Application Notes:

Flow Calibration of R&P Partisol 2025 Using the Bios Definer™ 220 Primary Standard

Introduction

In order for an environmental air monitor to accurately measure the quantity of pollutants in a volume of air, the monitor must sample at a constant, controlled rate. Our application note features the Rupprecht & Patashnick Partisol Model 2025 2.5 TP air monitor, also known as a PM 2.5 sampler (see Figure 1). While we focus here on the Model 2025 monitor, it should be noted that the environmental monitors made by other manufacturers use a similar mechanism for drawing in a fixed flow of air.

Figure 1: The Rupprecht & Patashnick Partisol Model 2025 2.5 TP

Purpose

Accurate monitoring by the Model 2025 is dependent on many variables, as next described in "Background." For example, it's important to keep in mind that any error in the measurement of the mass flow rate, the external air temperature or the barometric pressure will result in a volumetric air flow error.

Our application note is designed to help the environmental professional achieve optimum monitoring results through a better understanding of the equipment and the variables involved in the monitoring process. We also describe how our Bios Definer™ 220 primary gas flow standard can be used to quickly and precisely calibrate the Model 2025.

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Driving a Higher Standard in Flow Measurement℠

Background

The Model 2025 monitor is designed specially for the EPA market in order to sample the air for particulates of a certain size. It draws air at a set flow rate (typically 16.7 liters per minute). The flow is generated by a suction pump, which draws air from an accumulator through a needle valve and two parallel proportioning valves. The internal electronics adjust the flow by varying the proportioning valves in order to maintain a constant, volumetric flow at the inlet tube.

The internal electronics calculate the Model 2025's volumetric flow rate by measuring three things: The mass flow of air, using an internal mass flow meter; the outside air temperature; and the barometric air pressure. The Model 2025's internal processor calculates the air flow rate using the ideal gas law: PV=NKT, where:

P = atmospheric pressure;
V = volume of air;
N = the number of gas molecules (mass flow)
K = Bolzmann constant
T = temperature

Once the air flow rate is calculated, the monitor's proportioning valves are adjusted as needed so as to maintain the proper flow rate.

Air drawn into the monitor follows an air flow path through a long "down" tube and onto a WINS PM2.5 impactor, which removes the larger particulates from the air flow. If the applications calls for all of the particulates to be sampled rather than only those of a certain size, the WINS impactor is replaced with a "pass-through" adapter tube. The air flow path continues through a 47 mm filter and into the internal mass flow meter, followed by the controlling valves, then the accumulator, and then out through the suction pump.

Figure 2: Internal Mass Flow Meter

Figure 3: External Air Temperature Monitor

Figure 4: Barometric Air Pressure Sensor Input

Flow Calibration of the Model 2025

Typically, there are a few devices used to calibrate, or verify, the Model 2025. These include bubble meters, venturies, orifice transfer standards and primary piston provers, such as our Bios Definer™ 220. In this document, we provide the procedure for using our Definer 220 as the transfer standard, although we briefly describe use of an orifice.

Precautions:

For best accuracy, before verifying the flow of your environmental monitor you should observe the following precautions:

- Verify that the monitor doesn't have internal leaks. Leaks in either the internal connections or the filter assemblies can cause erratic and confusing flow readings
- Since air flow is adjusted from atmospheric pressure, verify that the monitor's atmospheric pressure reading is correct (was the barometric air pressure sensor recently calibrated by an accredited laboratory?)
- Since the external air temperature monitor adjusts flow, verify that its ambient air temperature reading is correct (was the external air temperature sensor recently calibrated by an accredited laboratory?). For example, if the ambient air sensor is located in the sun and the air intake is shaded, a temperature differential may likely exist, causing flow error
- The monitor should be running for a minimum of one hour before sampling begins in order to stabilize the flow. Stabilization time is a critical component of any flow control or flow measurement application, and is often overlooked

Using an Orifice Transfer Standard:

An orifice-type transfer standard is a low-cost, non-primary tool for checking a monitor's air flow. Although generally rugged and reliable, an orifice is less accurate than a primary standard. An orifice-type transfer standard is a secondary standard that obtains a volumetric flow rate by measuring the pressure drop across the orifice, in conjunction with the ambient temperature, pressure and calibrated orifice coefficients. The orifice is placed on the monitor's air drawtube for this purpose. An example of an orifice transfer standard is the Chinook Engineering Streamline FTS®.

Some orifi rely on the monitor's air temperature sensors and barometric pressure sensors for measurement. In this case, only a partial, incomplete calibration is possible. If the monitor's internal temperature sensors or pressure sensors are not accurate, the orifice will not detect these errors and thus will erroneously report an accurate air flow rate. The use of an orifice provides an acceptable degree of accuracy if its calibration constant – and both the monitor's temperature and pressure sensors – are accurate.

