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Air quality — Test method for filtration characterization of cleanable filter media

Qualité de l'air — Méthode d'essai pour la caractérisation de la filtration des filtres lavables

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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 11057 was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 1, *Stationary source emissions*.

Introduction

Cleanable filters are usually employed for the separation of particles from gases containing dust concentrations in the range of some hundred milligrams per cubic metre up to some hundred grams per cubic metre. Depending on the inlet dust concentrations concerned, a dust cake is more or less rapidly formed upon the surface of the filter medium which is periodically removed in order to maintain the filtration process. With most filters in use at the time of publication, this is usually accomplished by injecting a pulse of compressed air from the clean-gas side, i.e. inside the filter bag or cartridge. The design service life of these filters is usually 2 years to 4 years. They provide clean-gas concentrations of some milligrams per cubic metre without an excessive rise in residual pressure drop for the cleaned filter and a low cleaning frequency, respectively.

Although extensive investigations have been carried out concerning the operating conditions and design of filters and cleaning systems as well as the design and selection of the filter media (References [14] to [17]), the layout and operation of bag filters are still extensively based on data which were empirically obtained in industrial-sized installations or pilot plants.

The systematic characterization and evaluation of filter media with respect to their relevant long-term operational properties (filtration and cleaning behaviour) and emission, in addition to their well-defined textile properties, are still a major problem not only for the developers and manufacturers of filter media, but also for the producers and users of filter installations.

Therefore there is a demand for improved methods for the characterization and evaluation of cleanable filter media. This demand concerns data allowing statements about the filtration properties of a medium in long-term operation, which exceed the data supplied by filter media manufacturers about the non-dusted material.

This International Standard is based on VDI 3926 Part 1:2004[13], ASTM D6830-02:2008[8], JIS Z 8909-1:2005[10], and GB/T 6719:2009[9].

Air quality — Test method for filtration characterization of cleanable filter media

1 Scope

This International Standard specifies a standard reference test method for the comparative characterization of pulse-jet cleanable filter media, to be used in filter elements (e.g. bag filters, pocket filters, cartridge filters) applied in dry gas cleaning under standardized test conditions. The main purpose of testing is to gain information about both the operational performance and the particle emission of cleanable filter media.

It should be noted that while one test apparatus and operating method has been chosen and described herein, it is recognized that other apparatus and operating arrangements can be found acceptable. In order for a candidate apparatus to become an equivalent apparatus, a comparison has to be performed with the standard reference apparatus according to a specified procedure (6.1). The test procedure, the characteristics of the required test facility, and the test conditions, as well as the evaluation and presentation of the results, are specified.

The results obtained from this test method are not intended for prediction of the absolute performance of full-scale filter facilities. However, they are helpful for the selection and development of appropriate cleanable filter media and the identification of suitable operating parameters.

Additional tasks such as verifying filter media concerning $PM_{2,5}$ emissions, the classification of different media according to their filtration performance or the cleanability and durability of filter elements (i.e. projection of bag lifetime) can be addressed using the test method specified.

2 Terms and definitions

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

2.1
aerosol
suspension in a gaseous medium of solid particles, liquid particles or solid and liquid particles having a negligible falling velocity

[ISO 4225:1994[2], 3.2]

2.2
ageing
⟨air quality⟩ process applied to a filter medium to simulate long-term filter operation

NOTE Examples of changes in process behaviour are pressure drop and cycle time.

2.3
filter face velocity
flow rate (under operating conditions) of gas through the exposed filter area divided by that area

NOTE 1 Other frequently used terms are: air-to-cloth ratio and gas-to-cloth ratio.

NOTE 2 Filter face velocity is often expressed in cubic metres per square metre hour, i.e. metres per hour. Alternative units are metres per minute or feet per minute (deprecated).

2.4
calibration
⟨air filtration characterization⟩ comparison of a measuring device (e.g. an optical particle counter) with another instrument for reference measurements using, for example, a reference test aerosol with the objective of an exact determination of an experimental parameter

2.5
clean gas
gas flow exiting the filter

2.6
cleanable filter medium
filter medium whose aerodynamic and particle collection characteristics are regeneratable or recoverable

2.7 Particle concentration

2.7.1
particle number concentration
⟨air filtration characterization⟩ total number of particles per carrier gas volume

NOTE Particle number concentration is expressed in particle numbers per cubic metre or reciprocal cubic metres.

2.7.2
particle mass concentration
total mass of particles per carrier gas volume

NOTE Particle number concentration is expressed in grams per cubic metre.

2.8
cycle time
⟨air quality⟩ time between two cleaning pulses under defined operational conditions

2.9
detection limit of the clean gas concentration
⟨air filtration characterization⟩ minimum concentration in the clean gas which can be unambiguously determined by the described gravimetric method

2.10
dirty gas
dust-loaded gas which is fed into the inlet side of the filter

2.11
dispersion air
gas flow necessary for the dispersion of test dust, i.e. for the transformation of test dust into an aerosol

NOTE Dispersion air needs to be dry, oil-free, and at constant temperature and gas flow rate.

