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**Monitoring for inadvertent movement  
and illicit trafficking of radioactive  
material**

*Surveillance des mouvements non déclarés et des trafics illicites de  
matière radioactive*

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CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

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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 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](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

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

For an explanation of 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 World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

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

This second edition cancels and replaces the first edition (ISO 22188:2004), which has been technically revised.

The main changes are as follows:

- Update of the introduction, considering the continuous development of technology.
- Update of [Clause 2](#).
- There were 14 terms and definitions listed in the first edition (ISO 22188:2004). According to related standards and IAEA technical documents,
  - the following terms have been deleted: [3.1](#) control of radioactive material, [3.9](#) non-proliferation, [3.10](#) physical protection, [3.12](#) response, [3.13](#) safeguards and [3.14](#) special nuclear material;
  - the following terms have been added: [3.1](#) check source, [3.2](#) competent authority, [3.3](#) computer security, [3.9](#) nuclear material, [3.10](#) radioactive contamination, [3.11](#) radioactive material, [3.12](#) radiological monitoring, [3.13](#) radionuclide, [3.15](#) threat, [3.16](#) threat assessment and [3.17](#) threshold level. Terms and definitions count updated to 17.
- According to the standard's title, "instruments" in the title of [Clause 4](#) was deleted. Originally, there were 4 types of instruments categorized in the first edition (ISO 22188:2004); they were pocket-type instruments, hand-held instruments, installed instruments and radionuclide identifiers. In this second edition, the kinds of devices are updated to 7. Individually, they are personal radiation devices, hand-held instruments, hand-held radionuclide identification devices, installed radiation portal monitors, mobile systems, backpack-type radiation detectors, active interrogation and

imaging systems. For each instrument the general characteristics, operation, calibration and routine testing, minimum performance requirements and test methods are presented. References to the IEC standards covering the performance requirements for these types of instruments were added and the requirements listed in this document were removed.

- This document primarily covers radiological monitoring at borders from a technical and operational viewpoint. Whether, when or where to establish radiological monitoring at borders should be the result of a comprehensive national regulatory strategy for radioactive material control. Therefore, the training requirements for border agents, inspectors and first responders have been added (see [4.2](#)).
- Radiation monitoring systems, particularly those which are networked, connected to the internet or use cloud services, are vulnerable to a range of cyber threats. The computer security of these systems seeks to maintain the integrity, accessibility, authenticity and, where required, the confidentiality of data and instrument control. Guidance from national authorities for computer security should be sought by end-users for maintaining business continuity and reliability of radiation monitoring services and systems. A new [Clause 6](#) has been added to deal with this issue.
- Parts of [Annex A](#), and all of [Annex B](#) and [Annex C](#) were integrated into the text of [Clauses 4](#) and [5](#) of the revised document. Annex D was eliminated and references to applicable IEC standards were given for performance requirements and test methods. [Annex A](#) was rewritten and simplified as Alarms and threshold levels. A new [Annex B](#) was added to list the possible trafficked devices and radionuclides. Examples of naturally occurring radioactive material remain as [Annex C](#).
- Update of the Bibliography.

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](http://www.iso.org/members.html).

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## Introduction

The International Atomic Energy Agency (IAEA) Incident and Trafficking Database (ITDB) system has been recording incidents of inadvertent movement and illicit trafficking of nuclear and other radioactive materials since 1995. Although the numbers of reported incidents fluctuate over time, those related to trafficking or malicious use remain a concern. A small number of these reported incidents involve seizures of potentially weapons-usable nuclear material, but the majority involve unauthorized activities including stolen or missing radioactive material and the detection of contaminated manufactured goods. Examples include unintentional incorporation of radioactive materials into recycled steel, handling of lost radioactive sources by unsuspecting individuals, and deliberate theft of radioactive material.

