INSTRUCTION MANUAL

Model 205A

Manual Calibrator

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1.0 Introduction

This operations manual describes the setup and use of the manual calibrator designed to calibrate fast-response photo-ionization detectors (PID). The calibrator consists of a valve box, a precision gas-mixing rotometer and the necessary tubing and fittings required to interconnect the system. The manual calibrator will allow gas concentrations to be delivered to the sensor with an accuracy of about 5%. In order to use the calibrator the operator must have a supply of calibrated gas mixtures and zero air in high pressure cylinders. Regulators capable of accurately regulating the cylinder pressure to 20 PSIG are also required.

The miniPID and digitalPID photo-ionization detectors should be calibrated once every 30 hours of operation. The calibration is affected by lamp output, detection cell cleanliness, and pump flow rate. Therefore, in addition to routine calibration, the detector must also be calibrated after replacement, removal, or cleaning the lamp, after cleaning the detection cell, and after cleaning or replacing the pump.

The presence of UV absorbers (such as water vapour, and oxygen) will have a small effect on the detector output and calibration. It is recommended that the detector be calibrated using the background gas present during testing. In most applications the detector will be used to measure tracer gas concentration in air. If the sensor is to be used to measure contaminants in some other background gas ensure that the sensor is calibrated using the test background gas.

1.1 Operating Principle

The output of either the miniPID or digitalPID sensor can be accurately modelled using a 2nd order polynomial of the form

$$C = a_1 V^2 + a_2 V + a_3$$

where C is the concentration in ppm
V is the output voltage from the controller in volts
and a_1, a_2, a_3 are the coefficients of a least squares polynomial fit to the calibration data.

Because of the slight non-linearity in the output it is important that a multi-point calibration be used. This calibration can be performed by delivering several known concentrations of tracer gas to the sensor and then recording the output. This procedure is repeated for all gain settings of the instrument. A 2nd order polynomial is then fit to the output versus concentration data to yield the calibration equation. All ASI PID instruments are delivered with a factory calibration included.

The calibration technique consists of delivering a known concentration of gas to the sensor at a prescribed flow rate. It is important that the flow rate of the calibration gas is about 1.1 times the inlet flow rate of the sensor and that a slightly oversize tube is used to deliver the calibration gas to the sensor inlet needle. It is suggested that a vinyl tube with an ID in the range of 1/16" to 1/8" be used to deliver the calibration gas to the inlet needle. Insert the needle about 1/4" into the end of the vinyl tubing but do not attempt to seal the tube to the inlet needle. It is critical that the sensor draw the calibration gas from the delivery tube at atmospheric pressure. If the calibration flow is less than the sensor inlet flow then the sensor will draw in surrounding air and the concentration will be diluted (this results in an output which is lower than it should be). If the calibration flow is significantly greater than the inlet flow, or the delivery tube fits tightly on the inlet needle, then the sensor inlet will become pressurized resulting in a greater mass of material being drawn into the sensor (this results in an output value which is greater than it should be).

The calibration is performed by mixing zero air with a calibrated gas mixture to produce any desired concentration between zero concentration and the concentration of the calibrated mixture. For example mixing zero air and 100 ppm tracer in air will allow you to generate any concentration between 0 and 100 ppm (within the tolerance of the rotometers). Note that the total flow must be maintained at about 1.1 times the inlet flow rate of the sensor. Also note that this method is a volumetric mixing operation and therefore the pressures and temperatures of the two gases must be the same in order to maintain accuracy. A calibration procedure is outlined in chapter 2.

1.2 Calibrator Description

The manual calibrator consists of a valve box, a precision gas-mixing rotometer, and the necessary tubing and fittings to interconnect the system.

Valve Box

The valve box provides input connections for compressed gas cylinders comprised of the following: 1, 10, 100, 1000 ppm calibration gas in zero air, and zero air. A 4-way valve is connected to the calibrated gas concentration inlets which allow quick selection of the desired calibration gas. Two ball valves are also provided to allow both the selected calibration gas concentration and the zero air to be switched on and off. The valve box has two outlet connections one for the selected calibration gas concentration and the other for the zero air. The outlets are connected to the gas-mixing rotometer.

