Designation: D6061 – 01 (Reapproved 2018)ε1

Standard Practice for Evaluating the Performance of Respirable Aerosol Samplers[1]

This standard is issued under the fixed designation D6061; 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.

ε1 NOTE—Reapproved with editorial changes in December 2018.

1. Scope

1.1 This practice covers the evaluation of the performance of personal samplers of non-fibrous respirable aerosol. The samplers are assessed relative to a specific respirable sampling convention. The convention is one of several that identify specific particle size fractions for assessing health effects of airborne particles. When a health effects assessment has been based on a specific convention it is appropriate to use that same convention for setting permissible exposure limits in the workplace and ambient environment and for monitoring compliance. The conventions, which define inhalable, thoracic, and respirable aerosol sampler ideals, have now been adopted by the International Standards Organization (ISO 7708), the Comité Européen de Normalisation (CEN Standard EN 481), and the American Conference of Governmental Industrial Hygienists (ACGIH, Ref (**1**)),[2] developed (**2**) in part from health-effects studies reviewed in Ref (**3**) and in part as a compromise between definitions proposed in Refs (**3, 4**).

1.2 This practice is complementary to Test Method D4532, which specifies a particular instrument, the 10-mm cyclone.[3] The sampler evaluation procedures presented in this practice have been applied in the testing of the 10-mm cyclone as well as the Higgins-Dewell cyclone.[3,4] Details on the evaluation have been published (**5-7**) and can be incorporated into revisions of Test Method D4532.

1.3 A central aim of this practice is to provide information required for characterizing the uncertainty of concentration estimates from samples taken by candidate samplers. For this purpose, sampling accuracy data from the performance tests given here can be combined with information as to analytical and sampling pump uncertainty obtained externally. The practice applies principles of ISO GUM, expanded to cover situations common in occupational hygiene measurement, where the measurand varies markedly in both time and space. A general approach (**8**) for dealing with this situation relates to the theory of tolerance intervals and may be summarized as follows: Sampling/analytical methods undergo extensive evaluations and are subsequently applied without re-evaluation at each measurement, while taking precautions (for example, through a quality assurance program) that the method remains stable. Measurement uncertainty is then characterized by specifying the evaluation confidence (for example, 95 %) that confidence intervals determined by measurements bracket measurand values at better than a given rate (for example, 95 %). Moreover, the systematic difference between candidate and idealized aerosol samplers can be expressed as a relative bias, which has proven to be a useful concept and is included in the specification of accuracy (3.2.13, 3.2.13.1, 3.2.13.3).

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.*

[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 a list of references at the end of this practice.

[3] If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[4] The sole source of supply of the Higgins-Dewell cyclone known to the committee at this time is BGI Inc., 58 Guinan Street, Waltham, MA 02154.

2. Referenced Documents

2.1 *ASTM Standards:*[5]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D4532 Test Method for Respirable Dust in Workplace Atmospheres Using Cyclone Samplers

D6062 Guide for Personal Samplers of Health-Related Aerosol Fractions

D6552 Practice for Controlling and Characterizing Errors in Weighing Collected Aerosols

2.2 *International Standards:*[6]

ISO 7708 Air Quality—Particle Size Fraction Definitions for Health-Related Sampling, Brussels, 1993

ISO GUM Guide to the Expression of Uncertainty in Measurement, Brussels, 1993

2.3 *European Standards:*[7]

CEN EN 481 Standard on Workplace Atmospheres—Size Fraction Definitions for the Measurement of Airborne Particles in the Workplace, Brussels, 1993

CEN EN 13205 Workplace Atmospheres—Assessment of Performance of Instruments for Measurement of Airborne Particle Concentrations, 2001

2.4 *NIOSH Documents:*

NIOSH Criteria for a Recommended Standard, Occupational Exposure to Respirable Coal Mine Dust 1995[8]

NIOSH Manual of Analytical Methods (NMAM) 5th Edition, Ashley, K., and O'Connor, P., eds., 2017[9]

3. Terminology

3.1 *Definitions:*

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

3.1.2 Aerosol fraction sampling conventions have been presented in Guide D6062. The relevant definitions are repeated here for convenience.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aerodynamic diameter, D* (μm)—the diameter of a sphere of density, 10^3 kg/m, with the same stopping time as a particle of interest.

