INTERNATIONAL STANDARD

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Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities

Échantillonnage des substances radioactives contenues dans l'air dans les conduits et émissaires de rejet des installations nucléaires

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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 2889 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

This second edition cancels and replaces the first edition (ISO 2889:1975), which has been technically revised.

Introduction

This International Standard focuses on monitoring the activity concentrations and activity releases of radioactive substances in air in stacks and ducts. Other situations for monitoring the activity concentrations and activity releases of radioactive substances in air (environmental or workplace monitoring) are being addressed in subsequent standards. This International Standard provides performance-based criteria for the use of air-sampling equipment, including probes, transport lines, sample collectors, sample monitoring instruments and gas flow measuring methods. This International Standard also provides information covering sampling programme objectives, quality assurance, development of air monitoring control action levels, system optimization and system performance verification.

ISO 2889 was first published in 1975 as a guide to sampling airborne radioactive materials in the ducts, stacks, and working environments of installations where work with radioactive materials is conducted. Since then, an improved technical basis has been developed for each of the major sampling specialities. The focus of this International Standard is on the sampling of airborne radioactive materials in ducts and stacks.

The goal of achieving an unbiased, representative sample is best accomplished where samples are extracted from airstreams in which potential airborne contaminants are well mixed in the airstream. This International Standard sets forth performance criteria and recommendations to assist in obtaining valid measurements of the concentration of airborne radioactive materials in ducts or stacks.

Sampling airborne radioactive materials from the stacks and ducts of nuclear facilities

1 Scope

This International Standard sets forth performance-based criteria and recommendations for the design and use of systems for sampling of airborne radioactive materials in the effluent air from the ducts and stacks of nuclear facilities.

The requirements and recommendations of this International Standard are aimed at sampling that is conducted for regulatory compliance and system control. If existing air-sampling systems are not designed to the performance requirements and recommendations of this International Standard, an evaluation of the performance of the system is advised. If deficiencies are discovered, a determination of whether or not a retrofit is needed and practicable is recommended.

It can be impossible to meet the requirements of this International Standard in all conditions with a sampling system designed for normal operations only. Under off-normal conditions, the criteria or recommendations of this International Standard still apply; however, for accident conditions, special or separate accident air sampling systems can be necessary.

2 Normative references

The following referenced documents are indispensable for the application 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 10780:1994, *Stationary source emissions — Measurement of velocity and volume flowrate of gas streams in ducts*

3 Terms and definitions

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

3.1
abatement equipment
apparatus used to reduce contaminant concentration in the airflow exhausted through a stack or duct

3.2
absorbent
material that takes up a constituent through the action of diffusion, allowing the constituent to penetrate into the structure of the absorbent (if a solid) or dissolve in it (if a liquid)

NOTE When a chemical reaction takes place during absorption, the process is called chemisorption.

3.3
accident (conditions)
upset conditions that can lead to the release of abnormal amounts of radionuclides

3.4
accuracy
closeness of agreement between a measured quantity and the true quantity of the measurand

3.5
action level
threshold concentration of an effluent contaminant at which it is necessary to perform an appropriate action

3.6
adsorbent
material, generally a solid, that retains a substance contacting it through short-range molecular forces that bind the adsorbed material at the surface of the material

3.7
aerodynamic diameter
D_a
for a particle of arbitrary shape and density, the diameter of a sphere with density 1 000 kg/m^3 that has the same sedimentation velocity in quiescent air as the arbitrary particle

3.8
aerosol
dispersion of solid or liquid particles in air or other gas

NOTE An aerosol is not only the aerosol particles.

3.9
aerosol, monodisperse
aerosol comprised of (solid or liquid) particles that are all of approximately the same size

NOTE In general, the geometric standard deviation of the particle-size distribution of a monodisperse aerosol is less than or equal to 1,1.

3.10
aerosol, polydisperse
aerosol comprised of particles with a range of sizes

NOTE In general, the geometric standard deviation of the particle-size distribution of a polydisperse aerosol is greater than 1,1.

