TELEDYNE
ADVANCED POLLUTION INSTRUMENTATION
A Teledyne Technologies Company

MANUAL ADDENDUM

MODEL 700EU CALIBRATOR

(Standalone Addendum – For use with the M700E Operation Manual, P/N 05621)

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06601Rev A
DCN5603
05 April 2010

ABOUT THIS MANUAL

This manual is intended for use in conjunction with the Model 700E Dynamic Dilution Calibrator Operation Manual, part number 05621.

REVISION HISTORY

M700EU Calibrator Operation Manual, PN 06601

02 April 2010, Rev A, (DCN5603)				
Document	**PN**	**Rev**	**DCN**	**Change Summary**
M700EU Manual	06601	A	5603	Initial Release

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SAFETY MESSAGES

Your safety and the safety of others is very important. We have provided many safety messages throughout this manual; please read these messages carefully.

A safety message alerts you to potential hazards that could hurt you or others. Safety messages are associated with a safety alert symbol. These symbols are found in both the M700E and M700EU manuals and are also located inside the instrument. The definitions of these symbols are described below:

GENERAL WARNING/CAUTION: Refer to the instructions for details on the specific danger.

CAUTION: Hot Surface Warning

WARNING: Electrical Shock Hazard

Technician Symbol: All operations marked with this symbol are to be performed by qualified maintenance personnel only.

Electrical Ground: This symbol inside the instrument marks the central safety grounding point for the instrument.

CAUTION

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

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CONTENTS

LIST OF FIGURES

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1. OVERVIEW

This document details the operation of the M700EU calibrator. The M700EU is a modified version of the M700E calibrator, equipped with a special ozone generator capable of producing stable ozone concentrations for Gas Phase Titration (GPT) calibrations at much lower levels than the standard M700E.

2. SPECIFICATIONS

Minimum GPT O_3 Output	20 PPB•LPM*
Maximum GPT O_3 Output	6000 PPB•LPM*
Minimum GPT O_3 Concentration (at any flow rate)	3 PPB
* PPB•LPM refers to the product of the total output flow and the ozone concentration. For example: 20 PPB•LPM is equivalent to 20 PPB @ 1 LPM and 10 PPB @ 2 LPM and so forth.	

All other specifications are as listed in the M700E operator's manual.

3. OPERATIONAL MODES

The new M700EU ozone generator is designed to operate in two modes: a high range mode, which gives similar performance as a standard M700E ozone generator, and a low range, or "fractional" mode for producing low levels of ozone during a GPT calibration.

The low range mode is supported in the following M700EU Generation modes:

- GPTPS
- GPT
- GPTZ (accessed from the GEN menu, see the M700E operator's manual for more details.)

The selection of low range generator operation is made automatically by the M700EU software, based on the O_3 concentration and total flow specified. For O_3 output < 500 PPB•LPM, the low range operation is invoked.

3.1. GPTPS (GPT PRE-SET)

The GPTPS mode is used to fine-tune the ozone generator calibration to improve the accuracy of the O_3 concentration during a subsequent GPT. This function is only available if the optional O_3 photometer is installed in the instrument.

During a GPTPS calibration, the internal photometer is used to measure the O_3 output and the O_3 GEN DRIVE value is adjusted to achieve the specified O_3 concentration. Once the concentration has stabilized (as indicated by the ACTIVE led switching from a blinking state to a constant on state,) the instrument will store the updated O_3 GEN DRIVE value for later use when performing an actual GPT.

The following parameters must be entered for GPTPS:

Parameter	Definition	Notes
NO Concentration (ppb)	NO concentration that will be used in subsequent GPT	During the GPTPS, there is no NO gas generated. Instead, zero air is allowed to flow through the cal gas MFC at the same flow-rate that will be used during the GPT.
O_3 Concentration	O_3 concentration target	
Total Flow	Total output flow rate for subsequent GPT	The Total Flow parameter is used to calculate the Diluent flow required as follows: Diluent flow = Total Flow – O_3 Gen Flow – NO Cal Gas Flow

The parameters entered for the GPTPS should be identical to the parameters that will be entered for the GPT. If a multi-point GPT is to run, then a separate GPTPS should be run for each O_3 concentration point.

