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American National Standard Performance Criteria for Handheld Instruments for the Detection and Identification of Radionuclides

Accredited by the American National Standards Institute

Sponsored by the
National Committee on Radiation Instrumentation, N42

IEEE
3 Park Avenue
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USA

ANSI N42.34-2015
(Revision of
ANSI N42.34-2006)

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Secretariat

Institute of Electrical and Electronics Engineers, Inc.

Approved 23 November 2015

American National Standards Institute

Abstract: Performance specifications and testing methods for the evaluation of handheld instruments (also known as radionuclide identification devices or RIDs) used for the detection and identification of radionuclides, which emit gamma rays and, in some cases, neutrons, are contained in this standard. The specifications for general, radiological, environmental, electromagnetic and mechanical performances are given and the corresponding testing methods are described. The documentation to be provided by the manufacturer is listed as part of the requirements. Normative and informative annexes that provide guidance for the implementation of this standard are also included.

Keywords: ANSI N42.34, gamma rays, homeland security, industrial radionuclides, medical radionuclides, neutrons, special nuclear material (SNM)

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3 Park Avenue, New York, NY 10016-5997, USA

PDF: ISBN 978-1-5044-0700-7 STDGTPD20803
Print: ISBN 978-1-5044-0701-4 STDPD20803

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Introduction

This introduction is not part of ANSI N42.34-2015, American National Standard Performance Criteria for Handheld Instruments for the Detection and Identification of Radionuclides.

This standard is the responsibility of the Accredited American Standards Committee on Radiation Instrumentation, N42. The standard was approved on N42 letter ballot.

Contents

American National Standard Performance Criteria for Handheld Instruments for the Detection and Identification of Radionuclides

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1. Overview

1.1 Scope

This standard specifies general, radiological, environmental, electromagnetic, and mechanical requirements, and associated test methods for handheld radionuclide identification devices (RIDs). Successful completion of the tests described in this standard should not be construed as an ability to identify all radionuclides in all environments.

1.2 Purpose

This standard addresses instruments that are used to detect and identify radionuclides, display gamma-ray exposure rates, and when provided, indicate the presence of neutron radiation.

The identification requirements established by this standard are based on the sources and source configurations defined in this standard. When an RID is used operationally, the configuration of a source or object being analyzed is typically unknown, which may cause other radionuclides or isotopes to be identified.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI N42.17A, American National Standard for Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Normal Environmental Conditions.[1]

ANSI N42.42, American National Standard Data Format Standard for Radiation Detectors Used for Homeland Security.[2]

IEC 60068-2-27, Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock.[3]

IEC 60529, Degrees of protection provided by enclosures (IP Code).

IEC 60721-3-7, Classification of environmental conditions – Part 3-7: Classification of groups of environmental parameters and their severities – Portable and non-stationary use.

IEC 61000-4-2, Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.

MIL-STD-810, U.S. Department of Defense Test Method Standard—Environmental Engineering Considerations and Laboratory Tests.[4]

UL 913, Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations.[5]

3. Definitions

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be referenced for terms not defined in this clause.[6]

acceptance test: Evaluation or measurement of performance characteristics to verify that certain stated specifications and contractual requirements are met.

accuracy: The degree of agreement between the observed value and the conventionally true value of the quantity being measured.

adjust: To alter the reading of an instrument by means of a built-in variable (hardware or software) control.

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[1] ANSI N42 publications are available from the Institute of Electrical and Electronics Engineers (http://standards.ieee.org/) and the American National Standards Institute (http://www.ansi.org/).
[2] The ANSI N42.42 schema can be obtained from http://www.nist.gov/pml/div682/grp04/n42.cfm.
[3] IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch/) and in the United States from the American National Standards Institute (http://www.ansi.org/).
[4] MIL publications are available from DLA Document Services (http://quicksearch.dla.mil/).
[5] UL standards are available from Underwriters Laboratories (http://www.ul.com/).
[6] *IEEE Standards Dictionary Online* is available at: http://ieeexplore.ieee.org/Xplore/home.jsp.

alarm: An audible, visual, or other signal activated when the instrument reading or response exceeds a preset value or falls outside of a preset range.

calibrate: To adjust and/or determine the response or reading of a device relative to a series of conventionally true values.

calibration: A set of operations under specified conditions that establishes the relationship between values indicated by a measuring instrument or measuring system, and the conventionally true values of the quantity or variable being measured.

coefficient of variation (COV) (%): The square root of the variance, s^2, divided by the mean value of "*n*" number of readings times 100.

confidence indication: An indication provided by the instrument of the reliability assigned to the determined identification.

conventionally true value (CTV): The commonly accepted best estimate of the value of that quantity.