3.11
aerosol particle
solid or liquid particle constituents of an aerosol

3.12
analyser
device that provides for near real-time data on radiological characteristics of the gas (air) flow in a sampling system or duct

NOTE An analyser usually evaluates the concentration of radionuclides in a sampled air stream; however, some analysers are mounted directly in or outside a stack or duct.

3.13
aspiration efficiency
ratio of particle mass or number concentration in the nozzle inlet to the concentration in the free stream

3.14
bend
gradual change in direction of a sample transport line

NOTE The radius of curvature of a bend should be at least three times the inside diameter of the tubing.

3.15
bulk stream
air flow in a stack or duct, as opposed to the sample flow rate

3.16
burial
imbedding of a particle into a filter medium or the masking of a particle by subsequent deposits of particulate matter

3.17
calibration
operation that, under specified conditions, initially establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and then uses this information to establish a relation for obtaining a measurement result from an indication

3.18
coefficient of variation
COV
quantity that is the ratio of the standard deviation of a variable to the mean value of that variable

NOTE It is usually expressed as a percentage.

3.19
collector
component of a sampling system that is used to retain radionuclides for analysis

EXAMPLE A filter that is used to remove from a sample stream aerosol particles that carry alpha-emitting transuranic radionuclides or other radionuclides.

3.20

conditioning system

apparatus that can be used to purposefully, in a controlled manner, change the aerosol particle concentration, gas composition, particle-size distribution, temperature or pressure in a sample stream

3.21
continuous air monitor
CAM
near-real-time sampler and associated detector that provide data on radionuclides (e.g. concentration of alpha-emitting aerosol particles) in a sample stream

3.22
continuous monitoring
continuous near-real-time measurements of one or more sampling characteristics

3.23
continuous sampling
either uninterrupted sampling or sequential collection of samples obtained automatically at intervals short enough to yield results that are representative for the entire sampling period

NOTE The sample may be analysed in near-real-time (i.e. equivalent to monitoring) or it may be analysed post-sample-collection in a remote laboratory.

3.24
curvature ratio
ratio of bend radius to the tube diameter

3.25
depositional loss
loss of constituents of the sample on the internal walls of a sampling system

NOTE See also 3.92.

3.26
detection limit
minimum input signal to an instrument that can be said, with a predetermined confidence level, to exceed the inherent noise of the instrument

3.27
droplet
liquid aerosol particle

3.28
effective dose
sum of the products of the dose absorbed by an organ or a tissue and the factors relative to the radiation and to the organs or tissues that are irradiated

3.29
effluent
waste stream flowing away from a process, plant, or facility to the environment

NOTE This International Standard applies to the effluent air that is discharged to the atmosphere through stacks and ducts.

3.30
emission
contaminants that are discharged into the environment

3.31
emit
discharge contaminants into the environment

3.32
extractive sampling

NOTE See 3.72.

3.33
flow rate
rate at which a mass or volume of gas (air) crosses an imaginary cross-sectional area in either a sampling system tube or a stack or duct

NOTE The rate at which the volume crosses the imaginary area is called the volumetric flow rate; and the rate at which the mass crosses the imaginary area is called either the mass flow rate or the volumetric flow rate at standard conditions.

3.34
geometric mean of a variable
x_g
value given by Equation (1) for N observations of a random variable x_i:

$$\ln x_g = \frac{1}{N}\sum_{i=1}^{N} \ln x_i \qquad (1)$$

3.35
geometric standard deviation
s_g
the geometric standard deviation for N observations of a random variable, x_i, calculated from Equation (2):

$$\ln^2 s_g = \frac{1}{N-1}\sum_{i=1}^{N}\left(\ln x_i - \ln x_g\right)^2 \quad (2)$$

where x_g is the geometric mean of the random variable

3.36
high-efficiency particulate air filter
HEPA filter
high-efficiency filter used for removing aerosol particles from an air stream

NOTE A HEPA filter usually collects aerosol particles at the most penetrating particle size (between 0,1 µm and 0,3 µm diameter) with a high efficiency and is designed to collect greater fractions of aerosol particles with diameters either larger or smaller. The minimum efficiency of a HEPA filter is not defined in an International Standard.