Gas-Mixing Rotometer

A gas-mixing rotometer consists of two rotometers, two needle valves and a mixing tube. Three connections are supplied on the back of the rotometer unit, one inlet for calibration gas, one inlet for zero air, and one outlet for the gas mixture. Note that the needle valves are situated on the downstream side of each rotometer; this means that the rotometer will operate at the pressure set by the delivery gas cylinder regulator. Since the gas mixing is done on a volumetric basis, not a mass basis, it is very important that all calibration gas cylinders and the zero air cylinder operate at the same outlet pressure and gas temperature. Flow curves for the rotometers are included with this document as Appendix A. Note that the rotometers contain two float balls each, a glass ball and a stainless steel ball. Greater accuracy of flow measurement will be obtained with the glass ball therefore if the desired flow rate is within the range of the glass ball use it for measuring the flow instead of the stainless steel float. A length of 4mm OD polyurethane tubing connects the rotometer outlet to the inlet of the PID sensor to be calibrated.

1.3 Calibrator Setup

The following procedure can be used to set up the calibrator.

1) Purchase compressed gas cylinders containing analyzed mixtures of the selected tracer gas. These cylinders should have the following approximate concentrations, 1, 10, 100, and 1000 ppm tracer in zero air (propylene gas has been used successfully for many outdoor field trials). In addition to the above a compressed gas cylinder of ultra-zero air is also required. Gas product suppliers, such as Matheson Gas Products and Scott Specialty Gases, can supply these gas cylinders. Also purchase a two-stage regulator for each gas cylinder. These are also available from gas suppliers.
2) Attach the 1/8" NPT to push-lok fittings supplied with the calibrator to the outlet of the regulators.
3) Cut sufficient lengths of the supplied 4mm OD polyurethane tubing (SMC part # TU0425BU-20) to allow the regulators to be connected to the inlets on the valve box. Try to limit these tubes to no more than 10 feet long.
4) Push the tubing into the plastic ends of the push-lok fittings on the regulators and into the corresponding fitting on the valve box. If the tubing needs to be removed simply push the outer plastic ring towards the fitting and withdraw the tube.
5) Now push the tube attached to the gas inlet port of the rotometer into the gas outlet port of the valve box. Similarly connect the air inlet port of the rotometer to the air outlet port on the valve box.
6) Connect the rotometer outlet port to the PID sensor inlet needle which is to be calibrated. Note: ensure that the tubing connected to the sensor does not fit tightly on the sensor, merely insert the sensor inlet needle about 1/4" into the end of the polyurethane tubing.
7) Ensure that the flow shutoff valves on the valve box are in the off position and then turn on the gas bottle valves.
8) Adjust the regulators so that the output pressure is 20 PSIG. **ENSURE THAT THE PRESSURE TO THE CALIBRATOR NEVER EXCEEDS 200 PSIG.**
9) With the cylinders on and the system pressurized, check for leaks.
10) Select the 1 ppm calibration gas mixture using the 4-way valve and turn on the flow shutoff valve located on the valve box. Open the needle valve on the rotometer marked GAS and set the flow to about 100 units measured with the stainless steel float.
11) Select each of the other calibration gases in turn and ensure that the flow remains at the 100 unit level. If the flow changes with a particular gas cylinder then adjust that cylinder's regulator to bring the flow back to the 100 unit level. This will fine tune the regulator pressure to ensure that each one is set to the same pressure. Don't simply rely on the regulator pressure gauge for it may not be accurate. When all four gas mixtures have been set then turn the flow shutoff valve on the valve box to the off position.
12) Turn on the zero air flow shutoff valve on the valve box and adjust the rotometer needle valve on the AIR rotometer to ensure correct operation.

This completes the calibrator setup. See chapter 2.0 for the calibration procedure.

2.0 Calibration Procedure

Perform the following procedure to calibrate the sensor.

1) Turn on the sensor and allow it to warm up.
2) Select the gain range and sensor flow rate (if applicable) of interest.
3) Deliver zero air to the sensor inlet needle at a flow rate 1.1 times the sensor suction flow rate. Use the flow charts in Appendix A to calculate the required float level on the rotometer to deliver the required flow.
4) Zero the sensor (remember to leave a small positive offset on the output signal).
5) Record the output voltage.
6) Deliver the lowest gas concentration to the sensor and record the voltage.
7) Repeat step (6) with successively higher calibration gas concentrations.
8) Plot the voltage versus concentration and fit a 2nd order polynomial to the data.
9) Repeat the calibration procedure for each gain range and flow rate.

