What Type of Flow Rates and Gas Volumes Are You Reporting?

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Introduction

The key objectives of an air sampling program of an industrial facility may vary by industry and for each organization within an industry. A list of possible objectives are provided in Table I below:

Table I
TYPICAL AIR SAMPLING OBJECTIVES

1) To implement the health and safety goals of the organization.
2) To demonstrate compliance with industry standards, or the requirements of a regulatory agency.
3) To obtain air monitoring data that can be accurately compared among many air sampling locations within a multi-facility organization.
4) To obtain air monitoring data that can be accurately compared to similar data obtained by other industry members.

The above are not all inclusive and there probably exists other objectives that apply uniquely to a specific facility or organization.

Typical descriptions for various air sampling activities are listed below in Table II.

Table II
TYPICAL AIR SAMPLING ACTIVITIES

1) Personnel Inhalation Exposure Monitoring
2) Ambient air monitoring
3) Emissions air monitoring
4) Workplace area monitoring

The Air Sampling / Monitoring System

The typical pollutant collection and measurement system components utilized for implementing an air sampling protocol are listed in Table III below:

Table III
Typical Analytical Air Sampling System Components

1) Utilizations of a pollutant collection medium having a known collection efficiency for the subject pollutant(s) at the typical concentration ranges anticipated at the operating conditions of the sampling location.

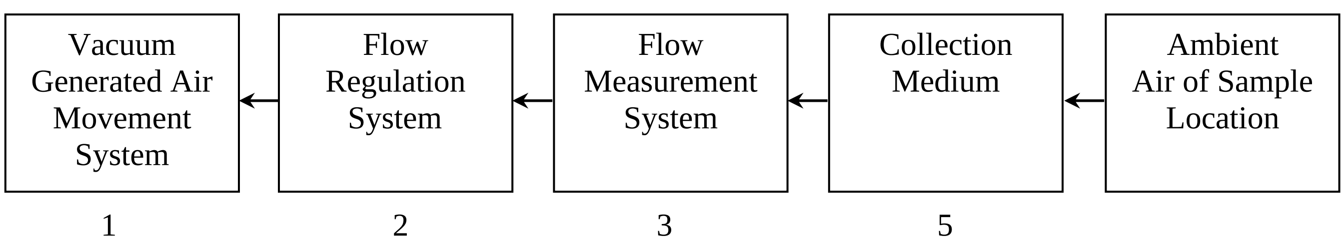
2) Utilization of the proper equipment and air sampling protocol necessary to accurately determine the total sample volume of air passing through the system during the sample event that is responsible for depositing a measureable amount of pollutant(s) on the collection medium.

3) A real time or secondary analytical measurement technique to determine accurately the quantitative value of the pollutant deposited on the collection medium.

Figure 1 below illustrates an example of the typical hardware components of an air sampling system for determination of pollutant concentration in a work place atmosphere or an environmental atmosphere.

Figure 1

Typical Air Sampling System Pathway of Air Flow *



Please note that this illustration can apply to any air sampling system whose source air is the ambient air of the air sampling instruments locale as opposed to an in-line process air sampling application.

***** The air sampling system circuitry is not shown as separate component in the above air sampling system diagram although it may have an impact on the flow measurement function.

Table IV below represents the air sampling system components in a tabular format.

Table IV
Typical Air Sampling System Components

1) Vacuum pump or vacuum blower system

2) Flow regulation system (manual or electronic)

3) Flow measurement system (volumetric or mass flow)

4) Air sampling system circuitry

5) Filter collection medium (media)

It is necessary to assess the potential magnitude of the errors in the values of each of the elements comprising the volumetric sample volume determination. The magnitude of the total error is a function of the combined errors in the flow measurement methodology and the sample duration.