3.37
humidifier
device for adding water vapour to a sample stream

3.38
hydraulic diameter
type of equivalent duct diameter for ducts that do not have a round cross-section

NOTE Generally, it is four times the cross-sectional area divided by the perimeter.

3.39
impaction
process by which aerosol particles are removed from an air stream by striking an object in the air stream

NOTE Curvature of air streamlines, principally on the front side of the object, causes particles with sufficient inertia to strike the object while the airflow passes around it.

3.40
in-line system
system where the detector assembly is adjacent to, or immersed in, the effluent stream or stream in the duct or stack

3.41
interception
process by which aerosol particles are removed from an air stream by an object in the flow, where the trajectory of the particle's centre of gravity misses the object but the body of the particle strikes the object

3.42
isokinetic
condition that prevails when the velocity of air at the inlet plane of a nozzle is equal to the velocity of undisturbed air in a stack or duct at the point where the nozzle inlet is located

NOTE Anisokinetic is the antonym of isokinetic. Sub-isokinetic refers to the condition where the nozzle inlet velocity is less than the free-stream velocity. Super-isokinetic refers to the condition where the nozzle inlet velocity is greater than the free-stream velocity.

3.43
laminar flow
flow regime in stacks or ducts associated with Reynolds numbers less than about 2 200

NOTE This regime is not usually encountered in effluent air flows. Mixing in laminar flow results from molecular diffusion, which is a much slower process than mixing in turbulent flow.

3.44
LLD
lower limit of detection

3.45
may
in regulatory applications, indicates that an action is permissible but not mandatory

3.46
membrane filter
filter medium consisting of thin, organic-based films having a range of selectable porosities and controlled composition

NOTE Thin, porous metallic filters are sometimes also called membrane filters.

3.47
mixing element
device placed in a stack or duct that is used to augment the mixing of the contaminant mass with the fluid

3.48
monitoring
continual measurement of a quantity (e.g. activity concentration) of the airborne radioactive constituent or the gross content of radioactive material, at a frequency that permits an evaluation of the value of that quantity in near-real-time, or at intervals that comply with regulatory requirements

3.49
nozzle
device used to extract a sample from an effluent stream and transfer the sample to a transport line or collection device

NOTE Within the nozzle, there is a transition zone where the sample stream adjusts to the conditions in the transport line.

3.50
nozzle exit (plane)
imaginary plane across the cross-section of a transport system that divides the nozzle region from the transport line

NOTE The nozzle is frequently a separate component and the nozzle exit plane is clearly defined as the downstream end of that component. If there is no separate component, the nozzle exit is the end of the transition zone of the nozzle flow.

3.51
nozzle inlet (plane)
imaginary cross-sectional inlet plane of a nozzle where the flow first enters the transport system

NOTE In the special case of a shrouded nozzle, the inlet is referenced to the inner nozzle rather than the shroud.

3.52
number size distribution
representation of the number of particles associated with intervals of particle size, over the full size range encountered in a sample

NOTE For samples consisting of aerosol particles, it is a representation of the relative number of particles (measured number of particles in a size interval divided by the total number of particles in the sample) associated with intervals of aerodynamic diameter.

3.53
off-line system
system whereby a sample is withdrawn from the effluent stream and analysed at a location that is remote from the region where extraction takes place

3.54
off-normal condition
condition that is unplanned and which presents a gap with normal conditions

EXAMPLES Accidents and equipment failure.

