
Cleaning of air and other gases — Terminology

Épuration de l'air et autres gaz — Terminologie

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 142, *Cleaning equipment for air and other gases*.

This second edition of ISO 29464 cancels and replaces the first edition (ISO 29464:2011), which has been technically revised.

Cleaning of air and other gases — Terminology

1 Scope

This document establishes a terminology for the air filtration industry and comprises terms and definitions only.

This document is applicable to particulate and gas phase air filters and air cleaners used for the general ventilation of inhabited enclosed spaces. It is also applicable to air inlet filters for static or seaborne rotary machines and UV-C germicidal devices.

It is not applicable to cabin filters for road vehicles or air inlet filters for mobile internal combustion engines for which separate arrangements exist. Dust separators for the purpose of air pollution control are also excluded.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purpose of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 General, applicable to both particulate and gas-phase air cleaners

3.1.1

air cleaner

device intended to remove *contaminants* (3.1.8) from air in a ventilation system or enclosed space

3.1.2

air velocity

rate of air movement

Note 1 to entry: It is expressed in m/s (fpm) to three significant figures.

3.1.3

bypass

air filter bypass

sneakage

proportion of the *challenge air stream* (3.5.13) that passes around an *air cleaner* (3.1.1) without interacting with the air cleaner

3.1.4

calibrate

to compare readings from the instrument to be calibrated with those from a reference device

3.1.5

capture

extraction of particles, liquid particles or gases, close to their sources for purposes of collection or sampling

3.1.6

classification

allocation of filters into groups and classes according to relevant aspects of their filtration performance

3.1.7

concentration

quantity of one substance dispersed in a defined amount of another

3.1.8

contaminant

pollutant

substance (solid, liquid or gas) that negatively affects the intended use of a fluid

3.1.9

contamination

pollution

presence of a substance that negatively affects the intended use of a fluid

3.1.10

decontamination factor

ratio of the *contaminant* (3.1.8) concentration or particle number upstream of the test device to the *contaminant concentration* (3.1.7) or particle number downstream of the device

Note 1 to entry: The decontamination factor can also be expressed as $1/(1 - \text{overall efficiency})$ or as $1/\text{penetration}$.

3.1.11

downstream

area or region into which fluid flows on leaving the test device

3.1.12

efficiency

filter efficiency

fraction or percentage of a challenge *contaminant* (3.1.8) that is removed by a test device

3.1.13

average efficiency

value of efficiency which results from averaging the efficiencies determined over a number of discrete intervals up to the final pressure differential

3.1.14

effluent

fluid discharged from a given source into the external environment

Note 1 to entry: This is a general term describing any fluid discharged from a given source; in this context, the discharged fluid may be liquid or gaseous and may contain associated liquid and/or particulate *contaminants* (3.1.8).

3.1.15

face velocity

filter face velocity

volumetric air flow rate divided by the *nominal filter face area* (3.1.18)

Note 1 to entry: filter face velocity is expressed in m/s.

3.1.16**filter****air filter**

device for separating solid or liquid particles or gaseous *contaminant* (3.1.8) from an air stream passing through the device

Note 1 to entry: The device is generally formed of a layer or layers of porous, fibrous or granular material.

Note 2 to entry: Air being cleaned by a filter must pass through the filter, whereas an *air cleaner* (3.1.1) can reduce air *contamination* (3.1.9) by any method.

3.1.17**filter face area**

cross-sectional face area of the filter including the header frame when viewed from the direction of air flow using exact dimensions

3.1.18**nominal filter face area**

cross-sectional face area of the filter including the header frame when viewed from the direction of air flow using nominal dimensions

3.1.19**filter insert**

replaceable part of a filter which contains the filter medium but which can only operate mounted inside a frame

3.1.20**filter medium**

material separating *particulate matter* (3.2.139) from gases and characterized by its separating structure and its structural and/or textile-technological characteristics

3.1.21**filter medium area**

area of *filter medium* (3.1.20) contained in the filter

Note 1 to entry: For filters with pleats or folds, the filter medium area may be much larger than the *filter face area* (3.1.17).

3.1.22**effective filter medium area****effective filtering area****exposed filter area**

area of the *filter medium* (3.1.20) contained in the filter through which air passes during operation

Note 1 to entry: This excludes areas covered by sealant, spacers, struts, etc.

Note 2 to entry: Effective filter medium area is expressed in m².

3.1.23**filter medium velocity****media velocity****medium velocity**

volumetric air flow rate divided by the *effective filter medium area* (3.1.22) of the *filter element* (3.2.77)

Note 1 to entry: Filter medium velocity is expressed in m/s.

Note 2 to entry: In devices where the filter medium surface area has been increased by use of pleats, folds or bags, the filter medium velocity may be much less than the *filter face velocity* (3.1.15).

3.1.24

flow rate

air flow rate

volume of air flowing through the filter per unit time

3.1.25

nominal flow rate

nominal air flow rate

air flow rate specified by the manufacturer

3.1.26

air flow rate, test

test air flow rate

test flow

test flow rate

test volume flow rate

air flow rate used for testing

Note 1 to entry: The flow rate is usually expressed in volumetric units (m³/s).

Note 2 to entry: Test flow rate may differ from the manufacturer's rated flow through the air cleaner.

3.1.27

rated flow

flow rate through a test device, either as stated by the manufacturer for defined conditions of use or as agreed between the interested parties for a particular installation

Note 1 to entry: The manufacturer's rated flow may differ from the *test air flow rate* ([3.1.26](#)).

3.1.28

gas

substance whose vapour pressure is greater than the *ambient pressure* ([3.5.50](#)) at ambient temperature

3.1.29

header frame

integral rigid frame of a filter enabling it to be fastened and sealed against the *holding frame* ([3.1.30](#))

3.1.30

holding frame

rigid structural frame, part of an air handling system into which filters are fastened and sealed

3.1.31

housing

device used to hold filter

3.1.32

hood

inlet device for extraction system

3.1.33

leak

point in a filter at which the local penetration exceeds a given value

3.1.34

penetration

breakthrough

ratio of contaminant concentration downstream of the test device to the upstream (challenge) *concentration* ([3.1.7](#))

Note 1 to entry: Sometimes expressed as a percentage.