NOTE—The CTV and the associated uncertainty will preferably be determined by a national or transfer standard, or by a reference instrument that has been calibrated against a national or transfer standard, or by a measurement quality assurance (MQA) interaction with the National Institute of Standards and Technology (NIST) or an accredited calibration laboratory. (See ANSI N42.22 and ANSI N42.23.)

detection limits: The extremes of detection or quantification for the radiation of interest.

NOTE—The lower detection limit is the minimum statistically quantifiable instrument response or reading. The upper detection limit is the maximum level at which the instrument meets the required accuracy.

detector: A device or component designed to produce a quantifiable response to ionizing radiation normally measured electronically.

effective range of measurement: Range of measurements within which the requirements of this standard are met.

exposure rate: The measure of ionization produced in air by x-ray or gamma-ray radiation.

NOTE—The unit of exposure rate is the Roentgen per hour, abbreviated in this standard as R/h.

false alarm: An indication of the presence of a radioactive source or increase in the measured radiation level when that radioactive source or increase is not present.

false identification: An identification attributed to a radionuclide that is not present.

indication: Displayed signal from the instrument to the user conveying information such as scale or decade, status, malfunction, or other critical information.

influence quantity: Quantity that may have a bearing on the result of a measurement without being the subject of the measurement, such as temperature and humidity.

instrument: A complete system consisting of one or more assemblies designed to quantify one or more characteristics of ionizing radiation or radioactive material.

range: All values lying between the lower and upper detection limits.

reading: The indicated or displayed value of the readout.

readout: The portion of the instrument that provides a visual display of the response of the instrument or the displayed value, with units, displayed and/or recorded by the instrument as a result of the instrument's response to quantity being measured.

reference point: Physical mark, or marks, on the outside of an instrument used to position it at a point where the conventionally true value of a quantity is to be measured, unless the position is clearly identifiable from the construction of the instrument.

response: Ratio of the instrument reading to the conventionally true value of the measured quantity.

restricted mode: An advanced operating mode that can be accessed by an expert user (i.e., via password) to control the parameters that can affect the result of a measurement (i.e., radionuclide library, routine function control, calibration parameters, alarm thresholds).

NOTE—This mode may also be called the "advanced" or "expert" mode.

routine mode: An access mode that enables the user to perform detection and identification of radionuclides, measure exposure or dose equivalent rate, and if applicable, detect the presence of neutrons.

standard deviation: The positive square root of the variance.

standard test conditions: The range of values of a set of influence quantities under which a calibration or a measurement of response is carried out.

test: A procedure whereby the instrument, circuit, or component is evaluated.

type test: Initial test of two or more production instruments made to a specific design to show that the design meets defined specifications.

uncertainty: The estimated bounds of the deviation from the conventionally true value, generally expressed as a percent of the mean, ordinarily taken as the square root of the sum of the square of two components: 1) random errors that are evaluated by statistical means and 2) systematic errors that are evaluated by other means.

user interface: The features of the radionuclide identification device (RID) with which the user interacts (e.g., controls, displays).

3.2 Acronyms and abbreviations

COV	coefficient of variation
cps	counts per second
CTV	conventionally true value
CZT	cadmium zinc telluride
DU	depleted uranium
ESD	electrostatic discharge
FWHM	full width-half max
HPDE	high density polyethylene
HEU	highly enriched uranium
HPGe	high purity germanium
MCNP	Monte Carlo N-particle transport code
MQA	measurement quality assurance

NaI	sodium iodide
NBC	nuclear, biological, and chemical
PMMA	polymethyl methacrylate
PVT	polyvinyl toluene
RF	radio-frequency
RID	radionuclide identification device
SNM	special nuclear material
WGPu	weapons-grade plutonium

4. General considerations

4.1 Standard test conditions

Except where otherwise specified, the tests in this standard shall be carried out under the standard test conditions shown in Table 1.

For those tests intended to determine the effects of variations in the influence quantities, all other influence quantities should be maintained within the limits for standard test conditions given in Table 1, unless otherwise specified in the test method.

Table 1—Standard test conditions[a]

Influence quantity	Standard test conditions
Ambient temperature	18 °C to 25 °C
Relative humidity (RH)	≤75%
Atmospheric pressure	70–103.3 kPa (525–775 mmHg at 0 °C)
Electromagnetic field of external origin	Natural conditions without the presence of man-made generators
Magnetic induction of external origin	Natural conditions without the presence of man-made generators
Gamma background	≤25 µR/h
Neutron background	≤200 n/s/m^2 (note that this neutron background is considerably higher than at sea level)

[a] Uncertainties are stated in 4.2.

