The Need to Clearly State the Reference Temperature and Pressure Conditions when Reporting Gas Volumes or Volumetric Flow Rates

In the physical sciences, such as chemistry, the standard temperature and pressure (STP) is a set of conditions for experimental measurements that enables true comparisons between sets of data representing gas volumes. There are many different definitions of standard temperatures and pressures applicable to gas volumes and volumetric flow rates. The differences depend on the organization defining the standard reference conditions.

Some of the numerous organizations defining standard reference conditions for the reporting of gas volumes and volumetric flow rates are listed below in Table I.

Table I
Organizations Which Define Reference Conditions for Gas Volumes

IUPAC	International Union of Pure and Applied Chemistry
ISO	International Organization for Standardization
EPA	U.S. 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

In industry and commerce, it is necessary to define the standard reference conditions of temperature (T) and pressure (P) when expressing a gas volume or volumetric flow rate because the volume of a gas varies with its temperature and pressure. The various definitions of standard reference conditions by the different organizations clearly indicate that there is not a universally accepted definition. In addition, the many air sampling programs that do not correct rotameter or other analog flow measurement devices to any reference standard does not enable one to compare different sets of air monitoring data among different industry members.

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Stating 1000 liters STP, or just 1000 liters, is not enough for comparing gas volumes collected in different sampling events. This reported volume has no meaning unless the applied reference temperature and pressure conditions are clearly stated; i.e. 1000 liters @ 25ºC, 760 mmHg.

Two different gas volumes reported with the reference conditions clearly stated can always be compared by means of the Ideal Gas Laws, even if such reference conditions are different.

The use of different reference conditions for gas volumes by different countries or different organizations is not a problem as long as the volumes and the reference conditions reported are clearly stated to enable direct or calculated comparisons with other data.

Several key reference temperature and pressure conditions (past and present) that are commonly utilized in the worldwide air sampling industry are listed in Table II below:

Table II
Key Reference Temperature and Pressure Conditions

Establishing Organization	Temperature (°C)	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)	25	101.325 (14.696)
SATP (*Journal of Physical and Chemical Reference Data*, 1982, Vol II, Supplement 2)	25	100.000 (14.504)
CAGI	20	100.00 (14.504)
	Temperature (ºF)	**Presasure (psia)**
OSHA	60	14.696
EGIA, OPEC, EIA	60	14.73

The most universally utilized reference conditions for gas volumes applied to air pollution monitoring data are listed below in Table III.

Table III
Common Gas Volume Reference Conditions Applied to Air Pollution Monitoring Data

	Temperature °C (°F)	Absolute Pressure
Classical STP [IUPAC (former definition)]	0 (32)	1 atm; 760 mmHg; 101.325 kPa
Normal T and P	20 (68)	1 atm; 760 mmHg; 101.325 kPa
Standard Ambient T and P	25 (77)	1 atm; 760 mmHg; 101.325 kPa
Modified Normal T and P (USA only)	21.1 (70)	1 atm; 760 mmHg; 101.325 kPa

The facts indicate that a considerable amount of reported gas volume data is being collected and processed in downstream calculations of pollutant concentrations and exposure rates without clearly stating any reference temperature and pressure conditions applied to the sample volumes, or the volumetric flow rates measured during the sampling event. Thus, comparisons of different sets of air monitoring data cannot be made accurately.

What is the Best Technological Solution for Achieving an Accurate and Credible Reporting of Data?

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

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

An evaluation of potential suppliers providing air sampling instruments capable of reporting flows and gas volumes at a reference T and P should be made, including an assessment of the quality of the instruments, industry experience and the time-saving functionality features they 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 off site contractors performing the environmental monitoring programs. An evaluation should include an investigation of current criteria in USA and foreign air monitoring standards, equipment already in use in the industry **and an industry organization, or regulatory agency positions, if any.**

As a practical matter, the selection of any specific standard reference condition is irrelevant as long as all gas volumes and volumetric flow rates are reported consistently at the same reference T and P standard, which is clearly stated in any reported results or air monitoring data submitted by the organization.

It should also be noted that ISO, EPA and NIST each have more than one definition of standard reference conditions for gas volumes in their various standards and regulations. Therefore, it is not necessary that all organizations within an industry group adopt the same reference standard. Measured gas volume data should be corrected to the organization's adopted reference standard and clearly reported as such both in internal documents and in those submitted to regulatory agencies.

The managerial decision to report air monitoring data with scientific clarity will demonstrate proper leadership and enhance the organization's technical and business credibility in the industry.