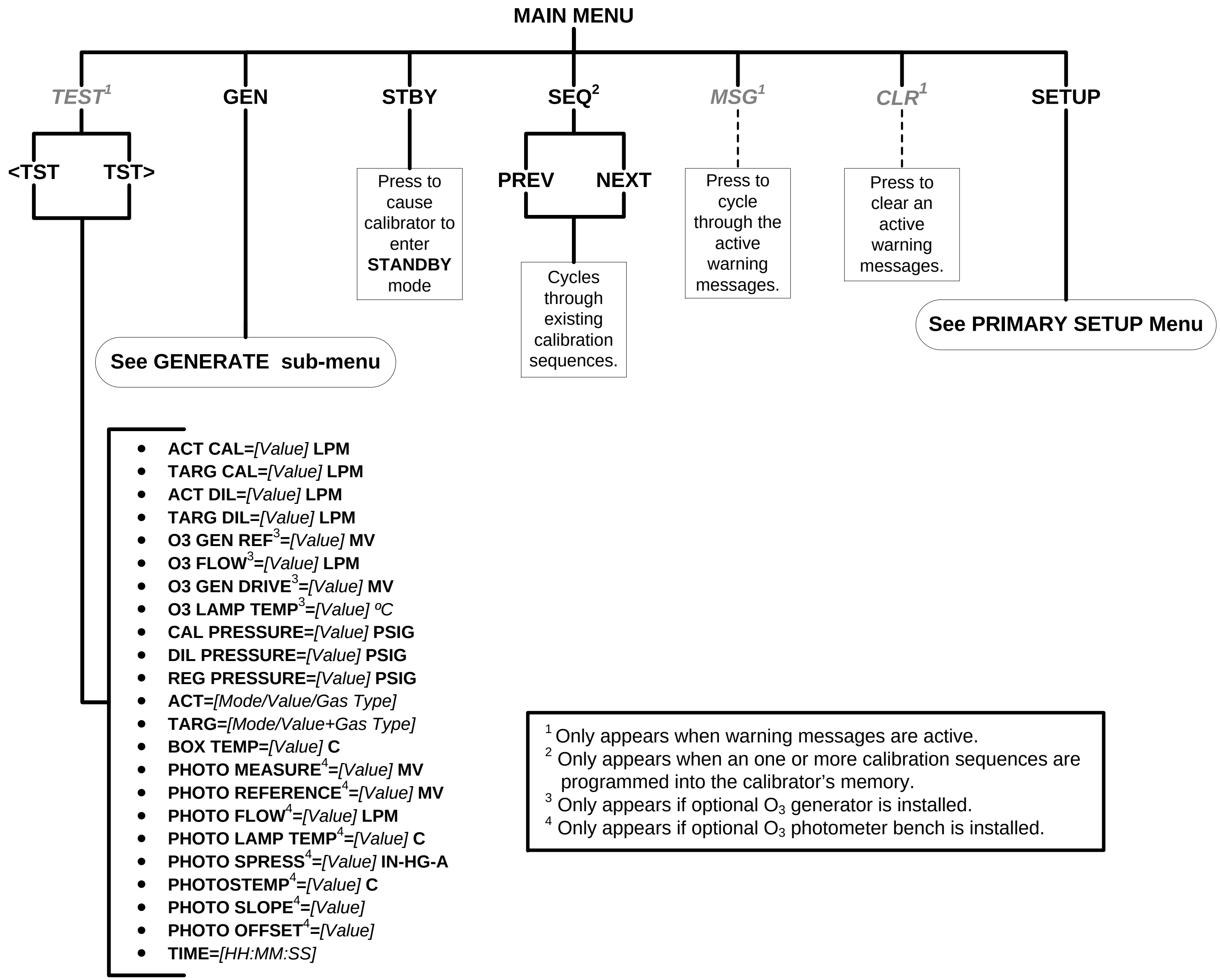
USER NOTES:

USER NOTES:

APPENDIX A – Version Specific Software Documentation

USER NOTES

APPENDIX A-1: Software Menu Trees, Revision D.1



[1] Only appears when warning messages are active.
[2] Only appears when an one or more calibration sequences are programmed into the calibrator's memory.
[3] Only appears if optional O_3 generator is installed.
[4] Only appears if optional O_3 photometer bench is installed.

