Designation: D6246 – 08 (Reapproved 2018)

Standard Practice for Evaluating the Performance of Diffusive Samplers[1]

This standard is issued under the fixed designation D6246; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the evaluation of the performance of diffusive samplers of gases and vapors for use over sampling periods from 4 to 12 h and for wind speeds less than 0.5 m/s. Such sampling periods and wind speeds are the most common in the indoor workplace setting. This practice does not apply to static or area sampling in wind speeds less than 0.1 m/s, when diffusion *outside* the sampler may dominate needed convection from the ambient air to the vicinity of the sampler. Given a suitable exposure chamber, the practice can be extended to cover sampler use for other sampling periods and conditions. The aim is to provide a concise set of experiments for classifying samplers primarily in accordance with a single sampler accuracy figure. Accuracy is defined (3.2.2) in this standard so as to take into account both imprecision and uncorrected bias. Accuracy estimates refer to conditions of sampler use which are normally expected in a workplace setting. These conditions may be characterized by the temperature, atmospheric pressure, humidity, and ambient wind speed, none of which may be constant or accurately known when the sampler is used in the field. Furthermore, the accuracy accounts for the effects of diffusive loss of analyte on the estimation of time-weighted averages of concentrations which may not be constant in time. Aside from accuracy, the samplers are tested for compliance with the manufacturer's stated limits on capacity, possibly in the presence of interfering compounds.

1.2 This practice is an extension of previous research on diffusive samplers (**1-14**)[2] as well as Practices D4597, D4598, D4599, and MDHS 27. An essential advance here is the estimation of sampler accuracy under actual conditions of use. Furthermore, the costs of sampler evaluation are reduced.

1.3 Knowledge gained from similar analytes expedites sampler evaluation. For example, interpolation of data characterizing the sampling of analytes at separated points of a homologous series of compounds is recommended. At present the procedure of (**9**) is suggested. Following evaluation of a sampler in use at a single homologous series member according to the present practice, higher molecular weight members would receive partial validations considering sampling rate, capacity, analytical recovery, and interferences. The test for diffusive analyte loss can be omitted if the effect is found negligible for a given sampler or analyte series.

1.4 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D4597 Practice for Sampling Workplace Atmospheres to Collect Gases or Vapors with Solid Sorbent Diffusive Samplers

D4598 Practice for Sampling Workplace Atmospheres to Collect Gases or Vapors with Liquid Sorbent Diffusional Samplers (Withdrawn 1995)[4]

D4599 Practice for Measuring the Concentration of Toxic Gases or Vapors Using Length-of-Stain Dosimeters

2.2 *International Standards:*

CEN EN 838 European Standard, Workplace Atmospheres – Diffusive Samplers for the Determination of Gases or

[1] This practice is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.04 on Workplace Air Quality.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[4] The last approved version of this historical standard is referenced on www.astm.org.

Vapours – Requirements and Test Methods[5]

MDHS 27 Protocol for Assessing the Performance of a Diffusive Sampler, Health and Safety Laboratory, United Kingdom[6]

MDHS 80 Volatile Organic Compounds in Air, Health and Safety Laboratory, United Kingdom[6]

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice, refer to Terminology D1356.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *diffusive sampler, n*—a device which is capable of taking samples of gases or vapors from the atmosphere at a rate controlled by a physical process such as gaseous diffusion through a static air layer or permeation through a membrane, but which does not involve the active movement of air through the sampler. As such, direct-reading dosimeters, as well as samplers requiring lab analysis, are considered diffusive samplers within this practice.