2.12
dust collection efficiency
mass of particulate material collected by the filter divided by the mass of inlet particulate material

2.13
equivalent particle diameter
⟨air filtration characterization⟩ particle size obtained on the basis of a specific method of measurement, and expressed in terms of the diameter of an "equivalent" sphere for that respective method

NOTE 1 Examples of specific measurements are: projected area, surface area, volume, mass, settling velocity or relaxation time, electrical mobility, scattered light intensity, and diffusion rate.

NOTE 2 It is in the nature of this definition that different measurement methods can produce equivalent diameters which do not necessarily coincide. Some of the relevant equivalent diameters are defined in 2.14 to 2.16.

2.14
aerodynamic diameter
⟨air filtration characterization⟩ measure of size for a particle of non-defined shape and density defined on the basis of settling velocity or inertial behaviour (both lead to the same equivalent diameter), which is also relevant for the separation behaviour of particles by inertial effects

NOTE 1 The aerodynamic diameter is based on an equivalent sphere of density $\rho = 1\,000$ kg/m^3.

NOTE 2 Typical measuring methods employ impactors or particle classifiers.

2.15
equivalent light-scattering particle diameter
measure of size for a particle of non-defined shape obtained on the basis of the scattered light signal detected by an optical particle counter, reflecting the diameter of an equivalent sphere of the aerosol (usually latex particles) used for the calibration of the measuring device

2.16
volume equivalent particle diameter
diameter of a sphere of the same volume as the unknown particle

2.17
exposed filter area
cross-sectional area of a filter medium which is directly exposed to the gas flow during the test

2.18
feed rate stability
measure of the degree of deviation of mass flow rate of the solid from the nominal value

NOTE The value obtained for the feed rate stability depends on the duration of the measurement, which itself can vary substantially from case to case (short or long time feeding).

2.19
filter face
upstream side of the filter medium where the dust is deposited during operation

2.20
filter medium
material separating particulate material from gases characterized by its separating structure and its structural and/or textile-technological characteristics

2.21
filtration characterization
⟨air filtration characterization⟩ determination of certain aerodynamic behaviour of a filter medium as it collects and rejects particulate material from a moving gas stream by measuring parameters, including pressure drop characteristic, development of residual pressure drop, cycle time, residual dust loading, and dust emission

2.22
nominal gas flow rate
⟨air quality⟩ flow rate determined (for the most part by the manufacturer) for a filter medium to be tested

2.23
operating gas flow rate
flow rate existing at the current operating conditions relating to temperature, pressure, humidity, gaseous composition or dust concentration

2.24
standard gas flow rate
flow rate under standard conditions, i.e. standard temperature, $T_n = 273{,}15$ K (0 °C) and standard pressure, $p_n = 1\,013{,}25$ hPa

NOTE Additional specifications, e.g. for the humidity of the gases, are indicated separately.

2.25
mixing section
part of the test apparatus (often the dirty-gas duct), which ensures that, over the duration of the test, concentration and dispersion of the test dust in the gas stream (i.e. the test aerosol) remain constant and homogeneous when arriving at the test filter

NOTE The particle size distribution and concentration can vary due to changes in the dust properties or in the device parameters of the dust generator and this can affect the uniformity of the dust distribution on the filter surface.

2.26
particle
⟨air filtration characterization⟩ small contiguous object in the solid or liquid state of aggregation that can be transported in the gas flow as a single unit

NOTE Since in practice particles very often present an irregular shape, it is difficult to assign simple geometric dimensions to them. This problem can be bypassed by specifying an equivalent diameter for a particle.

2.27
particle separator
dust collector
⟨air filtration characterization⟩ device for the removal of particles from a gaseous medium

2.28
particle size distribution
⟨air quality⟩ correlation between the quantity of the size fractions and particle size

NOTE 1 Distributions are not characterized adequately by only specifying the parameters characterizing the position of the distribution, such as median, mode or the mass median aerodynamic diameter. In addition, at least a specification relative to the width of distribution is required for which the standard deviation of pairs of variables, such as the minimum, x_{min}, and the maximum, x_{max}, particle diameters or better (since they allow a more precise measurement) $x_{0,05}$ and $x_{0,95}$, could be of use.

NOTE 2 Furthermore, for the unambiguous evaluation of a distribution, the type of measured quantity needs to be exactly defined. Also, the equivalent diameter, the measuring method and the test apparatus are to be specified. It is for instance not sufficient to state “optical particle counter with 90° detection”. In this case, the nature of the light source (laser or white light) and details of the shape of the measuring volume in the aerosol flow are missing.

2.29
optical particle counter
OPC
optical particle size measuring device with a fine classification according to sizes

2.30
photometer
⟨air quality⟩ optical measuring device for the monitoring and the recording of relative fluctuations of particle concentration and size distribution in the aerosol on the basis of multiple particle light extinction

NOTE The use of a photometer for recording variations of the concentration implies a constant particle size distribution.

2.31
pressure drop
difference of the static pressures at the entrance and the exit of a delimited system exposed to a gas flow, in this case the filter medium

NOTE This pressure difference has to be maintained in order to convey a certain amount of flowing medium through the system during steady state operation.