Note 2 to entry: Penetration is related to efficiency (*E*) by the expression: $E = (1 - P) \times 100 \%$.

Note 3 to entry: Penetration is related to the *decontamination factor* (DF) ([3.1.10](#)) by the expression: $DF = 1/\text{penetration}$.

3.1.35

reference device

primary device possessing accurately known parameters used as a standard for calibrating secondary devices

Note 1 to entry: Reference particle filters are laboratory tested for *removal efficiency by particle size* ([3.2.149](#)) and/or resistance to air flow.

3.1.36

resistance to air flow

differential pressure

pressure differential

pressure drop

difference in absolute (static) pressure between two points in a system

Note 1 to entry: Resistance to air flow is measured in Pa.

3.1.37

test air

air to be used for testing purposes

3.1.38

test device

filter element ([3.2.77](#)) being subjected to performance testing

3.1.39

upstream

area or region from which fluid flows as it enters the *test device* ([3.1.38](#))

3.1.40

washer

dust separator ([3.2.158](#)), *droplet separator* ([3.2.157](#)) or *gas purifier* ([3.5.38](#)) that depends on a liquid acting as a collecting medium for its operation

3.2 Particulate filters (including general ventilation, HEPA and ULPA filters)

3.2.1

aerosol

system of solid or liquid particles suspended in gas

Note 1 to entry: In general, one divides the atmospheric aerosol into three size categories: the ultrafine range $x < 0,1 \mu\text{m}$, the fine range $0,1 \mu\text{m} \leq x < 1$ and the coarse range $x \geq 1 \mu\text{m}$, whereby x is the *particle diameter* ([3.2.124](#)).

3.2.2

liquid phase aerosol

liquid particles suspended in a gas

3.2.3

monodisperse aerosol

aerosol, the width of whose distribution function, described by the geometric standard deviation σ_g , is less than 1,15 μm

3.2.4

aerosol photometer

light-scattering airborne particle mass *concentration* ([3.1.7](#)) measuring apparatus, which uses a forward-scattering-light optical chamber to make measurements

3.2.5

polydisperse aerosol

aerosol, the width of whose distribution function, described by the geometric standard deviation σ_g , exceeds 1,5 μm

3.2.6

quasi-monodisperse aerosol

aerosol, the width of whose distribution function, described by the geometric standard deviation σ_g , is between 1,15 μm and 1,5 μm

3.2.7

reference aerosol

defined approved aerosol for test measurement within a specific size range

3.2.8

solid phase aerosol

solid particles suspended in a gas

3.2.9

test aerosol

aerosol used for determining performance of the device being tested and for calibrating particle measurement devices

3.2.10

agglomerate

collection of solid particles adhering to each other

3.2.11

agglomeration

action leading to the formation of *agglomerates* ([3.2.10](#))

3.2.12

agglutination

action of joining, by *impact* ([3.2.102](#)), solid particles coated with a thin adhesive layer or of trapping solid particles by impact on a surface coated with adhesive

3.2.13

aggregate

relatively stable assembly of dry particles, formed under the influence of physical forces

3.2.14

arrestance

measure of the ability of a filter to remove a standard test dust from the air passing through it, under given operating conditions

Note 1 to entry: This measure is expressed as a weight percentage.

3.2.15

average arrestance

ratio of the total amount of loading dust retained by the filter to the total amount of dust fed up to final test pressure differential

3.2.16

average gravimetric arrestance

ratio of the total mass of a standard test dust retained by the filter to the total mass of dust fed up to final test pressure differential

3.2.17**gravimetric arrestance**

measure of the ability of a filter to remove mass of a standard test dust from the air passing through it under given operating conditions

Note 1 to entry: This measure is expressed as a weight percentage.

3.2.18**initial arrestance**

value of arrestance determined after the first loading cycle in a filter test

Note 1 to entry: For example, in ISO 29461-1 or ISO 16890-3 procedure.

Note 2 to entry: This measure is expressed as a weight percentage.

3.2.19**initial gravimetric arrestance**

ratio of the mass of a standard test dust retained by the filter to the mass of dust fed after the first loading cycle in a filter test

Note 1 to entry: This measure is expressed as a weight percentage.

3.2.20**ash**

solid residue of effectively complete combustion

3.2.21**fly ash**

ash entrained by combustion gases

3.2.22**bioaerosol**

particles of biological origin with an aerodynamic diameter of up to 100 µm suspended in a gaseous medium

Note 1 to entry: Bioaerosol particles include viruses, bacteria, fungi, pollen, plant debris, fragments of these and their derivatives such as endotoxins, glucans, allergens and mycotoxins.

3.2.23**burst pressure**

value of differential pressure across a filter, above which damage/destruction of the *filter medium* ([3.1.20](#)) or the structure occurs

3.2.24**calibration particle**

mono-disperse spherical particle with a known mean particle size, e.g. polystyrene latex (PSL) particle traceable to an international standard of length where the standard uncertainty of the mean particle size is equal to or less than $\pm 2,5\%$

Note 1 to entry: The refractive index of (PSL) calibration particles is close to 1,59 at a wavelength of 589 nm (sodium D line).

3.2.25**dust holding capacity****DHC**

total weight of loading dust captured by the air-cleaning device up to the final pressure differential

3.2.26**test dust capacity****dust loading capacity****TDC**

amount of a standard test dust held by the test device at the final test pressure differential

3.2.27

cleaning

<after clogging> removal of the deposit of solid or liquid particles which has produced clogging

3.2.28

clogging

deposition, progressive or otherwise, of solid or liquid particles on or within a *filter medium* ([3.1.20](#)), causing the flow to be obstructed

3.2.29

coagulation losses

particle losses due to collision and adhesion of particles

Note 1 to entry: Coagulation affects the measured particle parameters as follows: the *particle number concentration* ([3.2.131](#)) decreases, the *particle mass concentration* ([3.1.7](#)) remains the same and the *particle size* ([3.2.133](#)) increases.

3.2.30

coalescence

action by which liquid particles in *suspension* ([3.2.162](#)) unite to form larger particles

3.2.31

coefficient of variation

CV

standard deviation of a group of measurements divided by the mean

3.2.32

coincidence error

error which occurs because at a given time more than one particle is contained in the measurement volume of a particle counter

Note 1 to entry: The coincidence error leads to a measured *number concentration* ([3.1.7](#)) which is too low and a value for the *particle diameter* ([3.2.124](#)) which is too high.

