

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Radiation protection instrumentation –  
Vehicle-mounted mobile systems for the detection of illicit trafficking of  
radioactive materials**

**Instrumentation pour la radioprotection –  
Systèmes mobiles montés sur véhicules pour la détection du trafic illicite des  
matières radioactives**



**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2020 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

#### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

#### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

#### IEC online collection - [oc.iec.ch](http://oc.iec.ch)

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

#### A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

#### Recherche de publications IEC - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

#### IEC online collection - [oc.iec.ch](http://oc.iec.ch)

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

#### Service Clients - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: [sales@iec.ch](mailto:sales@iec.ch).

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Radiation protection instrumentation –  
Vehicle-mounted mobile systems for the detection of illicit trafficking of  
radioactive materials**

**Instrumentation pour la radioprotection –  
Systèmes mobiles montés sur véhicules pour la détection du trafic illicite des  
matières radioactives**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

ICS 13.280

ISBN 978-2-8322-1016-5

**Warning! Make sure that you obtained this publication from an authorized distributor.  
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

## CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references .....	8
3 Terms and definitions, abbreviated terms and symbols, quantities and units.....	8
3.1 Terms and definitions.....	8
3.2 Abbreviated terms and symbols .....	10
3.3 Quantities and units .....	11
4 General test procedure .....	11
4.1 General.....	11
4.2 Standard test conditions .....	11
4.3 Uncertainties.....	12
4.4 Statistical fluctuations .....	12
4.5 Background radiation during testing.....	12
4.6 Operating parameters and set up.....	12
4.7 Setup and test parameters .....	12
4.8 Dynamic testing .....	13
4.9 Static testing.....	13
4.10 Radiation sources .....	14
4.11 Special nuclear material (SNM) and depleted uranium (DU) sources.....	15
4.12 Functionality test and test acceptance range requirements .....	16
4.12.1 General requirements .....	16
4.12.2 Pre-test measurements.....	17
4.12.3 Intermediate-test measurements.....	18
4.12.4 Post-test measurements .....	18
4.12.5 Acceptance criteria .....	19
5 General requirements .....	19
5.1 General characteristics .....	19
5.2 Physical configuration.....	20
5.3 Data storage and data files .....	20
5.3.1 Requirements .....	20
5.3.2 Method of test.....	21
5.4 Communications protocol.....	21
5.4.1 Requirements .....	21
5.4.2 Method of test.....	21
5.5 Indication and alarm features .....	21
5.5.1 Requirements .....	21
5.5.2 Method of test.....	21
5.6 Markings .....	22
5.6.1 Requirements .....	22
5.6.2 Method of test.....	22
5.7 Power supply .....	22
5.7.1 Requirements .....	22
5.7.2 Method of test.....	22
5.8 User interface .....	22
5.8.1 User accessible controls requirements.....	22

5.8.2	Supervisory-user accessible indications and functions requirements.....	22
5.8.3	User display and visual indicators requirements .....	23
5.8.4	Warning indicators requirements.....	23
5.8.5	Method of test.....	23
6	Radiological tests .....	24
6.1	False alarm test .....	24
6.1.1	Requirements .....	24
6.1.2	Method of test.....	24
6.2	Gamma radiation alarm.....	24
6.2.1	Requirements .....	24
6.2.2	Method of test.....	25
6.3	Neutron radiation alarm .....	25
6.3.1	Requirements .....	25
6.3.2	Method of test.....	25
6.4	Over-range indication.....	25
6.4.1	Requirements .....	25
6.4.2	Method of test.....	26
6.5	Neutron indication in the presence of photons.....	26
6.5.1	Requirements .....	26
6.5.2	Method of test.....	26
6.6	Slowly approaching source—vehicle-mounted mobile system is stationary during use.....	27
6.6.1	Requirements .....	27
6.6.2	Method of test.....	27
6.7	Background effects—vehicle-mounted mobile system is mobile during use .....	27
6.7.1	Requirements and background information .....	27
6.7.2	Method of test.....	28
6.8	Radionuclide identification—when provided .....	30
6.8.1	Radionuclide categorisation.....	30
6.8.2	Single radionuclide identification .....	31
6.8.3	Simultaneous radionuclide identification .....	32
6.8.4	Radionuclide not in library .....	32
7	Climatic requirements .....	33
7.1	General.....	33
7.2	Ambient temperature.....	34
7.2.1	Requirements .....	34
7.2.2	Method of test.....	34
7.3	Relative humidity .....	34
7.3.1	Requirements .....	34
7.3.2	Method of test.....	34
7.4	Dust and moisture protection .....	35
7.4.1	Requirements .....	35
7.4.2	Method of test—dust.....	35
7.4.3	Method of test—moisture .....	35
8	Mechanical requirements.....	35
8.1	Microphonics/impact .....	35
8.1.1	Requirements .....	35
8.1.2	Method of test.....	36
8.2	Vibration .....	36

