



Air quality — Particle size fraction definitions for health-related sampling

This Technical Report was drawn up by Technical Committee ISO/TC 146, *Air quality*, and approved by the majority of its members. The reasons which led to the decision to publish the document in the form of a Technical Report are the following.

- It was considered that the document could only define conventions for particle size fractions to be collected for assessing possible health effects.
- The choice of a cut at 10 μm of aerodynamic diameter at the larynx as the basis for these conventions.
- Publication as a Technical Report will encourage further experience with and acceptance of the conventions.

0 Introduction

The biological effects of particles inspired into the human body depend on the nature of the particles and where they deposit, although very little is known about the relationships either for the whole respiratory tract or for individual regions. Nor is much known about the effect in one region of deposition in another.

Inspired droplets or soluble components of inspired solid particles may be absorbed by the tissues wherever they deposit, or the particles may cause damage close to the deposition site if they are corrosive or active. For other inspired particles, biological effects may depend on the region of deposition and on the clearance mechanism and route. For example inspired particles depositing extra-thoracically which are not expelled through the nose or mouth are likely to be swallowed and may cause a hazard by absorption in the gastro-intestinal tract. Inspired particles depositing in the tracheobronchial region and cleared by the mucociliary escalator are likely to be swallowed, so that gastro-intestinal absorption is a possible route for these particles also. Inspired particles depositing in the alveolar region may also be cleared by this route, or through the lymphatic system, or may cause a reaction in the alveolar region itself. All the factors considered — inspiration, deposition and clearance — may vary considerably from individual to individual.

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1 Scope and field of application

This Technical Report defines conventions for particle size fractions which should be collected for assessing possible health effects of ambient (see 2.20) airborne particles. A cut of 10 µm aerodynamic diameter at the larynx is assumed.

The conventions are intended to be used in occupational or non-occupational environments where particles that deposit in some part of the respiratory tract are considered potentially hazardous. Limitations of the conventions are given in 5.1.

It is assumed that any health effect is proportional to the mass of particles deposited, either in the whole respiratory tract or in individual regions.

The sampling convention chosen for collection and analysis will depend on the source of the biological effect for the chemical constituents of interest (see 5.2).

2 Definitions

For the purpose of this Technical Report, the following definitions apply. (A list of symbols is given in table 1.)

2.1 particle aerodynamic diameter, ϕ : The diameter of a sphere of density 1 g/cm³ with the same terminal velocity as the particle under the prevailing conditions of temperature and relative humidity.

NOTE — For particles of aerodynamic diameter less than 0,5 µm, the particle diffusion diameter replaces the particle aerodynamic diameter. The particle diffusion diameter means the diameter of a sphere with the same diffusion coefficient as the particle under the prevailing conditions of temperature and relative humidity.

2.2 mass distribution function, M : The mass concentration of ambient airborne particles per aerodynamic diameter interval.

2.3 total mass concentration (of ambient airborne particles), M_{tot} :

$$M_{\text{tot}} = \int_0^{\infty} M(\phi) d\phi$$

2.4 aspiration rate of the respiratory tract, q_R : The air volume inspired per unit time averaged over one or more breathing cycles.

2.5 aspiration rate of sampling instrument, q_s : The air volume per unit time passing into a sampler.

2.6 inspirability, ξ : The mass concentration of ambient airborne particles of aerodynamic diameter, ϕ , inspired through the nose and mouth, as a fraction of the ambient airborne mass concentration of those particles before the air is affected by the presence of the exposed individual and inspiration, under the prevailing conditions of air movement.

2.7 inspirable mass fraction (of ambient airborne particles), I : The mass concentration of inspirable particles as a fraction of the total mass concentration

$$I = \frac{\int_0^{\infty} M(\phi) \xi(\phi) d\phi}{M_{\text{tot}}}$$

2.8 deposition probability; depositability (deprecated), ψ : The probability of an inspired particle being deposited in the respiratory tract.

2.9 regional deposition probability, ψ_X : The probability of an inspired particle being deposited in region X of the respiratory tract.

2.10 extrathoracic deposition probability, ψ_E : The probability of an inspired particle being deposited in the head and pharynx down to and including the larynx.

2.11 tracheobronchial deposition probability, ψ_B : The probability of an inspired particle being deposited between the larynx and the unciliated airways.