3.2.33

correlation ratio

calculation of any potential bias between the upstream and downstream sampling systems

3.2.34

correlation ratio

<sampling points>downstream particle concentration divided by the upstream particle concentration (measured without filter)

3.2.35

counting efficiency

expression of that proportion of the particles of detectable size suspended in the volume flow under analysis that make their way through the measured volume and are counted by the particle counter

EXAMPLE The ratio of the *concentration* ([3.1.7](#)) measured to actual aerosol concentration.

Note 1 to entry: The counting efficiency depends on the *particle size* ([3.2.133](#)) and decreases progressively in the proximity of the lower detection limit of the particle counter.

3.2.36

counting rate

number of counting events per unit time

3.2.37

cyclone

dust separator ([3.2.158](#)) or *droplet separator* ([3.2.157](#)) utilizing essentially the centrifugal force derived from the motion of the gas

3.2.38**DiEthylHexylSebacate
DEHS**

liquid used for generating the DEHS *test aerosol* ([3.2.9](#))

3.2.39**equivalent diameter**

diameter of a spherical particle which will give behaviour equivalent to that of the particle being examined

3.2.40**median diameter**

diameter of the particle for which the cumulated volume fraction is equal to 50 % on a cumulated volume particle size distribution curve

3.2.41**count median diameter of aerosol
number median diameter of aerosol
CMD**

50th percentile of the number distribution of the aerosol

Note 1 to entry: 50 % of the particles are smaller than the count median diameter and 50 % are larger than the count median diameter.

3.2.42**final differential pressure**

differential pressure up to which the filtration performance is measured for *classification* ([3.1.6](#)) purposes

3.2.43**initial differential pressure**

differential pressure of the clean filter operating at its *test air flow rate* ([3.1.26](#))

3.2.44**mean differential pressure**

arithmetical mean value of the measured number of differential pressures

3.2.45**recommended final differential pressure**

maximum operating differential pressure of the filter as recommended by the manufacturer

3.2.46**diluter
dilution system**

system for reducing the sampled *concentration* ([3.1.7](#)) to avoid coincidence error in the particle counter

3.2.47**dispersion**

operation as a result of which solid particles or liquid particles are distributed in a fluid

Note 1 to entry: Also applied to a two-Phase System in which one phase, known as the “disperse phase”, is distributed throughout the other, known as the “continuous medium”. For example, Dioctyl phthalate (DOP) liquid or liquids with similar physical properties, are dispersed in air to generate a *test aerosol* ([3.2.9](#)).

3.2.48**D.O.P.**

dispersed oil particulates

3.2.49**DOP**

dioctyl phthalate

3.2.50

droplet

liquid particle of small mass, capable of remaining in *suspension* (3.2.162) in a gas

Note 1 to entry: In some turbulent systems, for example clouds, its diameter can reach 200 µm.

3.2.51

dust

airborne solid particles which settle by gravity in calm conditions

3.2.52

dust control

whole of the processes for the separation of solid particles from a gas stream in which they are suspended

Note 1 to entry: By extension, also the activities involved in the construction and commissioning of a *dust separator* (3.2.158).

3.2.53

dust feeder

device which is used to distribute test dust to the filter

3.2.54

loading dust

synthetic test dust

synthetic dust formulated specifically for determination of the test dust capacity and arrestance of *air filters* (3.1.16)

Note 1 to entry: A number of loading dusts are currently in use. Some of them are defined in ISO 15957:2015.

3.2.55

collection efficiency

ratio of the quantity of particles retained by a *separator* (3.2.156) to the quantity entering it with regard to *filters* (3.1.16), *dust separators* (3.2.158) and *droplet separators* (3.2.157)

Note 1 to entry: This measure is normally expressed as a percentage.

3.2.56

conditioned efficiency

efficiency of the conditioned filter medium operating at an average medium velocity corresponding to the *test air flow rate* (3.1.26) in the filter

Note 1 to entry: The conditioning procedure varies depending on the standard being used.

3.2.57

counting efficiency

ratio, expressed as a percentage, of detected number *concentration* (3.1.7) of particles divided by the actual number concentration of particles in a given size or range of sizes

3.2.58

dust loaded efficiency

efficiency of the filter operating at test flow rate and after dust loadings up to final test pressure differential

3.2.59

fractional efficiency

ability of an air cleaning device to remove particles of a specific size or size range

Note 1 to entry: The efficiency plotted as a function of particle size gives the particle size efficiency spectrum.

3.2.60**initial efficiency****initial particulate efficiency**

efficiency of the air cleaning device measured at the start of a performance test while operating at the *test air flow rate* ([3.1.26](#))

Note 1 to entry: Expressed in % for each selected size of particle.

3.2.61**integral efficiency****overall efficiency**

efficiency, averaged over the whole superficial face area of a filter under given operating conditions

3.2.62**local filter efficiency**

efficiency at a specific point of a *filter element* ([3.2.77](#)) under given operating conditions

3.2.63**minimum filter efficiency**

minimum value of the filter efficiency curve under given operating conditions

3.2.64**particle size efficiency (%)**

efficiency for a specific particle diameter

Note 1 to entry: The efficiency plotted as a function of the *particle diameter* ([3.2.124](#)) gives the fractional efficiency curve.

3.2.65**elutriation**

method of separating a mixture of particles according to their settling velocities within a fluid

3.2.66**superficial face area**

cross-sectional area of the *filter element* ([3.2.77](#)) through which the air flow passes

3.2.67**brush filter**

air filter ([3.1.16](#)) in which the medium consists of a screen of intermeshing brushes

3.2.68**cartridge filter**

compact filter often of cylindrical design

3.2.69**cellular filter**

replaceable *filter insert* ([3.1.19](#)) which is or may be installed in a multiple bank or wall structure

Note 1 to entry: Examples of these are *HEPA filters* ([3.2.84](#)), rigid bags and panels.

3.2.70**ceramic filter**

filter with a medium consisting of ceramic fibres or sintered porous ceramic

3.2.71**charged filter****electret filter**

filter with an electrostatically charged medium

3.2.72**filter class**

range of filtration performances clearly defined by lower and upper limit values

3.2.73

cleanable filter

filter designed to permit the removal of collected dust by application of an appropriate technique

Note 1 to entry: The removal of collected dust is usually partial.

