INTERNATIONAL STANDARD

ISO 10121-2

First edition
2013-04-01

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)

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

Partie 2: Dispositifs de filtration moléculaire (GPACD)

Reference number
ISO 10121-2:2013(E)

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Published in Switzerland

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10121-2 was prepared by Technical Committee 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 relies to a large extent on the performance of a gas-phase air cleaning media (GPACM) incorporated in the device. Still applications and device performance are often poorly understood by the users and suppliers 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 ISO 10121. 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[4], in-duct sorptive media gas-phase air-cleaning devices by ASHRAE[7] and for adsorptive media by ASHRAE[8] and ASTM[9]. No international standard for general filtration exists today.

This part of ISO 10121 prescribes methods, test equipment, data interpretation and reporting for gas-phase air cleaning devices intended for the removal of gas-phase contamination from air in 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 suitable analysis equipment for common test gases in addition to reference techniques given for the simplified benchmark setup in Clause 5.5.

— Annex C discusses different test stand designs.

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

ISO 10121 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.

— This part of ISO 10121 aims to give a standardized interface between suppliers of air cleaning devices and end customers seeking the most cost efficient way to employ gas-phase filtration.

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)

1 Scope

This part of ISO 10121 aims to provide an objective test method to estimate the performance of any full size gas filtration device (GPACD) for general filtration regardless of media or technique used in the device. In fact, the goal of this part of ISO 10121 is to avoid relating the test data to internal parameters altogether. The benefit with this approach is that customers of GPACDs will be able to concentrate on price/performance and suppliers will have access to a normative and objective test standard that will not require the release of proprietary information or reverse engineering of the product.

To ensure objectivity for test equipment suppliers, no specific design of the test apparatus is specified. Instead requirements of apparatus properties and validation tests are specified. However, different design examples in present use are outlined. This part of ISO 10121 can also be used with technologies such as scrubbers, absorbers, non-sorptive devices or packed columns as long as they fit into the test apparatus, can be meaningfully judged by the test method and are intended for general ventilation applications, both residential and non residential. Nuclear and military applications are specifically excluded.

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 29464:2011, *Cleaning equipment for air and other gases — Terminology*

EN 15805:2009, *Particulate air filters for general ventilation — Standardised dimensions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 29464 and the followings 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 surfaces 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 GPACD

Note 1 to entry: See “penetration”.

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 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 filter media of a GPACD 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
cf. 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.

[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 GPACD 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 oppsite of adsorption.

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

3.19
efficiency vs. time curve
plot of the GPACD 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 GPACD

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 × 300 × 300 mm up to approximately 610 × 610 × 610 mm or 2 × 2 × 2 feet.

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

3.24
GPACD face area
cross-sectional area of the GPACD also including a header frame if so equipped when viewed from the direction of air flow using exact dimensions

3.25
gas-phase air cleaning media
GPACM
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
initial efficiency
efficiency of an unexposed filter or GPACD calculated as soon after the start of a test as is possible

Note 1 to entry: For gas-phase, this should be calculated as soon as a steady reading can be obtained.

3.27
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

3.28
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.

3.29
ppm(v)
parts per million by volume
concentration measure normally used to record pollution levels in, for example, work place safety

Note 1 to entry: Units are cm^3/m^3 and ml/m^3.

3.30
penetration
P
ratio of contaminant concentration downstream of the filter to the upstream (challenge) concentration, sometimes expressed as a percentage

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

[Source: ISO 29464:2011; 3.2.51]

3.31
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)

[Source: ISO 29464:2011; 3.2.52]

3.32
pore
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]

3.33
pressure drop
Δp
difference in pressure between two points in an airflow system at specified conditions, especially when measured across a GPACD

3.34
removal efficiency
E
fraction or percentage of a challenge contaminant that is removed by a GPACD at a given time

3.35
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]

3.36
residence time
t_r
relative time that an increment of fluid (or contaminant) is within the boundaries of the media volume (e.g. 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 [$t_R = V$ (total bed volume) $/Q$ (air flow rate)].

