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Radiation protection — Monitoring of workers occupationally exposed to a risk of internal contamination with radioactive material

Radioprotection — Surveillance professionnelle des travailleurs exposés à un risque de contamination interne par des matériaux radioactifs

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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 20553 was prepared by Technical Committee ISO/TC 85, *Nuclear energy*, Subcommittee SC 2, *Radiation protection*.

Introduction

In the course of employment, individuals might work with radioactive materials that, under certain circumstances, could be taken into the body. Protecting workers against risks of incorporated radionuclides requires the monitoring of potential intakes and/or the quantification of actual intakes and exposures. The selection of measures and programmes for this purpose requires decisions concerning methods, techniques, frequencies etc. for measurements and dose assessment. The criteria permitting the evaluation of the necessity of such a monitoring programme or for the selection of methods and frequencies of monitoring usually depend upon the legislation, the purpose of the radiation protection programme, the probabilities of potential radionuclide intakes, and the characteristics of the materials handled.

This International Standard offers guidance for the decision whether a monitoring programme is required and how it should be designed. Its intention is to optimise the efforts for such a monitoring programme consistent with legal requirements and with the purpose of the radiation protection programme. Recommendations of international expert bodies and international experience with the practical application of these recommendations in radiation protection programmes have been considered in the development of this International Standard. Its application facilitates the exchanges of information between authorities, supervisory institutions and employers. The International Standard is not a substitute for legal requirements.

In the International Standard, the word “shall” is used to denote a requirement and no deviation is allowed. The word “should” is used to denote a recommendation from which justified deviations are allowed. The word “may” is used to denote permission.

Radiation protection — Monitoring of workers occupationally exposed to a risk of internal contamination with radioactive material

1 Scope

This International Standard specifies the minimum requirements for the design of professional programmes to monitor workers exposed to the risk of internal contamination by radioactive substances and establishes principles for the development of compatible goals and requirements for monitoring programmes.

This International Standard addresses the

a) purposes of monitoring and of monitoring programmes;

b) description of the different categories of monitoring programmes;

c) quantitative criteria for conducting monitoring programmes;

d) suitable methods for monitoring and criteria for their selection;

e) information that has to be collected for the design of a monitoring programme;

f) general requirements for monitoring programmes (e.g. detection limits, tolerated uncertainties);

g) frequencies of measurements;

h) special cases;

i) quality assurance; and

j) documentation, reporting, record-keeping.

This International Standard does not address

— the monitoring of exposure to radon and its radioactive decay products;

— detailed descriptions of measuring methods and techniques;

— detailed procedures for *in vivo* measurements and *in vitro* analyses;

— interpretation of monitoring results in terms of doses;

— biokinetic data and mathematical models for converting measured activities into absorbed dose, equivalent dose and effective dose; or

— the investigation of the causes or implications of an exposure or intake.

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 5725-1:1994, *Accuracy (trueness and precision) of measurement methods and results — Part 1: General principles and definitions*

ISO 12790-1:2001, *Radiation protection — Performance criteria for radiobioassay — Part 1: General principles*

BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML, *International vocabulary of basic and general terms in metrology (VIM), 1993*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5725-1, ISO 12790-1 and *International vocabulary of basic and general terms in metrology (VIM)* and the following apply.

3.1 Absorption types

3.1.1
type F
F
deposited materials that have high (fast) rates of absorption into body fluids from the respiratory tract

3.1.2
type M
M
deposited materials that have intermediate (moderate) rates of absorption into body fluids from the respiratory tract

3.1.1
type S
S
deposited materials that have low (slow) rates of absorption into body fluids from the respiratory tract

3.2
accuracy of measurement
characteristics of an analysis or determination that ensure that both the bias and precision of the resulting quantity remains within specified limits

3.3
activity
transition rate

NOTE The activity is stated in becquerels (Bq).

3.4
activity median aerodynamic diameter
AMAD
value of aerodynamic diameter such that 50 % of the airborne activity in a specified aerosol is associated with particles smaller than the AMAD, and 50 % of the activity is associated with particles larger than the AMAD

NOTE The aerodynamic diameter of an airborne particle is the diameter that a sphere of unit density would need to have in order to have the same terminal velocity when settling in air as the particle of interest.

3.5
clearance
net effect of the biological processes by which radionuclides are removed from the body or from a tissue, organ or region of the body

NOTE The clearance rate is the rate at which this occurs.

3.6
contamination
activity of radionuclides present on surfaces, or within solids, liquids or gases (including the human body), where the presence of such radioactive material is unintended or undesirable

3.7
dose
[ICRU Report 60:1998]

3.7.1
annual dose
committed effective dose resulting from all intakes occurring during a calendar year

3.7.2
committed effective dose
time integral of the equivalent-dose rate over an integration period

NOTE In this International Standard, the integration time is 50 years following any intake.

3.7.3
effective dose
sum of the weighted equivalent doses in all tissues and organs of the body

NOTE The effective dose is expressed in units of joules per kilogram (special name: sievert, Sv).

3.7.4
total dose
sum of effective dose from external radiation and committed effective dose from internal radiation

3.8
excretion function
the fraction of an intake excreted per day after a given time has elapsed since the intake occurred

3.9
event
any unintended occurrence, including operating error, equipment failure or other mishap, the consequences or potential consequences of which are not negligible from the point of view of protection or safety

3.10
intake
activity of a radionuclide taken into the body in a given time period or as a result of a given event

3.11
***in vitro* analysis**
analysis including measurements of radioactivity present in biological samples taken from an individual

NOTE 1 These include urine, faeces and nasal samples. In special monitoring programmes, samples of other materials such as blood and hair may be taken.