3.2.74

coarse filter

filtration device with particle *removal efficiency* (3.5.26) < 50 % in the PM₁₀ particle range

3.2.75

disposable filter

filter which is not intended to be cleaned or regenerated for reuse

3.2.76

efficient particulate air filter

EPA filter

filter with performance complying with requirements of classes ISO 15 to ISO 30 as given in ISO 29463-1

3.2.77

filter element

structure made of the filtering material, its supports and its interfaces with the filter housing

3.2.78

fabric filter

filter medium (3.1.20) manufactured either from woven or non-woven textile or a combination of both

Note 1 to entry: The term is most often applied to dust collectors. In these devices the filtering is effectively carried out by a bed of deposited dust, the textile providing a supporting substrate.

3.2.79

fibrous filter

filter comprising a medium consisting of a mass of fibres, including fine and very fine fibres

Note 1 to entry: The efficiency of these filters is derived from the presence of very fine fibres which are supported by coarser fibres in a relatively open structure.

Note 2 to entry: Fibrous filters are usually disposable.

3.2.80

final filter

air filter (3.1.16) used to collect the loading dust passing through or *shedding* (3.2.159) from the filter under test

3.2.81

fine filter

filtration device with particle removal efficiency ≥ 50 % in the PM₁₀ particle range

3.2.82

filter group designation

designation of a *group of filters* (3.2.83) fulfilling certain requirements in the filter classification

Note 1 to entry: ISO 16890-1 defines four groups of filters. Group designations are "ISO coarse", "ISO ePM₁₀", "ISO ePM_{2,5}" and "ISO ePM₁".

3.2.83

group of filters

comprises filters of more than one adjacent class within a performance spectrum

3.2.84**HEPA filter**

filters with performance complying with requirements of *filter class* ([3.2.72](#)) ISO 35H – ISO 45H per ISO 29463-1

3.2.85**filter installation**

filtration devices and systems such as a single filter or a *group of filters* ([3.2.83](#)) mounted together with the same inlet and outlet of air

3.2.86**metal filter**

filter with a medium consisting of metal mesh(es), fibres or sintered porous metal

3.2.87**filter pack**

filtering material in a preformed shape being a part of a complete filter

3.2.88**panel filter**

shallow parallel-faced *filter element* ([3.2.77](#)) or cell

3.2.89**particulate air filter**

filter designed to remove suspended particles from air flowing through it

3.2.90**pocket filter****bag filter**

filter in which the medium is formed into pockets or bags

3.2.91**renewable media filter**

filter in which the medium can be replaced

3.2.92**roll filter**

filter incorporating a means for advancing new medium

Note 1 to entry: For example, from a roll.

3.2.93**self-cleaning filter**

filter having an inbuilt mechanism for removing collected *contaminants* ([3.1.8](#))

3.2.94**filter type**

designation of the structure and test regime of a filter

3.2.95**ULPA filter**

filter with performance complying with the requirements of classes ISO 50 U – ISO 75 U as given in ISO 29463-1

3.2.96**sampling volume flow rate**

representative partial flow rate used for the determination of airborne particle characteristics

3.2.97**service flow**

gas flow rate through a *separator* ([3.2.156](#)) under given service conditions

3.2.98

folded pack

pack of the *filter medium* ([3.1.20](#)) formed by uniform individual folds

3.2.99

fume

solid aerosol generated by condensation, generally after evaporation from melted substances such as metals and often accompanied by chemical reactions such as oxidation

Note 1 to entry: In popular usage, gaseous effluent, often unpleasant and malodorous, which may arise from chemical processes.

3.2.100

general ventilation

process of moving air from outside the space, recirculated air, or a combination of these into or about a space or removing it from the space

3.2.101

grit

airborne solid particles in the atmosphere or flues

Note 1 to entry: In the UK, defined to be of size greater than 75 µm.

3.2.102

impact

collision of two particles with each other, or of a particle with a solid or liquid surface

3.2.103

impaction

inertial separation due to mass and velocity of a particle causing divergence from the airflow stream lines onto individual filter fibres

3.2.104

isoaxial sampling

sampling in which the flow in the sampler inlet is moving in the same direction as the flow being sampled

3.2.105

isokinetic sampling

technique for air sampling such that the probe inlet *air velocity* ([3.1.2](#)) is the same as the velocity of the air surrounding the sampling point

3.2.106

KCl

solid potassium chloride particles generated from an aqueous solution and used as *test aerosol* ([3.2.9](#))

3.2.107

measuring procedure with fixed sampling probes

determination of the *overall efficiency* ([3.2.61](#)) using fixed sampling probes upstream and *downstream* ([3.1.11](#)) of the filter being tested

3.2.108

minimum fractional test efficiency

fractional efficiency measured according to ISO 16890-2 after applying the conditioning method defined in this document (also named as "*minimum filter efficiency*" ([3.2.63](#)) or "minimum test efficiency")

3.2.109

mist

suspension ([3.2.162](#)) of droplets in a gas

3.2.110**neutralisation**

action of bringing the aerosol to a Boltzmann charge equilibrium distribution with bipolar ions

Note 1 to entry: This process is more often described as “discharging”.

3.2.111**particle**

small discrete mass of solid or liquid matter

3.2.112**particle bounce**

behaviour of particles that impinge on the filter without being retained

3.2.113**particle concentration method**

method that can determine the total concentration of particles in the aerosol either by multiple particle counting or chemical concentrations

Note 1 to entry: No particle size classification can be determined by this method.

3.2.114**particle counter**

device for detecting and counting numbers of discrete airborne particles present in a sample of air

3.2.115**allowable measurable concentration of the particle counter**

fifty percent of the maximum measurable concentration as stated by the manufacturer of the *particle counter* ([3.2.114](#))

3.2.116**particle counter border zone error**

particle sizing error that occurs when particles pass through the optical border of the sensing zone and receive less illumination

Note 1 to entry: The border zone error is device and particle size dependent and has a direct effect on the size resolution.

Note 2 to entry: Due to the border zone error, the *particle size* ([3.2.133](#)) is underestimated.