8.2.1	Requirements .....	36
8.2.2	Method of test.....	36
9	Electrical and electromagnetic requirements.....	36
9.1	Electrostatic discharge (ESD) .....	36
9.1.1	Requirements .....	36
9.1.2	Method of test.....	36
9.2	Radio frequency (RF).....	37
9.2.1	Requirements .....	37
9.2.2	Method of test.....	37
9.3	Radiated emissions.....	37
9.3.1	Requirements .....	37
9.3.2	Method of test.....	37
9.4	Battery lifetime.....	37
9.4.1	Requirements .....	37
9.4.2	Method of test.....	37
10	Documentation .....	38
10.1	Report.....	38
10.2	Operation and maintenance manual.....	38
Annex A (informative) Uranium/plutonium detection and identification guidance.....		39
Bibliography.....		40

**ITeh STANDARD PREVIEW**  
(standards.iteh.ai)

Figure 1 – Reference point diagram for a two-sided vehicle-mounted mobile system (top down view) .....	14
Figure 2 – Increasing background with source .....	29
Figure 3 – Decreasing background with source .....	29
Table 1 – Standard test conditions .....	11
Table 2 – Setup and test parameters .....	13
Table 3 – Test radionuclides and materials <sup>a</sup> used for Clause 6 of this document.....	15
Table 4 – SNM fluence rates.....	16
Table 5 – Test results analysis.....	19
Table 6 – Radionuclide library.....	30
Table 7 – Radionuclide decay products and impurities .....	30

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RADIATION PROTECTION INSTRUMENTATION –  
VEHICLE-MOUNTED MOBILE SYSTEMS FOR THE DETECTION  
OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIALS**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.  
<http://standards.iteh.ai/catalog/standards/sis/79d01069-a324-4b2e-985f-411111111111/iec-63121-2020>
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 63121 has been prepared by subcommittee 45B: Radiation protection instrumentation, of IEC technical committee 45: Nuclear instrumentation.

The text of this standard is based on the following documents:

FDIS	Report on voting
45B/946/FDIS	45B/955/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## iTeh STANDARD PREVIEW (standards.iteh.ai)

[IEC 63121:2020](#)

<https://standards.iteh.ai/catalog/standards/sist/79d91069-a224-4b2e-985f-9037968f4fff/iec-63121-2020>

## INTRODUCTION

Illicit and inadvertent movement of radioactive materials in the form of radiation sources and contaminated metallurgical scrap has become a problem of increasing importance. Radioactive sources out of regulatory control, so-called “orphan sources”, have frequently caused serious radiation exposures and widespread contamination. Although illicit trafficking of nuclear and other radioactive materials is not a new problem, concern about a nuclear “black market” has increased, particularly in view of its terrorist potential.

In response to the technical policy of the International Atomic Energy Agency (IAEA), the World Customs Organization (WCO), and the International Criminal Police Organization (Interpol) related to the detection and identification of special nuclear materials and security trends, radiation instrumentation companies have developed and manufactured instruments to assist in the detection of illicit movement of radioactive and special nuclear materials. This type of instrumentation is widely used for security purposes at nuclear facilities, border control checkpoints, and international seaports and airports.

To ensure that measurement results made at different locations are consistent, it is imperative that radiation instrumentation be designed to rigorous specifications based upon agreed performance requirements stated in this document. IEC standards have also been developed to address personal radiation detectors, radiation portal monitors, highly sensitive gamma and neutron detection systems, spectrometric personal radiation detectors, and backpack-based radiation detection and identification systems. Those standards are listed below.