4.2 Units and uncertainties

For the purposes of this standard the radiological unit of exposure rate, R/h, is used. Radiation test fields established by measurement shall be made using devices traceable to NIST or equivalent recognized organizations. Other than ambient background, measured radiation test fields shall be determined at an uncertainty of ±20% with a coverage factor (k) of 1. When radiation fields are determined through calculation, the technique used shall be described in the test record.

Measurement of test fields for climatic, dynamic, and electromagnetic conditions shall be made using equipment traceable to NIST or equivalent organizations.

4.3 Special word usage

The following word usage applies:

- The word “shall” signifies a mandatory requirement (where appropriate a qualifying statement is included to indicate that there may be an allowable exception).
- The word “should” signifies a recommended specification or method.
- The word “may” signifies an acceptable method or an example of good practice.

5. Design

5.1 General

RIDs shall be handheld and battery-powered. They shall be capable of operating at temperatures from –20 °C to +50 °C. RIDs used outside of the stated temperature range or other stated electromagnetic or mechanical (dynamic) requirements should be tested to verify proper operation prior to use.

Other than possibly the radiation detector, RIDs shall not require any external devices (e.g., laptop personal computer) for the detection and identification of radioactive material.

Viewing characteristics of the display (e.g., legibility, readability) while wearing a protective mask or at different visual angles should be considered as part of the design of the RID.

5.2 Test preparation

NOTE—Step 5.2.1 through step 5.2.7 should be used when preparing to perform a test based on this standard.

5.2.1 Manufacturer, model, and serial number

Record the manufacturer’s name along with the model, serial number, and software and firmware numbers of the RID and detector, if separate.

5.2.2 Documentation supplied

Verify that instructions for operating and checking the operation of the RID have been supplied and record the result of this verification. Check for all items listed in Clause 10.

5.2.3 Type of radiation detector

Identify and record the type of radiation measured (gamma only or gamma/neutron) and the radiation detector types used (e.g., sodium iodide [NaI], cadmium zinc telluride [CZT], high purity germanium [HPGe], ^{3}He).

5.2.4 Size

Note the dimensions specified by the manufacturer. Measure the dimensions (height, width, and length) of the RID and record.

5.2.5 Weight

Note the weight of the RID as specified by the manufacturer.

5.2.6 Case construction

Examine the RID's case to verify that there are no uncovered openings to the interior space, and that the reference point for the detector is marked. Record the results of the examination.

5.2.7 Photograph

Photograph the RID and retain the photo in the record.

5.3 Access modes

5.3.1 Requirement

RIDs shall have at least two different access modes as follows:

a) *Routine:* A mode that enables the user to perform detection and identification of radionuclides, measure exposure or ambient dose equivalent rate, and if applicable, detect the presence of neutrons. Routine mode may also be called "simple" or "automatic" mode.

b) *Restricted:* A mode that enables an expert user (i.e., via password) to control parameters that can affect the result of a measurement (e.g., radionuclide library, routine function control, calibration parameters, alarm thresholds). Restricted mode may also be called the "advanced" or "expert" mode. Restricted-mode functions may be performed by connecting the RID to a computer.

Any other available access modes should be described (e.g., maintenance mode).

5.3.2 Test method

The manual shall be reviewed to verify that the required modes are available. The described modes shall also be verified on the RID. The results of the verification shall be recorded.

5.4 Markings

5.4.1 General requirements

The general requirements for markings are as follows:

a) The following markings shall appear on the exterior of the RID or each major subassembly (i.e., detector probe) as appropriate:

   1) Manufacturer and model number

   2) Serial number

   3) Location of the reference point(s) of all detector(s) with markings on two adjacent sides

   4) Function designation for controls, switches, and adjustments that are not menu- or software-driven

b) External markings shall remain fixed after normal decontamination procedures (e.g., water and mild, nonabrasive detergent).

5.4.2 Test method

The test method to determine whether an RID meets the marking requirements is as follows:

a) Inspect the RID to verify that each marking is present. The reference point location requirement may be met by a drawing in the manual.

b) Verify that markings remain after decontamination, use water and mild, nonabrasive detergent to wipe over the marking. Record whether the marking was affected by the procedure.