Note 3 to entry: The larger the particle to be measured, the bigger the border zone error.

3.2.117**particle counter calibration curve**

graph depicting the relationship between scattered light intensity and particle size

Note 1 to entry: For the clear particle size and quantity determination, an unambiguous, monotonically increasing calibration curve offers advantages. This enables narrower size intervals to be chosen.

3.2.118**condensation particle counter****CPC**

type of *optical particle counter* ([3.2.119](#)) in which very fine airborne particles are enlarged by condensation to a size which may readily be counted by other particle counting methods

Note 1 to entry: It can provide data on *particle numbers* ([3.2.130](#)) but not the original size distribution.

Note 2 to entry: ISO committee dealing with CPC is TC 24/SC 4.

3.2.119

optical particle counter OPC

particle counter which functions by illuminating airborne particles in a sample flow of air, converting the scattered light impulses to electrical impulse data capable of analysis to provide data on particle population and size distribution

Note 1 to entry: See ISO 21501-4.

3.2.120

particle counter sizing accuracy

the sizing accuracy $\varepsilon(x)$ is determined by the function:

$$\varepsilon(x) = \frac{x_{\text{measured}} - x_{\text{reference}}}{x_{\text{reference}}} \cdot 100$$

Note 1 to entry: x_{measured} is the particle size indicated by the counter for a reference particle and $x_{\text{reference}}$ is the actual size of the reference particle. Sizes are usually stated in μm .

3.2.121

particle counter sizing resolution

indicates which particle sizes can be differentiated by a particle measuring instrument

Note 1 to entry: The sizing resolution can be evaluated for any particle size as follows:

$$R(x) = \frac{\sqrt{\sigma_{\text{measured}}^2(x) - \sigma_{\text{reference}}^2(x)}}{x_{\text{reference}}} \cdot 100, \sigma = \text{geometric standard deviation.}$$

σ_{measured} is the standard deviation of the reference particle size indicated by the particle counter. $\sigma_{\text{reference}}$ is the standard deviation of the reference particle size reported by the reference particle producer. $x_{\text{reference}}$ is the reference particle size reported by its producer.

3.2.122

particle counter sampling flow rate

particle counter sampling air flow

volumetric flow rate through the instrument

Note 1 to entry: Any error in the volumetric flow rate will affect the reported *particle number concentration* ([3.2.131](#)).

3.2.123

particle counting and sizing method

particle counting method which allows both the determination of the number of particles and also the classification of the particles according to size

EXAMPLE By using an *optical particle counter* ([3.2.119](#)).

3.2.124

particle diameter

geometric diameter (equivalent spherical, optical or aerodynamic, depending on context) of the particles of an aerosol

Note 1 to entry: Particle diameter is often referred to simply as “particle size”.

3.2.125

count mean particle diameter

number mean particle diameter

geometric average of the lower and upper limit of the size range

3.2.126**mean diameter****mean particle diameter**

geometric mean of the upper and lower border diameters in a size range

3.2.127**particle flow distribution**

distribution of the particle flow over a plane at right angles to the direction of flow

3.2.128**particle flow rate**

number of particles that are measured or that flow past a specified cross-section per unit time

3.2.129**particle lower size limit**

smallest *particle diameter* ([3.2.124](#)) with a counting *efficiency* ([3.1.12](#)) of $0,5 \pm 0,15$ (50 % $\pm$ 15 %)

3.2.130**particle number**

number of particles present in a defined group

3.2.131**particle number concentration**

number of particles per unit of volume of air

3.2.132**particle production rate**

number of particles produced per unit time by an aerosol generator

3.2.133**particle size**

geometric diameter (equivalent spherical, optical or aerodynamic, depending on context) of the particles of an aerosol

3.2.134**particle size analysis**

technique used to measure the size distribution of an assembly of particles

3.2.135**particle size distribution**

presentation, in the form of tables of numbers or of graphs, of the experimental results obtained using a method or an apparatus capable of measuring the equivalent diameter of particles in a sample or capable of giving the proportion of particles for which the equivalent diameter lies between defined limits

3.2.136**most penetrating particle size****MPPS**

particle size ([3.2.133](#)) at which the minimum of the particle size efficiency curve occurs under test conditions

Note 1 to entry: This MPPS is dependent on the *filter medium* ([3.1.20](#)) and the test conditions.

3.2.137**particle size range**

defined particle counter channel

3.2.138**particle upper size limit**

largest *particle diameter* ([3.2.124](#)) with a counting efficiency of $0,5 \pm 0,15$ (50 % $\pm$ 15 %)

3.2.139

particulate matter

PM

solid and/or liquid particles suspended in ambient air

3.2.140

particulate matter efficiency

ePM_x

efficiency (3.1.12) of an air cleaning device to reduce the mass concentration of particles with an optical diameter between 0,3 µm and x µm

3.2.141

particulate matter

PM₁₀

particulate matter (3.2.139) which passes through a size-selective inlet with a 50 % efficiency cutoff at 10 µm aerodynamic diameter

3.2.142

particulate matter

PM_{2,5}

particulate matter (3.2.139) which passes through a size-selective inlet with a 50 % efficiency cutoff at 2,5 µm aerodynamic diameter

3.2.143

particulate matter

PM₁

particulate matter (3.2.139) which passes through a size-selective inlet with a 50 % efficiency cutoff at 1 µm aerodynamic diameter

3.2.144

porous layer

permeable layer of solid material in any form having interstices of small size, generally known as “pores”

3.2.145

precipitation

operation in which particles are separated from a gas stream in which they are suspended

Note 1 to entry: For example, by the action of an electrical field or a thermal gradient.

3.2.146

electrostatic precipitator

device in which particles become charged and are precipitated on the collecting surface

Note 1 to entry: Also referred to as electrostatic collector, electrical separator or electrostatic separator.

3.2.147

purification

total or partial removal of unwanted constituents from a gaseous medium

3.2.148

re-entrainment

release to the air flow of particles previously collected on the filter

3.2.149

removal efficiency by particle size

ratio of the number of particles retained by the filter to the number of particles measured upstream of the filter for a given particle-size range

3.2.150**final resistance to air flow**

resistance to air flow up to which the filtration performance is measured to determine the average arrestance and test dust capacity

Note 1 to entry: Final resistance to air flow is measured in Pa.