Figure A-1: Main Menu

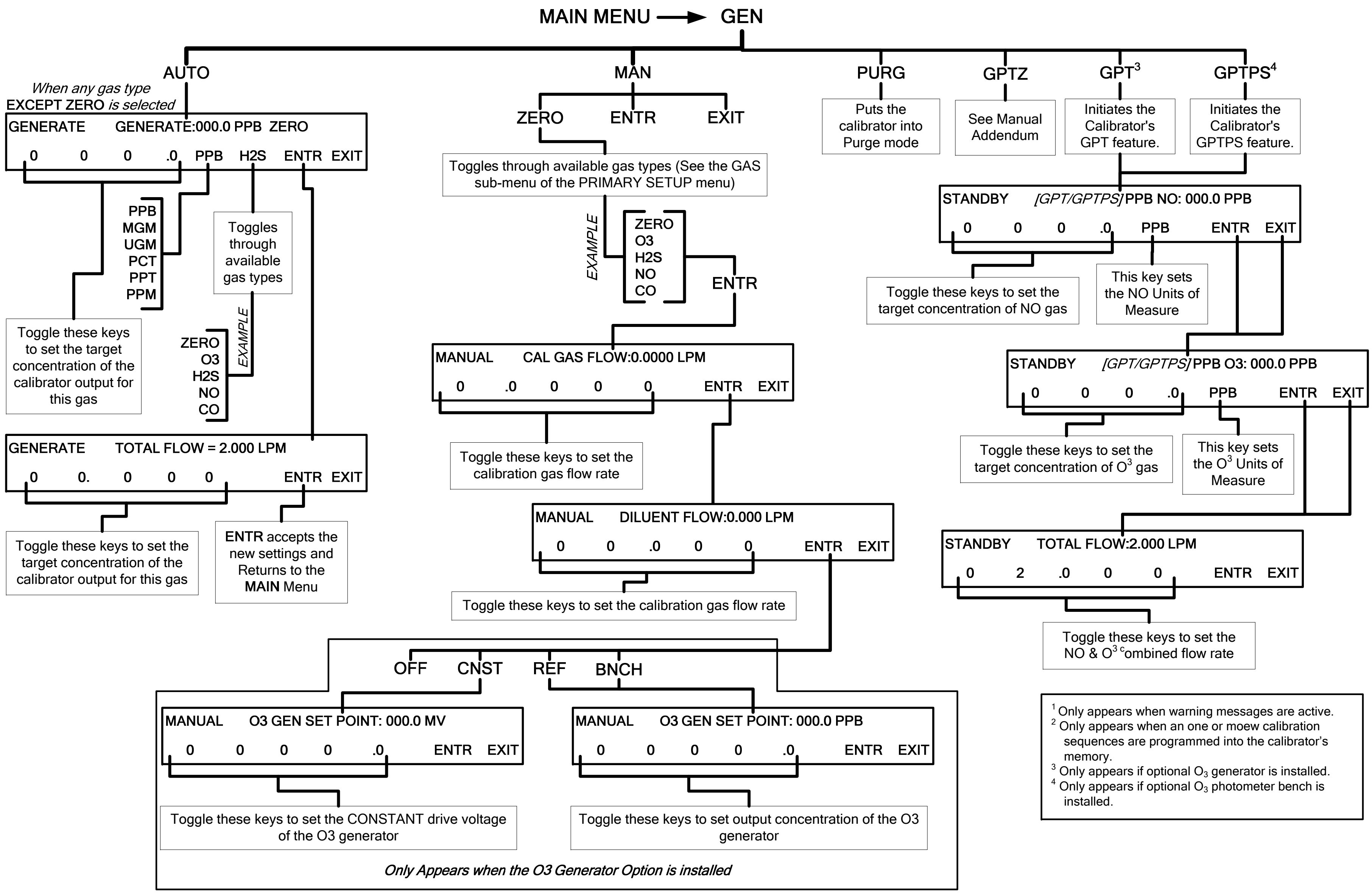


Figure A-2: MAIN Menu - GENERATE Submenu

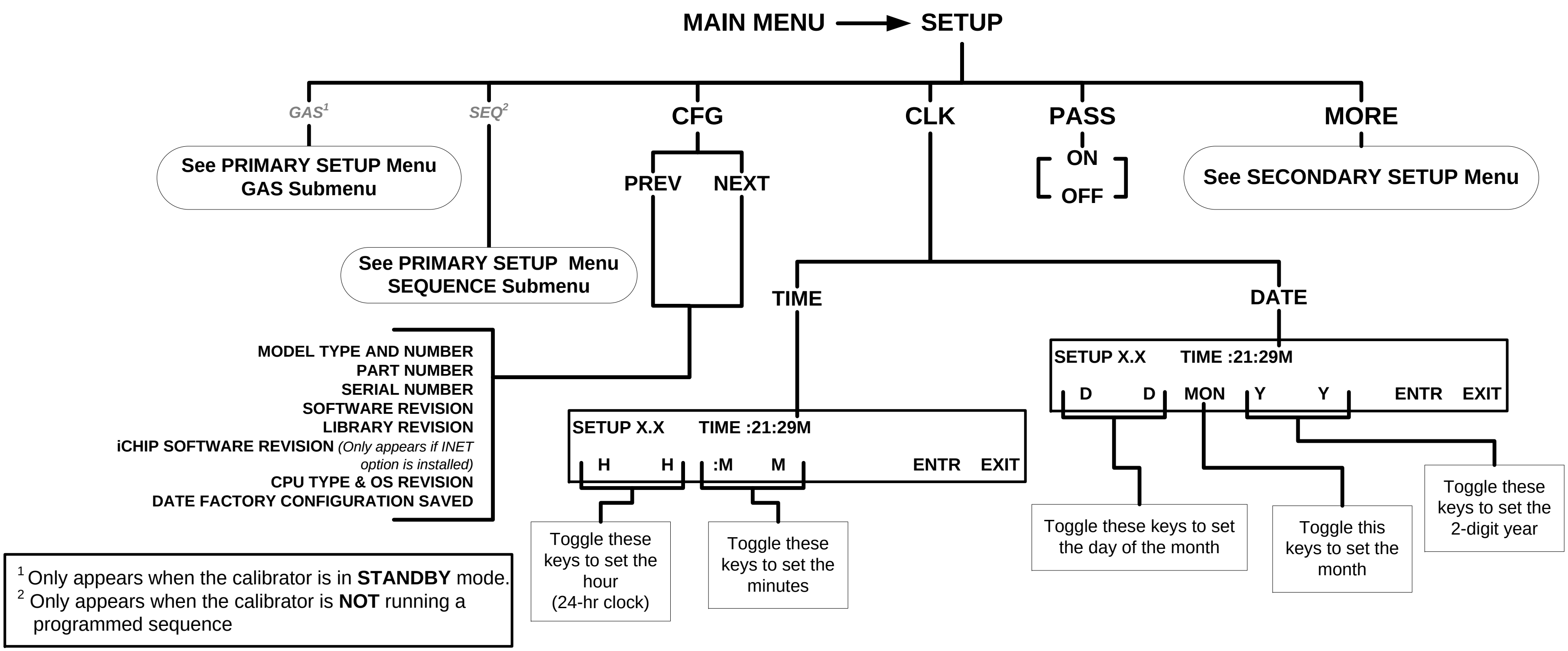
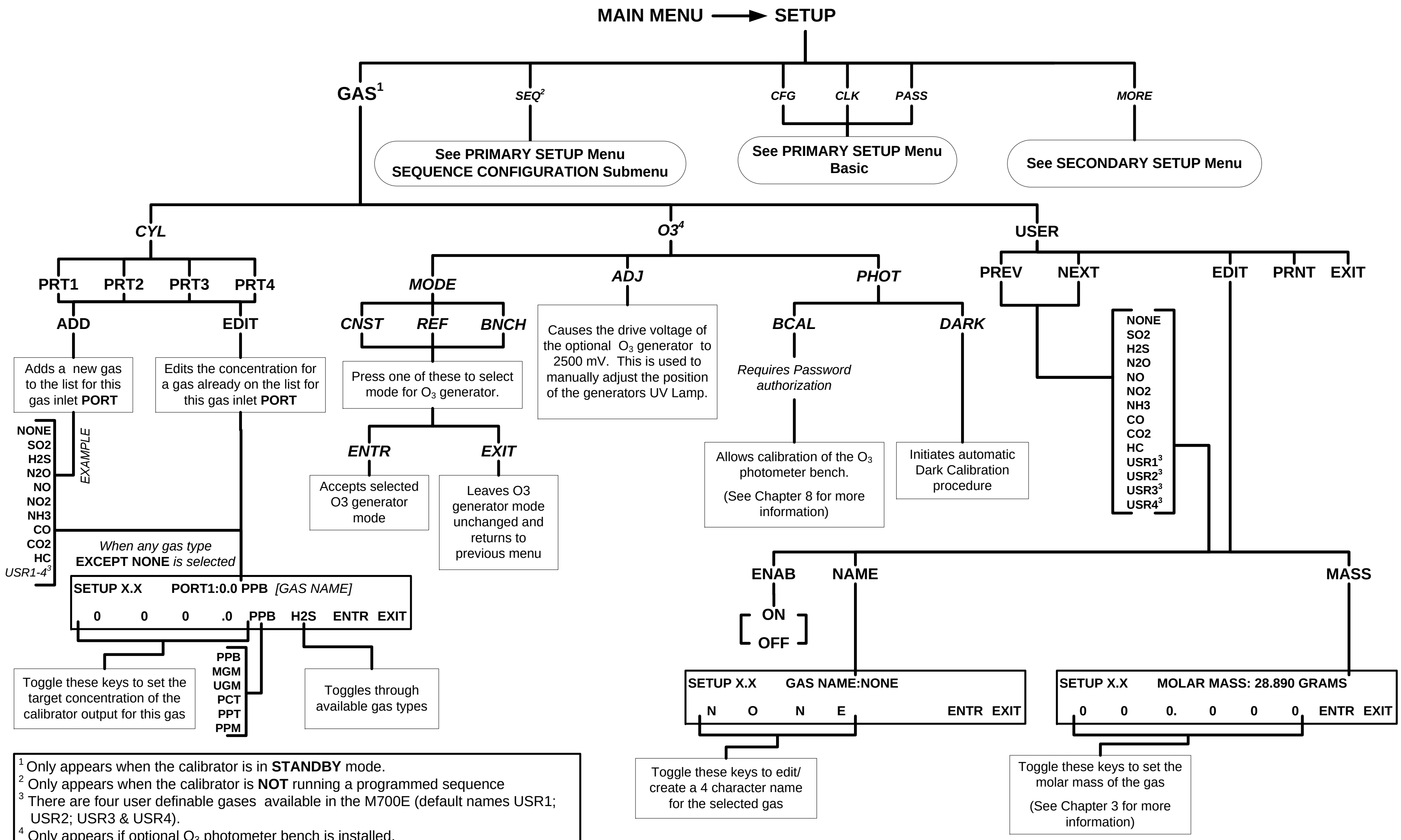


Figure A-3: PRIMARY SETUP MENU - Basics



[1] Only appears when the calibrator is in **STANDBY** mode.
[2] Only appears when the calibrator is **NOT** running a programmed sequence
[3] There are four user definable gases available in the M700E (default names USR1; USR2; USR3 & USR4).
[4] Only appears if optional O_3 photometer bench is installed.

