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Test method for assessing the performance of gas-phase air cleaning media and devices for general ventilation —

Part 1: Gas-phase air cleaning media

Méthodes d'essai pour l'évaluation de la performance des médias et des dispositifs de filtration moléculaire pour la ventilation générale —

Partie 1: Médias de filtration moléculaire (GPACM)

Reference number
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Foreword

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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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 142, *Cleaning equipment for air and other gases*.

ISO 10121 consists of the following parts, under the general title *Test methods for assessing the performance of gas-phase air cleaning media and devices for general ventilation*:

— *Part 1: Gas-phase air cleaning media (GPACM)*

— *Part 2: Gas-phase air cleaning devices (GPACD)*

Introduction

There is an increasing use and need for gas-phase filtration in general filtration applications. This demand can be expected to increase rapidly due to the increasing pollution problems in the world together with an increasing awareness that solutions to the problems are available in the form of filtration devices or phrased more technically: gas-phase air cleaning devices (GPACD). The performance of devices using adsorption for gas removal relies to a large extent on the performance of a solid gas-phase air cleaning media (GPACM) incorporated in the device. Still applications, device performance and media performance are often poorly understood by the user and supplier of such media and devices. Media tests may also be adequate to offer data for real applications if actual low concentrations (<100 ppb) and longer exposure times (>weeks) can be used in the test, provided that the geometrical configuration, packing density and flow conditions of the small-scale test specimen are equal to those used in the real applications. Such tests are however not included in the scope of this part of ISO 10121. This part of ISO 10121 attempts to increase understanding and communication by supplying a more standardized interface between media suppliers, device suppliers and end users. At present, standards exist for general ventilation in Japan[1] by JIS, Automotive filters by ISO, in-duct sorptive media gas-phase air-cleaning devices by ASHRAE[2] and for adsorptive media by ASHRAE[3] and ASTM.[5] No international standard for general filtration exists today.

This part of ISO 10121 provides methods, test equipment, data interpretation and reporting for three different types of gas-phase air cleaning media (GPACM) intended for use in gas-phase air cleaning devices (GPACD) for general ventilation applications.

In addition information is given in a number of annexes:

— Annex A describes the normative validation procedure in detail in a tabulated form.

— Annex B gives a list of possible test gases, generation sources and suggests proper analysis equipment for common test gases

— Annex C describes the design of the test stand except the normative sample holder.

— Annex D describes the normative test setup and normative section of the test stand for the three different media configurations.

A general introduction to molecular filtration and molecular filtration testing can be found in the scientific literature.

The ISO 10121 series aims to provide laboratory test methods for media and devices which are used for removal of gas-phase contaminants from air in general ventilation. It consists of two parts:

— ISO 10121-1 covers three different media configurations and is targeted towards giving a standardized interface between media suppliers and producers of air cleaning devices. It may also be used between media suppliers and end customers with regards to loose fill media properties.

— ISO 10121-2 aims to give a standardized interface between suppliers of air cleaning devices and end customers seeking the best performing and most economical way to employ gas-phase filtration.

Test method for assessing the performance of gas-phase air cleaning media and devices for general ventilation —

Part 1:
Gas-phase air cleaning media

1 Scope

This part of ISO 10121 aims to provide an objective laboratory test method, a suggested apparatus, normative test sections and normative tests for evaluation of three different solid gas-phase air cleaning media (GPACM) or GPACM configurations for use in gas-phase air cleaning devices intended for general filtration applications. This part of ISO 10121 is specifically intended for challenge testing and not for general material evaluation or pore system characterization. The three different types of GPACM identified in this part of ISO 10121 are GPACM-LF (particles of different shape and size intended for e.g. Loose Fill applications), GPACM-FL (FLat sheet fabric intended for e.g. flat one layer, pleated or bag type devices) and GPACM-TS (three dimensional structures that are many times thicker than flat sheet and e.g. used as finished elements in a device). The tests are conducted in an air stream and the GPACM configurations are challenged with test gases under steady-state conditions. Since elevated gas challenge concentrations (relative to general ventilation applications) are used, test data should be used to compare GPACM within the same configuration and not for the purpose of predicting performance in a real situation. It is also not implied that different GPACM configurations can be directly compared. The primary intention is to be able to compare like GPACM configurations to like, not between GPACM configurations. Testing of complete devices is described in ISO 10121-2.

To ensure objectivity for test equipment suppliers, no specific design of the test apparatus is defined: an example is illustrated in Annex C (informative). Instead normative demands for media sample holder design, apparatus properties and validation tests are specified.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10121-2, *Test methods for assessing the performance of gas-phase air cleaning media and devices for general ventilation — Part 2: Gas-phase air cleaning devices (GPACD)*

ISO 29464, *Cleaning equipment for air and other gases — Terminology*

ASTM D2854, *Standard Test Method for Apparent Density of Activated Carbon*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 29464 and the following apply.