3.2.151**initial resistance to air flow**

resistance to air flow of the clean filter operating at its *test air flow rate* ([3.1.26](#))

Note 1 to entry: Initial resistance to air flow is measured in Pa.

3.2.152**recommended final resistance to air flow**

maximum operating resistance to air flow of the filter as recommended by the manufacturer

Note 1 to entry: Recommended final resistance to air flow is measured in Pa.

3.2.153**sampling duration**

time during which the particles in the sampling volume flow are counted (upstream or *downstream* ([3.1.11](#)))

3.2.154**scan test**

test procedure by which local efficiency or penetration values are determined by sampling filtered air at the downstream filter face according to a specified grid pattern

3.2.155**sedimentation**

separation of particles from the fluid in which they are suspended, by the action of gravity

3.2.156**separator**

apparatus for separating solid or liquid particles or gases from a gaseous stream in which they are suspended or mixed

Note 1 to entry: A separator (also known as an inertial separator or a collector) takes larger *contaminants* ([3.1.8](#)) out of the air stream, often to prevent them from reaching filters downstream.

3.2.157**droplet separator**

apparatus for separating suspended liquid particles from a gas stream

3.2.158**dust separator**

apparatus for separating suspended solid particles from a gas stream

3.2.159**shedding**

release to the air flow of particles due to *particle bounce* ([3.2.112](#)) and reentrainment effects and to the release of fibres or *particulate matter* ([3.2.139](#)) from the filter or filtering material

3.2.160**smoke**

solid or liquid aerosol resulting from combustion of organic materials including fossil fuels, wood and cigarettes

3.2.161**soot**

deposits of agglomerated carbonaceous particles formed by incomplete combustion

3.2.162

suspension

two-phase system in which one phase, the disperse phase, is distributed throughout the other, known as the continuous phase

3.2.163

system efficiency

removal efficiency (3.5.26) of a filter system where upstream and downstream particle count measurements may be across several filter banks or other system components

3.2.164

total particle count method

particle counting method in which the total number of particles in a certain sample volume is determined without classification according to size

EXAMPLE 1 By using a *condensation particle counter* (3.2.118). [SOURCE: ISO 29463-5:2011]

EXAMPLE 2 By using a condensation nucleus counter. [SOURCE: ISO 29463-4:2011]

3.2.165

transmission

ratio of the quantity of particles leaving a *filter* (3.1.16), *dust separator* (3.2.158) or *droplet separator* (3.2.157), to the quantity entering it

3.2.166

undersize

percentage of particles smaller than a specified *particle size* (3.2.133) in a *particle size distribution* (3.2.135)

Note 1 to entry: Undersize measurement can be *particle number* (3.2.130) or concentration.

3.2.167

user nominal air volume flow rate

air volume flow rate specified by the user, at which the *filter element* (3.2.77) is tested in situ

Note 1 to entry: This flow rate may be different from the one specified by the manufacturer.

3.2.168

user nominal filter medium velocity

air volume flow rate specified by the user divided by the *effective filter medium area* (3.1.22)

3.2.169

zero count rate

number of counts registered per unit time by the particle counter when air, which is free of particles, is passed through the measuring volume

3.3 Air intake particulate filters for rotary machines

NOTE Some of the terms for this type of filter are used in the same way in other documents managed by ISO/TC 142. Such terms are defined in 3.1 or 3.2.

3.3.1

test aerosol

aerosol used for determining the *particulate efficiency* (3.3.6) of the filter

3.3.2

test air flow rate

volumetric airflow rate used for testing

3.3.3**average gravimetric efficiency**

ratio of the total amount of loading dust retained by the filter to the total amount of dust fed up to *final test pressure drop* (3.3.15)

Note 1 to entry: This definition is the same as the one used for “arrestance, average” in 3.2.

3.3.4**gravimetric efficiency**

weighted (mass) removal of loading dust after 50 g of dust load

3.3.5**minimum efficiency**

lowest *particulate efficiency* (3.3.6) of initial, conditioned or dust loaded efficiencies

3.3.6**particulate efficiency**

percentage particulate removal efficiency of the filter at specified particle sizes measured with a particle counter in the range of 0,3 µm to 3,0 µm

3.3.7**depth loading filter**

filter in which particles penetrate into the *filter medium* (3.1.20) and are collected on the fibres in the depth of the filter medium

3.3.8**low efficiency filter**

air filter (3.1.16) with an *initial particulate efficiency* (3.2.60) at 0,4 µm particles in the range $E < 35 \%$

3.3.9**medium efficiency filter**

air filter (3.1.16) with an *initial particulate efficiency* (3.2.60) at 0,4 µm particles in the range $35 \% \leq E \leq 85 \%$

3.3.10**high efficiency filter**

air filter (3.1.16) with an *initial particulate efficiency* (3.2.60) at 0,4 µm particles in the range $E \geq 85 \%$

3.3.11**pulse jet filter**

cleanable air filter, that typically is cleaned with air jet pulses to provide a longer service life

3.3.12**static filter**

air filter (3.1.16) that will be removed (exchanged) after it has reached its *final test pressure drop* (3.3.15) and that is not cleaned with jet pulses or other means in order to fully or partially, retrieve its initial performance (pressure drop and efficiency)

3.3.13**surface loading filter**

filter in which the dust is collected on the surface of the *filter medium* (3.1.20)

3.3.14**untreated filter**

air filter not submitted to conditioning

3.3.15**final test pressure drop**

maximum pressure drop of the filter up to which the filtration performance is measured

3.3.16

recommended final test pressure drop

maximum operating pressure drop of the filter as recommended by the manufacturer at rated airflow

3.3.17

initial pressure drop

pressure drop of the clean filter operating at the test airflow rate

3.4 Cleanable particulate filter degradation

3.4.1

aged flat filter sheet

flat filter sheet exposed under simulated hot and corrosive gas (3.4.7) conditions for a preset period of time to evaluate the change of filtration properties

3.4.2

air permeability

gas volume flow rate per unit filtration area at pressure drop of 124,5 Pa

3.4.3

average gas concentration

mean concentration of *test gases* (3.4.26) during the *exposure* (3.6.4)

3.4.4

batch type exposure chamber

chamber in which filter sheets are exposed to stationary *test gas* (3.4.26) mixture

3.4.5

chemical degradation

degradation (3.4.8) of chemical properties of filter media by the interaction with *test gas* (3.4.26)

3.4.6

continuous-flow-method

method of exposing a filter sheet in a continuous flow of *test gas* (3.4.26) mixture

3.4.7

corrosive gas

chemical which reacts with *filter medium* (3.1.20) and change its chemical and physical properties

3.4.8

degradation

change in physical and chemical performance of a *filter medium* (3.1.20) caused by interaction with *corrosive gases* (3.4.7)

3.4.9

elongation

incremental change in length of test specimen determined by tensile test

3.4.10

elongation at maximum load

incremental change in length of test specimen at maximum load determined by tensile test

3.4.11

elongation ratio

ratio of *elongation* (3.4.9) of test specimen to its initial *length between holders* (3.4.16)

Note 1 to entry: It can be expressed as a percentage.