Figure A-4: PRIMARY SETUP Menu - SOURCE GAS CONFIGURATION Submenu

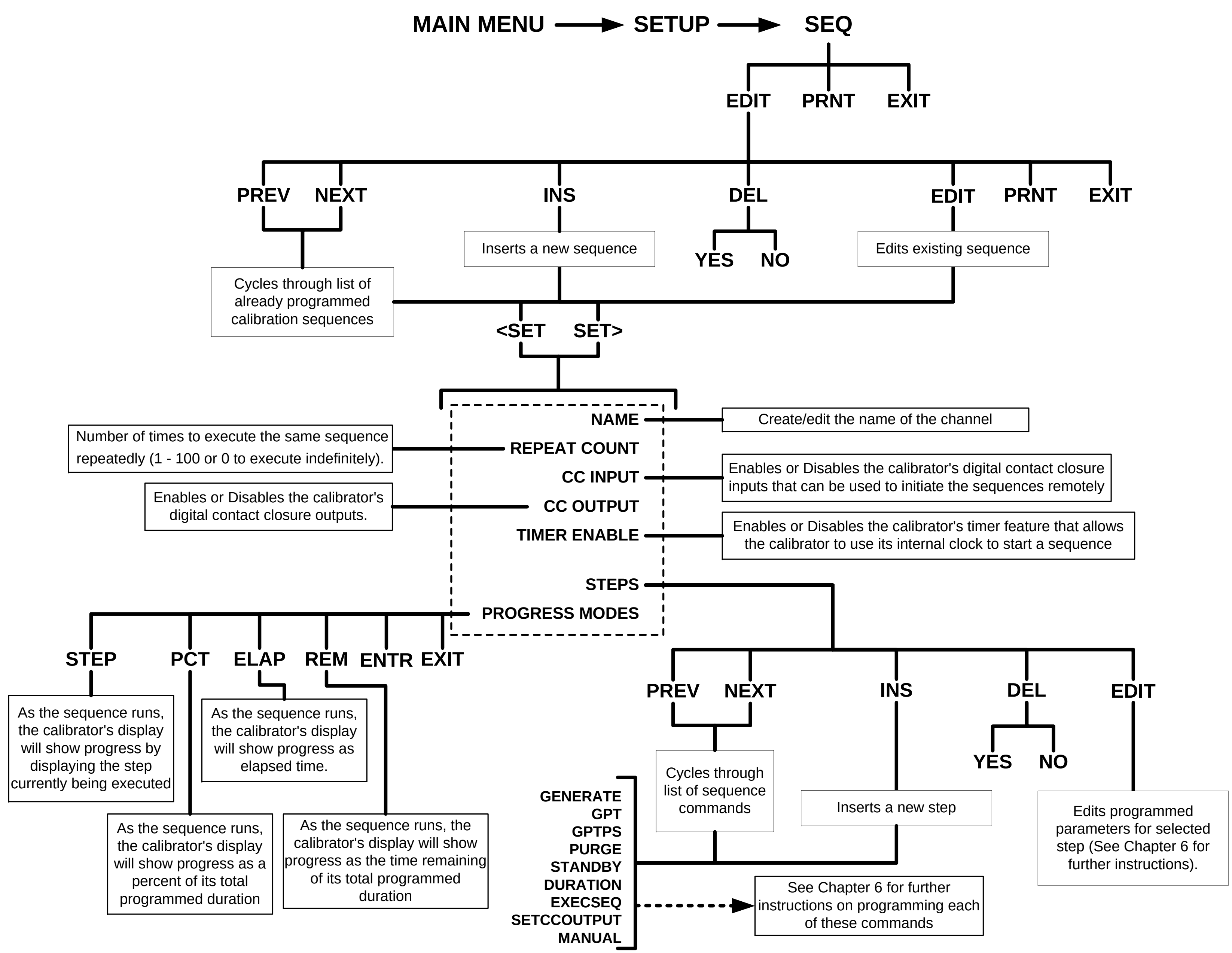


Figure A-5: PRIMARY SETUP Menu - SEQUENCE CONFIGURATION Submenu

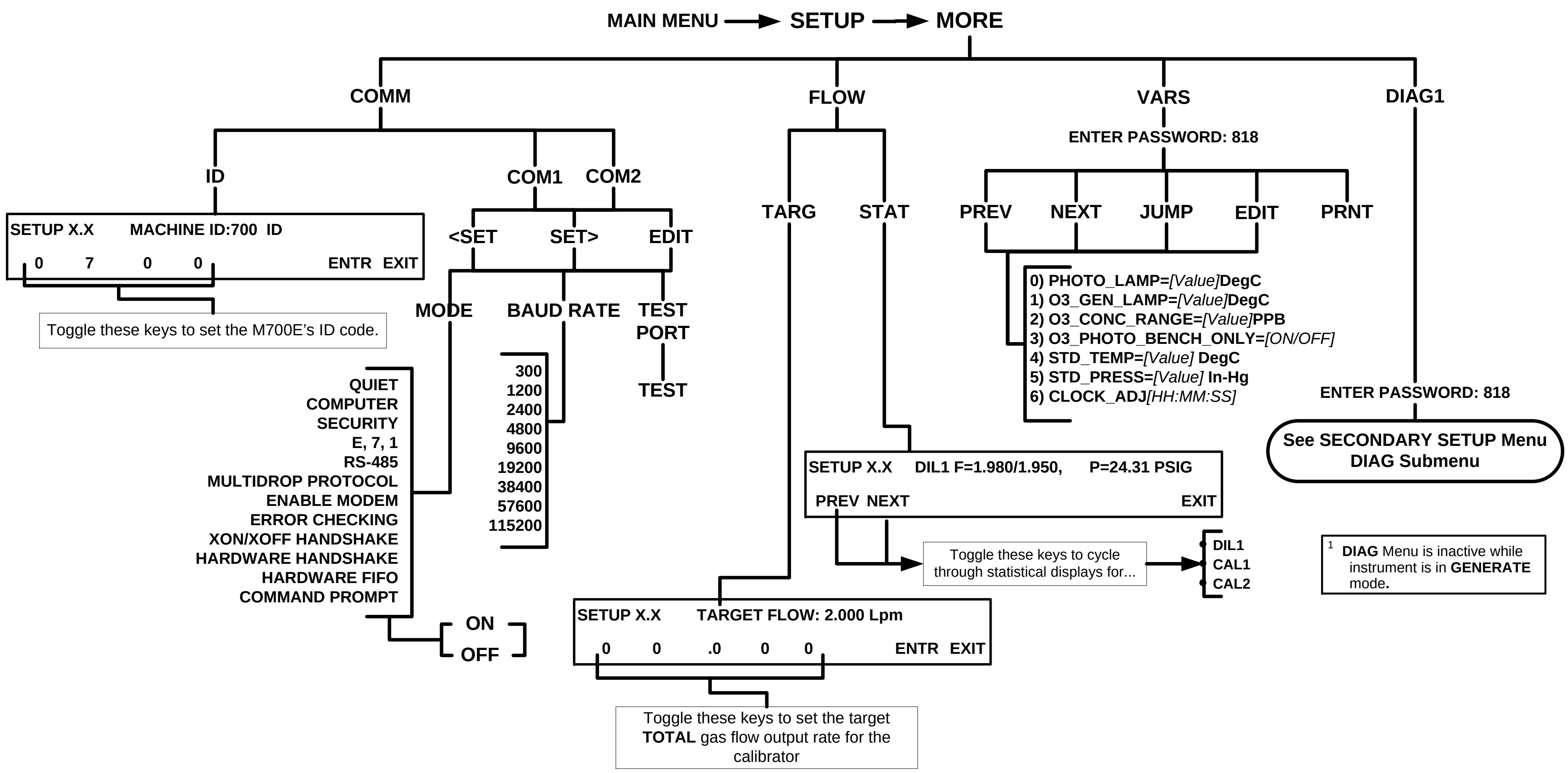


Figure A-6: SECONDARY SETUP Menu - Basic

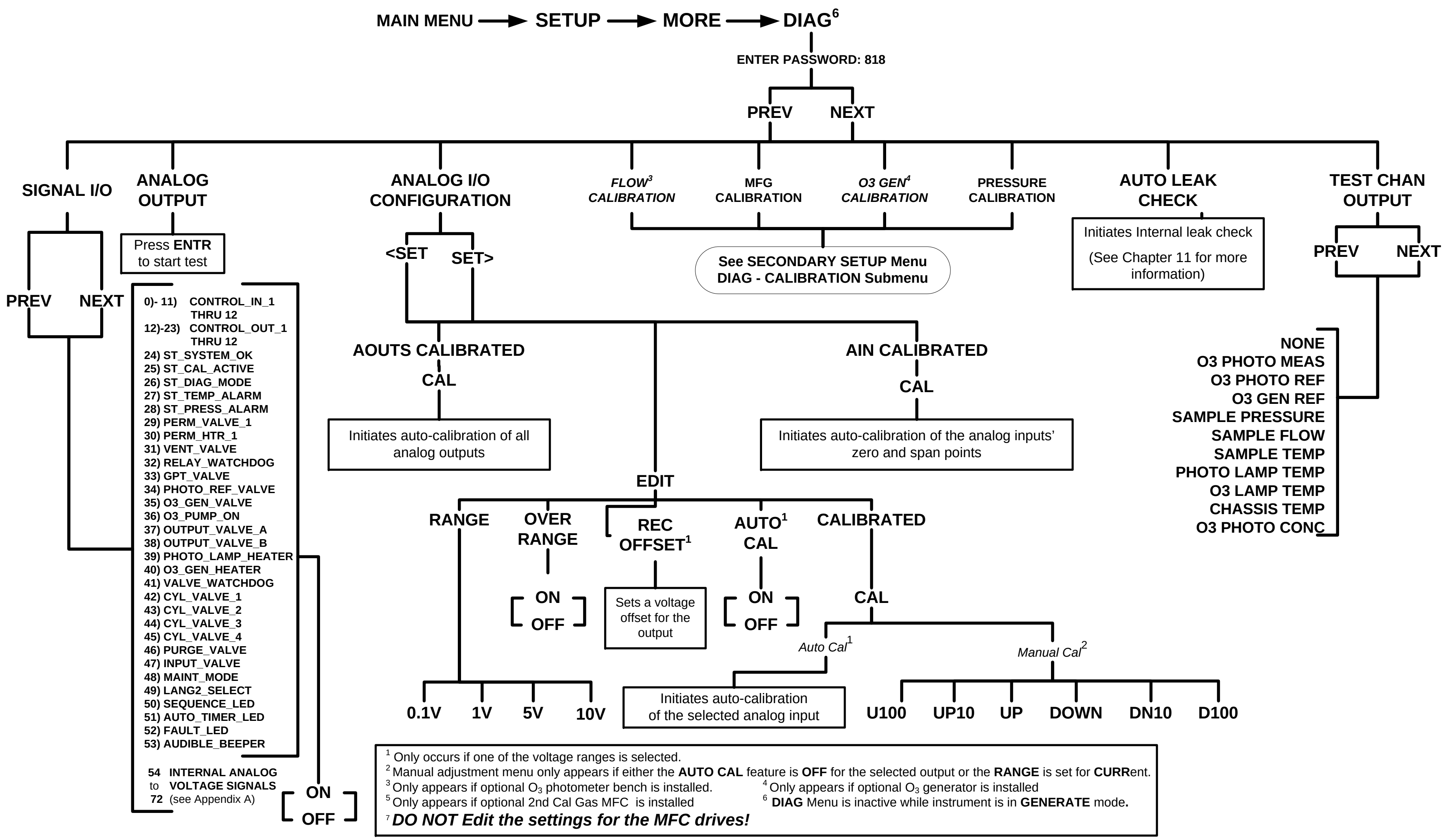


Figure A-7: SECONDARY SETUP Menu; DIAG Submenu – Basics

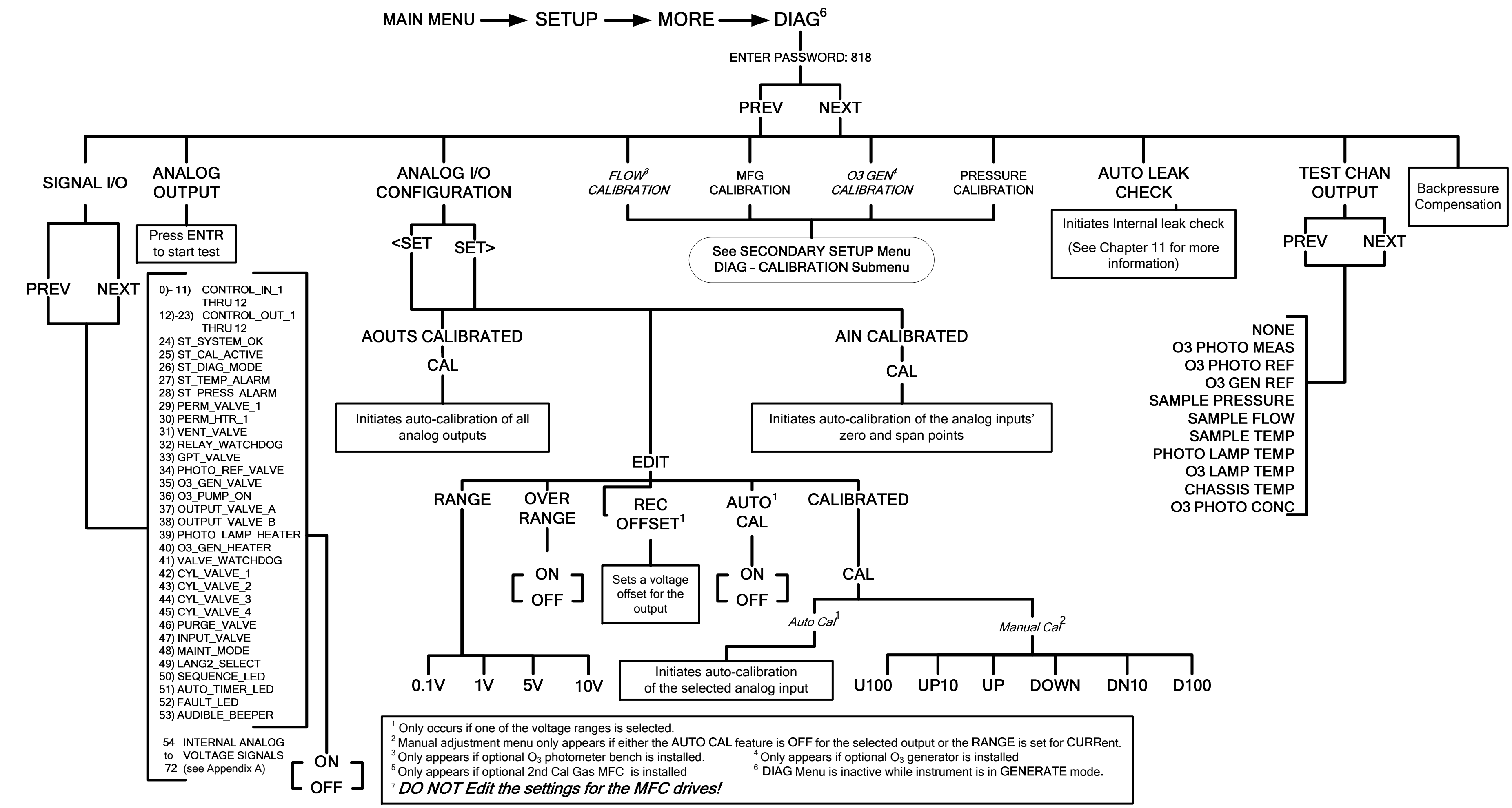


Figure A-8: SECONDARY SETUP Menu; DIAG Submenu – GAS CONFIGURATION

APPENDIX A-2: Setup Variables For Serial I/O, Revision D.1

Table A-1: M700E Setup Variables, Revision D.1

M700E Setup Variables for Latest Revision				
Setup Variable	**Numeric Units**	**Default Value**	**Value Range**	**Description**
Low Access Level Setup Variables (818 password)				
PHOTO_LAMP	ºC	58 Warnings: 56–61	0–100	Photometer lamp temperature set point and warning limits.
O3_GEN_LAMP	ºC	48 Warnings: 43–53	0–100	O_3 generator lamp temperature set point and warning limits.
O3_CONC_RANGE	PPB	500	0.1–20000	O_3 concentration range for test channel analog output.
O3_PHOTO_BENCH_ONLY	—	ON	OFF, ON	O_3 bench control flag. ON turns on pump and switches measure/reference valve only in bench generation mode.
STD_TEMP	ºC	25	0–100	Standard temperature for unit conversions.
STD_PRESS	"Hg	29.92	15–50	Standard pressure for unit conversions.
CLOCK_ADJ	Sec./Day	0	-60–60	Time-of-day clock speed adjustment.
Medium Access Level Setup Variables (929 password)				
LANGUAGE_SELECT	—	ENGL	ENGL, SECD, EXTN	Selects the language to use for the user interface. Enclose value in double quotes (") when setting from the RS-232 interface.
MAINT_TIMEOUT	Hours	2	0.1–100	Time until automatically switching out of software-controlled maintenance mode.
O3_DWELL	Seconds	2.5	0.1–30	Dwell time after switching measure/reference valve.
O3_SAMPLE	Samples	1	1–30	Number of O_3 detector readings to sample.
DARK_OFFSET	mV	0	-1000–1000	Photometer dark offset for measure and reference readings.
FILT_SIZE	Samples	32	1–100	Moving average filter size.
FILT_ASIZE	Samples	6	1–100	Moving average filter size in adaptive mode.
FILT_DELTA	PPB	20	1–1000	Absolute concentration difference to trigger adaptive filter.
FILT_PCT	Percent	5	1–100	Percent concentration difference to trigger adaptive filter.
