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Requirements for aerosol filters used in nuclear facilities against specified severe conditions —

Part 1: General requirements

Exigences pour les filtres à aérosols utilisés dans les installations nucléaires dans des conditions sévères spécifiées —

Partie 1: Exigences générales

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

A list of all parts in the ISO 23137 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

In the nuclear industry, as well as in many other applications using radioactive materials, some dangerous products are used/handled/stored/produced. The radioactive particles can be in aerosol form which implies the need for aerosol filters on the ventilation systems used at the exhaust of the facilities in order to protect workers, the members of the public and the environment against the risks of spread of radioactive materials.

These aerosol filters are used in normal operation for process filtration systems (e.g. for glove boxes, hoods, fume cupboards…), or on buildings ventilation systems. These aerosol filters are also used to cope with accidents conditions, creating severe specified conditions on the filters.

Some standards exist on the requirements to be associated with the filters used on these ventilation or process systems (e.g. ISO 17873,[1] ISO 26802[2]). These standards propose some specifications related to the need for high efficiency particulate air (HEPA) filters, their classification, the number of HEPA filters in series and on their monitoring.

Many nuclear operators have their own process for qualified filters with regards to those specified severe conditions. But no standard exists on the requirements associated with the conditions in which the filters are used against specific loads (e.g. high radioactive environment, fire conditions).

In the ISO 23137 series, ISO 23137-1 provides only the general requirements (e.g. types of filters to be tested, standardised sizes, principles for the qualification of the tests against loads such as repetition of tests, need for filter certificates, etc.). Other parts of the ISO 23137 series are intended to specify the expected performances, the detailed requirements, with regards to the loads for which the filters need to be qualified.

The loads against which the filters will have to be designed/fabricated/tested/certified, are reported in Annex A for information. This document covers the fundamental qualification requirements for HEPA filters for use in nuclear/radiological facilities while the other parts are intended to cover specific hazards in more detail.

In each part of the ISO 23137 series, specific detailed loads applicable to the HEPA filters are intended to be described, every part being related to a different type of loads. Every part will intend to present how the expected performances against these specific loads are, in order to specify how they will have to be designed, fabricated, tested and verified according to the technical specifications. Examples of loads that are intended to be specified in the series are presented in Annex A, such as:

— thermal loads (heated air flow, spot flame resistance) or pressure load (resistance to pressure, dust loading, water spray, air flow increase);

— radiation and radioactive contamination deposits;

— chemical loads;

— vibration/seismic/rough handling loads;

— combined loads (e.g. in a fire thermal loads are combined with dust loading and humidity).

These other parts of the series are intended to refer to this document for the general requirements (e.g. qualification requirements for filter being verified against technical specifications).

The specificities of process ventilation system protecting the workers inside the facilities are intended to be specified by another part of the ISO 23137 series.

Requirements for aerosol filters used in nuclear facilities against specified severe conditions —

Part 1:
General requirements

1 Scope

This document provides the general requirements associated with the specific characteristics of high efficiency particulate air (HEPA) filters used in nuclear facilities.

This document provides the manufacturer with general requirements for the performance, design, construction, acceptance testing and quality assurance for HEPA filters used in nuclear facilities (for qualification and production tests).

All types of HEPA filter used in such applications are covered, from the large size HEPA filters in exhaust HVAC systems to small size low flow rate cylindrical HEPA filters for glove boxes.

The design, fabrication, inspection and testing, certificates with regards to their expected performances are mentioned.

This document does not provide the specific conditions against which the nuclear filters are designed, tested and qualified.

This document applies only to the filters used for nuclear heating ventilation air conditioning (HVAC) or control rooms habitability applications or applications related to the exposure to radioactive ionizing radiations (e.g. medical or radioactive aerosols applications) in the severe conditions (e.g. fire, high radioactive challenge).