3.1.1. GPTPS FREQUENCY

The GPTPS is an optional function used to increase the accuracy of the O_3 concentrations during a GPT. The GPTPS function is not required to be performed before each GPT; however, doing so will provide the best O_3 accuracy possible. If somewhat less precision can be tolerated from one GPT calibration to the next, then the GPTPS function can be run less frequently. The operator will need to determine the appropriate frequency based on their requirements.

3.2. GPTZ (GPT ZERO)

The GPTZ mode is used for obtaining the baseline NO and NO_X readings for calculating the NOx converter efficiency. These readings are referred to as $[NO]_{orig}$ and $[NO_X]_{orig}$, respectively in the EPA calibration guidelines. [1], [2]

During GPTZ, NO gas is generated in the same manner as a GPT calibration, except that the O_3 generator lamp is un-energized, thus producing no O_3. This allows accurate measurement of the baseline NO and NO_X readings from the instrument under test.

3.2.1. GPTZ VS. AUTO GENERATION MODES

It may appear that the GPTZ and AUTO Generation modes are performing the same function: generating NO cal gas at a specified concentration and flow rate. However, there is an important difference in the flow configuration of these two modes.

In GPTZ mode, the total flow includes flow from the (un-energized) O_3 generator. This flow is not directly measured by the calibrator. The O_3 generator flow is measured at the factory and programmed into the M700EU and assumed to be constant thereafter. Since pressure and temperature changes between the factory cal and the customer's ambient conditions cannot be accounted for, there may be small discrepancies between the actual O_3 generator flow and the assumed flow that is used in the dilution calculations that the M700EU performs. Since these small flow discrepancies are present in both the GPTZ and GPT modes, they do not affect the accuracy of the converter efficiency calculations.

For the best overall dilution accuracy, for span calibrations for instance, the AUTO mode should still be used.

3.2.2. GPT

The GPT mode is used for performing the actual NO + O_3 titration used to produce the NO2 test gas. This mode allows for the measurement of the $[NO]_{rem}$ and $[NO_x]_{rem}$ readings referred to in the EPA calibration guidelines [1], [2].

4. GPT SETUP

Careful consideration must be given to the various parameters involved in the setup of a GPT calibration, such as total flow, NO flow, NO concentration, O_3 concentration and NO gas bottle concentration.

These guidelines assume that the user has already established the target O_3 and NO concentrations based on other criteria.

4.1. FLOW SETUP

The following requirements should be used for determining total flow:

- Instrument's Flow Demand

  The number and flow rate requirements of the instruments sampling from the output of the calibrator. The flow demand of all instruments connected to the test manifold, even those not directly involved in the testing, must be taken into account. The minimum output flow rate should be calculated as the sum of all instrument demand flows plus 10% minimum excess. (1)

- Target O_3 Concentration

  The output flow must be chosen to keep the O_3 generator output above the minimum specification of 20 PPB□LPM. The minimum flow rate (FT) can then be calculated using the following equation:

$$F_T \geq \frac{20\,ppb \bullet LPM}{O_3 Conc}$$

- NO Flow Requirements

  To achieve a reasonable response time during the GPT and to satisfy the EPA requirement(1) (2) that the residence time in the GPT reaction chamber be less than two minutes, the NO flow rate should be **greater than 45 cc/min**. Therefore, larger dilution flows may be required to achieve low concentrations of NO. An appropriate NO gas bottle concentration must be used in order to achieve this flow rate.

4.2. EXAMPLE GPT SEQUENCE

The following example shows the steps performed for a typical GPT calibration using the M700EU. Note that this example assumes that a zero and span calibration has already been performed on the NO_X analyzer per EPA guidelines [1].