[Source: ISO 29464:2011; 3.2.71]

3.37
rise time
t_{Rn}
time between initial injection of contaminant and reaching 95 % of the challenge concentration for an empty duct ($t_0 - t_{V0}$) measured at the downstream sampling location for a specific test (n), challenge gas and gas flow

3.38
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 compound present in the air stream e.g. gases and vapours.

3.39
sorption
process in which fluid molecules (gas or liquid) are removed by a GPACD media by absorption or adsorption

3.40
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_U	upstream concentration [ppb, ppm] measured at a position *X* mm before the device
C_D	downstream concentration [ppb, ppm] measured at a position *Y* mm after the device
Δp	pressure drop measured over the tested device [Pa]
E_I	initial removal efficiency [%] for the device measured at a low (< 1 ppm) challenge concentration during the initial efficiency test in 6.3
E_C	removal efficiency [%] for the device measured at the challenge concentration selected during the capacity test in 6.4
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 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_{sEI}	the integrated amount in moles or grams of challenge compound accumulated during the initial efficiency test in Formula (2)
m_{sU}	the integrated amount in moles or gram of challenge compound accumulated during measurement at the upstream position in Formula (3)
m_{sD}	the integrated amount in moles or grams of challenge compound accumulated during measurement at the downstream position in Formula (3)
m_s	the total integrated amount [g], [mol] of challenge compound accumulated during the whole challenge test
p_U	upstream pressure [Pa] measured at a position *X* mm before the device
p_D	downstream pressure [Pa] measured at a position *Y* mm after the device
Q	flow used in test (normally the rated flow for the tested device) [m^3/h] measured at a position *Z* mm after the device
RH_U	upstream relative humidity [%] measured at a position *X* mm before the device
RH_D	downstream relative humidity [%] measured at a position *Y* mm after the device
t_0	start time. The time when C_U (contamination concentration upstream) equals the selected challenge concentration for an empty duct
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_{DC} decay time for challenge concentration

t_{DE} decay time for initial efficiency concentration

t_{RC} rise time for challenge concentration

t_{RE} rise time for initial efficiency concentration

t_{VC} time noted at challenge gas valve closure

t_{VO} time noted at challenge gas valve opening

T_U upstream temperature [°C] measured at a position *X* mm before the device

T_D downstream temperature [°C] measured at a position *Y* mm after the device

v_f face velocity [m/s] calculated from flow and cross sectional area of device

X a position *X* positioned sufficiently far ahead of the device to allow undisturbed measurements, determined in the validation, Annex A. At the distance *X*, the concentration of challenge compound is sufficiently mixed and uniform over the cross sectional area of the duct while not being so close to the device that the device itself obscures the flow, pressure drop or concentration.

Y a position *Y* positioned sufficiently far after the device to allow undisturbed measurements, determined in the validation section, Annex A. At the distance *Y* the concentration of penetrating challenge compound is sufficiently mixed and uniform to represent the average of the device and not being so close to the device that the device itself obscures the flow, pressure drop or concentration.

Z a position *Z* positioned sufficiently far after the device to permit a reliable flow measurement using an orifice device, determined in the validation, Annex A

4.2 Abbreviated terms

ASHRAE American Society of Heating Refrigerating and Air-conditioning Engineers

ASTM ASTM International, formerly known as the American Society for Testing and Materials (ASTM)

HEPA High Efficiency Particulate Air (filter)

JIS Japanese Industrial Standards

JSA Japanese Standards Association

MSDS Material Safety Data Sheet

NMP n-Methyl –2-pyrrolidone

TLV threshold limit value. Amount of a chemical substance is a level to which it is believed a worker can be exposed day after day for a working lifetime without adverse health effects.

VOC Volatile Organic Compound