Title: Standard Operating Procedure for R&R Environmental Devices Model MFC201 Gas Dilution Calibrator		
Procedure No: SOP-029	Revision No: 1.1 (December 29, 2010)	Page No.: 1 of 7

1. INTRODUCTION AND SCOPE

To obtain timely data for the purpose of air quality assessment, air quality trend reporting, air quality index reporting and to meet the requirements for inclusion of the data in provincial and national air quality databases, a precise method of calibrating continuous ambient air monitoring analyzers is used. This method is capable of producing multiple precise and reproducible gas concentrations across the full monitoring range of an analyzer which is ±2% accurate when all factors are considered. This method can also be used to provide daily response data about the instrument baseline and upscale response of an analyzer. This method is capable of supporting measurement updates at a rate of once every five minutes or faster.

Readings from instruments utilizing this method provide instantaneous and averaged concentrations which enable instrument standardization and demonstrates instrument stability. Commercially available gas dilution calibrators are used in the method. This method is applicable to the calibration and verification of continuous ambient air monitoring analyzers which are standardized using the gas dilution method of calibration. Dependent on the concentration of the pollutant gas standard being used the method can provide multipoint calibrations covering ranges of 0 to 20 parts per billion (ppb) by volume to 0 to 10,000 ppb. The method is also applicable to the calibration of source gas instruments at much higher ranges.

This method adheres to the requirements of the current Air Monitoring Directive (AMD) drafted by Alberta Environment in 1989. In some cases the limits and specifications exceed the requirements of the current AMD. It should be considered that the current and any future amendments or drafts of the AMD will be used as the benchmark for requirements and criteria for ambient air monitoring practices conducted in the Province of Alberta. Information used to write this procedure was also taken from sources identified in the reference section.

2. PRINCIPLE OF THE METHOD

Dynamic dilution of high concentration compressed gas cylinders is the principle of operation of the Gas Dilution Calibrator. The calibrator utilizes direct sensing mass flow controllers to control both dilution air and pollutant gas flows at desired levels. Dilution air is delivered to the calibrator from a zero air source. Pollutant gases are delivered to the calibrator from high concentration high pressure gas cylinders. Pressure regulators are used to reduce the pressure of the pollutant gases to a level acceptable to the calibrator. The calibrator is capable of providing Zero air to establish ambient air analyzer baselines and because it is equipped with two pollutant gas mass flow controllers it can provide either a single diluted gas concentration or two pollutant gases

mixed and diluted simultaneously. All flows must be accounted for when calculating diluted gas concentrations.

Specifically;

$$\text{GAS A Conc} = \frac{\text{GAS A cylinder conc} \times \text{GAS A flow}}{\text{TOTAL FLOW}}$$

$$\text{GAS B Conc} = \frac{\text{GAS B cylinder conc} \times \text{GAS B flow}}{\text{TOTAL FLOW}}$$

Where:

GAS A Conc is the diluted concentration of gas from cylinder A.

GAS B Conc is the diluted concentration of gas from cylinder B.

GAS A cylinder conc. Is the certified concentration of gas in cylinder A.

GAS B cylinder conc. Is the certified concentration of gas in cylinder B.

GAS A and GAS B flows are the predetermined or measured flow of gas from the certified gas cylinder.

TOTAL FLOW is the sum of all flows including DILUTION AIR + GAS A + GAS B.

NOTE: It is essential to remember that changing any of the gas flows will result in a change in output gas concentration.

Calibration of a continuous ambient air monitoring analyzer is performed by connecting the Sample Output of the calibrator to the Sample Input of the analyzer upstream of the particulate filter. A TEE is installed in line to prevent pressurization of the analyzer input. Dilution air from the zero air source is connected to the Dilution Input and pollutant gases are connected to one or both Gas A and Gas B inputs.