Type of instrumentation	IEC number	Title of the standard
Body-worn	62401	Radiation protection instrumentation – Alarming Personal Radiation Devices (PRDs) for the detection of illicit trafficking of radioactive material
	62618	Radiation protection instrumentation – Spectroscopy-Based Alarming Personal Radiation Devices (SPRD) for the detection of illicit trafficking of radioactive material
	62694	Radiation protection instrumentation – Backpack-type radiation detector (BRD) for the detection of illicit trafficking of radioactive material
Portable or hand-held	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
	62533	Radiation protection instrumentation – Highly sensitive hand-held instruments for photon detection of radioactive material
	62534	Radiation protection instrumentation – Highly sensitive hand-held instruments for neutron detection of radioactive material
Portal	62244	Radiation protection instrumentation – Installed radiation portal monitors (RPMs) for the detection of illicit trafficking of radioactive and nuclear materials
	62484	Radiation protection instrumentation – Spectroscopy-based portal monitors used for the detection and identification of illicit trafficking of radioactive material
Mobile system	63121	Radiation protection instrumentation – Vehicle-mounted mobile systems for the detection of illicit trafficking of radioactive materials
Data format	62755	Radiation protection instrumentation – Data format for radiation instruments used in the detection of illicit trafficking of radioactive materials

# RADIATION PROTECTION INSTRUMENTATION – VEHICLE-MOUNTED MOBILE SYSTEMS FOR THE DETECTION OF ILLICIT TRAFFICKING OF RADIOACTIVE MATERIALS

## 1 Scope

This document applies to vehicle-mounted mobile systems (also known as mobile systems or mobile monitors) that are used for the detection of illicit trafficking of radioactive materials; these instruments may also be used for protection of major public events and for rapid screening of large areas. These vehicle-mounted mobile systems consist of one or more radiation detectors mounted in a vehicle, e.g., car or van, which travels predominantly on public roads. This document does not apply to detection systems mounted in other types of vehicles, e.g., planes, helicopters, trains, or boats. Vehicle-mounted detection systems covered by this document are designed to detect radioactive sources while the vehicle is in motion. They may also be used as stationary monitors that scan stationary or moving objects. Vehicle-mounted mobile systems detect gamma radiation and may include neutron detection and/or identification of gamma-ray emitting radionuclides.

The purpose of this document is to set minimum requirements for vehicle-mounted mobile systems for the detection of radioactive material. This document establishes general, radiological, climatic, mechanical, electric and electromagnetic, and documentation requirements, and the associated test methods.

## 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 60050-395:2014, *International Electrotechnical Vocabulary (IEV): Part 395: Nuclear instrumentation: physical phenomena, basic concepts, instruments, systems, equipment and detectors*

IEC 61187, *Electrical and electronic measuring equipment – Documentation*

IEC 62706, *Radiation protection instrumentation – Environmental, electromagnetic and mechanical performance requirements*

IEC 62755, *Radiation protection instrumentation – Data format for radiation instruments used in the detection of illicit trafficking of radioactive materials*

## 3 Terms and definitions, abbreviated terms and symbols, quantities and units

### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-395, as well as the following apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 3.1.1

#### **acceptance test**

contractual test to prove to the customer that a device meets certain conditions of its specification

### 3.1.2

#### **alarm response**

audible signal or visual signal, initiated when the reading of an instrument exceeds a pre-set value or falls outside a pre-set range

### 3.1.3

#### **ambient dose equivalent**

dose equivalent at a point in a radiation field, produced by the corresponding aligned and expanded field, in the ICRU sphere at a depth  $d$ , on the radius opposing the direction of the aligned field

Note 1 to entry: This definition does not include the notes that are part of the definition IEC 60050-395:2014,395-05-43.

### 3.1.4

#### **background**

radiation field in which there are no external sources present other than those in the natural radiation field at the location of the measurements

### 3.1.5

#### **categorisation**

ability of an instrument to determine the type of radioactive material based on its emitted radiation, e.g., naturally occurring radioactive material, nuclear material, medical radionuclides, and industrial sources

### 3.1.6

#### **coefficient of variation**

ratio of the standard deviation to the mean of a value

### 3.1.7

#### **coverage factor**

##### **$k$**

numerical factor,  $k$ , used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty

### 3.1.8

#### **detection zone**

location from which radiation emitted by an object being monitored may be detected by the detection assembly

### 3.1.9

#### **error of indication**

difference between the indicated value  $v$  of a quantity and the conventionally true value  $v_c$  of that quantity at the point of measurement

iteh STANDARD PREVIEW

(standards.iteh.ai)

