Small Volume Sampling with the EGM-5

This application note outlines processes and procedures used for measuring CO_2 concentration of small gas samples from a syringe, jar or gas sample bag using the EGM-5 CO_2 Gas Analyzer.

Introduction

The **EGM-5** is a flow-through gas analyzer with an internal pump that continuously draws sample air from the **Gas In** port and exhausts to the **Gas Out** port. In cases where only a small volume of sample gas is available, two alternative operational modes will still allow the EGM-5 to make accurate CO_2 measurements. These two modes—called **Static** and **Injection** in the EGM-5 **Processes** menu—are described in this application note.

Static Process

The *Static Process* is a simple technique in which the internal sampling pump is turned off, and the small volume of gas to be measured is presented directly into the **Gas Out** port of the EGM-5 from a syringe or gas sampling bag. The **Gas Out** port is preferred for this technique because there is very little additional tubing or components between the CO_2 IRGA and the **Gas Out** port. Five (5) ml of gas is the minimum needed to back fill the IRGA from the **Gas Out** port, although we recommend using 10 ml or more to fully flush out the lines and eliminate rapid diffusion of ambient air.

Equipment Required

- **EGM-5 CO_2 Gas Analyzer**
- Syringe or small sample bag with flexible tubing connected to EGM-5 **Gas Out** port as shown.

1 Start Process

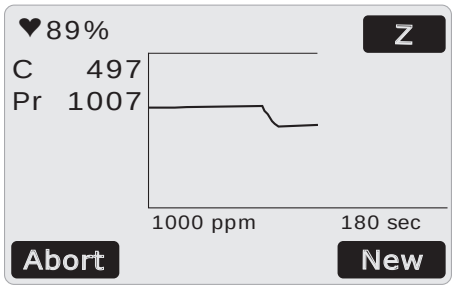
From the **Main Menu**, choose **Processes** > **Static**. Then, confirm the start of the *Static Process* by choosing the right arrow.

2 Perform Zero

The graph screen is displayed and an **Auto-Zero** is initiated as indicated by the **Z 23.0** countdown in the status area. When the **Auto-Zero** is complete, the sample pump automatically turns off.

3 Measurement Phase

Push in the gas sample to be measured into the **Gas Out** port. Value of **C** indicates the current CO_2 reading inside the IRGA, and **Pr** indicates IRGA pressure. The sample gas will displace the ambient air that was present at the end of the **Auto-Zero** (in the screenshot below, ambient air was 675 ppm and the small volume sample gas was 497 ppm). Once the reading stabilizes, record the **C** value.



The IRGA pressure (**Pr**) is displayed to help identify when gas is pushed into the EGM-5 too quickly causing overpressure and unstable readings. Use a slow and steady stroke to keep the pressure near ambient.

Injection Process

The *Injection Process* is a technique used to measure the concentrations of small samples of gas, typically collected in sampling jars, and transferred to the EGM-5 with a syringe. The *Injection Process* is an alternative to static sampling and can yield more reliable and consistent results for some users.

Equipment Required

- **EGM-5 CO_2 Gas Analyzer**
- **ACS037 Sample Injection Kit**
- Syringe with needle size ≤ 18 gauge (user supplied)

Measurement Principle

The concentration of CO_2 in a gas sample is calculated by injecting the sample into a fixed flow of gas with a known CO_2 concentration (the baseline CO_2 level) and integrating the resulting CO_2 measurements until they return to baseline. This is similar to the Pulse Tracer Gas Technique used for HVAC duct flow to infer the unknown flow rate by measuring the concentration of a known mass of tracer gas injected into the duct over time. In our case, the gas flow rate F is known, the syringe volume V is known, but the sample (or tracer gas) concentration is unknown.

The concentration in the syringe is calculated as:

$$CO_{2\,INT} = \int C(t)dt \cdot \frac{F}{V} = \sum (CO_{2\_m} - CO_{2\_b}) \cdot \frac{\Delta t}{60} \cdot \frac{F}{V}$$

Where:

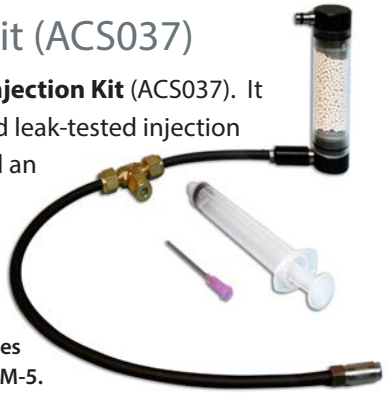
$CO_{2\,INT}$ (ppm) = calculated CO_2 concentration inside syringe ("integrated" CO_2)
CO_{2_b} (ppm) = baseline CO_2 readings before the measurement phase (averaged over 10 readings)
CO_{2_m} (ppm) = CO_2 readings during the measurement phase
Δt (s) = sample interval, typically one second
F (ml min^{-1}) = flow rate
V (ml) = syringe volume

The process consists of three phases: **Baseline Phase**, **Injection Phase** and **End Phase**. The **Baseline Phase** establishes a baseline measurement of fixed CO_2 concentration by calculating the average concentration over 10 measurements at one-second intervals. Upon completion of the **Baseline Phase**, the instrument will enter the **Injection Phase**. In this phase the sample is slowly injected, and the measured CO_2 concentrations are integrated over the duration of the **Injection Phase**.