The potential volumetric flow measurement error utilizing a mechanical DP type flow sensor is a function of the following:

a) Temperature of the air at the point where the flow is measured

b) The absolute pressure of the air at the point where the flow is measured which in itself is a function of the barometric pressure at the sample site elevation. The absolute pressure at the flow measurement point is the pressure drop difference between the ambient barometric pressure (B.P.) and the absolute pressure at the point of flow measurement.

The pressure drop difference between B.P. and the point of the flow measurement is comprised of three elements:

1) The pressure drop across the filter collection medium which is a function of the flow rate

2) The pressure drop across the instruments air flow circuitry (line losses)

3) The pressure drop due to dust loading, on the filter(s) during the sample event, if any

THE IMPACT OF LOCAL WEATHER CONDITIONS

The dissimilarity of the sample air temperatures among national or international industry members will be a function of the location and the elevation of each specific facility and the typical diurnal and seasonal temperature range of an industry member’s location. It isn’t a constant dissimilarity, but a variable one. This may be of importance when attempting to compare one facility’s air sampling data with the data of another facility when significant differences in latitude or elevations are involved.

The absolute pressure at the inlet of the sampling instrument is usually equivalent, or very close to the local barometric pressure at the sampling location. The barometric pressure will vary within a typical range depending whether it is a clear sunny high pressure day or a rainy stormy low pressure day. Excluding unusual climatic conditions such as a hurricane or typhoon, the barometric pressure range is generally very predictable for a location.

The vacuum system draws the air from the atmosphere through the collection medium, then through the sampler's air circuitry flow path, followed by the pathway through the flow measurement system and then followed by a possible mechanical flow regulation component (such as a bypass flow regulator) prior to entry into the vacuum generating device inlet (vacuum pump).

The absolute pressure of the air sample decreases as it passes through every component of the air sampling system. These decreases in pressure are commonly described, respectively, as "The pressure drop across the filter(s)", "the air circuitry line losses" and "the pressure drop across the flow sensor".

The volumetric flow measurement system flow sensor is thus measuring the air flow at a location in the sample system where the absolute pressure is less than the sample location's barometric pressure i.e., the air entering the sample system. The difference is absolute pressure between the air entering the sample system and the flow measurement location could vary significantly from one industry member to another. The variation may range from as little as 10 inches of water (2.5 kPa) to ~130 inches of water (32.5 kPa).

In most instances, the difference in pressure drop is primarily due to the pressure drop across the filter collection medium utilized by different facilities throughout an industry. It is pertinent to note that local dust loading at any sample site could cause the pressure drop to increase over the initial value measured with a clean filter.

Traditional analog differential pressure (DP) flow measurement devices such as a variable area rotameters, orifices, venturis, etc, can provide a flow measurement uncorrected for temperature (T) or pressure (P) at the flow measurement location. They report or display "Actual Flow" or "Indicated Flow". Actual Flow can be defined as the unique flow value at the flow sensor location measured at T (Actual) and P (Actual) (flow sensor location) without a correction to any stated reference value of T and P.

Normalization of Measured Flow Rates

It is standard practice among air monitoring professionals and environmental regulatory agencies to "Normalize" measured flow rates and volumes to internationally recognized reference standards of temperature (T) and pressure (P). This normalization is normally applied to emissions monitoring ambient air monitoring and typical workplace area monitoring.

The normalization process for inhalation dosimetry air monitoring purposes is different. The prevailing view among occupational inhalation radiation exposure health physicists is to normalize to the T and P of the air atmosphere that the worker is inhaling during the sample event. This will require (1) measurement of the absolute P existing at the DP flow sensor location and (2) measurement of the barometric pressure (BP) of the atmospheric air the worker is inhaling. Assuming the atmospheric air temperature is very similar to the T of the air flowing throng the DP flow sensor, measurement of the atmospheric air T should result in a T correction factor of ~1.00

The required instrument capabilities needed to properly correct air flow rates and volumes to the ambient atmospheric conditions are as follow in Table V below:

Table V

a) measurement of absolute Pressure at the mechanical DP flow sensor

b) measurement of the barometric pressure at the air sampling location

c) measurement of the sample location temperature, or the instrument's inlet air temperature

d) measurement of indicated (Actual Flow) of the mechanical DP type flow measurement device

If the radiation protection program implements mass flow measurement instruments, then the required instrument capabilities are listed in table VI below:

Table VI

a) measurement of the barometric pressure at the air sampling location

b) measurement of sample location temperature, or the instrument's inlet air temperature

c) knowledge of T and P standard utilized by the manufacturer for the display of volumetric flow rate on the mass flow meter display

d) correction of the volumetric flow output of the mass flow meter to ambient T and P conditions for inhalation dosimetry purposes

It is pertinent to note that mass flow type instruments measure the mass of air per unit time (g/min) and convert the mass flow to volumetric flow utilizing the density of the air at the manufacturer's chosen T and P reference for displaying the volumetric flow on the instrument

$$\text{Vol}_{(\text{flow})} = \frac{M^{\circ}}{\rho_{(T,P)}} = \frac{g/min}{g/liter} = \frac{liters}{min}\ (T,P)$$

M^{o} = mass flow (g/min)
$\rho_{(\text{T,P})}$ = density of air at a specific T and P (g/liter)
$\text{Vol}_{(\text{flow})}$ = Volumetric flow rate @ T and P (liters/min)

The variety of flow rates that can be measured and reported internally or externally by an organization performing air sampling are summarized in Table VII below.

Table VII
Variety of Flow Rate Reportable and Their Validation Reference

Type of Reported Flow/Volume	Reference Validity
1. DP Sensor Indicated Flow (Actual Flow)	Meaningless without T and P
2. DP Sensor Normalized Flow	Internationally recognized standard of T and P
3. Mass Flow	Mass/unit time (g / minute) 0°C, 760 mmHg
4. Mass Flow converted to Volumetric Flow	Internationally recognized standard of T and P
5. Flow at Ambient Air Conditions	Referenced to average BP and T of atmospheric air at the time of the sample event

All of the above types of reported flow or volumes can be compared to reported values of any other organization except for flow/volume type 1 unless a T and P is reported for the volumetric flow value. If no T and P is stated, the reported value is useless since volumes or volumetric flow rates must be defined by the T and P at which the volume, or the flow rate is measured.

In the case where flow rates and volumes are to be reported to the ambient air conditions of T and P the instruments should have the ability to measure and record T and BP values at least once every 10 minutes and to average the T and P results over the duration of the sample event. This feature will enable the air sampling specialist to achieve an acceptable accuracy whether the sample event is of short or long duration.

A significant emphasis should be made by the responsible air monitoring program managers to report flow rate and volume values that are truly comparable to the results reported by other similar monitoring programs implemented by other industry members within the industry in which they operate.

To accomplish this, the following courses of action are recommended.

1. Survey thoroughly the air sampling activities currently being performed within your organization to document the following:

    a. what are the objectives of these air monitoring activities?

    b. what are the regulatory agency reporting requirements and applicable standards?

    c. what instrumentation is being utilized to meet items a. and b. above?

    d. identify and upgrade programs in which the instrumentation cannot meet a. or b. above

2. Perform training programs for each type of air sampling application performed in your organization emphasizing the following:

    a. Air sampling reporting requirements

    b. Applicable standards

    c. Instrumentation capabilities

    d. Supplemental measurements or processes needed to comply with 2.a. and 2.b. above.

3. Communication with other industry members to obtain a consensus on the big picture related to the reporting of air sampling and air monitoring results. It is necessary to report data in a similar manner whose reported results will be truly comparable as a measure of performance among all industry members. This object requires all industry members to normalize all air sampling/monitoring data to anyone of several internationally recognized standards of T and P, or state the T and P of the volumetric flow or volume representative of the reported value.