3.1
absorption
transport and dissolution of a sorbate into an absorbent

3.2
adsorbate
molecular compound in gaseous or vapour phase that will be retained by the adsorbent material of the media

3.3
adsorbent
material that collects adsorbates on its surface through physical or chemical processes

3.4
adsorption
process in which the molecules of a gas 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
breakthrough
amount of gaseous contaminant in the effluent of a GPAC Media or Device

Note 1 to entry: See *penetration* (3.33).

3.6
breakthrough vs. time curve
plot of contaminant penetration versus time for a particular challenge concentration and airflow

[SOURCE: ISO 29464:2011; 3.2.67]

3.7
bypass
proportion of the challenge air stream that passes around the GPACD without contacting the filter media

[SOURCE: ISO 29464:2011; 3.2.64]

3.8
capacity
m_s
amount (mass or moles) of a selected sorbate that can be contained in the GPAC Media or Device at given test conditions, and a specific end point

Note 1 to entry: Capacity can also be negative during desorption.

3.9
challenge concentration
concentration of the test contaminant(s) of interest in the air stream prior to filtration (challenge air stream)

3.10
challenge compound
chemical compound that is being used as the contaminant of interest for any given test

3.11
challenge air stream
test contaminant(s) of interest diluted to the specified concentration(s) of the test prior to filtration

[SOURCE: ISO 29464:2011; 3.2.16]

3.12
channeling
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

[SOURCE: ISO 29464:2011; 3.2.17]

3.13
chemisorption
chemical adsorption
trapping of gaseous or vapour contaminants on an adsorbent involving chemical reaction on the adsorbent surface

[SOURCE: ISO 29464:2011; 3.2.19]

3.14
concentration
C_n
quantity of one substance dispersed in a defined amount of another

Note 1 to entry: Indices "n" denote location or origin.

[SOURCE: ISO 29464:2011; 3.2.21]

3.15
contaminant
substance (solid, liquid, or gas) that negatively affects the intended use of a fluid

[SOURCE: ISO 29464:2011; 3.2.23]

3.16
decay time
t_{Dn}
time required for the gas contaminant monitoring instrument to record a reduction from greater than 95 % of the challenge concentration to less than 5 % of the challenge concentration (t_{END} - t_{VC}) at the downstream sampling point for a specific test (n), challenge gas and gas flow after stopping the injection of the contaminant with no GPAC Media or Device present

3.17
desorption
process in which adsorbate molecules leave the surface of the adsorbent and re-enter the air stream

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

3.18
downstream
area following the filter in the direction of fluid flow

3.19
efficiency vs. time curve
plot of the GPAC Media or Device removal efficiency against time over the duration of a challenge test for a particular challenge concentration and airflow

[SOURCE: ISO 29464:2011; 3.2.31]

3.20
efficiency vs. capacity curve
plot of the GPACD removal efficiency against the integrated capacity over the duration of a challenge test for a particular challenge concentration and airflow

[SOURCE: ISO 29464:2011; 3.2.28]

3.21
face velocity
air flow rate divided by the cross sectional area of the GPAC Media or Device

3.22
gas
substance whose vapour pressure is greater than the ambient pressure at ambient temperature

[SOURCE: ISO 29464:2011; 3.2.44]

3.23
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 feet × 2 feet × 2 feet.

[SOURCE: ISO 29464:2011; 3.2.45, modified – NOTE has been modified.]

3.24
GPAC media or device face area
cross-sectional area of the GPAC Media 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

3.25
gas-phase air cleaning media
GPACM
solid media or media configuration used for filtering a contaminant

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 in the form of small sized particles, granules, spheres or powder; a woven or nonwoven fabric completely made from an adsorbent material.

3.26
GPACM-LF
adsorbent in the form of particles of different shape and size intended for e.g. loose fill applications

3.27
GPACM-FL
adsorbent in the form of flat sheet that is flexible, thin, and nominally 2-dimensional

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

3.28
GPACM-TS
adsorbent in the form of a three dimensional structure that is many times thicker than flat sheet and e.g. 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.

3.29
initial efficiency
E_i
efficiency calculated as the intersection of vertical efficiency axis by extrapolation of a linear fit of efficiency vs. time from the values between 2 to 12 minutes of the E vs. time graph generated during testing of a GPAC Media or Device

3.30
molecular contamination
contamination present in gas or vapour phase in an air stream and excluding compounds in particulate (solid) phase regardless of their chemical nature

3.31
ppb(v)
parts per billion by volume concentration measure normally used to record ambient levels of outdoor pollution

Note 1 to entry: Units are mm^3/m^3.

3.32
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 cm^3/m^3 and ml/m^3.

3.33
penetration
P
ratio of contaminant concentration downstream of the filter to the upstream (challenge) concentration

Note 1 to entry: Sometimes expressed as a percentage.