Using a Primary Piston Prover:

A primary piston prover, like the Bios Definer 220, performs direct volumetric measurement of air flow by measuring the time required to displace the piston through a glass cylinder of known volume (accuracy is dimensional, based upon length and time, two of the primary units of measure, or the SI Base Units).

As a direct volumetric device, the Definer 220 calibrator isn't affected by air temperature, barometric pressure, air composition or humidity. For these reasons, primary piston provers like the Definer 220 are the best means of uncovering flow errors hidden by transfer standards or mass flow-type meters. However, piston provers do apply a time-varying pressure change to the air flow stream due to the piston alternately rising and falling within its glass flow measuring cylinder. This time-varying pressure effect, or pressure spike, may cause dynamic flow variations through the environmental monitor's air flow stream. This can be prevented by minimizing the air volume (or "dead air" volume) between the monitor's flow control mechanism and the Definer 220.

Also note that the monitor's temperature sensor should be located near the calibrator, preferably in the shade, to minimize any temperature difference between the sampling location and the calibrator.

The following is our recommended Model 2025 calibration procedure using our Definer 220. In this procedure, the air flow rate is checked at the location of the WINS impactor in order to eliminate the volume of air contained in the monitor's down tube and preserve full accuracy.

Procedure:

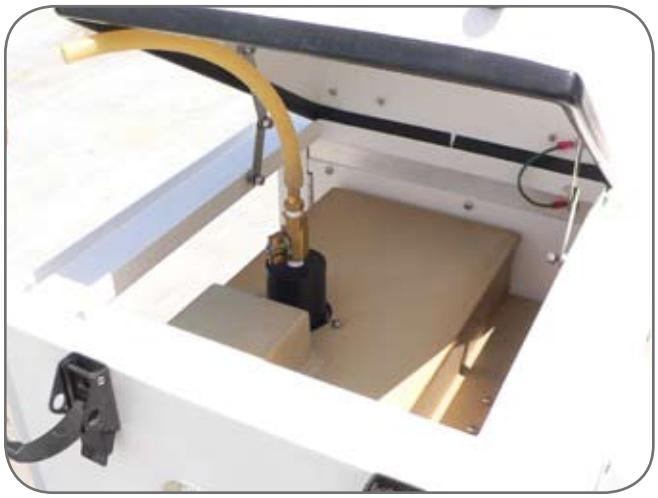
Step 1
Turn on your Definer 220. Using its navigation pad, go to "Setup" and then "Readings." Choose Volumetric flow. Then, choose your preferred number of measurements in the average, from 1 to 100 (we recommend at least 10 for the best results). Lastly, set the time interval (time between readings) to one minute

Step 2
Verify the monitor's temperature and pressure and adjust its readings as necessary

Step 3
Unlatch and open the top cover of the monitor to gain access to the WINS Impactor. The WINS Impactor is attached to an upper and lower tube

Step 4
To remove the WINS Impactor from the monitor, pull straight upward

Step 5
Attach the flow audit adapter to the exposed tube and open its valve



Step 6
Connect the tubing from the flow adapter to your Definer 220's outlet

Step 7
Remove the temperature probe from the monitor's solar shield and place it close to your Definer 220's inlet. This ensures that the temperature sensor is seeing the air temperature at the Definer 220. Make sure that both your Definer 220 and the monitor's temperature probe are shielded from direct sunlight

Step 8
From your Definer 220's menu screen, select "Measure" and then press ENTER to begin taking flow measurements. Your Definer 220 will indicate the volumetric flow. If the indicated flow is not what you expected, check items 1-4 under "Precautions" and also see "Application Notes." Also, run the monitor for an additional hour, and the check the results again.

Application Notes:

- Leak test the monitor before it's calibrated by your Definer 220
- Allow the monitor to run for 45-60 minutes before recording results, and allow your Definer 220 to stabilize to ambient temperature as well
- Verify and adjust the monitor's temperature and pressure reading before it's calibrated by the Definer 220
- Your Definer 220 shouldn't be placed in direct sunlight and should be at ambient temperature
- Your Definer 220 should be in volumetric flow mode, not in standardized flow mode (should not be set to automatically correct for temperature and pressure conditions)

About Bios

Bios is a recognized leader in **primary** gas flow measurement. We provide products, services and solutions for professionals in diverse disciplines, including environmental protection, occupational health and safety, industrial process control, research and development and calibration laboratories.

Our Butler, New Jersey facility is one of the world's most accurate gas flow measurement laboratories. Since 2004, we've been accredited to the calibration laboratory quality and proficiency standards set forth by ISO 17025, ANSI Z-540 and NIST Handbook 150, through the National Voluntary Laboratory Accreditation program (**NVLAP**) of the National Institute of Standards and Technology (**NIST**), the national lab of the United States.

We're pleased to state that our **Scope of Accreditation** uncertainty is ±0.071% of reading for gas flow measurements from 5 to 50,000 scc per minute. A current copy of our accreditation certificate and scope may be found on our website, at: **http://www.biosint.com/pdf/NVLAP-accreditation.pdf.**

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