SMART AIR SAMPLING INSTRUMENTS HAVE THE ABILITY TO IMPROVE THE ACCURACY OF AIR MONITORING DATA COMPARISONS AMONG NUCLEAR INDUSTRY FACILITIES

Frank M. Gavila
F&J SPECIALTY PRODUCTS, INC.
404 Cypress Road
Ocala, FL 34472
fandj@fjspecialty.com

INTRODUCTION

Valid inter-comparisons of operating performance parameters among all members of the nuclear industry are essential for the implementation of continuous improvement and for obtaining credibility among regulators and the general public. It is imperative that the comparison of performances among different industry facilities be as accurate as possible and normalized to industry-accepted reference standards.

REFERENCE STANDARDS

The concept of reference standards is well accepted within the scientific community. The measuring instruments utilized in the field are calibrated against reference standards at an accepted periodic frequency. [1]

Procedural standards are developed and utilized to perform scientific measurements or chemical and physical analyses in order to ensure that all industry members reporting scientific data are performing and reporting the measurement results in a consistent manner. [2]

In the reporting of air monitoring and air sampling data, such as flow rates and volumes, various industry groups and regulatory agencies responsible for the enforcement of air pollution laws and regulations have adopted reference conditions of temperature (T) and pressure (P) under which industry members must report volumetric flow rates and gas volumes. [3]

This normalization of measured values of air sampling events is required to ensure valid inter-comparisons of the scientific data involving the gas volumes reported by all industry members. Some of the numerous organizations defining temperature and pressure reference conditions for the reporting of gas volumes and volumetric gas flow rates are listed below in *Table 1*. The values that these organizations have chosen for the reference T and P are listed in *Table 2*.

The variety of definitions adopted by the different organizations confirms that there is not a universally accepted definition of reference conditions for T and P for the reporting of gas volumes.

Table 1. Organizations Defining the Temperature and Pressure Conditions for Reporting Gas Volumes

IUPAC	International Union of Pure and Applied Chemistry
ISO	International Organization for Standardization
EPA	US Environmental Protection Agency
NIST	National Institute of Standards and Technology
EEA	European Environmental Agency
CAGI	Compressed Air and Gas Institute
SPE	Society of Petroleum Engineers
OPEC	Organization of Petroleum Exporting Countries
EIA	US Energy Information Administration
ACGIH	American Conference of Governmental Industrial Hygienists

Table 2. Key Reference Temperature and Pressure Conditions

Establishing Organization	**Temperature** *(ºC)*	**Absolute Pressure** *[kPa (psia)]*
IUPAC (present definition)	0	100.000 (14.504)
IUPAC (former definition)	0	101.325 (14.696)
EPA, NIST	20	101.325 (14.696)
EPA (SATP) [4]	25	101.325 (14.696)
SATP [5]	25	100.000 (14.504)
CAGI	20	100.00 (14.504)
ACGIH [6]	25	101.325 (760 torr)
	Temperature *(ºF)*	**Pressure** *(psia)*
OSHA	60	14.696
EGIA, OPEC, EIA	60	14.73

In viewing the variety of reference standards adopted by various organizations, it becomes abundantly clear that if one states that gas flows at two standard cubic meters per hour, or that one has measured 1000 liters of air at standard conditions, it has no meaning. One must state the reference T and P conditions along with the measured values of flow and/or gas volumes.

Radiation protection professionals utilize instruments to assess the health and safety impact exerted by their facilities upon their workers and the general public. The measured value of a volumetric gas flow rate indicated by an air sampling or airflow calibration instrument is not a precise term unless it is clearly defined by the temperature and pressure conditions under which the value was measured or corrected. [7]

The flow at the volumetric gas flow sensor (such as a differential pressure sensor) is often defined as the “Indicated Flow”. The volumetric gas flow at an instrument’s flow sensor (such as a variable area rotameter) is a function of the following factors:

- The temperature of the air at the flow measurement location (not always the same as ambient temperature)
- The local barometric pressure
- The filter collection media pressure drop
- The pressure drop due to the air circuitry design
- The pressure differences due to daily barometric pressure variations
- The pressure drop due to dust loading, if applicable

The result of all the above mentioned physical impacts on the volumetric gas flow rate produces variations in every air sampling system because a flow sensor measures the flow under a unique set of dynamic conditions of temperature and pressure that depends on the many variables listed above.

One possible scenario for trying to achieve normalization of data is to mathematically correct the indicated flow measured by the analog sensor to the local ambient temperature and pressure conditions existing during the sampling event; thus, one can report “Ambient Flow” and “Ambient Volume”. Ambient flow does not represent a unique comparable value among many different sampling stations or industry members due to the differences in local barometric pressures and temperatures existing at the many different air sampling stations throughout the world at a given time. Of great importance in this scenario is the need to measure ambient temperature and pressure at the local air sampling station during the period of the sampling event, as well as the T and P at the flow sensor. For long term sampling events —lasting a week or longer, averaging the temperature and pressure data can be an intensive manpower task, even if continuous T and P measurement devices are used for this purpose.