5.5 Data transfer interface

5.5.1 Requirement

RIDs shall have the ability to transfer data to an external device, such as a computer. The transfer interface shall be fully described in the manual and should use a communications port that meets the requirements of Ethernet, USB, wireless, or other electronic means such as a removable media device. Consideration should be given to data security when using wireless data transfer techniques. The naming convention used for each file shall be defined in the manual.

NOTE—Annex D provides details regarding the transfer process, format, and structure of data files for remote analysis of spectrometric information.

5.5.2 Test method

Verification shall be made through review of the manual and inspection of the RID. The steps are as follows:

a) Review the manual to verify that each stated requirement is described and record the results. If wireless transfer is used, the data security technique shall be described.

b) Following the instructions provided in the manual, perform a radionuclide identification, save the results, and then transfer those results to a computer.

c) Verify that the process as described by the manufacturer in the manual, including the naming convention, matches the process used when performing the tasks. Record any differences.

NOTE—The format of each data file is verified in 5.13.

5.6 User interface

5.6.1 Requirements

The requirements for the user interface are as follows:

a) Physical design

1) Switches and other external controls shall be designed such that the RID can be operated properly while minimizing accidental or erroneous switch operation when the user is wearing gloves including those that are used in cold weather or contamination control.

2) The display and external control functions shall be visible in low light (<150 lx) and bright light (>10 000 lx) conditions.

NOTE—It is recommended that external switches be guarded or designed to prevent inadvertent operation. It is also recommended that switches for which erroneous operation (unintentionally selecting the wrong switch) could result in loss of capability be differentiated from adjacent switches by coding dimension in addition to labeling (e.g., color, shape, location).

b) Using the available controls on the RID, the trained user shall have the ability to:

1) Switch from scanning for increases in radiation levels to identification of radionuclides.

2) Perform a radionuclide identification and save the results.

3) Perform a manual calibration or stabilization when prompted or through an access-controlled menu.

4) Access spectrum files and select any or all of them for transfer or deletion.

5) Transfer radionuclide identification data files.

5.6.2 Test method

In order to verify the requirements in 5.6.1, a minimum of *three potential users* shall review the operating instructions provided by the manufacturer. The review of the manual should focus on verifying that the manual is complete, up to date, easily accessed, readable, and compatible with the skill levels of the intended users. To provide variability between participants, it is recommended that one be at the 5th percentile female body dimensions, another at the 95th percentile male in body dimensions, and the third at the 50th percentile male body dimensions. It is recommended that test personnel not be the performers of this test. In addition, the same RID may be used for the entire test. Following the review, each participant shall:

a) Turn on the RID and verify that it is working properly (e.g., the battery is charged, the detector is present and working, memory is available, self-check passed)

b) Calibrate (if necessary)

c) Operate the RID to perform a search or scan

d) Make a radionuclide identification of a single radionuclide and save the results

e) Transfer the data package to an external device, such as a computer

f) Using the manufacturer-provided password for access (if applicable), verify that the radionuclide library can be accessed (do not make any changes)

g) Turn off the instrument (or switch off the detector only)

h) Document any observations

i) Repeat step a) through step h) in low-light levels (<150 lx) and in high-light levels (>10 000 lx). If the display has a backlight, ensure that it is set to maximum intensity during the low- and high-light level testing.

j) Repeat step a) through step d) and then step g) and step h) with each participant wearing protective gloves. Gloves worn shall be typical of those used for thermal protection. For test purposes, it is recommended that two users wear insulated thermal protection gloves and the third user wear nuclear, biological, and chemical (NBC) protection gloves. Record the type of gloves used for the test.

NOTE—Some of the results are subjective (based on opinion of the participant) and therefore no pass or fail requirements are established.

5.7 Visual indicators

5.7.1 Requirements

The display shall provide the following indications, when appropriate:

a) Gamma alarm

b) Neutron alarm, if applicable

c) Radionuclide cannot be identified (e.g., "not identified," "unknown")

d) Count rate readings

e) Count rate is too high for radionuclide identification

f) Radiological over-range conditions (e.g., "over-range" or "high counts")

g) Radionuclide categorization, identification, and confidence indicator

h) Access mode (e.g., routine or restricted)

i) Battery status

j) Operational status (e.g., normal, calibration needed, stabilization needed)

k) Radiation protection alarm (verified in step 5.14)

l) High or low detector count rate conditions indicative of a detector failure

m) Energy stabilization or calibration invalid or not acceptable

5.7.2 Test method

Review the manual and inspect the RID to verify that each requirement is available.