Required gas concentrations are calculated and the appropriate dilution flow is selected on the calibrator. Flows may be either measured or taken from predetermined documented flows. With no pollutant gas introduced into the dilution air the zero baseline of the instrument is determined and corrected if necessary. Pollutant gases are then introduced into dilution air stream at the levels previously calculated to first calibrate the analyzer followed by additional points to demonstrate the linearity of the analyzer as required by the regulations.

The Gas Dilution Calibrator can also be used to fulfill daily zero/span requirements. In order to use the calibrator for this purpose it is connected to the analyzer Span or Zero port with a TEE to prevent over pressurization of the input. Dilution air and the appropriate pollutant gas or gases are connected to the gas input ports. Dilution and gas flows are set to provide the desired span concentration. The calibrator Mode switch is put into the Remote mode and zero and span activation signals are connected to the calibrator Remote Control Input from the data collection system in order to activate the daily zero/span cycle.

3. MEASUREMENT RANGE AND SENSITIVITY

The R&R MFC 201 dilution calibrator utilizes 3 mass flow controllers to control the dilution flows. These three components of the calibrator govern the range and sensitivity of the calibrator. The table below indicates the range and sensitivity for all three components.

Component	Range	Sensitivity (accuracy)	Repeatability
MFC - Dilution	0 - 5000 SCCM	± 0.5% of set point	Not specified
MFC Gas A	0 – 50 SCCM	± 0.5% of set point	Not specified
MFC Gas B	0 – 50 SCCM	± 0.5% of set point	Not specified

The method is also applicable to the calibration of source gas instruments at much higher ranges.

4. EQUIPMENT AND APPARATUS

The following are components that are used with this SOP to complete a multipoint calibration on an ambient analyzer. Different available brand names may be used, but essentially provide a similar function.

- R&R Environmental Devices Model MC201 Gas Dilution Calibrator.
- Zero air generator
- Calibration gas cylinder – use highest quality standard available.
- Teflon tubing with appropriate stainless steel fittings. Note: tubing must be free of kinks, cracks, dirt, moisture or other foreign material or defects
- Stainless Steel two stage regulator and proper cylinder gas adapter (CGA)
- Primary reference flow measuring device

This list does not exclude the use of other equipment that has received the USEPA Reference and Equivalent Method designation.

5. INTERFERENCES

Interferences with the operation of the dilution calibrator are typically the two listed below. However, it must be considered that when changing calibration gases, residue of one gas may interfere with the next gas used. A good practice to reduce the possibility of these types of interferences is to flush the calibrator thoroughly with zero air after the completion of each multipoint calibration.
Two common interferences with a dilution calibrator are:

- Moisture can consume source gas molecules if allowed to enter the system. This is prevented by ensuring the zero air generator is functioning properly.
- Ambient temperature swings can affect the OGC of the calibrator.

6. PRECISION AND ACCURACY

The measurement precision is generally considered to be the “repeatability of the measurement”. Precision in the context of the dilution calibrators relates to the repeatability of the mass flow controllers. The factory specifications for repeatability are quoted in section three of this document. It is, however, prudent to confirm this by conducting MFC calibrations on at least a yearly basis. See section 10.0 in this document for information on these procedures.

The accuracy is generally considered to be the “deviation from true”. This means how close it is to what it should be. The factory specifications for accuracy are quoted in section three of this document. Accuracy is also confirmed through yearly MFC calibrations, procedures identified in section 10.

7. SITE REQUIREMENTS

The R&R Model MFC201 and all supporting equipment should be set up inside a temperature controlled structure to avoid influence of temperature drift. It is also recommended to not set up calibration equipment out doors due to effects of the weather, i.e. rain, wind, dust, temperature, etc. The calibrator should be set up so that the controls and display are easily accessible as changes need to be made throughout an analyzer calibration.

The source gas cylinder's regulator needs to be purged prior to connecting the Teflon lines to the calibrator.