Filter housing qualification is not part of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 29463-1:2017, *High efficiency filters and filter media for removing particles from air — Part 1: Classification, performance, testing and marking*

ISO 29463-5:2022, *High-efficiency filters and filter media for removing particles in air — Part 5: Test method for filter elements*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp/ui

— IEC Electropedia: available at https://www.electropedia.org/

3.1
load
forces caused by any physical or chemical hazard

EXAMPLE Pressure, thermal, radiation, vibration, ground motion, humidity, clogging, chemical hazards as well as cumulated loads such those involved in hazards such as natural or accelerated ageing.

Note 1 to entry: In nuclear facilities or in facilities handling radioactive aerosols, the confinement function of radioactive materials is a nuclear safety function, creating confined spaces modifying the loads that can challenge filters compared to the ones that occur in open (not confined) spaces.

3.2
loss of coolant accident
LOCA
accident scenario in nuclear facilities induced by a pipe break leading to lose the radioactive hot pressurised coolant, and adding pressure, steam and thermal loads in the rooms served by the ventilation systems equipped with HEPA filters

Note 1 to entry: In some nuclear reactor designs (for which the rooms are in a static confinement mode), the LOCA would not affect directly the HEPA filters in operational conditions (except shutdown states for which the LOCA directly expose the HEPA filters). But, in some others, the rooms where a LOCA can occur are permanently served by a confinement system, exposing the HEPA filters to LOCA loads.

3.3
high energy line break
HELB
accident scenarios in nuclear facilities induced by a high-pressure pipe whipping onto another pipe

Note 1 to entry: When charged with hot pressurised fluids, it can lead to lose the radioactive hot pressurised coolant from the first pipe and to the discharge into the rooms of the fluid contained in the target pipe, and to pressure, steam and thermal loads in the rooms served by the ventilation systems equipped with HEPA filters.

3.4
most penetrating particle size
MPPS
particle size 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 and the test applications conditions.

[SOURCE: ISO 29464:2017, 3.2.136]

3.5
most penetrating particle size range
MPPS range
particle size range covering the most penetrating particle size of the filter

Note 1 to entry: Dispersed oil particulates (not to be confused with dioctyl phthalate) of 0,3 µm mass median cover the MPPS range for HEPA filters.

4 General requirements

4.1 General design requirements of the filters

4.1.1 Layout requirements

The filter element shall be designed or marked so as to prevent incorrect mounting (e.g. upside down).

The filter element shall be designed so that when correctly mounted in the ventilation housing, the leak that would occur along the sealing edge does not challenge its performances.

If, for any reason, dimensions do not allow testing of a filter under standard test conditions, assembly in parallel of two or more filters of the same type or model at the testable dimensions is permitted (as a global resulting filter), provided it does not modify the leak that would occur in the resulting filter.

Annex B provides examples of general sizes and layout of filters used in nuclear ventilation systems.

4.1.2 Materials

The filter is comprised of the filter medium, separators, adhesive, faceguards and seals. The filter shall be made of suitable material to withstand normal and severe usage and exposures to the loads that are likely to be encountered (e.g. temperatures, humidity, chemical, radioactive and corrosive environments). The filter element shall be designed so that it will withstand mechanical constraints that are likely to be encountered during normal and severe use.

Dust or fibres released from the filter media by the air flow through the filter element shall not constitute a nuisance for the people (or devices) potentially exposed to filtered air (e.g. when the air is recycled).

The fire and temperature resistance of the materials depends on the customer requirements with regards to hot temperatures and fire risk in the nuclear facility. When fire and hot temperature risks are a nuclear safety issue for a specific filter, the filter element shall have capabilities to limit its flammability or when a flame is no longer present, the filter shall not continue its combustion.

NOTE Even though the filter medium is made with non-flammable materials, the dust loaded on the filter can still be flammable.

The filter, including its casing, should be able to be compacted such as to minimize radioactive waste volumes. When fire and hot temperature risks are not a nuclear safety issue for a specific filter, consideration should be given to use materials which allows incineration for disposal.

The filter materials and its casing materials submitted to a corrosive atmosphere should be chosen or treated to avoid corrosion.

Potential leaks from the interfacing parts between the filter and the filter housing shall not modify the filter global efficiency or the different qualifying loads.