2.32
residual pressure drop
stable difference of the static pressures across the filter medium, determined shortly after its (pulse-jet) cleaning

NOTE Since an online pulse-jet cleaning is a dynamic procedure, the time period between the cleaning by pressure pulse and the reading of the residual pressure drop needs to be defined (e.g. 4 s). This can be done by comparing the pressure drop immediately after the pulse-jet cleaning with the pressure drop that is reached when the dust supply is disconnected.

2.33
repeatability conditions
observation conditions where measurement results are obtained with the same method on identical filter media in the same test apparatus by the same operator using the same equipment within short intervals of time

NOTE 1 Adapted from ISO 3534-2:2006[1], 3.3.6.

NOTE 2 Conditions of measurement include the same measurement procedure, same operators, same measuring system, same operating conditions and same location, and replicate measurements on the same objects over a short period of time.

NOTE 3 The spread is determined from several repeated individual measurements: the smaller the spread, the greater the repeatability.

2.34
reproducibility conditions
observation conditions where measurement results are obtained with the same method on identical filter media in different test apparatus with different operators using different equipment

NOTE 1 Adapted from ISO 3534-2:2006[1], 3.3.11.

NOTE 2 Conditions of measurement include different locations, operators, measuring systems, and replicate measurements on the same or similar objects.

NOTE 3 The reproducibility of a filter testing method, for example, can only be determined by a round robin test.

2.35
residual dust
particulate matter remaining on or in the filter medium after cleaning

2.36
test dust
⟨air quality⟩ particulate matter with defined physical and chemical properties and particle size distribution

2.37
weighing accuracy
d
specification for the balance supplied by the manufacturer relating to a certain measurement range.

EXAMPLE An analytical balance whose $d = 0{,}01$ mg at a maximum range of 60 g. The weighing accuracy is normally an integer multiplied by the detection limit of the instrument.

3 Gases and materials

3.1 Compressed air. The compressed air used by the dust feeder shall be dry and oil-free. It is suggested to use a refrigerant compressed air dryer providing a constant water vapour dew point of 3 °C at 0,6 MPa.

3.2 Filter material for compressed air. The dehumidified compressed air should additionally be cleaned, using a 2-stage filter, comprising a prefilter with pore size of 0,3 µm and a fine filter of 0,01 µm.

3.3 Test dust. Pural NF[1)] consists of boehmite, an aluminium-oxide-hydroxide [γ-AlO(OH)] mineral. The mass mean particle size, $x_{50,3}$, is about 4,5 µm (further specifications by the manufacturer are $x_{10,3}$ = 1,2 µm, $x_{90,3}$ range, 15 µm to 20 µm, measurement by light diffraction spectrometry in aqueous suspension after 2 min ultrasonic treatment). The manufacturer has specified this special fraction of the Pural product as being suitable for testing filters, but does not guarantee the specifications on the particle size for each batch; they are subject to variations in production and thus are nominal values. For each production batch they have to be verified anew and selected especially for filter testing. Comparative tests shall always be done with the same reference batch.

3.4 Filter medium for gravimetric clean gas measurements. Glass fibre filters should be used as absolute filters to measure the particle mass content in the clean gas. They shall offer a separation efficiency of at least 99,95 % (e.g. according to EN 1822-1[6], H13: 99,95 % or equivalent).

4 Principle

When selecting an appropriate test method, practicability and flexibility of the filter tests were taken into account. At the same time, the execution of the test should not be too time consuming and should be easy to handle. The experience over many years with existing filter testing methods referred to herein shows that the results provide useful performance information about the comparability of different filter media under prescribed standard conditions indicating the operating and separation behaviour of various filter media during practical use (see Figure 1, References [3][4][12][18] to [23]).

The test method for filter media to be used in cleanable filters (e.g. bag filters, pocket filters, cartridge filters) was developed with the application of these filter types in mind. It was designed so that the local filtration and cleaning conditions of a filter element are simulated as exactly as possible, in accordance with knowledge at the time of publication. The loading of the filter sample with the test dust is executed in a constant and reproducible manner. The test is performed on flat, round samples of the test filter media in a laboratory filter test apparatus.

During the test, the filter sample is exposed to a constant gas flow and a constant dust concentration. When the predetermined maximum pressure drop is reached, a cleaning pulse is activated to remove the dust cake towards the dirty-gas (upstream) side. The cleaning pulse shall be a well-defined and reproducible pressure pulse leading to a uniform pressurization across the exposed filter sample area.

The test filter media are compared and assessed on the basis of the development of so-called characteristic filtration data, which are the shape of pressure drop curves, the development of residual pressure drop, filtration/cleaning cycle time, residual dust cake mass, and dust penetration through the test sample. Test conditions and materials (e.g. test dust) for this method are specified exactly in this International Standard.

5 Standard reference apparatus and procedure

5.1 General

The standard reference apparatus and the standard test procedure are chosen to ensure good reproducibility and repeatability of the test. Figure 1 shows a schematic design of the standard reference apparatus.

1) Pural NF is the trade name of a product supplied by Sasol. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.