In order to generate multiple concentrations simply use the next highest calibration gas and mix it with the zero air in the proportions required to yield the desired gas concentration.
For example: assume that a concentration of 5 ppm (C_{cal}) is to be delivered to the sensor and that the supply cylinder concentration available is 10.9 ppm (C_{supply}) tracer in air. In addition assume that the sensor inlet flow rate is 945 SCCM (Q_{sensor}) and that all the regulators are set to 20 PSIG.

1) Calculate the required flow rate to the sensor.

$$Q_{cal} = 1.1 \bullet Q_{sensor} = 1.1 \bullet 945 = 1040\ SCCM$$

2) Calculate the required flow rate of calibration gas and zero air to achieve the desired concentration.

$$Q_{gas} = \frac{C_{cal} \bullet Q_{cal}}{C_{supply}} = \frac{5.0 \bullet 1040}{10.9} = 477\ SCCM$$

and

$$Q_{air} = Q_{cal} - Q_{gas} = 1040 - 477 = 563\ SCCM$$

3) Look up the required float level using the 20 PSIG flow charts located in Appendix A.

4) The required gas flowrate is 477 SCCM = 60 with the glass float or 29 with the stainless steel float. Use the glass float for better accuracy. The required air flowrate is 563 SCCM = 68 with the glass float or 34 with the stainless steel float. Once again use the glass float for better accuracy.

5) Set the 4-way valve on the valve box to the 10 ppm setting and turn on both flow shutoff valves on the valve box. Adjust the rotometer needle valves to the levels indicated in step 3.

3.0 Maintenance and Troubleshooting

3.1 Valve Box

The valve box is a collection of valves, fittings and tubing. Periodically remove the base plate on the valve box and check the internal connections for leaks. Tighten the valve and fitting mounting nuts as required. Tighten the valve handle locking set screws as required. If the 4-way valve does not have pronounced detent positions then tighten the two set screws which can be seen on top of the valve handle. Clean the valve box with mild detergent and water, do not use solvents on the nameplate. Do not immerse the valve box in water. Ensure that when not in use the valve inlet and outlet ports are blocked to prevent dust and dirt from entering the system.

3.2 Gas-Mixing Rotometer

See Appendix B for installation, operating and maintenance instructions for the Matheson gas-mixing rotometer.

3.3 Technical Assistance

Technical assistance is available by regular mail, email, phone, or fax. Use the information below to contact S+J Engineering Inc.

Address: Aurora Scientific Inc.
Calibrator Technical Assistance
P.O. Box 2724
Richmond Hill, Ontario, CANADA
L4E 1A7

Phone: 1 905 727-5161
FAX: 1 905 713-6882
Email: questions@aurorascientific.com

4.0 Warranty

Products manufactured by Aurora Scientific Inc. (ASI) are guaranteed to the original purchaser for a period of one (1) year. Under this warranty, the liability of ASI is limited to servicing, adjusting and replacing any defective parts that are of ASI manufacture. ASI is not liable to the customer for consequential or other damages, labour losses or expenses in connection with or by reason of the use or inability to use the products manufactured by ASI. Guarantee of parts and components not manufactured by ASI shall be the same as the guarantee extended by the manufacturer of such components or parts. Where possible such parts returned to ASI will be sent to the manufacturer for credit or replacement. Ultimate disposition of these items will depend upon the manufacturer's decision. All shortages must be reported within ten (10) days from receipt of shipment.

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Repair or service work not covered under the limited warranty will be billed at current service rates. ASI will provide its customers warranty service expedited by premium-time, work overtime, Saturday, Sunday or holiday at the customer's option. When the customer authorizes premium-time work, charges will be 50% above the standard rate.

ASI will also make available warranty service at the customer's location, provided the customer elects to pay all travel time and expenses.

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Appendix A Flow Curves for the Matheson Gas Proportioner

Appendix B Gas Proportioner Product Literature