Once the gas returns to baseline, it enters the **End Phase**. Any gas with a known, constant CO_2 concentration can be used as a baseline, but a gas with zero CO_2 concentration can be readily produced with an absorber column filled with soda lime.

Sample Injection Kit (ACS037)

PP Systems offers a **Sample Injection Kit** (ACS037). It includes a fully-assembled and leak-tested injection port with four spare septa and an absorber column to establish a zero baseline.



The syringe and soda lime shown are not included with the Sample Injection Kit, however soda lime does come standard with every new EGM-5.

The injection port includes a 9 mm low-bleed septum that can withstand up to 50 injections (per the manufacturer's specification) and a guide hole that will accommodate up to a 22-gauge syringe.

For best results, we recommend changing the septum every 25 injections.

Syringe

Your syringe should allow you to easily inject gas continuously for at least 25 seconds. The injection technique is relatively insensitive to the volume of the syringe.

We recommend at least an 18-gauge syringe with a minimum volume of 10 ml for best results. Glass syringes are ideal if available (e.g. typical GC syringes), however plastic (polypropylene) syringes will work as well.

The *Injection Process* works best for samples with concentrations greater than 100 ppm. The process will work at lower concentrations, but percent error will be significantly larger.

Assembly

The **Sample Injection Kit** comes pre-assembled. If needed, the individual components can be taken apart and re-assembled as shown. Most of the connections are hand-tightened. Push the soda lime column onto the adapter with the included o-ring for sealing.

Preparation

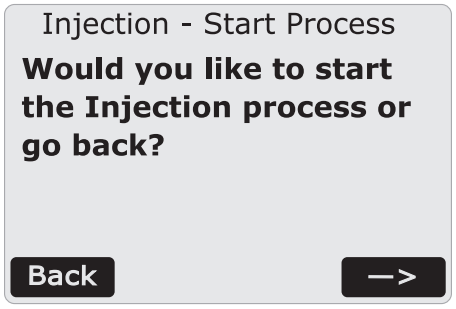
Fill the absorber column of the **Sample Injection Kit** with fresh soda lime, then connect the open end of the kit to the **GAS IN** port on the back of the EGM-5.

NOTE:
The column must remain vertically oriented throughout the process.

It is best to turn off averaging by setting the **CO_2 Avg Limit** to 0 (**Main Menu** > **Settings** > **Settings 2** > **Averaging**). Also for low concentration samples, it is advantageous to turn the pump flow rate to about 100 ml/min (**Main Menu** > **Settings** > **Flow** > **Pump Power 15%**).

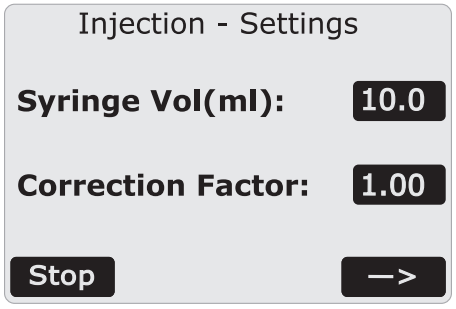
1 Start Process

The first screen asks the user to confirm that they would like to start the *Injection Process*.



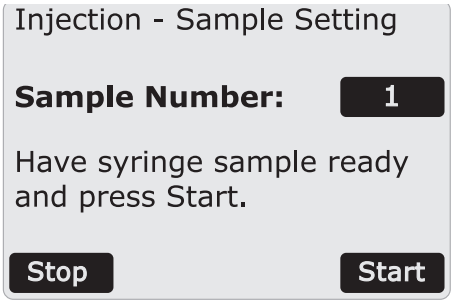
2 Settings

The **Syringe Volume** and **Correction Factor** settings are defined in this screen.