5.8 Restricted access user accessible indications and functions

5.8.1 Requirements

The following information and control shall be provided for the restricted access user through access controls or special commands that are described in the manufacturer provided technical manual:

a) Access to and control of operating parameters (e.g., radionuclide library, integration time)

b) Access to and control of data logging process

c) Access to status indication criteria including the ability to set the exposure rate for activation of the radiation protection alarm

d) Access to energy and/or efficiency calibration information

5.8.2 Test method

Using the manufacturer-provided access technique, perform each of the requirements stated in 5.8.1 and record the results.

5.9 Other indicators

5.9.1 Requirements

RIDs shall provide an audible alarm to alert an operator to different types of conditions (e.g., detection of gamma radiation, detection of neutron radiation, battery low, and fault detection). Different techniques may be used by the RID to differentiate between each type of event that caused an audible alarm. The description shall be provided in the manual.

The frequency of an audible alarm shall be from 1000 Hz to at least 4000 Hz. Where an intermittent alarm signal is provided, the interval shall not exceed 2 s. The A-weighted volume at a distance of 30 cm from the RID shall be at least 80 dB(A) and shall not exceed 100 dB(A).

It shall not be possible to disable both the vibration and audible alarm indications simultaneously, except through the restricted mode. When both alarm signals are off, an indication shall be provided on the display to inform the user of this condition.

An earphone connection should be available to enable use of the audible function in a high-noise environment.

5.9.2 Test method

To verify the audio indicator requirements, perform the following steps:

a) Activate the audible alarm signal with an appropriate radiation source that may be placed as close to the instrument as practical.

b) Measure the A-weighted sound level and frequency at a distance of 30 cm using appropriate equipment. Each reading shall be from 80 dB(A) to 100 dB(A) and the frequency shall be from 1000 Hz to at least 4000 Hz.

c) Verify that it is not possible to switch off the audible and vibration alarm signals simultaneously without accessing the restricted mode.

d) Verify that when both alarm modes are off, an indication is provided on the display.

e) If an earphone connection is provided, verify that the earphone functions when connected and that the external audible signal is off.

f) Record the results.

5.10 Warm-up time

5.10.1 Requirement

The manufacturer shall state the time required for the RID to become fully functional from either a dead start or when in a standby mode (i.e., HPGe detector is cooled but the RID is not on). The maximum time shall be less than 5 min.

5.10.2 Test method

The test method to determine whether an RID meets the warm-up time requirement is as follows:

a) Switch the RID on from a dead start or from standby.

b) After the manufacturer-stated warm-up time or 5 min, whichever is shorter, position the RID near a ^{137}Cs source and perform an identification. This is only verification that the RID is functional. Therefore, accurate measurement of the exposure rate is not required for this test.

c) Verify that the RID is able to perform a radionuclide identification within the manufacturer-stated identification time or 2 min, whichever is the shorter, and provide an indication of the gamma-ray exposure rate.

d) If the RID has neutron response capabilities, expose the RID to a moderated (see 6.4) neutron source (^{252}Cf) and document whether it responds to the source.

5.11 Battery power

5.11.1 Requirements

The requirements for battery power are as follows:

a) RIDs shall have the ability to operate for a minimum of 5 h of continuous use (non-alarm state) in standard test conditions (see Table 1).

b) The manufacturer shall state the expected continuous operating time using the recommended batteries at standard test temperature conditions and at −20 °C. The batteries selected should enable the RID to operate for at least 1 h at −20 °C.

c) RIDs shall have a low-battery indication.

d) Non-rechargeable batteries shall be widely available, shall not be unique to the RID, and shall be field replaceable (e.g., AA, 9 V) without the use of special tools.

e) Battery chargers for rechargeable batteries shall meet applicable US electrical standards.

f) RIDs should be capable of operating from an external dc source (e.g., 12 V vehicle electrical system, battery pack, ac converter).

g) It should be possible to switch batteries without having to shut down the RID.

5.11.2 Test method

NOTE—This test may be combined with the false alarm test described in step 6.2.

The test method to determine whether an RID meets the battery power requirements is as follows:

a) To verify the operational time requirement, perform the following steps:

    1) Replace the batteries with new batteries or fully charge rechargeable batteries.

    2) After allowing the RID to warm up, perform a simultaneous radionuclide identification using ^{241}Am and ^{60}Co, and if applicable, expose the RID to a moderated neutron source. Record the results, including the indicated exposure rate and neutron count rate, if provided.