The filter and its casing envelope materials should be selected such as to minimize their activation (where neutron activation is possible on the filter materials) and to allow their processing or disposal in a radioactive waste facility.

4.1.3 Nominal air volume flow rate

The filter element shall be tested at its nominal air volume flow rate for which the filter has been designed by the manufacturer.

4.1.4 Pressure difference

The pressure difference across the filter element is recorded at the nominal air volume flow rate. Maximum resistance to clogging shall be defined as well as the ultimate burst structural strength as ratio functions of their nominal pressure difference obtained when the filter is new.

4.1.5 Filtration performance

The filtration performance is expressed by the efficiency or the penetration as described by the procedures in ISO 29463-1. After testing in accordance with ISO 29463-1:2017, Clause 7, filters used as HEPA filters in nuclear facilities shall have an efficiency that meets or exceeds ISO 35H defined in ISO 29463-1:2017, Table 1.

Depending on national regulations required by nuclear safety authorities, the filtration performances can also be specified according to approved national standards.

NOTE For nuclear aerosols filters used for confinement systems, ISO 26802[2] related to ventilation systems for nuclear reactors and ISO 17873[1] related to ventilation systems for nuclear facilities other than nuclear reactors provide general requirements on filters to be used. The minimal performance is generally set for filter and housing at a minimal efficiency of 99,95 % for overall MPPS values (minimal decontamination factor of 2 000), even though in most safety cases, the minimal decontamination factor at MPPS range is 1 000. The minimal efficiency of 99,95 % corresponds to ISO 35H according to ISO 29463-1.

4.1.6 Filter lifetime

The lifetime of the filter under storage or usage in specified conditions shall be provided by the manufacturer.

Annex E provides general information related to service life or storage conditions of the filters.

Depending on national regulations required by nuclear safety authorities, the filtration service life can also be specified according to approved national standards.

4.2 General qualification principles

HEPA filter designs shall be verified against their technical specifications. Tests shall be performed at a test facility, based on criteria agreed between the manufacturer and the user, when criteria are not available in existing standards.

A qualification sample of filters shall be manufactured using the same methods, materials, equipment, and processes as will be used during production.

Each filter in the qualification sample shall be visually examined for any macroscopic defects that would appear to question the integrity of the filter. The acceptance criterion for the filter pack is no visual indication of damage to the filter media, no tears on the surface edge of the filter pleats, and no tears where the filter pack is embedded in the adhesive at the frame/case. The acceptance criterion for the frame/case and faceguards is no visual indication of dents or deformation. The acceptance criterion for the gel channel and gasket sealing is no visual indication of dents that can interfere with proper sealing. The acceptance criterion for the gasket seal is no visual indication of looseness or tears.

Acceptance shall be contingent on no visual indications of improper assembly, physical damage, structural deformations and no degradation that would impair the ability of a component to perform its intended function.

The qualification samples shall be tested for those requirements specified by the end user as critical to safety for their systems or processes. Failure of any filter to comply with the requirements of 4.2 shall be cause for the rejection of the qualification testing. An appropriate number of samples of a filter showing adequate performances should be provided to allow for testing of the specified loads (generally at least four).

The verification of the compliance shall comprise all the specified loads. After the test, the filter is sent to a qualified test rig where its performances are measured. The level of performances is measured, including its filtration performances, and reported in a sheet certificate.

HEPA filter manufacturers shall provide evidence that qualified HEPA filters meet the test requirements against the qualifying loads. Requalification of the filter series is required every five years in order to continue to specify that the filter is still in compliance with its technical specifications, otherwise it shall be demonstrated that the production process (including materials) does not change. In case there is a same filter technology, it may be possible to qualify only a specific size, but the manufacturer shall provide substantiated evidences that the specific selected size covers all the other sizes.

Generally, the bigger size is the one to qualify. In case a filter that is already certified does not comply with the requirements, the agreed test laboratory shall inform the manufacturer. Before publishing the failed results for a failed filter, the test laboratory shall allow the manufacturer to propose a new filter to test.