Gas Bottle: 1.0 PPM NO

Step	Generation Mode		Notes	Values Obtained for Converter Efficiency Calculations [1]
1	**GEN-GPTPS**		Optional step. Used to increase the accuracy of the O_3 concentration during GPT generation mode.	N/A
	NO Conc	10 PPB		
	O_3 Conc	8 PPB		
	Total Flow	8 SLPM		
	Target NO Flow (calculated by M700EU)	80 SCCM		
2	**GEN-AUTO-ZERO**		Optional step. Used to verify zero calibration of NO_X analyzer.	N/A
	Total Flow	8 SLPM		
3	**GEN-AUTO-GPT**		Produces NO_2 test gas using GPT with the ozone generator ON. The O_3 lamp drive value is used from the previous GPTPS.	$[NO]_{rem}$, $[NO_x]_{rem}$
	NO Conc	10 PPB		
	O_3 Conc	8 PPB		
	Total Flow	8 SLPM		
	Target NO Flow (calculated by M700EU)	80 SCCM		
4	**GEN-AUTO-GPTZ**		Delivers NO gas only for determining baseline ("orig") NO and NO_X values. Ozone generator is OFF.	$[NO]_{orig}$, $[NO_x]_{orig}$
	NO Conc	10 PPB		
	O_3 Conc	8 PPB		
	Total Flow	8 SLPM		
	Target NO Flow (calculated by M700EU)	80 SCCM		

5. TYPICAL NO_X ANALYZER RESPONSE

The chart below shows the typical response of a low level NO_X analyzer, such as an M200EU, when subjected to the GPT sequence described above.

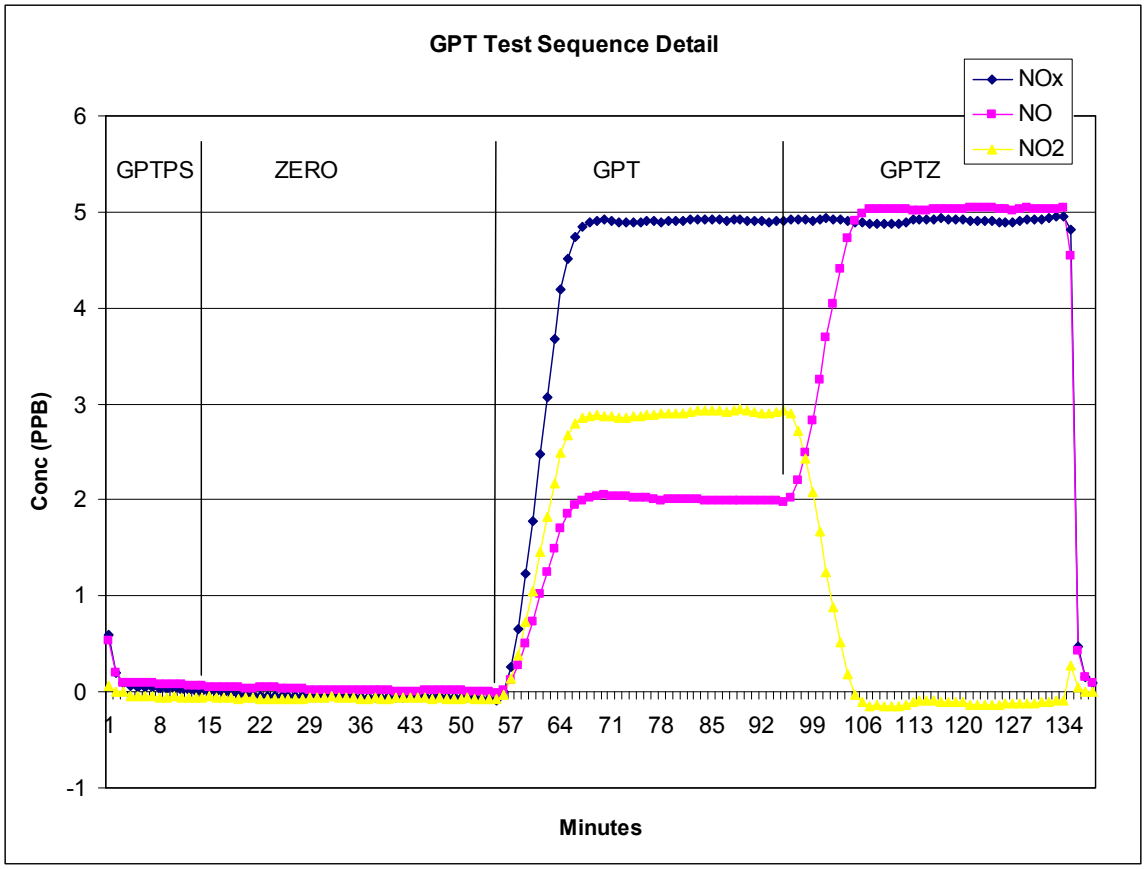

Figure 1. NO_X Analyzer Typical Resonse to GPT Test Sequence

6. PNEUMATIC DIAGRAMS

The pneumatic diagrams shown below can be used as an aid for troubleshooting.