3.55
particle
aggregate of molecules, forming a solid or liquid, ranging in size from a few molecular diameters to several millimetres

3.56
particle, large
particle that has an aerodynamic diameter greater than 10 µm

3.57
particle-size distribution
distribution of particle size as a function of mass or activity rather than number

3.58
penetration
ratio of the concentration at the outlet of the sampling system, transport lines included, to that in the duct or at the stack

3.59
potential emission
radionuclides that can be released to the environment from a facility in the absence of control equipment

3.60
precision
closeness of agreement between indications obtained by replicate measurements on the same or similar objects under specified conditions.

NOTE A value of precision is obtained by repetitive testing of a homogenous sample under specified conditions. The precision of a method is expressed quantitatively as either the standard deviation computed from the results of a series of controlled determinations or as the coefficient of variation of the measurements.

3.61
probe
tubing or apparatus inserted into a stack or duct through which a sample of the stream is withdrawn

NOTE A probe usually refers to one or more nozzles and part of the transport line.

3.62
profile
distribution of air velocity, of gas concentration or of particle concentration over the cross-sectional area of the stack or duct

3.63
quality assurance
planned and systematic actions necessary to provide confidence that a system or component performs satisfactorily in service and that the results are both correct and traceable

3.64
radionuclide
unstable isotope of an element that decays or converts spontaneously into another isoptope or different energy state, emitting radiation

3.65
record sample
sample that is collected for reporting purposes

NOTE Record samples are often analysed off-line.

3.66
reference method
apparatus and instructions for providing results against which other approaches may be compared

NOTE The application of a reference method is assumed to define correct results.

3.67
representative sample
sample with the same quality and characteristics for the material of interest as that of its source at the time of sampling

3.68
sample
portion of an air stream of interest or one or more separated constituents from a portion of an air stream

3.69
sample-extraction location
location of extraction of a sample from the air

NOTE Location of inlet of the sampling system.

3.70
sampler
device that collects or analyses constituents of the air sample

3.71
sample stream
air that flows through a sampling system

3.72
sampling
process of removing a sample from the free air and transporting it to a collector or an analyser (monitor)

3.73
sampling environment
conditions of the air flow and gas within a stack that can influence the sampling process

NOTE Factors to take into account include pressure, temperature and molecular composition of the gas.

3.74
sampling location

NOTE See 3.69.

3.75
sampling plane
cross-sectional area where the sample is extracted from the air flow

3.76
sampling system
system consisting of an inlet, a transport line, a flow conditioning system and a collector or monitor

NOTE Depending upon the application, a flow conditioner might not be used in the sampling system.

3.77
sedimentation velocity
terminal (maximum) velocity an aerosol particle attains in quiescent fluid (air) as a result of the gravitational force

3.78
sensitivity
change in indication of a mechanical, nuclear, optical or electronic instrument as affected by changes in the variable quantity being sensed by the instrument

NOTE This is the slope of a calibration curve of an instrument, where a calibration curve shows output values of an instrument as a function of input values.

3.79
shall
in regulatory compliance, indicates that an action is mandatory

3.80
should
in regulatory compliance, indicates that an action is desirable but not mandatory

3.81
shroud
aerodynamic decelerator placed around and extending beyond a sampling nozzle to reduce sampling biases

3.82
standard conditions
temperature of 25 °C and a pressure of 101,325 kPa

NOTE Used to convert air densities to a common basis. Other temperature and pressure conditions may be used but should be applied consistently.

3.83
transmission ratio
ratio of the aerosol particle concentration at the nozzle outlet to that in the free stream

NOTE It is stated whether a mass or activity basis is used.

3.84
transport line
part of a transport system between the nozzle exit plane and the entrance plane of a collector or analyser

3.85
transport system
all components of a sampling system, excluding the collector or analyser

3.86
turbulent flow
flow regime characterized by bulk mixing of fluid properties

NOTE For example, in a tube, the flow is turbulent if the Reynolds number is greater than about 3 000 and laminar if the Reynolds number is below about 2 200. There is little mixing in the laminar flow regime.