IEC 63121:2020

[https://standards.iteh.ai/catalog/standards/sist/79d91069-a224-4b2e-985f-](https://standards.iteh.ai/catalog/standards/sist/79d91069-a224-4b2e-985f-903796844ff7/iec-63121-2020)

[903796844ff7/iec-63121-2020](https://standards.iteh.ai/catalog/standards/sist/79d91069-a224-4b2e-985f-903796844ff7/iec-63121-2020)

### 3.1.10 nuclear material

plutonium except that with isotopic concentration exceeding 80 % in plutonium-238 ( $^{238}\text{Pu}$ ); uranium-233 ( $^{233}\text{U}$ ); uranium enriched in the isotope 235 or 233 ( $^{235}\text{U}$  or  $^{233}\text{U}$ ); 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-TECDOC-1311, September 2002]

### 3.1.11 reference point

location marked on the instrument or described in the manual used to establish radiation source to instrument distances and orientation for test or calibration purposes

### 3.1.12 relative intrinsic error

relative error of indication of a piece of equipment or an assembly with respect to a quantity when subjected to a specified reference quantity under specified reference conditions, expressed as:

$$e_i = (v - v_c)/v_c,$$

where

$v$  is the indicated value of a quantity, and

$v_c$  is the conventionally true value of this quantity at the point of measurement.

Note 1 to entry: Simple definition: error of a measuring instrument when used under reference conditions.

[IEC 63121:2020](https://standards.iteh.ai/catalog/standards/sist/79d91069-a224-4b2e-985f-903796844fff/iec-63121-2020)

### 3.1.13

#### type test

conformity test made on one or more items representative of the production

### 3.1.14

#### uncertainty <of measurement>

parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand

## 3.2 Abbreviated terms and symbols

AAI	additional acceptable identification
CISPR	Comité International Spécial des Perturbations Radioélectriques (Special International Committee on Radio Interference)
COV	coefficient of variation
DU	depleted uranium
ESD	electrostatic discharge
HDPE	high-density polyethylene
HEU	highly-enriched uranium
ICRU	International commission on radiation units and measurements
NORM	naturally occurring radioactive material
PMMA	polymethyl methacrylate
RF	radio frequency
RGPu	reactor grade plutonium
RI	required identification

SNM special nuclear material  
 WGPu weapons-grade plutonium

### 3.3 Quantities and units

In the present document, units of the International System (SI) are used<sup>1</sup>. The definitions of radiation quantities are given in IEC 60050-395.

The following units may also be used:

- for energy: electron-volt (symbol: eV), 1 eV = 1,602 × 10<sup>-19</sup> J;
- for time: years (symbol: y), days (symbol: d), hours (symbol: h), minutes (symbol: min);
- for temperature: degrees Celsius (symbol: °C), 0 °C = 273,15 K.

Multiples and submultiples of SI units are used, when practicable, according to the SI system.

## 4 General test procedure

### 4.1 General

Unless otherwise specified in an individual step, tests enumerated in this document may be used as part of a type test or an acceptance test.

### 4.2 Standard test conditions

Except where otherwise specified, the tests described in this document should be performed under the standard test conditions given in Table 1, understanding that vehicle-mounted mobile systems may be large, and that testing may need to be performed in an uncontrolled environment. The ambient temperature, relative humidity, and atmospheric pressure shall be recorded during testing.

**Table 1 – Standard test conditions**

Influence quantity	Standard test conditions
Ambient temperature	18 °C to 25 °C
Relative humidity	≤ 75 %
Atmospheric pressure	70 kPa to 106,6 kPa
Gamma radiation background	Ambient dose equivalent rate less than or equal to 0,15 μSv·h <sup>-1</sup>
Neutron background	Neutron fluence rate less than 200 s <sup>-1</sup> ·m <sup>-2</sup>

NOTE Vehicle-mounted mobile systems are typically used in non-radiological areas, e.g., shipping ports and border locations. Man-made radiological materials such as radiation sources are not expected to be present in these areas. Non-radiological areas are expected to be used when testing vehicle-mounted mobile systems.

<sup>1</sup> International Bureau of Weights and Measures: The International System of Units, 8<sup>th</sup> edition, 2006.

### 4.3 Uncertainties

The radiation field or ambient dose equivalent rate uncertainty should not exceed  $\pm 20\%$ , except for the radiation background measurements, for which the uncertainty may be larger than the value stated here. Unless otherwise stated, the uncertainties are specified with a coverage factor  $k = 1$ .