FILT_DELAY	Seconds	60	0–60	Delay before leaving adaptive filter mode.
FILT_ADAPT	—	ON	OFF, ON	ON enables adaptive filter; OFF disables it.

PDELTA_GAIN	PPB/dIn-Hg	0	-200–200	Multiplied by difference between measure and reference pressure and added to concentration.
PDELTA_CAL_DUR	Minutes	5	0.1–20	Duration of pressure compensation calibration procedure.
O3_SLOPE_CONST	—	1.0	0.1–10	Constant factor to keep visible slope near 1.
O3_SLOPE	—	1	0.850–1.150	O_3 photometer slope.
O3_OFFSET	PPB	0	-1000–1000	O_3 photometer offset.
O3_BCAL_SET	PPB	400	0.1–10000	Target O_3 concentration during bench span calibration.
O3_PUMP_STARTUP	—	ON	OFF, ON	O_3 pump startup enable. ON enables startup procedure.
O3_PUMP_MIN_FLOW	LPM	0.2	0–1	Minimum flow rate that indicates O_3 pump is on.
O3_PUMP_TIMEOUT	Seconds	30	1–180	O_3 pump startup timeout.
O3_PUMP_PULSE	Seconds	0.5	0.1–10	O_3 pump power off pulse duration.
PHOTO_CYCLE	Seconds	10	0.5–30	Photometer lamp temperature control cycle period.
PHOTO_PROP	—	0.5	0–10	Photometer lamp temperature PID proportional coefficient.
PHOTO_INTEG	—	0.05	0–10	Photometer lamp temperature PID integral coefficient.
PHOTO_DERIV	—	0.2	0–10	Photometer lamp temperature PID derivative coefficient.
PHOTO_FLOW_SLOPE	—	1	0.001–100	Slope term to correct photometer sample flow rate.
O3_DEF_DRIVE	mV	800	0–5000	O_3 generator default drive setting.
O3_GEN_FLOW	Lpm	0.105	0.001–1.000	O_3 generator nominal flow rate.
O3_GEN_MODE	—	CNST	CNST, REF, BNCH	O_3 generator control mode. Enclose value in double quotes (") when setting from the RS-232 interface.
O3_MIN_CONC	PPB	25	0–100	O_3 generator minimum reliable concentration. Less than this is treated as zero.
REF_DELAY	Seconds	60	1–300	O_3 generator reference feedback control delay.
REF_FREQ	Seconds	1	1–60	O_3 generator reference adjustment frequency.
REF_FSIZE	Samples	4	1–10	O_3 generator reference filter size.
REF_INTEG	—	0.1	0–10	O_3 generator reference PID integral coefficient.
REF_DERIV	—	0.2	0–10	O_3 generator reference PID derivative coefficient.
BENCH_DELAY	Seconds	120	1–300	O_3 generator bench feedback control delay.
BENCH_FREQ	Seconds	10	1–60	O_3 generator bench adjustment frequency.
BENCH_FSIZE	Samples	3	1–10	O_3 generator bench filter size.

