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Standard Guide for Personal Samplers of Health-Related Aerosol Fractions[1]

This standard is issued under the fixed designation D6062; 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 guide defines conventions for personal samplers of specific particle-size-dependent fractions of any given non-fibrous airborne aerosol. Such samplers are used for assessing health effects and in the setting of and testing for compliance with permissible exposure limits in the workplace and ambient environment. The conventions have been adopted by the International Standards Organization ~~(Technical Report ISO TR~~ (ISO 7708), the Comité Européen de Normalisation (CEN ~~Standard~~ EN 481), and the American Conference of Governmental Industrial Hygienists (ACGIH) (**1**).[2] The conventions were developed (**2**) in part from health-effects studies reviewed (**3**) by the ACGIH and in part as a compromise between definitions proposed by the ACGIH (**3**) and by the British Medical Research Council (BMRC) (**4**). Conventions are given here for inhalable, thoracic, and respirable fractions.

1.2 This guide is complementary to Test Method D4532, which describes the performance of ~~a particular instrument, the 10-mm cyclone,~~ respirable dust cyclones and operational procedures for use. The procedures, specifically the optimal flow rate, are still valid although the estimated accuracy differs somewhat from use with previous aerosol fraction definitions. Details on ~~this instrument and also the Higgins-Dewell cyclone have recently~~ these instruments have been published (**~~5-7~~11**).

1.3 *Limitations:*

1.3.1 The definitions given here were adopted by the agencies listed in 1.1 in part on the basis of expected health effects of the different size fractions, but in part allowing for available sampling equipment. The original adoption by CEN was, in fact, for the eventual setting of common standards by the EC countries while permitting the use of a variety of instrumentation. Deviations of the sampling conventions from health-related effects are as follows:

1.3.1.1 The inhalable fraction actually depends on the specific air speed and direction, on the breathing rate, and on whether breathing is by nose or mouth. The values given in the inhalable convention are for representative values of breathing rate and represent averages over all wind directions.

1.3.1.2 The respirable and thoracic fractions vary from individual to individual and with the breathing pattern. The conventions are approximations to the average case.

1.3.1.3 Each convention applies strictly to a fraction penetrating to a region, rather than depositing. Therefore, samples collected according to the conventions may only approximate correlations with biological effects. For example, the respirable convention overestimates the fraction of very small particles deposited in the alveolar region of the respiratory system because some of the particles are actually exhaled without being deposited (**~~8~~12**). In many workplaces, these very small particles contribute insignificantly to the sampled mass. Furthermore, the large variability between individuals and the details of clearance may be as important as this type of effect.

1.3.1.4 The thoracic convention applies to mouth breathing, for which aerosol collection is greater than during nose breathing.

1.4 The values stated in SI units are to be regarded as ~~the standard. The values given in parentheses are for information only.~~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~~ safety, health, and ~~health~~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.*

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[1] This guide 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 standard.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

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

2.2 *International Standards:*

ISO ~~TR~~ 7708 ~~Technical Report on~~ Air Quality—Particle Size Fraction Definitions for Health-Related Sampling, ~~Brussels, 19931995~~[4]

CEN EN 481 Standard on Workplace Atmospheres. Size Fraction Definitions for the Measurement of Airborne ~~Particles in the Workplace, Brussels,~~ Particles, 1993[5]

CEN EN 13205 Standards on Workplace Exposure. Assessment of Sampler Performance for Measurement of Airborne Particle Concentration, 2014[5]

3. Terminology

3.1 ~~Many terms used in this guide are defined in Terminology D1356.~~*Definitions:*

3.1.1 For terms that are not defined herein, refer to Terminology D1356.

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *inhalable convention, E_I*—the target specification for sampling instruments when the inhalable fraction is the fraction of interest. ~~Specifically, E_I is taken (Technical Report ISO TR 7708, CEN Standard EN 481, and the ACGIH threshold limit values (1)) as follows:~~

~~$$E_I = 0.50\,(1+\exp[-0.06\,D]),\ D<100\ \mu m \quad (1)$$~~

~~defined in terms of aerodynamic diameter, D.~~ **D1356**

3.2.2.1 *Discussion*—

Specifically, E_I is taken (ISO 7708, CEN EN 481, and the ACGIH threshold limit values (**1**)) as follows:

$$E_I = 0.50\,(1+\exp[-0.06\,D]),\ D<100\ \mu m \quad (1)$$

defined in terms of aerodynamic diameter, D.