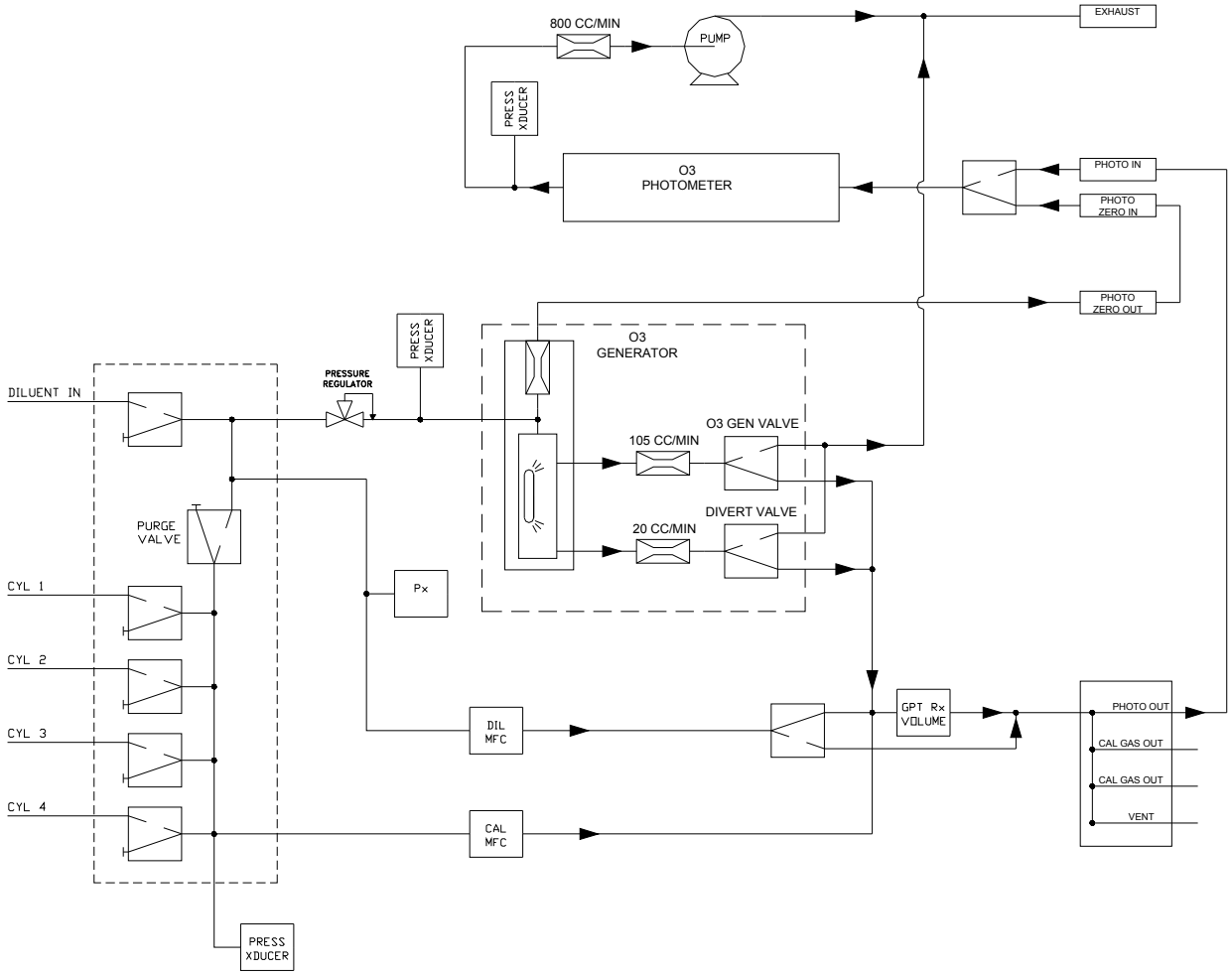

Figure 2. M700EU Pneumatic Diagram, Base Configuration

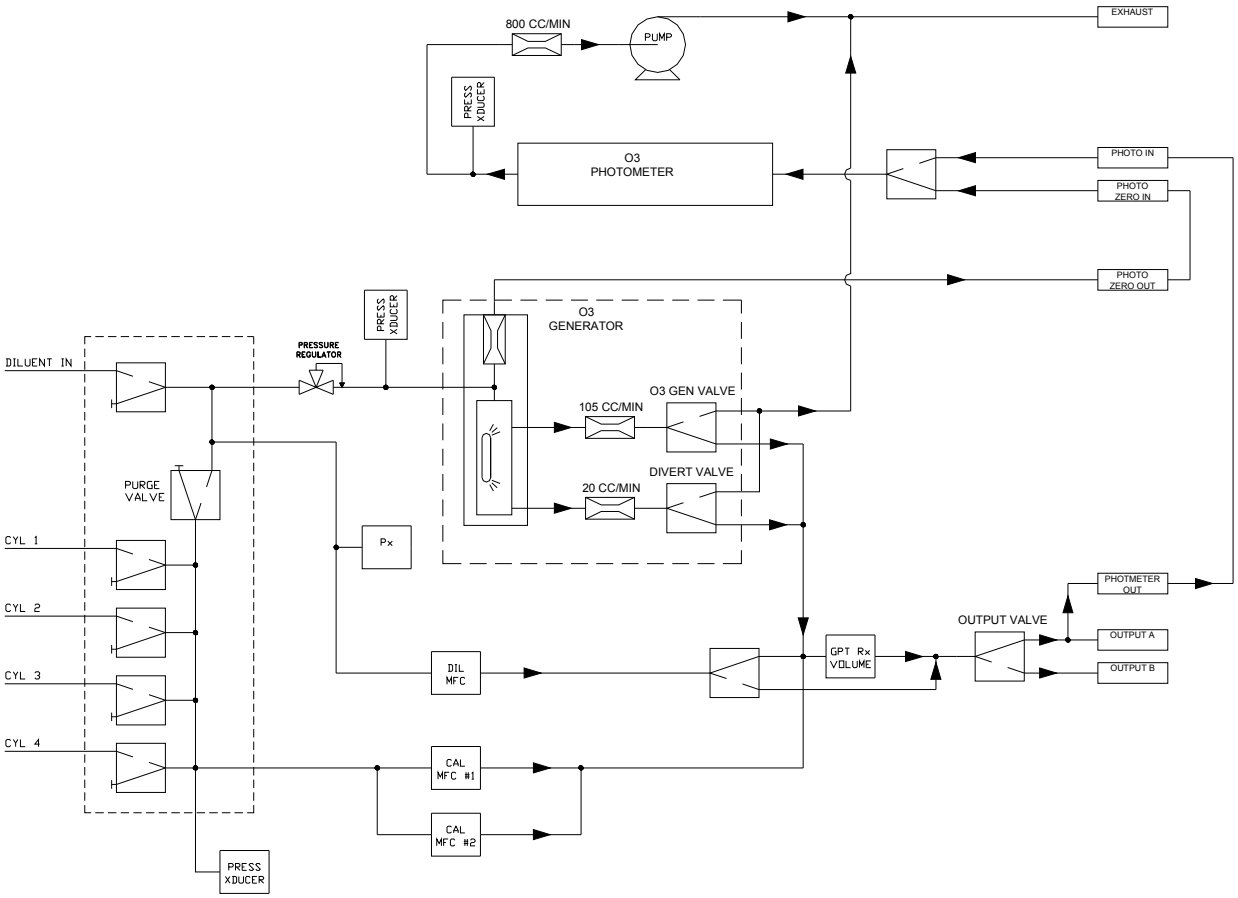

Figure 3. M700EU Pneumatic Diagram, with Dual Output and Three MFC Options

7. REFERENCES

1. 40 CFR part 50 Appendix F, “Measurement Principle and Calibration Procedure for the Measurement of Nitrogen Dioxide in the Atmosphere (Gas Phase Chemiluminescence)”
2. E. C. Ellis, “Technical Assistance Document for the Chemiluminescence Measurement of Nitrogen Dioxide,” EPA-E600/4-75-003, Environmental Monitoring and Support Laboratory, Research Triangle Park, NC 27711.