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In situ test methods for high efficiency filter systems in industrial facilities

Méthodes d'essai in situ pour les systèmes filtrants à très haute efficacité dans les installations industrielles

Reference number
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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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

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

This corrected version of ISO 16170:2016 incorporates the following corrections.

All figures have been replaced with higher quality diagrams.

In C.3.2 the key and cross-references within the text to Figure C.3 have been corrected.

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Introduction

Methods for measuring the performance of high efficiency gas cleaning devices are described in a number of existing standards. These specify procedures for quality assurance following manufacture (e.g. ISO 29463 and EN 1822).

Some other standards specify the filter medium used in such devices, how they are constructed and how they are installed within industrial facilities.

Installations of high efficiency particulate filters are extensively used within nuclear and toxic material processing plants and laboratories to confine these materials within the facility and prevent their discharge to the environment.

Radioactive and other toxic materials are confined within processing facilities inside containment zones bordered by barriers. Air and gases vented from these zones are decontaminated by passage through a series of highly efficient particulate filters before final discharge to the environment. The membrane (filter medium) of the filters acts as part of the containment barrier. In view of its perceived fragility, confirmation of its integrity is required on a periodic basis because operational safety cases depend on the knowledge that the effectiveness of these filters is maintained at all times. These periodic checks are made by the procedure(s) known as "in-situ" or "in-place" testing.

The basic principles of *in situ* tests on installed filters are the same as for laboratory tests, such as those described in EN 1822 and ISO 29463, insofar as known quantities of a challenge aerosol are dispersed into the airstream upstream of the filter installation; the particulate contents of the unfiltered and filtered air are sampled and analysed to determine whether the integrity of the filters has been compromised.

In the case of testing a single unit (manufacturer's production test or in the case of a laboratory testing on a single filter unit), the purpose is to confirm that the unit performance [efficiency/penetration at Most Penetrating Particle Size (MPPS) and other parameters] lies within specified limits, and further, that the results are globally reproducible. To achieve this requires the use of a laboratory test rig setup with full dispersion of a challenge aerosol, prescribed geometry of the test rig, and to obtain and analyse fully representative particulate samples both upstream and downstream of the test filter. Some ventilation systems are highly complex and it should be noted that many facilities use ventilation systems in which a high percentage of the air is recirculated.

The purpose of an *in situ* test is to detect any adverse change in the filtration performance of the installation and to compare it with the expected efficiency or decontamination factor. Such a change might be caused by deterioration of a unit or units or a faulty sealing system and would be manifested by the appearance of a proportion of unfiltered aerosol in the effluent airstream. Testing methodologies developed in this International Standard do not cover the other requirements that relate to filters in terms of mechanical resistance, burst strength or temperature and moisture resistance.

It is neither fully necessary nor useful for the results of an *in situ* test to replicate the results of production tests on the individual filters in the installation, nor is it necessary to confine the test aerosol size distribution to one which replicates that used in production tests.

No International Standard for general *in situ* testing of high efficiency filters has been produced before, explaining the needs for such an International Standard.

This International Standard describes the requirements for test equipment, data interpretation and reporting for the *in situ* testing of HEPA and ULPA air cleaning installations designed for the removal of airborne particulate contamination in high-integrity ventilation systems.

This International Standard includes specification of the test interval, aerosol type, aerosol mixing and measurement methods, i.e. the following:

— aerosol: solid or liquid, monodisperse or polydisperse;

— mixing: degree of mixing, mixing lengths, etc.;

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— method: injection, detection.

This International Standard proposes an outline testing philosophy to highlight the following:

— principle of the method;

— prerequisites;

— preparatory conditions;

— injected aerosol properties;

— qualification and selection of measuring devices;

— qualification of test personnel;

— test setup;

— test sequence;

— evaluation and reporting.

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In situ test methods for high efficiency filter systems in industrial facilities

1 Scope

This International Standard specifies *in situ* test methods for high efficiency particulate air filters used to limit releases towards the environment (e.g. from nuclear facilities or facilities with aerosol toxic or biological releases). This applies where installations of these filters are used to clean effluent air before discharge to the environment from industrial (including nuclear) installations where toxic/radioactive/biological materials are handled or processed.

This International Standard excludes the application already covered by ISO 14644-3.

The scope of this International Standard includes detail of two methods, either of which applies to the periodic testing of high efficiency filters which are used in demanding applications aiming at protecting the environment, such as the nuclear industry.

In the case of nuclear applications, this International Standard is applicable to installations covered by ISO 17873 (applications other than nuclear reactors) and ISO 26802 (nuclear reactors).

The two reference methods specified in this International Standard are not equivalent, but related to, the requirements to be addressed by the test results. The choice of which of the two methods is adopted in any specific case depends on whether the outcome requires an integrity test or a statutory efficiency accountancy test.

For industries handling or processing radioactive or toxic materials giving rise to a risk of possible release, the main goal of the tests is to confirm that the filter installation is fit for purpose. In the case of integrity tests (Annex B), this is to confirm that no significant leakage of toxic aerosols through the filter installation is possible.

In the case of efficiency accountancy tests (Annex C), the test is designed to make an accurate measurement of decontamination factor with respect to the MPPS size range of particles.

The reference method described in Annex B (integrity test) requires a test aerosol of dispersed oil particles mainly submicrometre in size range, which is stable during the test procedure and compatible with other installation components. Particle concentrations are measured in real time by light scattering instrumentation (optical detectors).

The reference method described in Annex C (efficiency accountancy test) requires a test aerosol of particles having a narrow size range centred on MPPS size range for HEPA filter media. Their concentration both upstream and downstream the filters is measured by fluorimetric analysis of aqueous solution obtained by washing the membrane sampling filters.