3.2.2.2 *Discussion*—

The inhalable convention E_I is illustrated in Fig. 1. Note that $E_I \rightarrow 0.50$ (50 %) at large D.Eq 1 approximates the inhalable fraction when averaged over all wind directions for windspeeds $v < 4$ m/s. At higher wind speeds, the following convention has been tentatively suggested as follows (**913**):

$$E_I = 0.50\,(1+\exp[-0.06\,D]) + 10^{-5}\,v^{2.75}\exp[0.055\,D], \quad (2)$$

$$4\ \text{m/s} < v < 9\ \text{m/s}$$

3.2.3 *inhalable fraction*—the total airborne particle mass fraction inhaled through the nose and mouth, that is, which enters the respiratory system. **D1356**

3.2.4 *respirable convention, E_R*—the target sampling curve for instruments approximating the respirable fraction. ~~E_R is defined (Technical Report ISO TR 7708, CEN Standard EN 481, and the present ACGIH Threshold Limit Values (1)) in terms of the cumulative normal function (10) Φ as follows:~~

~~$$E_R = E_I\,\Phi[\ln[D_R/D]/\sigma_R] \quad (3)$$~~

~~where the indicated constants are $D_R = 4.25$ μm and $\sigma_R = \ln[1.5]$. The cumulative normal function Φ is easily approximated using the algorithm given in Appendix X1.~~ **D1356**

[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] Available from International Organization for ~~Standardization, Caisse Postale 56, CH-1211, Geneva 20, Switzerland.~~Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[5] Available from ~~CEN Central Secretariat: rue de Stassart 36, B-1050 Brussels, Belgium.~~European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

3.2.4.1 *Discussion—*

E_R is defined (ISO 7708, CEN EN 481, and the present ACGIH Threshold Limit Values (**1**)) in terms of the cumulative normal function (**14**) Φ as follows:

$$E_R = E_I \cdot \Phi[\ln[D_R/D]/\sigma_R] \quad (3)$$

where the indicated constants are $D_R = 4.25$ µm and $\sigma_R = \ln[1.5]$. The cumulative normal function Φ is easily approximated using the algorithm given in Appendix X1.

3.2.4.2 *Discussion—*

For protecting the sick or infirm or children, a quantity $D_R = 2.5$ µm has been suggested ~~(Technical Report ISO TR~~ (ISO 7708). This accounts for the fact that in children and in adults with certain chest diseases, the tracheobronchial region is more effective at collecting particles of small aerodynamic diameter than it is in healthy adults. The respirable convention E_R is illustrated in Fig. 1. Note that 50 % of total airborne particles with $D = 4.0$ µm are in the respirable fraction.

3.2.5 *respirable fraction*—the mass fraction of total airborne particles penetrating to the alveolar region of the respiratory system.

3.2.6 *sampling convention*—a target specification that approximates to a specific health-related fraction of aerosol of given aerodynamic diameter. A sampling convention is specified in terms of the sampling efficiency E, the fraction of particles at given aerodynamic diameter collected by an ideal instrument.

3.2.7 *thoracic convention, E_T*—the target sampling curve for instruments approximating the thoracic fraction. E_T is defined ~~(Technical Report ISO TR~~ (ISO 7708, CEN ~~Standard~~ EN 481, and the present ACGIH Threshold Limit Values (**1**)) in terms of the cumulative normal function (~~10~~**14**) Φ as:

$$E_T = E_I \cdot \Phi[\ln[D_T/D]/\sigma_T] \quad (4)$$

where the indicated constant parameters are $D_T = 11.64$ µm and $\sigma_T = \ln[1.5]$.

3.2.7.1 *Discussion—*

The thoracic convention E_T is illustrated in Fig. 1. Note that 50 % of total airborne particles with $D = 10$ µm are in the thoracic fraction.

3.2.8 *thoracic fraction*—the mass fraction of total airborne particles penetrating beyond the larynx.

3.3 *Symbols and Abbreviations:*

3.3.1 D (µm)—aerosol aerodynamic diameter.

3.3.2 D_R (µm) —respirable sampling convention parameter equal to 4.25 µm in the case of healthy adults, or 2.5 µm for the sick or infirm or children.

3.3.3 D_T (µm) —thoracic sampling convention parameter equal to 11.64 µm.

3.3.4 E—sampling convention in general.

3.3.5 E_I—inhalable sampling convention.

3.3.6 E_R—respirable sampling convention.

3.3.7 E_T—thoracic sampling convention.

3.3.8 v (m/s)—wind speed.

3.3.9 σ_R—respirable sampling convention parameter equal to ln[1.5].

3.3.10 σ_T—thoracic sampling convention parameter equal to ln[1.5].

3.3.11 *Φ[x]*—cumulative normal function defined, given argument x.

4. Significance and Use

~~4.1 The convention to be used is not always straightforward, but generally depends on what part of the respiratory system is affected by the aerosol particles. For example, if an aerosol (for example, silica) is expected to be hazardous mainly in the alveolar regions of the respiratory system, then the respirable convention applies. On the other hand, if an aerosol is extremely soluble (for example, KCN), then the inhalable convention should be used for monitoring or setting exposure limit standards. The conventions are often applied for approximating mass fractions, but they may also be used in the evaluation of total surface area or the number of particles in the collected material.~~