BENCH_INTEG	—	0.2	0–10	O_3 generator bench PID integral coefficient.
BENCH_DERIV	—	0.5	0–10	O_3 generator bench PID derivative coefficient.
DRIVE_STABIL	mV	10	0.1–100	O_3 generator drive stability limit to update concentration cache.
CACHE_RESOL	PPB	2	0.1–20	O_3 generator cache un-normalized concentration resolution.
O3_LAMP_CYCLE	Seconds	2	0.5–30	O_3 generator lamp temperature control cycle period.
O3_LAMP_PROP	1/DegC	0.2	0–10	O_3 generator lamp temperature PID proportional coefficient.
O3_LAMP_INTEG	Gain	0.01	0–10	O_3 generator lamp temperature PID integral coefficient.
O3_LAMP_DERIV	Gain	0.2	0–10	O_3 generator lamp temperature PID derivative coefficient.
MFC_PRESS_LIMIT	PSIG	25 Warnings: 15–36	0–50	MFC pressure warning limits. Set point not important.
REG_PRESS_LIM	PSIG	20 Warnings: 15–25	0–50	Regulator pressure warning limits. Set point not important.
PERM_SET1	ºC	50 Warnings: 49–51	0–100	Permeation tube #1 temperature set point and warning limits.
PERM_SET2 [2]	ºC	50 Warnings: 49–51	0–100	Permeation tube #2 temperature set point and warning limits.
TARGET_FLOW	Lpm	2	0.01–20.00	Default total output flow rate, if flow not specified in individual actions or steps.
RS232_MODE	BitFlag	0	0–65535	RS-232 COM1 mode flags. Add values to combine flags. 1 = quiet mode 2 = computer mode 4 = enable security 8 = enable hardware handshaking 32 = enable multi-drop 64 = enable modem 128 = ignore RS-232 line errors 256 = disable XON / XOFF support 512 = disable hardware FIFOs 1024 = enable RS-485 mode 2048 = even parity, 7 data bits, 1 stop bit 4096 = enable command prompt 8192 = even parity, 8 data bits, 1 stop bit

BAUD_RATE	—	19200	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	RS-232 COM1 baud rate. Enclose value in double quotes (") when setting from the RS-232 interface.
MODEM_INIT	—	"AT Y0 &D0 &H0 &I0 S0=2 &B0 &N6 &M0 E0 Q1 &W0" [0]	Any character in the allowed character set. Up to 100 characters long.	RS-232 COM1 modem initialization string. Sent verbatim plus carriage return to modem on power up or manually.
RS232_MODE2	—	0	0–65535	RS-232 COM2 mode flags. *(Same settings as RS232_MODE.)*
BAUD_RATE2	—	19200	300, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	RS-232 COM2 baud rate.
MODEM_INIT2	—	"AT Y0 &D0 &H0 &I0 S0=2 &B0 &N6 &M0 E0 Q1 &W0" [0]	Any character in the allowed character set. Up to 100 characters long.	RS-232 COM2 modem initialization string. Sent verbatim plus carriage return to modem on power up or manually.
RS232_PASS	Password	940331	0–999999	RS-232 log on password.
LINE_DELAY [1]	ms.	0	0–1000	RS-232 inter-line transmit delay (0=disabled).
MACHINE_ID	ID	700	0–9999	Unique ID number for instrument.
COMMAND_PROMPT	—	"Cmd> "	Any character in the allowed character set. Up to 100 characters long.	RS-232 interface command prompt. Displayed only if enabled with *RS232_MODE* variable. Enclose value in double quotes (") when setting from the RS-232 interface.
TEST_CHAN_ID			NONE, O3 PHOTO MEAS, O3 PHOTO REF, O3 GEN REF, REGULATO	Diagnostic analog output ID. Enclose value in double quotes (") when setting from the RS-232 interface.

			R PRESSURE SAMPLE PRESSURE, SAMPLE FLOW, SAMPLE TEMP, PHOTO LAMP TEMP, O3 LAMP TEMP, CHASSIS TEMP, DCPS VOLTAGE, O3 PHOTO CONC	
PASS_ENABLE	—	ON	OFF, ON	ON enables passwords. OFF disables them.
DEF_CC_OUTPUT	—	"000000000000"	Any string of exactly 12 characters consisting of the digits 0 and 1 only.	Default contact closure output pattern when not executing a sequence. Enclose value in double quotes (") when setting from the RS-232 interface.
PHOTO_LAMP_POWER	mV	4500	0–5000	Photometer lamp power setting.
LAMP_PWR_ENABLE	—	ON	OFF, ON	ON enables photometer lamp power cycling. OFF disables it.
LAMP_PWR_PERIOD	Hours	24	0.01–1000	Photometer lamp power cycling period.
LAMP_OFF_DELAY	Seconds	0.1	0.02–5	Length of time photometer lamp is turned off.
DET_VALID_DELAY	Seconds	20	1–300	Delay until valid concentration is computed.
REF_SDEV_LIMIT	mV	3	0.1–100	Photometer reference standard deviation must be below this limit to switch out of startup mode.
PATH_LENGTH	cm	41.96	0.01–99.999	Photometer detector path length.
BOX_SET	ºC	30 Warnings: 5–45	0–100	Internal box temperature set point and warning limits.
GAS_MOL_WEIGHT	MolWt	32	1–99.999	Molar mass of sample gas for computing concentrations by weight instead of volume.
SERIAL_NUMBER	—	"00000000 "	Any character in the allowed character set. Up to 100 characters long.	Unique serial number for instrument.

DISP_INTENSITY	—	HIGH	HIGH, MED, LOW, DIM	Front panel display intensity. Enclose value in double quotes (") when setting from the RS-232 interface.
I2C_RESET_ENABLE	—	ON	OFF, ON	I^2C bus automatic reset enable.
MFC_BUSY_TIME [4]	ms.	20	10–1000	Time it takes for MFC to process command.
CLOCK_FORMAT	—	"TIME=%H:%M:%S"	Any character in the allowed character set. Up to 100 characters long.	Time-of-day clock format flags. Enclose value in double quotes (") when setting from the RS-232 interface. "%a" = Abbreviated weekday name. "%b" = Abbreviated month name. "%d" = Day of month as decimal number (01 – 31). "%H" = Hour in 24-hour format (00 – 23). "%I" = Hour in 12-hour format (01 – 12). "%j" = Day of year as decimal number (001 – 366). "%m" = Month as decimal number (01 – 12). "%M" = Minute as decimal number (00 – 59). "%p" = A.M./P.M. indicator for 12-hour clock. "%S" = Second as decimal number (00 – 59). "%w" = Weekday as decimal number (0 – 6; Sunday is 0). "%y" = Year without century, as decimal number (00 – 99). "%Y" = Year with century, as decimal number. "%%" = Percent sign.
FACTORY_OPT	—	0	0–65535	Factory option flags. Add values to combine options. 1 = permeation tube #1 installed (do not enable dual gas outputs option) 2 = O_3 generator installed 4 = O_3 photometer installed 8 = enable high concentration 16 = enable high pressure diluent sensor 32 = O_3 generator reference detector installed (implies that O_3 generator is installed) 64 = enable MFC flow correction 128 = enable dual gas outputs (do not enable permeation tube

				option) 256 = enable dual diluent inputs 512 [2] = permeation tube #2 installed (do not enable O_3 photometer option) 1024 = enable software-controlled maintenance mode 2048 [3] = enable Internet option 4096 = enable switch-controlled maintenance mode

[1] Dasibi emulation version only.

[2] Dual permeation tube option.

[3] iChip option.

[4] I^2C MFC option.