3.4.12**elongation ratio at maximum load**

ratio of *elongation* (3.4.9) of test specimen at maximum load in tensile test to its initial *length between holders* (3.4.16)

3.4.13**exposure chamber**

chamber to expose test filter sheet to *corrosive gases* (3.4.7)

3.4.14**flow-through type replacement**

method to replace test gas in the *batch type exposure chamber* (3.4.4) by introducing *test gas* (3.4.26) continuously to the chamber

3.4.15**initial load**

load applied to the test specimen at the start of tensile test

3.4.16**length between holders**

length between the jaws of the top and bottom holding chucks as positioned at the start of the tensile test

3.4.17**load**

tensile strength (3.4.25) of test specimen observed in the tensile test

3.4.18**non-continuous-flow-method**

method of exposing a filter sheet in a stationary *test gas* (3.4.26) mixture

3.4.19**nonwoven fabric**

filter medium (3.1.20) manufactured using fabric made from long fibres bonded together with each other by chemical, mechanical, heat or solvent treatment

3.4.20**number of replacement**

number of *test gas* (3.4.26) replacement for whole heating space volume of the test chamber

3.4.21**replacement of gas**

exchange gas to maintain *test gas* (3.4.26) concentration within certain concentration range

3.4.22**retention of tensile strength**

ratio of *tensile strength* (3.4.25) of the test specimen subjected to thermal and/or acid gas exposure to that of the test specimen without the *exposure* (3.6.4)

3.4.23**strip method**

method of implementing tensile test with holding whole width of the test specimen with a holding device

3.4.24**tensile speed**

speed to pull a test specimen in tensile test

3.4.25**tensile strength**

value of the maximum *load* (3.4.17) divided by the width of test specimen

3.4.26

test gas

gas which may cause changes in physical properties of filter media to be used for tensile test

3.4.27

thermal exposure

exposure (3.6.4) of filter medium to an elevated temperature to accelerate the change in its physical properties

3.4.28

vacuum replacement

method to replace *test gas* (3.4.26) in the *batch type exposure chamber* (3.4.4) by the use of vacuum

3.4.29

woven fabric

filter medium (3.1.20) manufactured using a fabric formed by weaving

3.5 Gas phase air cleaners (GPAC)

3.5.1

absorption

the transport and dissolution of a sorbate into an absorbent to form a mixture having the characteristics of a solution

3.5.2

active site

position on an *adsorbent* (3.5.4) surface with the potential to trap an *adsorbate* (3.5.3) molecule

3.5.3

adsorbate

molecular compound in gaseous or vapour phase that may be retained by an *adsorbent* (3.5.4) medium

3.5.4

adsorbent

material having the ability to retain gaseous or vapour *contaminants* (3.1.8) on its surface by physical or chemical processes

3.5.5

regenerable adsorbent

adsorbent (3.5.4) material which, after saturation, may be treated to recover its adsorption properties thereby enabling its reuse

3.5.6

ageing of adsorbent

chemical or physical process which reduces the effectiveness (efficiency and/or capacity) of an *adsorbent* (3.5.4)

Note 1 to entry: Ageing reduces the number of *active sites* (3.5.2).

3.5.7

adsorption

process in which the molecules of a gas or vapour adhere by physical or chemical processes to the exposed surface of solid substances, both the outer surface and inner pore surface, with which they come into contact

3.5.8

activated alumina

aluminium oxide, usually in the form of granules, treated to enhance its surface area and consequent ability to adsorb gases

3.5.9**bed depth**

depth of the *adsorbent* (3.5.4) medium through which the gas being processed passes

Note 1 to entry: See 3.1.34.

3.5.10**breakthrough time**

time to reach a specified penetration (x)

Note 1 to entry: Relevant breakthrough times may be defined as penetrations of 5 %, 50 % and 95 % (tb5, tb50, tb95)

Note 2 to entry: Breakthrough time is sometimes referred to as breakthrough point.

3.5.11**breakthrough vs. time curve**

plot of *contaminant* (3.1.8) penetration versus time for a particular *challenge concentration* (3.5.14) and airflow

3.5.12**adsorbate capacity**

amount (mass or moles) of a selected *adsorbate* (3.5.3) that can be contained in the GPAC Medium or Device under given test conditions and end point (termination time)

Note 1 to entry: Capacity can also be negative during *desorption* (3.5.21).

3.5.13**challenge air stream**

test *contaminant(s)* (3.1.8) of interest diluted to the specified concentration(s) of the test prior to filtration

3.5.14**challenge concentration**

concentration of the test *contaminant(s)* (3.1.8) of interest in the air stream prior to filtration (*challenge air stream* (3.5.13))

3.5.15**challenge compound**

chemical compound that is being used as the *contaminant* (3.1.8) of interest for any given test

3.5.16**channelling**

disproportionate or uneven flow of gas through passages of lower resistance due to inconsistencies in the design or production of a GPACD, particularly in packed granular beds

3.5.17**activated charcoal****activated carbon**

carbon, usually in the form of granules, treated to enhance its surface area and consequent ability to adsorb gases through a highly developed pore structure

Note 1 to entry: Usually produced from coal, carbonized coconut shell or other organic materials.