8. INSTALLATION REQUIREMENTS

The set up of the calibration system is done at the station where the monitoring is taking place. Follow the steps below for proper set up of the calibration system.

The R&R model MFC 201 calibrator needs to be set up in a location where the controls and display are easily accessible. It can be mounted in a standard 19" instrument rack, or placed on a solid workbench. The vents on the bottom near the front need to be exposed to allow air flow through the calibrator during operation. The zero air generator should be set up nearby, but not adjacent to the calibrator.

9. OPERATIONAL REQUIREMENTS

Descriptions of the operation R&R model MFC201 dilution calibrator can be found in the Operating Instruction Manual. It is strongly recommended that the operating manual be reviewed prior to completing the steps below.

The R&R model MFC 201 calibrator generates gas concentrations by manually entering the desired flows. Follow the steps outlined in Section 8 and 9 of SOP -011 on Dilution Calibrations to complete a multipoint calibration.

The recommended method of generating points would be to enter in the desired flows for each calibration point for each gas that is typically used in the calibrator, and step through the desired calibration points manually recording the measured flows and cylinder gas concentration on the calibration field sheet.

9.1 Calibrator Operational Parameters

Operational parameters of the gas dilution calibrator should be verified regularly and recorded on an instrument checklist (see controlled documents for an example of a station checklist).

9.2 Calibrator Maintenance

Preventative maintenance tasks should be completed on the calibrator on a periodic basis. These tasks are outlined in the operations manual.

These tasks include:

1. Verification of mass flow controller flows
2. Leak checks
3. Verification of pollutant gas standards and regulators
4. Replacement of calibration lines

A strict regiment of these tasks should be adhered to as they are intended to fix a problem before it happens. Any maintenance must be recorded in the instrument log that accompanies each instrument.

10. CALIBRATION

Calibration of the R&R Model MFC201 calibrator involves measuring and adjusting the MFC's (if required) the flows generated by the mass flow controllers. Calibration of MFC's on dilution calibrators used by AENV does not need to be completed regularly since AENV calibration procedure requires that both gas and dilution flows be measured at each calibration point. Calibration of the MFC's should be completed as required depending on repairs or problems. Multipoint flow calibrations are conducted on the R&R Model MFC201 calibrator to verify precision, accuracy and linearity of the flow controllers.

Included in the manual are flow calibration sheets which are the results of flow measurements performed after the calibrator was assembled and during initial testing of the calibrator. Because field mass flow meters tend to vary from one to the other it is recommended that the user's mass flow measurement device be used to verify the flows of the calibrator mass flow controllers. This eliminates any possible discrepancy between the manufacturer's measured flows and those of the user which might impact final calculations.

When performing flow measurements on the mass flow controllers it is recommended that they be verified individually. Unused inputs should be capped. All flows should be measured at the SAMPLE OUTPUT. To perform a flow measurement, ensure that only the device being tested is turned on. To turn off other mass flow controllers, set the corresponding 3 digit control to 000, this ensures that the mass flow controller is shut off. If the unit is equipped with individual controls to activate or deactivate the pollutant gas mass flow controllers, these may also be used for this purpose. If the calibrator is to be used as a multipoint calibrator the entire range of the mass flow controllers should be

measured and documented. If the calibrator is to be used only as a Span source the flows of only the desired set point need to be measured. The entire range of all mass flow controllers should be verified as required to ensure that the operating characteristics of the devices are known. During initial use more frequent verification is recommended.

11. APPLICABLE DOCUMENTS

EM-029a R & R Model MFC201 Gas Dilution Calibrator Operating Instruction Manual

12. LITERATURE REFERENCES

None

13. REVISION HISTORY

Revision 1.0 May 21, 2010 major rewrite
Revision 1.1 December 29, 2010
Changed Calibration gas requirement section 4: Equipment and Apparatus

14. APPROVAL

Harry Benders

Approved by: **Harry Benders** **Date: December 29, 2010**
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