APPENDIX A-3: Warnings and Test Functions, Revision D.1

Table A-2: M700E Warning Messages, Revision D.1

M700E Messages for Latest Revision		
Name [1]	**Message Text**	**Description**
Warnings		
WSYSRES	SYSTEM RESET	Instrument was power-cycled or the CPU was reset.
WDATAINIT	DATA INITIALIZED	Data storage was erased.
WCONFIGINIT	CONFIG INITIALIZED	Configuration storage was reset to factory configuration or erased.
WPHOTOLTEMP	PHOTO LAMP TEMP WARNING	Photometer lamp temperature outside of warning limits specified by *PHOTO_LAMP* variable.
WO3GENTEMP	O3 GEN LAMP TEMP WARNING	O_3 generator lamp temperature outside of warning limits specified by *O3_GEN_LAMP* variable.
WPERMTEMP1	PERM TUBE #1 TEMP WARNING	Permeation tube #1 temperature outside of warning limits specified by *PERM_SET1* variable.
WPERMTEMP2 [3]	PERM TUBE #2 TEMP WARNING	Permeation tube #2 temperature outside of warning limits specified by *PERM_SET2* variable.
WPHOTOREF	PHOTO REFERENCE WARNING	Photometer reference reading less than 2500 mV or greater than 4999 mV.
WLAMPSTABIL	PHOTO LAMP STABILITY WARNING	Photometer lamp reference step changes occur more than 25% of the time.
WO3GENREF	O3 GEN REFERENCE WARNING	O_3 reference detector drops below 5 mV during reference feedback O_3 generator control.
WREGPRESS	REGULATOR PRESSURE WARNING	Regulator pressure outside of warning limits specified by *REG_PRESS_LIM* variable.
WMFCPRESS	MFC PRESSURE WARNING	Any MFC pressure outside of warning limits specified by *PRESS_LIMIT* variable.
WMFCFLOW	MFC FLOW WARNING	Any MFC drive less than 10% of full scale or greater than full scale.
WMFCCAL	MFC CALIBRATION WARNING	Any MFC sensor offset greater than allowable limit.
WO3PUMP	O3 PUMP WARNING	O_3 pump failed to turn on within timeout period specified by *O3_PUMP_TIMEOUT* variable.
WOUTPUT	INVALID OUTPUT WARNING	An invalid output has been selected for the requested gas generation. For example, output B was selected when generating ozone.
WREARBOARD	REAR BOARD NOT DET	Rear board was not detected during power up.
WRELAYBOARD	RELAY BOARD WARN	Firmware is unable to communicate with the relay board.
WVALVEBOARD	VALVE BOARD WARN	Firmware is unable to communicate with the valve board.
WLAMPDRIVER	LAMP DRIVER WARN	Firmware is unable to communicate with

		either the O_3 generator or photometer lamp I^2C driver chip.
WFRONTPANEL	FRONT PANEL WARN	Firmware is unable to communicate with the front panel.
WMFCCOMM [4]	MFC COMMUNICATION WARNING	Firmware is unable to communicate with any MFC.
WANALOGCAL	ANALOG CAL WARNING	The A/D or at least one D/A channel has not been calibrated.

Table A-3: M700E Test Functions, Revision D.1

Test Measurements		
ACTCALFLOW	ACT CAL=0.0800 LPM	Actual cal. gas flow rate.
TARGCALFLOW	TARG CAL=0.0000 LPM	Target cal. gas flow rate.
ACTDILFLOW	ACT DIL=1.920 LPM	Actual diluent flow rate.
TARGDILFLOW	TARG DIL=0.000 LPM	Target diluent flow rate.
O3GENREF	O3 GEN REF=1000.0 MV	O_3 generator reference detector reading.
O3GENFLOW	O3 FLOW=0.1050 LPM	O_3 generator flow rate. Note: this is simply a constant, specified by the *O3_GEN_FLOW* variable.
O3GENDRIVE	O3 GEN DRIVE=800.0 MV	O_3 generator lamp drive output.
O3GENTEMP	O3 LAMP TEMP=49.7 C	O_3 generator lamp temperature.
CALPRESS	CAL PRESSURE=25.1 PSIG	Cal. gas pressure.
DILPRESS	DIL PRESSURE=25.1 PSIG	Diluent pressure.
REGPRESS	REG PRESSURE=20.1 PSIG	Regulator pressure.
ACTCONC	ACT=GENERATE 37 PPB O3	Actual concentration being generated, computed from real-time inputs.
TARGCONC	TARG=GENERATE 100 PPB O3	Target concentration to generate.
BOXTEMP	BOX TEMP=31.2 C	Internal chassis temperature.
PERMTEMP1	PERM TUBE #1 TEMP=50.4 C	Permeation tube #1 temperature.
PERMTEMP2 [3]	PERM TUBE #2 TEMP=50.4 C	Permeation tube #2 temperature.
PERMFLOW	PERM FLOW=0.1050 LPM	Permeation tube flow rate. This is a property of the permeation tube (**SETUP-GAS-PERM**). Its value depends on which permeation tube is in use.
PHOTOMEAS	PHOTO MEASURE=2998.8 MV	Photometer detector measure reading.
PHOTOREF	PHOTO REFERENCE=3000.0 MV	Photometer detector reference reading.
PHOTOFLOW	PHOTO FLOW=0.2978 LPM	Photometer sample flow rate.
PHOTOLTEMP	PHOTO LAMP TEMP=52.6 C	Photometer lamp temperature.
PHOTOSPRESS	PHOTO SPRESS=29.9 IN-HG-A	Photometer sample pressure.
PHOTOSTEMP	PHOTO STEMP=31.8 C	Photometer sample temperature.
PHOTOSLOPE	PHOTO SLOPE=1.000	Photometer slope computed during zero/span bench calibration.
PHOTOOFFSET	PHOTO OFFSET=0.0 PPB	Photometer offset computed during zero/span bench calibration.
PHOTOSTABIL [2]	PHOTO STABIL=0.1 PPB	Photometer concentration stability (standard deviation of 25 bench concentration samples taken 10 seconds apart).
TESTCHAN	TEST=2753.9 MV	Value output to *TEST_OUTPUT* analog output, selected with *TEST_CHAN_ID* variable.
CLOCKTIME	TIME=14:48:01	Current instrument time of day clock.

[1] The name is used to request a message via the RS-232 interface, as in "T BOXTEMP".

[2] O_3 photometer stability measurement option.

[3] Dual permeation tube option.

[4] I^2C MFCs.

APPENDIX A-4: Signal I/O Definitions for 300E Series Analyzers, Revision D.1

Table A-4: Signal I/O Definitions for 300E Series Analyzers, Revision D.1

M700E I/O Signal List for Latest Revision		
Signal Name	**Bit or Channel Number**	**Description**
U11, J1004, control inputs, pins 1-6 = bits 0-5, read, default I/O address 321 hex		
CONTROL_IN_1 – CONTROL_IN_6	0–5	0 = input asserted 1 = de-asserted
	6–7	Always 1
U14, J1006, control inputs, pins 1-6 = bits 0-5, read, default I/O address 325 hex		
CONTROL_IN_7 – CONTROL_IN_12	0–5	0 = input asserted 1 = de-asserted
	6–7	Always 1
U17, J1008, control outputs, pins 1-8 = bits 0-7, write, default I/O address 321 hex		
CONTROL_OUT_1 – CONTROL_OUT_8	0–7	0 = output asserted 1 = de-asserted
U21, J1008, control outputs, pins 9-12 = bits 0-3, write, default I/O address 325 hex		
CONTROL_OUT_9 – CONTROL_OUT_12	0–3	0 = output asserted 1 = de-asserted
U7, J108, internal inputs, pins 9-16 = bits 0-7, read, default I/O address 322 hex		
	0–7	Spare
U8, J108, internal outputs, pins 1-8 = bits 0-7, write, default I/O address 322 hex		
	0–7	Spare
U24, J1017, A status outputs, pins 1-8 = bits 0-7, write, default I/O address 323 hex		
ST_SYSTEM_OK	0	0 = system OK 1 = any alarm condition or in diagnostics mode
	1	Spare
ST_CAL_ACTIVE	2	0 = executing sequence 1 = not executing sequence
ST_DIAG_MODE	3	0 = in diagnostic mode 1 = not in diagnostic mode
ST_TEMP_ALARM	4	0 = any temperature alarm 1 = all temperatures OK
ST_PRESS_ALARM	5	0 = any pressure alarm 1 = all pressures OK
	6–7	Spare
U27, J1018, B status outputs, pins 1-8 = bits 0-7, write, default I/O address 324 hex		
	0–7	Spare
Relay board digital output (PCF8575), write, default I^2C address 44 hex		
RELAY_WATCHDOG	0	Alternate between 0 and 1 at least every 5 seconds to keep relay board active
VENT_VALVE	1	0 = vent valve open 1 = close
PERM_HTR_2 [2]	2	0 = permeation tube #2 heater on 1 = off