The potential radiological hazard to workers, the general public and the environment caused by misappropriated radioactive materials adds an additional threat to inadvertent movement and illicit trafficking. There have been instances in which loss of control over radioactive materials has led to serious, even fatal, consequences. Detection of radioactive materials at border crossings as well as maritime ports, airports and inside countries, for example at check points, is therefore an important issue.

This document addresses the procedural aspects of detecting radioactive materials. The procedural aspects cover the techniques to search, locate and possibly identify radioactive substances. Guidelines for appropriate training programs and maintenance of equipment are also considered a relevant aspect. Instruments used in the process are characterized with respect to minimum requirements in order to make the recommended procedures applicable. These include personal radiation devices, hand-held instruments, hand-held radionuclide identification devices, installed radiation portal monitors, backpack-type radiation detectors, mobile systems, active interrogation, and imaging systems. Specifications for the minimum performance requirements and test methods for instrumentation are covered by other existing standards, which are listed in the normative references clause.

Due to advances continually being made in the field of border radiation monitoring equipment, it is assumed that it can represent a consensus on the minimum specifications presently achievable. It is assumed that this document will allow more efficient use and operation of existing equipment, enhance communication across borders, and encourage activities to detect and counteract inadvertent movement and illicit trafficking of radioactive materials. The benefits thus gained contribute towards the efforts to counter nuclear weapons proliferation and increase radiation protection. A lack of standardization can delay implementation of intended activities, specifically if certain parameters, for example threshold level, are not agreed upon internationally. Technical documents published by the IAEA in this subject area provide a set of technical specification that can be used in design testing, qualifying and purchasing border radiation monitoring equipment, they are the basis for recommending justifiable and agreed specifications and procedures, see References [1], [2], [3], [4], [5], [6] and [7].

# Monitoring for inadvertent movement and illicit trafficking of radioactive material

## 1 Scope

This document specifies methods and means of monitoring for inadvertent movement and illicit trafficking of radioactive material. It provides guidelines on the use of both stationary and portable, for example hand-held, instruments to monitor for radiation signatures from radioactive material. Emphasis is placed on the operational aspects, i.e., requirements derived for monitoring of traffic and commodities mainly at border-crossing facilities. Although the term border is used repeatedly in this document, it is meant to apply not only to international land borders but also maritime ports, airports, and similar locations where goods or individuals are being checked. This document does not specifically address the issue of detection of radioactive materials at recycling facilities, although it is recognized that transboundary movement of metals for recycling occurs, and that monitoring of scrap metals might be done at the borders of a state.

This document is applicable to

- regulatory bodies and other competent authorities seeking guidance on implementation of action plans to combat illicit trafficking,
- law enforcement agencies, for example border guards, to obtain guidelines on recommended monitoring procedures,
- equipment manufacturers in order to understand minimum requirements derived from operational necessities according to this document, and
- end-users of radiation detection equipment applicable to 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.

IEC 60325, *Radiation protection instrumentation — Alpha, beta and alpha/beta (beta energy > 60keV) contamination meters and monitors*

IEC 61526, *Radiation protection instrumentation — Measurement of personal dose equivalents  $H_p(10)$  and  $H_p(0,07)$  for X, gamma, neutron and beta radiations – Direct reading personal dose equivalent meters*

IEC 62244, *Radiation protection instrumentation — Installed radiation portal monitors (RPMs) for the detection of illicit trafficking of radioactive and nuclear materials*

IEC 62327, *Radiation protection instrumentation — Hand-held instruments for the detection and identification of radionuclides and for the estimation of ambient dose equivalent rate from photon radiation*

IEC 62387, *Radiation protection instrumentation — Dosimetry systems with integrating passive detectors for individual, workplace and environmental monitoring of photon and beta radiation*

IEC 62401, *Radiation protection instrumentation — Alarming personal radiation devices (PRDs) for the detection of illicit trafficking of radioactive material*

IEC 62484, *Radiation protection instrumentation — Spectrometric radiation portal monitors (SRPMs) used for the detection and identification of illicit trafficking of radioactive material*