The best alternative, and the most beneficial for air monitoring professionals, is to have advanced-technology instrumentation that reports volumetric gas flow rates and volumes to a recognized and accepted set of reference temperature and pressure conditions, regardless the T and P conditions at the flow sensor, or at the location of the sampling event. We can define these gas flows and gas volumes as “Reference Flows” and “Reference Volumes”.

This proposition for radiation protection programs was unthinkable as recently as the mid 1980s. Since then, the rapid evolution of microprocessor technology has revolutionized the world of computers to a plateau that was unimaginable at that time. Furthermore, the evolution of small but powerful microprocessors and the advancement of software techniques has enabled the creation of innovative, powerful and feature-rich devices for both consumers and scientists.

This very technology is exerting an impact upon the instruments employed for air sampling and air monitoring applications in radiation protection programs. The traditional analog flow measurement devices employed in air sampling instruments are being replaced by microprocessor-controlled instruments accepting electronic signals in real time from pressure and temperature sensors and performing many calculations at lightning speed to provide air monitoring professionals with volumetric flow rates and volumes corrected to whatever set of temperature and pressure conditions they require.

The ideal situation is for all radiation air monitoring professionals to agree to and accept a specific T and P at which all industry members will report the volumetric gas flow rates and gas volumes obtained from air sampling measurements in the field. Thus, the radioactivity concentrations and dose rate calculations (such as Derived Air Concentrations)[8] obtained with the volume parameter as one of the components of the calculation could be accurately compared among nuclear industry members.

An added bonus from implementing advanced-technology air sampling instruments for achieving the display (or recording) of gas volumes to industry-agreed-upon conditions of temperature and pressure is the ability of the end-users to avail themselves of additional features that microprocessor technology facilitates. Some of these features are listed in *Table 3* below.

Table 3. Functionality Features Available from Advanced-technology Air Sampling Systems

- Digital Display
- Operator Programmable Feature
  - — Auto Shut-off on Time or Volume
  - — Periodic Sampling Operation
- Multiple on-board Calculations
  - — elapsed time of the sample event
  - — flow rates and volumes corrected to reference T and P
  - — averages, minimums, maximums for measured or calculated parameters
- RS232 Communications Port
- Data Storage and/or data transmission options
- Interactive Software Features

What is the process required for moving from traditional analog air monitoring/sampling systems —whose data are not

comparable— to advanced-technology instruments —whose data are comparable?

Informed forward-thinking managers of air monitoring programs should determine which is the best process for incorporating the reporting of gas sample volumes and volumetric flow rates with clearly stated reference conditions of T and P into their air monitoring programs.

Firstly, the existing air sampling instruments in the organization need to be inventoried and classified as capable or **<u>not</u>** capable of reporting gas volumes or flow rates at a given set of reference T and P conditions. The instruments that do not comply need to be scheduled for upgrading at a future date.

Secondly, an evaluation of potential suppliers providing air sampling instruments capable of reporting flows and gas volumes at reference T and P conditions should be made, including an assessment of the quality of their instruments, the supplier's experience in the industry and the time-saving functionality features that these suppliers offer.

Lastly, a decision needs to be made as to the reference temperature and pressure conditions that should be adopted for the reporting of all gas volumes and flow rates throughout the entire organization, including the off-site contractors implementing the environmental monitoring programs. In order to make an informed decision an evaluation should include an investigation of the current criteria applied in the USA, Europe and Asia for air monitoring standards already in place, as well as an evaluation of the advanced-technology equipment already in use in the nuclear industry. Additionally, it is recommended that an investigation be made to determine whether a position on this issue has already been taken by any industry organization or nuclear industry regulatory agency.

CONCLUSION

As a practical matter, the selection of any specific set of standard reference conditions is irrelevant as long as all gas volumes and volumetric flow rates are reported consistently to the same reference T and P standard, the latter being clearly stated in any reported air monitoring data submitted by the organization.

It should also be noted that organizations, such as, EPA and NIST, each have more than one definition of standard reference conditions for gas volumes in their various standards and regulations. Therefore, there is no need for all the organizations within an industry group to adopt the same reference standard. Measured gas volume data should be corrected to the reference standard adopted by the organization and clearly reported, as such, both in its internal documents and in those submitted to regulatory agencies. If a set of data needs to be converted to another set of T and P reference values, this can be easily performed utilizing the Ideal Gas Law equations.

The managerial decision of an organization to report air-monitoring data with scientific clarity will demonstrate proper leadership and enhance the organization's technical and commercial credibility in the nuclear sector.

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