	3–4	Spare
GPT_VALVE	5	0 = open GPT bypass valve 1 = close
PHOTO_REF_VALVE	6	0 = photometer valve in reference position 1 = measure position
O3_GEN_VALVE	7	0 = open O_3 generator valve 1 = close
O3_PUMP_ON	8	0 = pump on for photometer to measure O_3 1 = off
OUTPUT_VALVE_A	9	0 = open output shut-off valve A 1 = close
OUTPUT_VALVE_B [1]	10	0 = open output shut-off valve B 1 = close
PERM_VALVE_1	11	0 = open permeation tube #1 valve 1 = close
PERM_VALVE_2 [2]	12	0 = open permeation tube #2 valve 1 = close
PERM_HTR_1	13	0 = permeation tube #1 heater on 1 = off
PHOTO_LAMP_HEATER	14	0 = O_3 photometer lamp heater on 1 = off
O3_GEN_HEATER	15	0 = O_3 generator lamp heater on 1 = off
Valve board digital output (PCA9557), write, default I^2C address 3A hex		
VALVE_WATCHDOG	0	Alternate between 0 and 1 at least every 5 seconds to keep valve board active
CYL_VALVE_1	1	1 = open cylinder gas valve 1 0 = close
CYL_VALVE_2	2	1 = open cylinder gas valve 2 0 = close
CYL_VALVE_3	3	1 = open cylinder gas valve 3 0 = close
CYL_VALVE_4	4	1 = open cylinder gas valve 4 0 = close
PURGE_VALVE	5	1 = open purge valve 0 = close
INPUT_VALVE	6	1 = open input (zero-air) shut-off valve 0 = close
DIL_VALVE_2 [5]	7	1 = open diluent valve #2 0 = open diluent valve #1
Front panel I^2C keyboard, default I^2C address 4E hex		
MAINT_MODE	5 (input)	0 = maintenance mode 1 = normal mode
LANG2_SELECT	6 (input)	0 = select second language 1 = select first language (English)
SEQUENCE_LED	8 (output)	0 = sequence LED on (executing sequence)

		1 = off
AUTO_TIMER_LED	9 (output)	0 = automatic timer LED on (automatic sequence timer enabled) 1 = off
FAULT_LED	10 (output)	0 = fault LED on 1 = off
AUDIBLE_BEEPER	14 (output)	0 = beeper on (for diagnostic testing only) 1 = off
Rear board primary MUX analog inputs		
PHOTO_DET	0	Photometer detector reading
O3_GEN_REF_DET	1	O_3 generator reference detector reading
DIL_PRESS	2	Diluent pressure
CAL_PRESS	3	Cal. gas pressure
	4	Temperature MUX
O3_PERM_PRESS	5	Ozone/perm tube pressure
	6–7	Spare
MFC_FLOW_3 [4]	8	MFC 3 (cal. gas #2) flow output
REF_4096_MV	9	4.096V reference from MAX6241
	Photometer flow	
PHOTO_SAMP_PRES	11	Photometer sample pressure
MFC_FLOW_1	12	MFC 1 (diluent) flow output
MFC_FLOW_2	13	MFC 2 (cal. gas #1) flow output
	14	DAC loopback MUX
REF_GND	15	Ground reference
Rear board temperature MUX analog inputs		
BOX_TEMP	0	Internal box temperature
PHOTO_SAMP_TEMP	1	Photometer sample temperature
PHOTO_LAMP_TEMP	2	Photometer lamp temperature
O3_GEN_TEMP	3	O_3 generator lamp temperature
PERM_TEMP_1	4	Permeation tube #1 temperature
PERM_TEMP_2 [2]	5	Permeation tube #2 temperature
	6–7	Spare
Rear board DAC MUX analog inputs		
DAC_CHAN_1	0	DAC channel 0 loopback
DAC_CHAN_2	1	DAC channel 1 loopback
DAC_CHAN_3	2	DAC channel 2 loopback
DAC_CHAN_4	3	DAC channel 3 loopback
Rear board analog outputs		
MFC_DRIVE_1	0	MFC 1 (diluent) flow drive
MFC_DRIVE_2	1	MFC 2 (cal. gas #1) flow drive
MFC_DRIVE_3 [4]	2	MFC 3 (cal. gas #2) flow drive
TEST_OUTPUT	3	Test measurement output
I^2C analog output (AD5321), default I^2C address 18 hex		
PHOTO_LAMP_DRIVE	0	O_3 photometer lamp drive (0–5V)
I^2C analog output (AD5321), default I^2C address 1A hex		

O3_GEN_DRIVE	0	O_3 generator lamp drive (0–5V)

[1] Must be enabled with a factory option bit.
[2] Dual permeation tube option.
[4] Triple-MFC option.
[5] Dual diluent option.

APPENDIX A-5: Terminal Command Designators, Revision D.1

Table A-5: Terminal Command Designators, Revision D.1

COMMAND	ADDITIONAL COMMAND SYNTAX	DESCRIPTION
? [ID]		Display help screen and commands list
LOGON [ID]	password	Establish connection to instrument
LOGOFF [ID]		Terminate connection to instrument
T [ID]	SET ALL|name|hexmask	Display test(s)
	LIST [ALL|name|hexmask] [NAMES|HEX]	Print test(s) to screen
	name	Print single test
	CLEAR ALL|name|hexmask	Disable test(s)
W [ID]	SET ALL|name|hexmask	Display warning(s)
	LIST [ALL|name|hexmask] [NAMES|HEX]	Print warning(s)
	name	Clear single warning
	CLEAR ALL|name|hexmask	Clear warning(s)
C [ID]	ZERO|LOWSPAN|SPAN [1|2]	Enter calibration mode
	ASEQ number	Execute automatic sequence
	COMPUTE ZERO|SPAN	Compute new slope/offset
	EXIT	Exit calibration mode
	ABORT	Abort calibration sequence
D [ID]	LIST	Print all I/O signals
	name[=value]	Examine or set I/O signal
	LIST NAMES	Print names of all diagnostic tests
	ENTER name	Execute diagnostic test
	EXIT	Exit diagnostic test
	RESET [DATA] [CONFIG] [exitcode]	Reset instrument
V [ID]	LIST	Print setup variables
	name[=value [warn_low [warn_high]]]	Modify variable
	name="value"	Modify enumerated variable
	CONFIG	Print instrument configuration
	MAINT ON|OFF	Enter/exit maintenance mode
	MODE	Print current instrument mode

The command syntax follows the command type, separated by a space character. Strings in [brackets] are optional designators. The following key assignments also apply.

Table A-6: Terminal Key Assignments, Revision D.1

TERMINAL KEY ASSIGNMENTS	
ESC	Abort line
CR (ENTER)	Execute command
Ctrl-C	Switch to computer mode
COMPUTER MODE KEY ASSIGNMENTS	
LF (line feed)	Execute command
Ctrl-T	Switch to terminal mode

APPENDIX B – M700E Spare Parts List

NOTE

Use of replacement parts other than those supplied by API may result in non-compliance with European standard EN 61010-1.

- 05735 – Spare Parts List, M700E

M700E Spare Parts List

Part Number	Description
000940100	ORIFICE, 3 MIL, 03 GEN
003290000	THERMISTOR, BASIC (VENDOR ASSY)(KB)
006120100	ASSY, UV LAMP, OZONE GENERATOR
014540300	CONTROLLER, MFC, HFC-212, 100SCCM *
014550300	CONTROLLER, MFC, HFC-212, 10 SLM *
014570100	ASSY, INLET MANIFOLD, M700A/E (KB)
014900000	ASSY, GPT, M700
016590100	ASSY, GPT VALVE, M700E
022710000	ABSORPTION TUBE, QUARTZ, M400A/E (KB)
024710000	ASSY, TUBING, CLEAR FEP 1/8" (TU1), 6FT
024720000	ASSY, TUBING, (B/F) TU0000002, 6FT
024730000	ASSY, TUBING, TU0000005, 6FT
024750000	ASSY, TYGON TUBING (B/F) TU0000009, 6FT
039530700	MASK, FRONT PANEL, M700E (OBS)
040010000	ASSY, FAN REAR PANEL, E SERIES
040030500	PCA, PRESS SENSORS (2X),700E (KB)
040030600	PCA, PRESS SENSORS (1X), 700E OZONE OPT
041200000	PCA, DET PREAMP w/OP20, M400E/M700E/M703
041200200	PCA, DET PREAMP w/OP20 M700E/ M400E/M703
041240001	MANIFOLD, DETECTOR, M400E (KB)
041270000	LAMP BLOCK, M400E (KB)
041280000	LAMP SPACER, M400E (KB)
041300000	EXAUST MANIFOLD, M400E (KB)
041440000	PCA, DC HEATER/TEMP SENSOR, OPTICAL BENCH
041710000	ASSY, CPU, CONFIGURATION, "E" SERIES *
042010000	ASSY, SAMPLE THERMISTOR, M400E
042580000	PCA, KEYBOARD, E-SERIES, W/V-DETECT
042900100	PROGRAMMED FLASH, E SERIES
045230100	PCA, RELAY CARD, E SERIES
046740000	ASSY, PUMP, 12VDC, M460M/M700E
048190300	ASSY, RELAY/PS, M700E
049290000	CLIP, THERMISTOR HOLDER
050490000	ASSY, O3 GENERATOR W/BRKT & REG, M700E
050500000	ASSY, O3 GENERATOR, 5LPM M700E
050940000	GUARD, RELAY BOARD (OBS)
052400000	ASSY, BENCH UV LAMP, (BIR), CR *
052910200	ASSY, OPTICAL BENCH, M700E
054690000	PCA, VALVE DRIVER, M700E
055020000	ASSY, INLET MANIFOLD W/PCA, 700E
055210000	OPTION, PHOTOMETER, M700E (KB)
055220000	ASSY, VALVE, PHOTOMETER
055240000	OPTION, OZONE, M700E (KB)
055270000	ASSY, EXHAUST MANIFOLD, M700E(KB)
055560000	ASSY, VALVE, VA59 W/DIODE, 5" LEADS
055580100	DOC, w/SOFTWARE, M700E
056440000	ASSY, VALVE (VA23)