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

[SOURCE: ISO 29464:2011; 3.2.51]

3.34
physisorption
physical adsorption attraction of an adsorbate to the surface, both outer surface and inner pore surface, of an adsorbent by physical forces (Van der Waals forces)

3.35
pores
minute passageways through which fluid may pass or that expose to the fluid stream the internal surfaces of an adsorbent media

[SOURCE: ISO 29464:2011; 3.2.55]

3.36
pressure drop
Δp
difference in pressure between two points in an airflow system at specified conditions, especially when measured across a GPAC Media or Device

3.37
removal efficiency
E
fraction or percentage of a challenge contaminant that is retained by a GPAC Media or Device at a given time

3.38
retentivity
m_r
measure of the ability of an adsorbent or GPACD to resist desorption of an adsorbate

Note 1 to entry: Computed as the residual capacity (fraction remaining) after purging the adsorbent with clean, conditioned air only, following challenge breakthrough.

[SOURCE: ISO 29464:2011; 3.2.61, modified – NOTE has been added]

3.39
residence time
t_r
relative time that an increment of fluid (or contaminant) is within the boundaries of the media volume

EXAMPLE An example of the media volume is a bed of granules or a non-woven sheet.

Note 1 to entry: In typical use and in this part of ISO 10121, this value neglects the fact that the media and possible support structures occupy a significant portion of the volume of the bed [tR = V (total bed volume) / Q (air flow rate)].

[SOURCE: ISO 29464:2011; 3.2.71]

3.40
rise time
t_{Rn}
time between initial injection of contaminant and reaching 95 % of the challenge concentration for an empty duct (t_0 - t_{VO}) measured at the downstream sampling location for a specific test (n), challenge gas and gas flow

3.41
sorbate
molecular compounds that are retained in the adsorbent of the device

Note 1 to entry: The sorbate will refer to both intended compounds like the selected challenge gas in a test or pollution in real service but also any other compounds present in the air stream, e.g. gases and vapours.

3.42
sorption
process in which fluid molecules (gas or liquid) are removed by the GPACM by absorption or adsorption

3.43
space velocity
sv
measure of residence time of the airflow to pass through the adsorbent bed

EXAMPLE sv = volumetric flow rate/total volume of the bed.

Note 1 to entry: [sv] = (residence time)$^{-1}$.

3.44
vapour
substance whose vapour pressure is less than the ambient pressure at ambient temperature, but is present in the gas-phase through evaporation or sublimation

[SOURCE: ISO 29464:2011; 3.2.74]

4 Symbols and abbreviated terms

4.1 Symbols

C	concentration
C_D	downstream concentration [ppb, ppm] measured at a position Y mm after the media sample or device
C_U	upstream concentration [ppb, ppm] measured at a position X mm before the media sample or device
d_{pa}	the average particle diameter of a loose fill adsorbent

E_C	removal efficiency [%] for the device measured at the challenge concentration selected during the capacity test
E_{END}	efficiency recorded at stop test time or value agreed between user and supplier [%]
m_r	retentivity; [g],[mol] the amount withheld by the media or device after ventilating with clean air at the same flow selected during the capacity test until C_D reaches a specified value close to zero.
m_s	the total integrated amount [g], [mol] of challenge compound accumulated by the GPAC media or device during the whole challenge test
m_{sD}	the integrated amount in moles or gram of challenge compound accumulated during measurement at the downstream position
m_{sU}	the integrated amount in moles or gram of challenge compound accumulated during measurement at the upstream position
n_p	the number of pores along the (shortest) diameter of a GPACM-TS sample
p_D	downstream pressure [Pa] measured at a position Y mm after the media sample or device
p_U	upstream pressure [Pa] measured at a position X mm before the media sample or device
Q	air flow rate; flow used in test (given by 5.4 or 5.5) [m^3/h] measured at a position Z mm from the media sample or device
Q_A	the average air flow rate calculated from individual measurements evenly distributed over the test period.
RH_D	downstream relative humidity [%] measured at a position Y mm after the media sample or device
RH_U	upstream relative humidity [%] measured at a position X mm before the media sample or device
t	time
t_0	start time. The time when C_U (contamination concentration upstream) equals the selected challenge concentration for an empty sample holder or duct
t_{DC}	decay time for challenge concentration used in the capacity measurement
t_{END}	time when a test is stopped. The time when a desired concentration or other termination criteria have been met in any of the prescribed test procedures (agreed between user and supplier)
t_{RC}	rise time for challenge concentration used in the capacity measurement
t_{VC}	time noted at challenge gas valve closure
t_{VO}	time noted at challenge gas valve opening
T_D	downstream temperature [°C] measured at a position Y mm after the media sample or device
T_U	upstream temperature [°C] measured at a position X mm before the media sample or device
v_f	face velocity [m/s] calculated from flow and cross sectional area of media sample or device
X	a position X positioned sufficiently far ahead of the device to allow undisturbed measurements, determined in the validation, Annex A. At the position X the concentration of challenge compound is sufficiently mixed and represents the upstream concentration that the GPACM sample will be challenged with.