NOTE 2 These analyses are sometimes referred to as indirect measurements.

3.12
***in vivo* measurement**
measurement of radioactivity present in the human body, carried out using detectors to measure the radiation emitted

NOTE 1 Normally the measurement devices are whole-body counters or part-body (e.g. lung, thyroid) counters.

NOTE 2 Sometimes also referred to as direct measurements.

3.13
investigation level
level of dose, exposure or intake (specified by the employer or the regulatory authority) at or above which an investigation is conducted

NOTE 1 See Clause 6.

3.14
detection limit
DL
smallest actual amount of a measurand that can be detected by a measuring method

NOTE Adapted from ISO 11929-7:2005.

3.15
monitoring
measurement of dose or contamination for the purpose of the assessment or control of exposure to radiation or radioactive material, and the interpretation of the results

3.15.1 Categories of monitoring programme

NOTE The present International Standard distinguishes four different categories of monitoring programme, namely **routine monitoring programmes** (3.15.1.1), **special monitoring programmes** (3.15.1.2), **confirmatory monitoring programmes** (3.15.1.3), and **task-related monitoring programmes** (3.15.1.4).

3.15.1.1
routine monitoring programme
systematic monitoring programme
monitoring programme associated with continuing operations and intended to demonstrate that working conditions, including the levels of individual dose, remain satisfactory, and to meet regulatory requirements

3.15.1.2
special monitoring programme
monitoring programme performed to quantify significant exposures following actual or suspected abnormal events

3.15.1.3
confirmatory monitoring programme
monitoring programme carried out to confirm assumptions about working conditions, for example that significant intakes have not occurred

3.15.1.4
task-related monitoring programme
specific monitoring programme
monitoring programme related to a specific operation, to provide information on a specific operation of limited duration, or following major modifications applied to the installations or operating procedures, or to confirm that the routine monitoring programme is suitable

3.15.2 Types of monitoring

NOTE This International Standard distinguishes two different types of monitoring in each category of monitoring, **individual monitoring** (3.15.2.2) and **workplace monitoring** (3.15.2.3). A further type of monitoring, **collective monitoring** (3.15.2.1), is regarded as a particular form of workplace monitoring.

3.15.2.1
collective monitoring
monitoring applied to representative members of a group of workers whose working conditions are not significantly different in terms of the risk of intakes

3.15.2.2
individual monitoring
monitoring by means of equipment worn by individual workers, or measurement of the quantities of radioactive materials in or on the bodies of individual workers, or measurement of radioactive material excreted by individual workers

3.15.2.3
workplace monitoring
monitoring using measurements made in the working environment

3.16
monitoring interval
period between two times of measurement

3.17
quality assurance
QA
planned and systematic actions necessary to provide adequate confidence that a process, measurement or service will satisfy given requirements for quality, for example, those specified in a licence

3.18
quality control
QC
part of quality assurance intended to verify that systems and components correspond to predetermined requirements

3.19
quality management
QM
all activities of the overall management function that determine the quality policy, objectives and responsibilities, and implement them by means such as quality planning, quality control, quality assurance and quality improvement within the quality system

3.20
recording level
level of dose, exposure or intake (specified by the employer or the regulatory authority) at or above which values of dose, exposure or intake received by workers are to be entered in their individual exposure records

NOTE See Clause 6 for the reference levels.

3.21
reference level
investigation level or recording level

3.22
retention function
fraction of an intake present in the body or in a tissue, organ or region of the body after a given time has elapsed since the intake occurred

3.23
time of measurement
in the case of *in vitro* analysis, the time at which the biological sample (e.g. urine, faeces) was taken from the individual concerned. In the case of *in vivo* measurements, the time at which the *in vivo* measurement begins.

4 Symbols and abbreviated terms

AMAD	Activity median aerodynamic diameter
A_{DL}	Mathematical symbol for the detection limit, used in equations
DL	Detection limit
$e(50)$	Dose coefficient: committed effective dose accumulated within 50 years following a unit intake
$E(t)$	Value of the excretion function at time, t, (in days) after a unit intake
f_1	Gastro-intestinal uptake fraction
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
QA	Quality assurance
QC	Quality control
QM	Quality management
$R(t)$	Value of the retention function at time, t, (in days) after a unit intake
RPE	Respiratory protective equipment
ΔT	Time interval (in days) between two measurements in a routine monitoring programme

5 Purpose and need for monitoring programmes

The purpose of monitoring, in general, is to verify and document that the worker is protected adequately against risks from radionuclide intakes and the protection complies with legal requirements. Therefore, it forms part of the overall radiation protection programme, which starts with an assessment to identify work situations in which there is a risk of radionuclide intake by workers, and to quantify the likely intake of radioactive material and the resulting committed effective dose received. Decisions about the need for monitoring and the design of the monitoring programme should be made in the light of such a risk assessment.

Routine monitoring programmes are performed to quantify exposures where there is the possibility either of undetected accidental intakes or of chronic intakes. The basis for routine monitoring programmes is the assumption that working conditions, and thus risks of intake, remain reasonably constant. The design of such a programme of regular measurements strongly depends on the level of the annual dose the quantification of which is ensured. This level should be well below legally relevant limits; its definition should take into account uncertainties, for example in activity measurement and dose assessment. If this level is too high, intakes representing considerable fractions of dose limits could be overlooked, whilst a low value can cause the expenditure of unnecessary efforts at low exposures.

Special monitoring programmes are performed to quantify significant exposures following actual or suspected abnormal events. Therefore, in comparison to routine monitoring programmes, the time of intake is usually much better known and additional information can be available, which helps to reduce the uncertainty of