### 4.4 Statistical fluctuations

For tests involving the use of radioactive sources to verify susceptibility to a climatic, electromagnetic, or mechanical condition (Clauses 7, 8, and 9), the radiation field produced by the sources to verify the vehicle-mounted mobile system response shall be adjusted to reduce the magnitude of the statistical fluctuations.

If the magnitude of the statistical fluctuations of the vehicle-mounted mobile system indication arising from the random nature of radiation alone is a significant fraction of the variation of the indication permitted in the test (i.e., fluctuations greater than 12 %), then the radiation field should be increased to reduce the fluctuation of the readings (to ensure that the mean value of such readings may be estimated with sufficient accuracy to demonstrate compliance with the test in question). If the radiation field cannot be increased to meet the required coefficient of variation (COV) then the number of readings should be increased as necessary. The COV for the nominal mean reading shall be less than or equal to 12 %.

For measurements without sources (i.e., at the level of background radiation), the vehicle-mounted mobile system is observed in order to verify that alarms and spurious indications are not produced by an influence quantity (e.g., temperature, humidity, RF, impact, vibration), as readings are expected to display large fluctuations. Therefore, testing without sources can be performed even when the COV is larger than 12 %.

### 4.5 Background radiation during testing

IEC 63121:2020  
<https://standards.iteh.ai/catalog/standards/sist/79d91069-a224-4b2e-985f-80371691871e-63121-2020>

Testing shall be performed in an area having a radiation background as defined in Table 1. The background shall be measured prior to testing and monitored during testing. A background spectrum shall also be acquired using a spectroscopic (e.g., high-purity germanium [HPGe]) detector to ensure that only naturally-occurring radionuclides (e.g.,  $^{40}\text{K}$ ,  $^{232}\text{Th}$  series,  $^{238}\text{U}$  series) are present in the testing area. The neutron background should be measured unless it can be confirmed that no neutron sources are in the test area. The elevation at the test location shall be recorded.

### 4.6 Operating parameters and set up

Vehicle-mounted mobile systems shall be set up based on the manufacturer's specifications. Operating parameters such as alarm settings should remain unchanged throughout the test.

For testing purposes, the reference point is the centre point of the detection assembly face or the adjacent side of the vehicle to which the detection assembly is mounted; see Figure 1. The testing distance is measured from the front face of the detection assembly; it is not measured from the outside of the vehicle.

The vehicle-mounted mobile system shall be oriented as defined by the manufacturer. If the vehicle-mounted mobile system requires a background measurement, it shall be allowed to acquire the data in a manner specified by the manufacturer prior to the start of a test.

### 4.7 Setup and test parameters

Setup and test parameters are given in Table 2.

For testing purposes, the height of the detection zone is defined as ranging from 1 m to 3 m above the ground or road surface. The detection assembly shall be placed at the height specified by the manufacturer. Additional setup and test parameters are listed in Table 2 and illustrated in Figure 1.

**Table 2 – Setup and test parameters**

Source to reference point distance	Dynamic speed	Measurement time for static testing
cm	m•s <sup>-1</sup>	s
300 ± 1	2,2 ± 0,2	60

If the vehicle-mounted mobile system is two-sided, i.e., it utilises radiation detectors mounted on each side of the vehicle, then each side of the system should be tested independently. If the detector assemblies on both sides of the system are the same, it is not necessary to test both detector assemblies.

#### 4.8 Dynamic testing

Unless otherwise stated, each source shall be passed horizontally through the middle of the bottom half and the middle of the top half of the detection zone (i.e., 1,5 m and 2,5 m from the ground) at the speed and distance provided in Table 2. The source shall be configured such that there is no shielding around the source other than that required for a specific test. The vehicle-mounted mobile system's alarm shall be reset between successive trials, if appropriate and as needed. There shall be a 10 s minimum delay between each trial with the source either shielded or positioned at a distance where it does not affect the background surrounding the vehicle-mounted mobile system.

#### 4.9 Static testing

With the vehicle-mounted mobile system set up for a static measurement, place each source at the vertical centre of the detection zone (i.e., at 2 m from the ground), in the horizontal centre of the detection assembly, with the source at a distance of 3 m from the reference point, and initiate a measurement cycle for the static measurement time shown in Table 2. The vehicle-mounted mobile system's alarm shall be reset between each trial, if appropriate and as needed.