3.5.18**chemisorption****chemical adsorption**

trapping of gaseous or vapour contaminants on an *adsorbent* (3.5.4) involving chemical reaction on the adsorbent surface

3.5.19

close valve time

time when the challenge gas(es) are initially turned off or when switching from upstream to downstream monitoring

3.5.20

decay time

time required for the gas contaminant monitoring instrument to record a reduction from an initial value greater than 95 % of the *challenge concentration* (3.5.14) to a final value of less than 5 % of the challenge concentration at the downstream sampling point for a specific test, challenge gas and gas flow, after stopping the injection of the *contaminant* (3.1.8) with no GPAC Media or Device present

3.5.21

desorption

process in which *adsorbate* (3.5.3) molecules leave the surface of the *adsorbent* (3.5.4) and reenter the air stream

Note 1 to entry: Desorption is the opposite of adsorption.

3.5.22

efficiency vs. capacity curve

plot of the GPACD *removal efficiency* (3.5.26) against the integrated capacity over the duration of a challenge test for a particular *challenge concentration* (3.5.14) and airflow

3.5.23

efficiency vs. time curve

plot of the GPAC Medium or Device *removal efficiency* (3.5.26) against time over the duration of a challenge test for a particular *challenge concentration* (3.5.14) and airflow

3.5.24

end efficiency

removal efficiency (3.5.26) calculated from the concentrations at the end of the test

3.5.25

initial efficiency

efficiency of an unexposed filter or GPACD calculated as soon after the start of a test as is possible

3.5.26

removal efficiency

fraction or percentage of a challenge contaminant that is retained by a GPAC Medium or Device at a given time

Note 1 to entry: Removal efficiency is also known simply as “efficiency”.

3.5.27

carbon filter

filter in which the filtering medium is, or includes, *activated charcoal* (3.5.17) and which is used for the separation of gaseous substances from the passing air

3.5.28

sorption filter

filter that removes gases or vapour contaminants from a gas stream using adsorption or absorptive processes

3.5.29

filtration

separation of *contaminants* (3.1.8) from a fluid stream in which they are suspended through retention of the contaminants (by extension, also the whole of the activities involved in the construction and commissioning of a *filter installation* (3.2.85))

3.5.30**flow rate sampling point**

location where the air flow rate is sufficiently stable to permit a reliable flow measurement

3.5.31**test volume flow rate**

volumetric air flow rate used for testing

3.5.32**gas phase air cleaning device****GPACD**

assembly of a fixed size enabling the removal of specific gas- or vapour-phase contaminants

Note 1 to entry: It is normally box shaped or fits into a box of dimensions between 300 mm × 300 mm × 300 mm up to approximately 610 mm × 610 mm × 610 mm or 2 ft × 2 ft × 2 ft.

3.5.33**GPAC medium or device face area**

cross-sectional area of the GPAC Medium or Device also including a header frame or other support structures if so equipped when viewed from the direction of air flow using exact dimensions

3.5.34**gas phase air cleaning medium****GPACM**

solid medium or medium configuration used for filtering a *contaminant* (3.1.8)

EXAMPLE A porous film or fibrous layer; a bead shaped granular or pelletized adsorbent (or chemisorbent); a support structure of fabric, foam or monoliths containing *adsorbent* (3.5.4) in the form of small-sized particles, granules, spheres or powder; a woven or *nonwoven fabric* (3.4.19) completely made from an adsorbent material.

3.5.35**GPACM-LF**

adsorbent (3.5.4) in the form of particles of different shape and size intended for e.g. loose fill applications

3.5.36**GPACM-FL**

adsorbent (3.5.4) in the form of flat sheet that is flexible, thin and nominally 2-dimensional

EXAMPLE Woven or *nonwoven fabrics* (3.4.19), wet laid papers, smooth pads, felts, etc. normally handled as roll goods.

3.5.37**GPACM-TS**

adsorbent (3.5.4) in the form of a three-dimensional structure that is many times thicker than flat sheet and used as a finished element in a device

EXAMPLE Flexible open-cell structures, i.e. of thicker impregnated foam, corrugated pads, etc. and air permeable rigid structures, i.e. of bonded particles, honeycomb trays, extruded monoliths, etc.

3.5.38**gas purifier**

apparatus for totally or partially removing one or more constituents from a gas mixture

3.5.39**lag time****rise time**

time between initial injection of *contaminant* (3.1.8) and reaching 95% of the *challenge concentration* (3.5.14) for an empty duct measured at the downstream sampling location

Note 1 to entry: Lag/rise time is specific to a particular test, challenge gas and gas flow rate.

3.5.40

molecular contamination

contamination (3.1.9) present in gas or vapour phase in an air stream and excluding compounds in particulate (solid) phase regardless of their chemical nature

3.5.41

molecular sieve

silica-based mineral having a crystalline three-dimensional structure with cavities and channels whose surfaces can adsorb small molecules

3.5.42

open valve time

time at which challenge contaminants are initially injected into the test duct

3.5.43

ppb(v)

parts per billion by volume concentration measure normally used to record ambient levels of outdoor pollution

Note 1 to entry: Units are mm³/m³.

3.5.44

ppm(v)

parts per million by volume concentration measure normally used to record pollution levels in, e.g. work place safety

Note 1 to entry: Units are cm³/m³ and ml/m³.

3.5.45

physisorption

physical adsorption

attraction of an *adsorbate* (3.5.3) to the surface, both outer surface and inner pore surface, of an *adsorbent* (3.5.4) by physical forces (Van der Waals forces)

3.5.46

pores

minute passageways through which fluid may pass or that expose to the fluid stream the internal surfaces of an *adsorbent* (3.5.4) medium

3.5.47

macro-pores

largest sized *pores* (3.5.46) (diameter > 50 nm) of *adsorbent* (3.5.4) media

3.5.48

meso-pores

intermediate sized *pores* (3.5.46) (diameter > 2 nm and < 50 nm) of *adsorbent* (3.5.4) media

3.5.49

micro-pores

smallest sized *pores* (3.5.46) (diameter < 2 nm) of *adsorbent* (3.5.4) media

3.5.50

ambient pressure

absolute pressure immediately outside the test rig

3.5.51

purge time

time required for the contaminant sampling system and monitoring instrument to register a change from an initial value lower than 1 % of the *challenge concentration* (3.5.14) to a final value greater than 95 % of the challenge concentration (or vice versa), as when a single instrument is switched from upstream to downstream monitoring and back