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Radiological protection - Monitoring and internal dosimetry for specific materials —

Part 1:
Uranium

Radioprotection - Contrôle et dosimétrie interne des éléments spécifiques —

Partie 1: Uranium

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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 16638-1 was prepared by Technical Committee ISO/TC 85, *Nuclear energy, nuclear technologies, and radiological protection*, Subcommittee SC 2, *Radiological protection*.

This second/third/... edition cancels and replaces the first/second/... edition (), [clause(s) / subclause(s) / table(s) / figure(s) / annex(es)] of which [has / have] been technically revised.

ISO 16638 consists of the following parts, under the general title *Radiological protection — Monitoring and internal dosimetry for specific materials*:

— *Part 1: Uranium*

Introduction

In the course of employment, individuals may 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 doses resulting from internal radiation exposure arising from contamination by radioactive substances cannot be measured directly. 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 legislation, the purpose of the radiation protection programme, the probabilities of potential radionuclide intakes, and the characteristics of the materials handled.

For these reasons, three ISO standards addressing laboratory requirements (28218:2010), monitoring programmes (20553:2006) and dose assessments (27048:2011) have been developed and can be applied in a straightforward manner to many radionuclides. However, for a number of specific materials, their practical application is complex and further guidance may be required, e.g for accreditation purposes. Such guidance was requested by a number of countries during the consultation phase for these standards.

Monitoring and internal dosimetry for uranium and its compounds are addressed in this standard because of:

— the growing interest in nuclear energy production and the associated increase in uranium mining and fuel production;

— the large variation of isotopic compositions of the compounds that may be encountered in the workplace; and,

— the importance of taking into account both the chemical and the radiological risks arising from exposures to uranium.

An ISO standard that addresses the specific issue of monitoring and internal dosimetry for uranium will contribute to harmonising monitoring of occupationally exposed persons while remaining complementary to the three earlier standards.

This International Standard offers guidance on the need for a monitoring and internal dosimetry programme for the different compounds of uranium and how it should be designed. Recommendations of international expert bodies and international experience with the practical application of these recommendations in radiological 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.

Radiological protection — Monitoring and internal dosimetry for specific materials — Part 1: Uranium

1 Scope

This International Standard specifies the minimum requirements for the design of professional programmes to monitor workers exposed to the different compounds of uranium and establishes principles for the development of compatible goals and requirements for monitoring programmes and the dose assessment for workers occupationally exposed to the risk of internal contamination. It presents procedures and assumptions for the risk analysis, for the monitoring programmes and for the standardised interpretation of monitoring data, in order to achieve acceptable levels of reliability for uranium and its compounds. Limits are set for the applicability of the procedures in respect of the dose levels above which more sophisticated methods have to be applied.

Uranium is both radiologically and chemically toxic. Hence the bases of current occupational exposure standards are reviewed in addition to radiation exposure limits. This standard addresses those circumstances when exposure could be constrained by either radiological or chemical toxicity concerns.

This International Standard addresses, for uranium and its compounds the following items:

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) procedures for dose assessment based on reference levels for routine and special monitoring programmes;

i) assumptions for the selection of dose-critical parameter values;

j) criteria for determining the significance of monitoring results;

k) interpretation of workplace monitoring results;

l) uncertainties arising from dose assessments and interpretation of bioassays data;

m) reporting/documentation;

n) quality assurance.

It is not applicable to the following:

a) the monitoring of exposure uranium progeny including radon;

b) detailed descriptions of measuring methods and techniques for uranium;

c) dosimetry for litigation cases;

d) modelling for the improvement of internal dosimetry;

e) the potential influence of counter-measures (e.g. administration of chelating agents);

f) the investigation of the causes or implications of an exposure;

g) dosimetry for ingestion exposures and for contaminated wounds

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/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement* (GUM:1995)

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms* (VIM)

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

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results — Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 5725-3, *Accuracy (trueness and precision) of measurement methods and results — Part 3: Intermediate measures of the precision of a standard measurement method*

ISO 20553:2006, *Radiation protection — Monitoring of workers occupationally exposed to a risk of internal contamination with radioactive material*

ISO 28218:2010, *Radiation protection — Performance criteria for radiobioassay*

ISO 27048:2011, *Radiation protection — Dose assessment for the monitoring of workers for internal radiation exposure*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC Guide 99, ISO 5725-1, ISO 5725-2, ISO 5725-3, and in Publications of ICRP and ICRU [6,7,8,9,10,11,12,13,14,15,16,17,18,19 and 20] and the following apply.

3.1
absorption
transfer of material from lungs to body fluids, characterised by its rate.

Note 1 to entry: In the absence of absorption rate values for specific radionuclide compounds, default values of type F, M and S can be applied.

3.2
absorption type F
deposited materials that have high (fast) rates of absorption into body fluids from the respiratory tract

3.3
absorption type M
deposited materials that have intermediate (moderate) rates of absorption into body fluids from the respiratory tract

3.4
absorption type S
deposited materials that have low (slow) rates of absorption into body fluids from the respiratory tract

3.5
activity
number of spontaneous nuclear disintegrations per unit time

Note 1 to entry: The activity is stated in becquerels (Bq), i.e. the number of disintegrations per second.