IEC 62533, *Radiation protection instrumentation — Highly sensitive hand-held instruments for photon detection of radioactive material*

IEC 62534, *Radiation protection instrumentation — Highly sensitive hand-held instruments for neutron detection of radioactive material*

IEC 62618, *Radiation protection instrumentation — Spectroscopy-based alarming Personal Radiation Detectors (SPRD) for the detection of illicit trafficking of radioactive material*

IEC 62694, *Radiation protection instrumentation — Backpack-type radiation detector (BRD) for the detection of illicit trafficking of radioactive material*

IEC 62945, *Radiation protection instrumentation — Measuring the imaging performance of X-ray computed tomography (CT) security screening systems*

IEC 62963, *Radiation protection instrumentation — X-ray computed tomography (CT) inspection systems of bottled/canned liquids*

IEC 63085, *Radiation protection instrumentation — System of spectral identification of liquids in transparent and semitransparent container (Raman systems)*

IEC 63121, *Radiation protection instrumentation — Vehicle-mounted mobile systems for the detection of illicit trafficking of radioactive materials*

### 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>
- IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1 check source

radioactive source, not necessarily calibrated, used to confirm the continuing satisfactory operation of an instrument designed to detect photonic or particulate radiation

#### 3.2 competent authority

any body or authority designated or otherwise recognized as such for any purpose in connection with the transport regulations

[SOURCE: IAEA Nuclear Safety and Security Glossary: 2022(interim) edition. Vienna: IAEA, 2022. 248 p]

Note 1 to entry: This term is used only with reference to the Transport Regulations for consistency with terminology used in the wider field of regulation of the transport of dangerous goods. Otherwise, the more general term regulatory body should be used, with which competent authority is essentially synonymous.

#### 3.3 computer security

particular aspect of information security that is concerned with the protection of computer-based systems against compromise

[SOURCE: IAEA Nuclear Safety and Security Glossary: 2022(interim) edition. Vienna: IAEA, 2022. 248 p]

#### 3.4 detection

discovery of the presence of radioactive material on the basis of measurements and interpretation of results



**3.5****detection limit**

smallest true value of the measurand which ensures a specified probability of being detectable by the measurement procedure

[SOURCE: ISO 12749-1: 2020, 3.4.11]

**3.6****false-alarm rate**

rate of alarms which are not caused by a radioactive source under the specified background conditions

**3.7****illicit trafficking**

any intentional unauthorized movement of radioactive materials, particularly across national borders, for subsequent illegal sale, use, storage or further transfer

**3.8****inadvertent movement**

any unintentional unauthorized receipt, possession, use or transfer of radioactive materials

**3.9****nuclear material**

plutonium except that with isotopic concentration exceeding 80 % in  $^{238}\text{Pu}$ ;  $^{233}\text{U}$ ; uranium enriched in the isotope 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore residue; any material containing one or more of the foregoing

[SOURCE: IAEA Nuclear Safety and Security Glossary: 2022(interim) edition. Vienna: IAEA, 2022. 248 p]

**3.10****radioactive contamination**

radioactive substances on surfaces, or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable, or the process giving rise to their presence in such places

[SOURCE: ISO 12749-1: 2020, 3.3.4] <https://standards.iteh.ai/catalog/standards/sist/9e6d3ce0-8623-462f-9ff5-0f86bbf08963/iso-22188-2023>

**3.11****radioactive material**

material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity

[SOURCE: IAEA Nuclear Safety and Security Glossary: 2022(interim) edition. Vienna: IAEA, 2022. 248 p]

Note 1 to entry: This is the “regulatory” meaning of radioactive, and should not be confused with the “scientific” meaning of radioactive.

Note 2 to entry: The term radioactive substance is also used to indicate that the “scientific” meaning of radioactive is intended, rather than the “regulatory” meaning of radioactive suggested by the term radioactive material.