3.2.2 *symmetric accuracy range A, n*—the fractional range, symmetric about the true concentration *c*, within which 95 % of sampler measurements are to be found **(14-19)**. In terms of the bias Δ relative to true concentrations and the total (true) relative standard deviation *RSD* (sometimes designated as *TRSD*), the accuracy range A is closely approximated **(19)** by:

$$A = \begin{cases} 1.960 \times \sqrt{\Delta^2 + RSD^2}, \text{ if } |\Delta| < RSD/1.645 \\ |\Delta| + 1.645 \times RSD, \text{ otherwise} \end{cases} \quad (1)$$

3.2.2.1 *Discussion*—In the case that bias is corrected, leaving only an uncorrectable residual bias due to uncertainty in the correction, 95 %-confidence limits on *A* play the role of the expanded uncertainty in **(20)**. As described in **(14)**, such an interpretation is an extension of **(20)** for measurement, as in occupational hygiene, of concentrations which are neither spatially nor temporally constant. Rather than continually re-evaluating a method through estimate replicates, the accuracy provides confidence intervals bracketing (true) concentrations at greater than a given probability (95 %) for a fixed confidence (95 %) in the initial sampler evaluation. Such intervals with double confidence levels (in both measurement and evaluation) are related to a branch of statistics known as the theory of tolerance or prediction intervals.

3.3 *Symbols:*

A = symmetric accuracy range as defined in terms of bias and imprecision
$\hat{A}$ = estimated symmetric accuracy range A
$A_{95\,\%}$ = 95 % confidence limit on the symmetric accuracy range A
c(mg/m^3) = true or reference analyte concentration
$\hat{c}$(mg/m^3) = mean of (four) concentration estimates (including (p, T)-corrections) obtained in accordance with instructions of sampler manufacturer
h = humidity (expressed as partial pressure)
n = number of diffusive samplers tested for measuring sampler capacity
p = atmospheric pressure
RSD = overall (true) relative standard deviation of concentration estimates (dependent on assumed environmental variability) expressed relative to a "true" concentration
RSD_{run} = relative standard deviation characterizing inter-run chamber variability
RSD_s = inter-sampler imprecision (relative to the reference concentration)
$\hat{RSD}_s$ = estimated inter-sampler imprecision RSD_s
RSD_t = pulse-induced imprecision
$\hat{RSD}$ = estimated overall relative standard deviation RSD
$\hat{RSD}_{95\,\%}$ = 95 % confidence limit on the overall relative standard deviation RSD
s = estimated standard deviation characterizing inter-sampler imprecision
$t_{0.95}(\upsilon)$ = value which, at probability 95 %, exceeds random variables distributed according to the studentized t-distribution with υ degrees of freedom
T = temperature
v (m/s) = ambient wind speed
α_x = concentration estimate dependence on environmental variable x (T, h, v, or c).
Δ = bias relative to reference concentration c
$\hat{\Delta}$ = estimated bias Δ
$\hat{\Delta}_{95\,\%}$ = 95 % confidence limit on the bias Δ
Δ_t = bias associated with concentration pulse
υ = degrees of freedom in determining RSD_s
υ_{eff} = effective number of degrees of freedom in determining RSD
σ_c = assumed concentration variability
σ_h = assumed humidity variability
σ_T = assumed temperature variability
σ_v = assumed ambient wind speed variability

4. Summary of Test Method

4.1 *Bias, Inter-Sampler Imprecision and the Effects of Environmental Uncertainty:*

4.1.1 This practice gives a procedure for assessing the effects of variability in the following workplace variables: temperature T, humidity h (expressed in terms of the water vapor partial pressure to minimize interaction with the temperature), the ambient wind speed v across the sampler face (see 4.7 regarding wind direction), and concentration c. An experiment is carried out which provides information about the concentration estimates' dependencies on these variables near conditions of intended sampler use (T_0, h_0, v_0, and c_0). Testing is required at the concentration c_0 of intended use, as well as at concentrations reduced at least to $c_0/2$. Furthermore, the sampler bias and the inter-sampler standard deviation are measured. Finally, the effect of diffusion of material out of the sampler is measured. Pressure effects result in correctable bias and are not evaluated in this practice (4.6).

4.1.2 Using four samplers for each of five experimental runs (the minimum possible), the sensitivities α_T, α_h, α_v, and α_c

[5] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

[6] Available from HMSO Books, PO Box 276, London, England, SW8 5DT.