M700E Spare Parts List

Part Number	Description
056450000	ASSY, VALVE (VA32)
056970000	PCA, EXT OUTPUT ADPTR, LEADS M700E/M703
057230000	PCA, SINGLE VALVE DRIVER
057360000	ASSY, 3/8" VENT ADAPTER, M700E
057400001	FT41 FRONT FERRULE, SS, 1/4", SILCOSTEEL
057520001	FT19 FRONT FERRULE, SS, 1/8", SILCOSTEEL
057630000	ASSY, DUAL OUTPUT VALVE, M700E
058020400	PCA, E-SERIES MOTHERBOARD, M700E, GEN 5
058430001	FT 40 FITTING BODY, SILCOSTEEL COATED
058440001	FT 36 FITTING BODY, SILCOSTEEL COATED
060340001	FT 85 FITTING BODY, SILCOSTEEL COATED
061630000	ASSY, FILTER, DFU, DESORBER (SOAKED)
064130000	ASSY, DC HEATER/THERM PCA, O3 GEN
CN0000073	POWER ENTRY, 120/60 (KB)
CN0000458	CONNECTOR, REAR PANEL, 12 PIN
CN0000520	CONNECTOR, REAR PANEL, 10 PIN
CN0000640	CONNECTOR, REAR PANEL, 14 PIN
DS0000025	DISPLAY, E SERIES (KB)
FM0000004	FLOWMETER (KB)
FM0000007	REGULATOR, PRESSURE, 0-30PSI(KB)
FT0000013	CONNECTOR-M, T, 1/8" (KB)
FT0000036	TEE-TTT, SS, 1/4" (HK)
FT0000040	UNION, BULKHEAD, SS, 1/4" (HK)
FT0000056	TEE-TTT, SS, 1/8" (HK)
FT0000085	PORT CONNECTOR, SS, 1/4" (HK)
FT0000134	BLKHD, UNION, REDUCING, SS, 1/4-1/8 (HK
FT0000151	UNION, CROSS, TFE, 2-1/4", 2-1/8" KB
FT0000192	ELBOW, B, 1/8 X 1/4 TUBING, M400A
FT0000278	FEMALE COUPLING, 10-32, BRASS
FT0000279	HEX EXTENSION, B, 10-32 M-F
FT0000321	PORT CONNECTOR, SS, 1/8" (HK)
FT0000330	FITTING, PHOTOMETER FLOW, 13 MIL
FT0000332	FITTING, 9 MIL, ZERO AIR FLOW
FT0000364	.003 ORIFICE, 10-32 X 10-32 W/ORING, BRA
HW0000005	FOOT
HW0000120	SHOCKMOUNT, GROMMET ISOLATOR
HW0000130	GROMMET, QUICK RELEASE
HW0000131	PLUNGER, QUICK RELEASE
HW0000149	SEALING WASHER, #10
HW0000252	CLAMP, NYLON LOOP 5/8" (WHITE)
HW0000327	HEATSINK CLIP, TO-220
HW0000328	INSULATING THERMAL PAD, TO-220
HW0000356	PAD, THERMAL, TO-220, W/ ADHV
KIT000253	ASSY & TEST, SPARE PS37, E SERIES
KIT000289	KIT, UV LAMP P/S PCA, 041660100
KIT000290	KIT, UV LAMP P/S PCA, 041660500
OP0000014	LAMP WINDOW, OPTICAL BENCH
OP0000031	WINDOW, OPTICAL BENCH & OZONE GEN FEEDBACK
OR0000001	ORING, SAMPLE FLOW & OZONE GENERATOR

M700E Spare Parts List

Part Number	Description
OR0000026	ORING, ABSORPTION TUBE
OR0000039	ORING, OPTICAL BENCH & OZONE GEN FEEDBACK
OR0000046	ORING, 2-019V
OR0000048	ORING, OZONE GEN UV LAMP
OR0000077	ORING, 2-018V
OR0000089	ORING, OPTICAL BENCH
PS0000039	PS, SWITCHING, 12V/7.5A (KB)
PS0000040	PS,EXT,AC/DC (90-264V/47-63HZ),12V/3.75A
SW0000051	SWITCH, POWER, CIRCUIT BREAKER
WR0000008	POWER CORD, 10A

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CUSTOMER:______________________________ PHONE: ____________________________________

CONTACT NAME: _________________________ FAX NO. ____________________________________

SITE ADDRESS:____

MODEL TYPE: ____________ SERIAL NO.:_______________ FIRMWARE REVISION:____________

Are there any failure messages? ____

____

____

____

____ *(Continue on back if necessary)*

PLEASE COMPLETE THE FOLLOWING TABLE:

PARAMETER	RECORDED VALUE	ACCEPTABLE VALUE
ACT CAL	LPM	TARG CAL ± 1%
TARG CAL	LPM	0.001 – 0.100LPM
ACT DIL	LPM	TARG DIL ± 1%
TARG DIL	LPM	0.01 – 10LPM
O3 GEN REF [1, 2]	mV	0 – 5000mV
O3 FLOW [1, 2]	LPM	0.100 ± 0.025LPM
O3 GEN DRIVE [1, 2]	mV	0 – 5000mV
03 LAMP TEMP [1, 2]	ºC	48 ± 1ºC
CAL PRESSURE	PSI	25 – 35PSI
DIL PRESSURE	PSI	25 – 35PSI
REG PRESSURE [1, 2]	PSI	20 ± 1PSI
ACT		TARG ± 1%
TARG		
BOX TEMP [2]	ºC	AMBIENT ± 5ºC
PERM TUBE #1 TEMP [3]	ºC	50 ± 1ºC
PERM FLOW [3]	CC/MIN	0.100 ± 0.025LPM
PHOTO MEASURE [2]	mV	2500 – 4800mV
PHOTO REFERENCE [2]	mV	2500 – 4800mV
PHOTO FLOW [2]	CC/MIN	0.720 – 0.880LPM
PHOTO LAMP TEMP [2]	ºC	58 ± 1ºC
PHOTO SPRESS [2]	IN-HG-A	AMBIENT ± 1 IN-HG-A
PHOTO STEMP [2]	ºC	AMBIENT ± 3ºC
PHOTO SLOPE [2]		0.85-1.15
PHOTO OFFSET [2]	PPB	±10 PPB

Depending on options installed, not all test parameters shown below will be available in your calibrator)
[1] If ozone generator option installed.
[2] If photometer option installed.
[3] if permeation tube installed.

What is measured photometer flow rate ____cc/min

What is measured O_3 generator flow rate? ____cc/min

what is the pressure change during the **AUTO LEAK CHECK** procedure? ________________________ psi

What are the failure symptoms? ____

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____

____

What tests have you done trying to solve the problem? _____________________________________

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Thank you for providing this information. Your assistance enables Teledyne Instruments to respond faster to the problem that you are encountering.

OTHER NOTES: ____

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TELEDYNE INSTRUMENTS CUSTOMER SERVICE
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APPENDIX D: Diagrams and Schematics

Table D-1: List of Included Diagrams and Schematics

Document #	Document Title
05818	Interconnect Drawing M700E
05821	Interconnect List M700E
04420	SCH, PCA 04120, UV DETECTOR, M400E
04422	SCH, PCA 04144, DC HEATER/TEMP SENSOR
04421	SCH, PCA 04166, UV LAMP POWER SUPPLY, M400E
04259	SCH, PCA 04258, KEYBOARD, E-SERIES
04354	SCH, PCA 04003, Pressure/Flow Transducer Interface
04395	SCH, PCA 04394, INTRFC,ETHERNET,E-SERIES
04524	SCH, PCA 04523, RELAY CARD, M100E/M200E/M400E
05470	SCH, PCA 05469, VALVE DRIVER, M700E
05698	SCH, PCA 05697, ADPTR, EXT VALVE DRIVER, M700E
05703	SCH, PCA 05702, MTHERBRD, E-SER, GEN-4