2.12 alveolar deposition probability, ψ_A : The probability of an inspired particle being deposited in the unciliated airways.

2.13 thoracic deposition probability, ψ_T : The sum of the tracheobronchial deposition probability and the alveolar deposition probability

$$\psi_T = \psi_B + \psi_A$$

2.14 rate of mass deposition in the respiratory tract, D_R : The mass of particles deposited in the respiratory tract per unit time.

2.15 rate of mass deposition in sampler, D_s : The mass of particles deposited in a sampler per unit time.

2.16 collection efficiency, E : The ratio of the mass concentration of ambient airborne particles of aerodynamic diameter ϕ measured by a sampler, to the ambient airborne mass concentration of those particles before the air is affected by the presence of the sampler or by the presence of the sampler and exposed individual if he wears the sampler.

2.17 sampling convention factor, K_X : The ratio of the fraction of the ambient airborne mass concentration at an aerodynamic diameter ϕ , measured using a sampler following the sampling convention for the region X of the respiratory tract, to the probability function $\xi(\phi) \psi_X(\phi)$ for ambient airborne particles depositing in region X of the respiratory tract.

2.18 deposited mass fraction, F : The ratio of the mass of particles depositing in the respiratory tract per unit volume of air inspired, to the total mass concentration of ambient airborne particles

$$F = \frac{\int_0^{\infty} M(\phi) \xi(\phi) \psi(\phi) d\phi}{M_{\text{tot}}}$$

2.19 regional deposited mass fraction, F_X : The ratio of the mass of particles depositing in region X of the respiratory tract per unit volume of air inspired to the total mass concentration of ambient airborne particles

$$F_X = \frac{\int_0^{\infty} M(\phi) \xi(\phi) \psi_X(\phi) d\phi}{M_{\text{tot}}}$$

2.20 ambient air : The air surrounding the human body or sampler, before the air is affected by the presence of the body or sampler.

This applies to both occupational and non-occupational environments.

Table 1 — Symbols

Symbol	Term
D_R	Rate of mass deposition in the respiratory tract (2.14)
D_s	Rate of mass deposition in sampler (2.15)
E	Collection efficiency (2.16)
F	Deposited mass fraction (2.18)
F_X	Regional deposited mass fraction (2.19)
I	Inspirable mass fraction (2.7)
K_X	Sampling convention factor (2.17)
M	Mass distribution function (2.2)
M_{tot}	Total mass concentration (2.3)
q_R	Aspiration rate of the respiratory tract (2.4)
q_s	Aspiration rate of sampling instrument (2.5)
ξ	Inspirability (2.6)
ϕ	Particle aerodynamic diameter (2.1)
ψ	Deposition probability (2.8)
ψ_A	Alveolar deposition probability (2.12)
ψ_B	Tracheobronchial deposition probability (2.11)
ψ_E	Extrathoracic deposition probability (2.10)
ψ_T	Thoracic deposition probability (2.13)
ψ_X	Regional deposition probability (2.9)

3 General expression for deposition

The rate of mass deposition of ambient particles in the respiratory tract is given by the equation

$$D_R = q_R \int_0^\infty M(\phi) \xi(\phi) \psi(\phi) d\phi \dots (1)$$

which takes into account the probability of ambient airborne particles being inspired by the nose and mouth, the probability of those particles then being deposited, and the air volume inspired per unit time. Then if F is the mass fraction of ambient airborne particles that deposit per unit volume of air inspired, and M_{tot} is the total mass concentration of ambient airborne particles

$$D_R = q_R F M_{tot} \dots (2)$$

Analogous equations apply for each region X of the respiratory tract, $\psi(\phi)$ in equation (1) then being replaced by $\psi_X(\phi)$, and F in equation (2) being replaced by F_X .

4 The basis of measurement

During measurement, ambient airborne particles are collected by an instrument which has a collection efficiency $E(\phi)$ equal to the inspirability $\xi(\phi)$, i.e. which collects the same mass fraction F of ambient airborne particles as the respiratory tract, but at a rate D_s

$$D_s = q_s F M_{tot} \dots (3)$$

so that

$$D_R = \frac{D_s q_R}{q_s} \dots (4)$$