It should be noted that the requirements for an efficiency accountancy test also cover the requirements of an integrity test, which is considered to be a minimum requirement.

Test methods developed in this International Standard do not cover the other *in situ* performance requirements, such as mechanical resistance, bursting resistance or humidity resistance. Specific systems operating at high temperature or with specific gaseous effluents might require specific test methods.

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The engineering design of HEPA and ULPA filter installations does not fall within the scope of this International Standard.

NOTE In the field of filters for general ventilation applications, ISO 29462 is a detailed and comprehensive description of a method which uses scanning and particle counting methods to evaluate the performance of a filter in terms of particle grade efficiency, as well as pressure drop. Such a method and procedure would not be applicable in those nuclear installations where quantification of the decontamination factor at MPPS size is needed.

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 29463-1, *High-efficiency filters and filter media for removing particles in air — Part 1: Classification, performance testing and marking*

ISO 14644-3:2005, *Cleanrooms and associated controlled environments — Part 3: Test methods*

ISO 17873, *Nuclear facilities — Criteria for the design and operation of ventilation systems for nuclear installations other than nuclear reactors*

ISO 26802, *Nuclear facilities — Criteria for the design and the operation of containment and ventilation systems for nuclear reactors*

ISO 2889, *Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities*

3 Terms and definitions

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

3.1
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 $x \leq 0{,}1$ µm, the fine range 0,1 µm < x ≤ 1 µm, and the coarse range $x > 1$ µm, where x is the particle diameter.

[SOURCE: ISO 29464:2011, 3.1.1]

3.1.1
monodisperse aerosol
aerosol (3.1), the width of whose distribution function, described by the geometric standard deviation σ_g, is less than 1,15 µm

[SOURCE: ISO 29464:2011, 3.1.2]

3.1.2
polydisperse aerosol
aerosol (3.1), the width of whose distribution function, described by the geometric standard deviation σ_g, exceeds 1,5 µm

[SOURCE: ISO 29464:2011, 3.1.3]

3.1.3
quasi-monodisperse aerosol
aerosol (3.1), the width of whose distribution function, described by the geometric standard deviation σ_g, is between 1,15 µm and 1,5 µm

[SOURCE: ISO 29464:2011, 3.1.4]

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3.1.4
test aerosol
aerosol (3.1) used for determining filter efficiency

3.2
decontamination factor
ratio between the concentration or particles number upstream the filter and the concentration or particles number contamination downstream the filter

Note 1 to entry: This ratio is also defined by 1/(1- *overall efficiency* (3.13)).

3.3
effective filter media area
area of the media contained in the filter (without adhesive spaces or ligament) and passed by air during operation

[SOURCE: ISO 29464:2011, 3.1.11]

3.4
efficiency
E
fraction of contaminant entering the filter which is retained

[SOURCE: ISO 29464:2011, 3.1.55]

3.5
efficiency accountancy test
in-situ test procedure meeting a requirement for an accurate system *overall efficiency* (3.13) determination at *MPPS* (3.11)

3.6
integrity test
in-situ test procedure meeting the requirement for confirming the absence of unfiltered leakage of the system

3.7
filter element
filtering material in a preformed shape being a part of a complete filter

[SOURCE: ISO 29464:2011, 3.1.67]

3.8
filter face area
frontal face area of the filter including the header frame

[SOURCE: ISO 29464:2011, 3.1.83]

3.9
HEPA filter
filter with performance complying with requirements of filter class ISO 35 – ISO 45 as per ISO 29463-1

[SOURCE: ISO 29464:2011, 3.1.88]

3.10
filter medium
material used for filtering

[SOURCE: ISO 29464:2011, 3.1.90]

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3.11
most penetrating particle size
MPPS
particle size at which the minimum of the *particle size efficiency* (3.14) curve occurs under test conditions

Note 1 to entry: This MPPS is media and ventilation conditions dependent. This MPPS is in the 0,1 µm to 0,2 µm medium aerodynamic size range for fibreglass type filters commonly used in nuclear applications.

[SOURCE: ISO 29464:2011, 3.1.129]

3.12
user nominal air volume flow rate
$q_{v,nom}$
air volume flow rate specified by the user, at which the *filter element* (3.7) is tested *in situ*

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

3.13
overall efficiency
efficiency averaged over the whole *superficial face area* (3.15) of a *filter element* (3.7) under given operating conditions of the filter

Note 1 to entry: It is expressed in percentage (%).

3.14
particle size efficiency
efficiency for a specific particle diameter

Note 1 to entry: The efficiency plotted as a function of the particle diameter gives the fractional efficiency curve.

Note 2 to entry: It is expressed in percentage (%).

3.15
superficial face area
cross-sectional area of the *filter element* (3.7) through which the air flow passes

3.16
ULPA filter
filters with performance complying with requirements of filter class ISO 55 – ISO 75 as per ISO 29463-1

[SOURCE: ISO 29464:2011, 3.1.100]

3.17
user nominal filter medium face velocity
nominal air volume flow rate divided by the effective *filter medium* (3.10) area

4 Principle of the method

For industries handling radioactive and/or toxic materials, the main goals of the tests are the following.

a) For efficiency accountancy tests: to confirm that the overall filtration efficiency, in particular the decontamination factor for the MPPS size range and other performance parameters, remain within the operating envelope criteria authorized in the site operating licence.

b) For integrity tests: to detect any significant leakages of airborne particles bypassing the filter media.

The test procedure follows the following sequence:

— measure the main ventilation parameters (e.g. flow rates, pressure drops, temperature and humidity) of the system under test;

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