3.6
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 1 to entry: 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.

3.7
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 1 to entry: The *clearance rate* is the rate at which this occurs.

3.8
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

3.9
critical value
maximum value for the result of a single measurement in a monitoring programme where it is safe to assume that the corresponding extrapolated annual dose does not exceed a predefined dose level

3.10
decision threshold
fixed value of the measurand by which, when exceeded by the result of an actual measurement of a measurand quantifying a physical effect, it is decided that the physical effect is present

3.11
detection limit
smallest true value of the measurand which is detectable by the measuring method

3.12
annual dose
committed effective dose resulting from all intakes occurring during a calendar year

Note 1 to entry: The term “annual dose” is not used to represent the dose received in a year from all preceding intakes.

3.13
committed effective dose = effective dose
sum of the products of the committed organ or tissue equivalent doses and the appropriate tissue weighting factors where the integration time, in the context of this International Standard, is 50 years following any intake

3.14
equivalent dose
product of the absorbed dose and the quality factor for the specific radiation at this point

3.15
excretion function
fraction of an intake excreted per day after a given time has elapsed since the intake occurred

3.16
event = Incident
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

3.17
intake
activity of a radionuclide taken into the body in a given time period or as a result of a given event

3.18
***in vitro* analyses**
indirect measurements
analyses including measurements of radioactivity present in biological samples taken from an individual

Note 1 to entry: These include urine, faeces and nasal samples; in special monitoring programmes, samples of other materials such as blood and hair may be taken.

3.19
***in vivo* measurement**
direct measurements
measurement of radioactivity present in the human body carried out using detectors to measure the radiation emitted

Note 1 to entry: Normally, the measurement devices are whole-body or partial-body (e.g. lung, thyroid) counters.

3.20
monitoring
measurements made for the purpose of assessment or control of exposure to radioactive material and the interpretation of the results

Note 1 to entry: This International Standard distinguishes four different *categories* of monitoring programmes, namely **confirmatory monitoring programme** (3.21), **routine monitoring programme** (3.22), **special monitoring programme** (3.23), and **task-related monitoring programme** (3.24), as well as two different *types* of monitoring, namely **individual monitoring** (3.25) and **workplace monitoring** (3.26), which feature in each category.

3.21
confirmatory monitoring programme
monitoring programme carried out to confirm assumptions about working conditions

EXAMPLE Monitoring programme carried out to confirm that significant intakes have not occurred.

3.22
routine 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

3.23
special monitoring programme
monitoring programme performed to quantify significant exposures following actual or suspected abnormal events

3.24
task-related 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

3.25
individual monitoring
monitoring by means of equipment worn by individual workers, by measurement of the quantities of radioactive materials in or on the bodies of individual workers, or by measurement of radioactive material excreted by individual workers

3.26
workplace monitoring
monitoring using measurements made in the working environment

3.27
monitoring interval
period between two consecutive times of measurement

3.28
quality assurance
planned and systematic actions necessary to provide adequate confidence that a process, measurement or service satisfy given requirements for quality such as those specified in a licence

3.29
quality control
part of quality assurance intended to verify that systems and components correspond to predetermined requirements

3.30
quality management
all activities of the overall management function that determine the quality policy, objectives and responsibilities, and that implement them by means such as quality planning, quality control, quality assurance and quality improvement within the quality system

3.31
recording level
level of dose, specified by the employer or the regulatory authority, at or above which values of dose received by workers are to be entered in their individual records

3.32
reference level
investigation level or recording level

3.33
retention function
function describing the 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

3.34
scattering factor
geometric standard deviation of the lognormal distribution of bioassay measurements

3.35
time of sampling
⟨*in vitro* analysis⟩ time at which the biological sample (e.g. urine, faeces) was provided by the individual concerned, that is the end time of the collection period.

3.36
time of measurement
⟨*in vivo* analysis⟩ time at which the measurement begins

4 Symbols and abbreviated terms

4.1 Symbols

D_v committed effective dose due to annual intake (Sv) such that lower doses may be discounted for the purpose of the monitoring programme (maximum value: 0,1 mSv)

$E(50)$ committed effective dose within 50 years

$e(50)$ dose coefficient: committed effective dose per unit intake

f_1 gastro-intestinal uptake factor

I intake

$m(t_i)$ predicted value of the measured quantity at time, t, for unit intake (excretion or retention function at time, t_i, for unit intake)

$m_c(t_i)$ predicted value of the quantity measured after a period of t days of a chronic unit intake per day (excretion or retention function at time, t_i, for chronic unit intake per day)

M_i measurement value at time, t_i

M_c critical value

ΔT duration of the monitoring interval (in days)

$\Delta T/2$ mid-time of the monitoring interval (in days)

$E(t)$ Value of the excretion function at time t (day) after a unit intake;

$R(t)$ Value of the retention function at time t (day) after a unit intake

A_{DL} Detection limit