**3.12****radiological monitoring**

radiation monitoring

measurement of dose, dose rate or activity for reasons relating to the assessment or control of exposure to radiation or exposure due to radioactive substances, and the interpretation of the results

[SOURCE: ISO 12749-1: 2020, 3.3.5]

Note 1 to entry: The general term “dose” refers to ambient dose equivalent if not stated otherwise in this document.

### 3.13

#### **radionuclide**

nuclide which is in an unstable state due to excess of internal energy and which will attain a stable state by emitting radiation

Note 1 to entry: Radionuclides are either naturally occurring radionuclides, such as  $^{40}\text{K}$ ,  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{232}\text{Th}$  and their radioactive decay products or produced by activation or other artificial means.

[SOURCE: ISO 12749-1: 2020, 3.1.8]

### 3.14

#### **regulatory body**

authority or system of authorities designated by the government of a State as having legal authority for conducting the regulatory process, including issuing authorizations, and thereby regulating nuclear, radiation, radioactive waste and transport safety

[SOURCE: IAEA Nuclear Safety and Security Glossary: 2022(interim) edition. Vienna: IAEA, 2022. 248 p]

### 3.15

#### **threat**

person or group of persons with motivation, intention and capability to commit a malicious act

[SOURCE: IAEA Nuclear Safety and Security Glossary: 2022(interim) edition. Vienna: IAEA, 2022. 248 p]

### 3.16

#### **threat assessment**

evaluation of the *threat* (3.15), based on available intelligence, law enforcement, and open source information, that describes the motivation, intentions, and capabilities of these threats

[SOURCE: IAEA Nuclear Safety and Security Glossary: 2022(interim) edition. Vienna: IAEA, 2022. 248 p]

### 3.17

#### **threshold level**

level of some measurable (or otherwise assessable) quantity such that, if that level is exceeded, something happens.

[SOURCE: IAEA Nuclear Security glossary: 2020 edition, draft. Vienna: IAEA, 2020. 60 p]

Note 1 to entry: The threshold level for a detection instrument is a level of the measured quantity (for example, of dose rate) that, if exceeded, triggers the instrument to generate an alarm. Such a threshold level is set by the user of the instrument at the lowest level that might indicate some form of malicious act.

## 4 Monitoring

### 4.1 Overview

The process for detection of inadvertent movement or illicit trafficking of radioactive material is illustrated by the flowchart in [Figure 1](#). This provides an outline for the various clauses of this document. It has the following main steps:

- a) strategic evaluation of the need for border monitoring;
- b) selection of instruments;
- c) determination of threshold levels;
- d) evaluation of alarms, by verification and localization of the radioactive material;
- e) evaluation of radioactive material found.

This document primarily covers radiological monitoring at borders from a technical and operational viewpoint. The decisions regarding whether, when, or where to establish radiological monitoring at borders should result in a comprehensive national regulatory strategy for radioactive materials control.

One of the key factors in the development of a national strategy is threat assessment. By evaluating historical, political, sociological, economic and geographic factors, a State can come to a reasonable assessment as to the potential, or threat of illicit trafficking or inadvertent movement of radioactive materials across its borders. For some countries, at certain border locations, monitoring may be regarded as a necessary component of their overall strategy. For many others, the potential problem is so low that it would not be considered sufficiently cost-beneficial to implement border monitoring. However, it is recognized that sometimes radiological monitoring at borders is put in place more for political, or public peace-of-mind reasons rather than a rational need based on a significant threat.

Should it be determined that border monitoring is needed, the results of the strategic analysis also helps in the determination of the types of instruments to be used and where they should be deployed. The monitoring process is most effective if it is conducted at locations that have the greatest potential for identifying and intercepting illicit trafficking or inadvertent movement of radioactive material. In general terms, these are “control points” or “nodal points” where the flow of people, vehicle movement or freight converges. These locations may already be control points for other purposes, such as weigh-stations or customs.