3.2.2 *conventional respirable concentration* c_R (mg/m^3)—the concentration measured by a conventional (that is, ideal) respirable sampler and given in terms of the size distribution *dC/dD* as follows:

$$c_R = \int_0^\infty dD\, E_R\, dC/dD \tag{1}$$

3.2.2.1 *Discussion*—Note that samples are often taken over an extended time period (for example, 8 h), so that *dC/dD* of Eq 1 represents a time-averaged, rather than instantaneous, size-distribution.

3.2.3 *flow number F*—the number (for example, 4) of sampler flow rates *Q* tested.

3.2.4 *flow rate Q (L/min)*—the average flow rate of air sampled by a given sampler over the duration of the sampling period.

3.2.5 *mean concentration c*—the population mean of c_s.

3.2.6 *mean relative bias Δ*—of measurement *c* relative to the conventional respirable concentration c_R, defined as follows:

$$\Delta \equiv (c - c_R)/c_R \tag{2}$$

3.2.7 *mean sampled concentration* c_s—the concentration that sampler *s* would give, averaged over sampling pump and analytical fluctuations, in sampling aerosol of size-distribution C^{-1} *dC/dD* is given as follows:

$$c_s = \int_0^\infty dD\, E_s\, dC/dD \tag{3}$$

3.2.8 *replication number n (for example, 4)*—the number of replicate measurements for evaluating a given sampler at specific flow rate and aerodynamic diameter.

3.2.9 *respirable sampling convention,* E_R—defined explicitly at aerodynamic diameter *D* (μm) as a fraction of total airborne aerosol in terms of the cumulative normal function (**9**) Φ as follows:

$$E_R = 0.50\,(1 + \exp[-0.06\,D])\;\Phi\,[\ln[D_R/D]/\sigma_R] \tag{4}$$

where the indicated constants are $D_R = 4.25$ μm and $\sigma_R = \ln[1.5]$.

3.2.9.1 *Discussion*—The respirable sampling convention, together with earlier definitions, is shown in Fig. 1. This convention has been adopted by the International Standards Organization (ISO 7708), the Comité Européen de Normalisation (CEN Standard EN 481), and the American Conference of Governmental and Industrial Hygienists (ACGIH, Ref (**1**)). The definition of respirable aerosol is the basis for the recommended exposure level (REL) of respirable coal mine

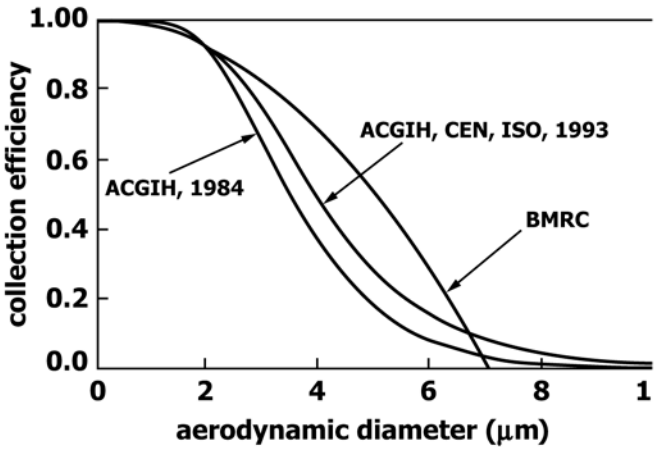

FIG. 1 Respirable Aerosol Collection Efficiencies

[5] 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.

[6] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

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

[8] Available from National Institute for Occupational Safety and Health (NIOSH), Cincinnati, OH, https://www.cdc.gov/niosh.

[9] Available from National Institute for Occupational Safety and Health (NIOSH), Cincinnati, OH, https://www.cdc.gov/niosh/nmam.