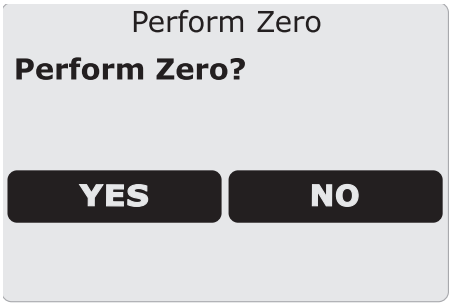
3 Sample Setting

The **Sample Number** is defined in this screen. Take your syringe sample (e.g. from a chamber or airbag) drawing more gas from your sample source than required, and then squeeze out excess (e.g. Draw at least 11 ml into your syringe for a 10 ml sample). Then slowly push the plunger to the 10 ml mark, place it in septum and press **Start**.



4 Perform Zero

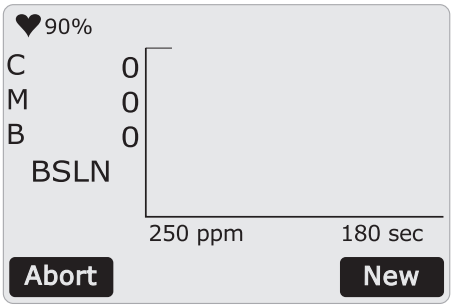
Your opportunity to **Perform Zero** is within this next screen.



When measuring multiple samples, only **Perform Zero** at the onset. After that, **Perform Zero** every 30 minutes.

5 Baseline Phase

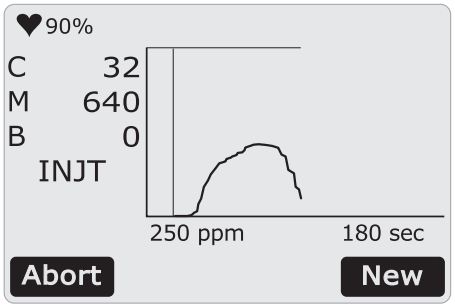
When the **Baseline Phase** is entered, the EGM-5 records the baseline reading for the first 10 seconds—the CO_2 concentration of the air before the sample is injected (typically 0 ppm) and indicated by **BSLN**. After 10 seconds the **Injection Phase** begins.



If the baseline (**B**) does not drop to either 0 or a very small number (typically 1-3 ppm), there is either a leak in the system, or the system has not adequately "zeroed". Abort the process, wait 2-3 minutes, and try again. If the problem persists, inspect the injection setup for leaks and ensure that the absorber column is properly seated and contains fresh soda lime.

6 Injection Phase

During the **Injection Phase**, the syringe is slowly and steadily injected into the airstream through the septum over a period of at least 10 seconds. This phase is indicated by **INJT**.

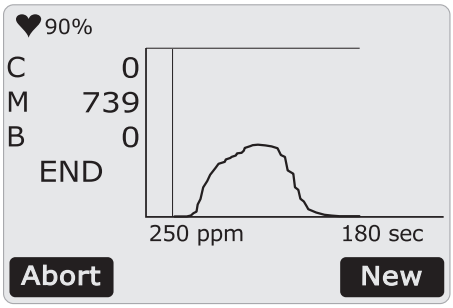


Typically during an injection, the first value will rise quickly and drop back to zero; correspondingly, the value of **M** will increase quickly as the value of **C**, then plateau at a constant value. Once **C** has dropped to 0 ppm (or a very low background value), wait 3-5 seconds to make sure **M** has stabilized and take note of the value. **NOTE:** If using a USB memory stick, the value will automatically be recorded.

Injection measurement errors are typically greater than flow-through methods. We recommend measuring the same sample multiple times, calculating an average whenever possible.

7 End Phase

Once the gas returns to baseline, the **End Phase** is entered. **END** indicates the **End Phase** on the screen.



Correction Factor

The accuracy of the sample injection measurement requires accurate measurement of flow rate and syringe volume, as well as careful syringe handling techniques to minimize leakage, diffusion, and dead space volume. The flow meter built into the EGM-5 has a specified accuracy of ±5% (although we typically find they are within 1-2%). We have found that the sample injection technique can be quite repeatable when performed by the same user, but often has systematic errors. The **Correction Factor** allows compensation for these errors, and should be experimentally determined and entered by each user as part of the sample injection process.

With a syringe sample of known CO_2 concentration, perform all the steps of the sample injection process, and use the resulting CO_2 measurement to compute a Correction Factor as follows:

Correction Factor = CO_{2_Known} / CO_{2_m}

A sample of known CO_2 can ideally be obtained from a certified calibration gas source, or it is possible to use the EGM-5 itself to measure an unknown ambient gas sample. In this latter technique, a one (1) liter or more smoothing/mixing volume with a remote ambient air inlet is connected to the EGM-5 **Gas Inlet**, and the syringe sample is drawn from the EGM-5 **Gas Out** (optionally with the injection kit connected to the **Gas Out** without the zero column).

If you would like to learn more about this application or speak with one of our experienced technical staff, please feel free to get in direct contact with us via any of the contact information listed below:

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