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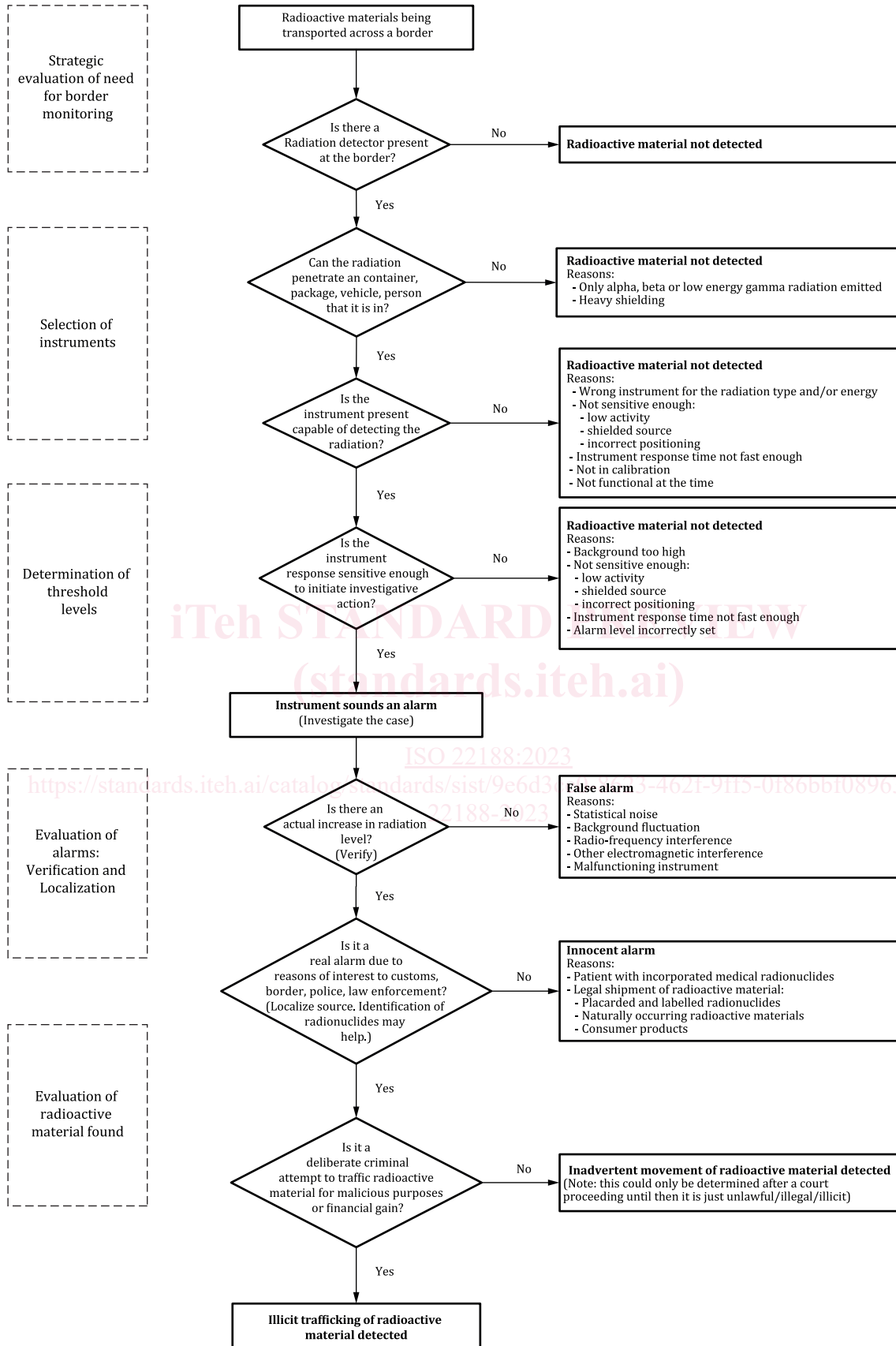


Figure 1 — Flowchart for detection of inadvertent movement or illicit trafficking of radioactive material