    3) Leave the RID on and, after a period of 5 h, perform another radionuclide identification and neutron response test with the sources in the same position.

    4) The RID shall be able to perform the identification and indicate exposure rate and neutron presence as required.

b) Review the manual to verify that the manufacturer provided the expected continuous operating time using the recommended batteries at standard test temperature conditions and at −20 °C.

c) Verify that the RID provides a low battery indication through review of the manual and direct observation of the RID's display (low battery indication may be activated during the performance of step a).

d) Verify the non-rechargeable battery requirement by review of the manual and inspection of the RID.

e) For the battery charger, review the manual for a description and inspect the charger for UL or other certifications, if the charger is a separate component.

f) Determine if the RID can operate from an external power source and if the batteries are replaceable while the RID is on. Record the results.

g) Record the result of each verification.

5.12 Effective range of measurement

5.12.1 Requirement

The manufacturer shall state the range for gamma-ray exposure rate or dose-equivalent rate measurement and for neutron count rate indication, if applicable. The exposure rate range (or equivalent dose-equivalent rate range) should be at least 25 μR/h to 2 mR/h.

5.12.2 Test method

Review the manual and record the results.

5.13 Data file configuration

5.13.1 Requirements

The RID shall have the ability to internally store at least 10 complete identification data files and deliver them in the ANSI N42.42 format. Each data record shall contain the following information:

a) RID manufacturer name, model, and serial number

b) Software version

c) Gamma detector kind (e.g., NaI, polyvinyl toluene [PVT])

d) Date and time of measurement

e) Measured gamma-ray radiation level (e.g., exposure rate)

f) Background spectrum

g) Live time and real time for background spectrum

h) Measured spectrum

i) Live time and real time for measured spectrum

j) Energy calibration for the background and measured spectrum

k) Radionuclide identification results

l) Confidence indication

If the RID has neutron detection capabilities, the data file shall include the following information:

1) Neutron detector kind (e.g., He-3, Li-Glass) and volume (when applicable)
2) Measured neutron radiation levels (e.g., count rate)

5.13.2 Test method

Verify the requirement by performing 10 radionuclide identifications using the same radionuclide. When complete, transfer the stored results to a computer. On the computer, verify that each data file contains the required information in the required ANSI N42.42 format.

NOTE—The ANSI N42.42 format can be verified using one of several publically available tools. A tool that can be used for verification can be found at https://secwww.jhuapl.edu/n42/Account/LogOn.

5.14 Personal protection alarm

5.14.1 Requirement

An alarm shall be provided to alert the user that the ambient radiation intensity is above a user-selected threshold level (typically 2 mRem/h). The alarm shall be both audible and visual, and shall only be adjustable through the restricted access mode. The alarm shall have an "acknowledge" or other similar control to silence the audible function. It shall not be possible to switch off all alarm indicators at the same time.

5.14.2 Test method

The test method to determine whether an RID meets the personal protection alarm requirement is as follows:

a) Following the instructions provided in the RID manual, set the personal protection alarm to activate at a level that is above the ambient background.
b) Cause the personal protection alarm to activate using a gamma-ray emitting radiation source of sufficient strength.
c) Silence the alarm with the source present and verify that the visual alarm remains active.
d) Access the RID setup menu to verify that it is not possible to disable all alarm indications at the same time.
e) Record the results of the test.

5.15 Explosive atmospheres

5.15.1 Requirements

The manufacturer shall state in its manual whether or not the RID is certified for use in explosive atmospheres. If certification is claimed, documentation shall be provided by the manufacturer. Certification shall be based on UL 913.

5.15.2 Test method

The test method to determine whether an RID meets the explosive atmospheres requirements is as follows:

a) Review the manual to verify that the manufacturer states whether or not the RID is certified for use in explosive atmospheres. Record the results of the verification.

b) If certification is claimed, verify that supporting documentation based on testing done in accordance with UL 913 is provided.

6. Radiological tests

6.1 General test method

This clause provides information for test setup and execution. Additional information regarding the determination of the test acceptance range and confidence interval, the analysis of test results including functionality, radiation response, and identification results, and the process for determining test-caused degradation can be found in Annex B.

6.1.1 Background radiation during testing

Testing shall be performed in an area with a nominal radiation (gamma-ray and neutron) background as defined in Table 1 and that has only natural variation. When tests are performed, the gamma-ray background intensity shall be measured using a pressurized ion chamber or similar environmental radiation measurement device that is calibrated to provide gamma-ray exposure rate. A background spectrum shall also be acquired using an HPGe detector to determine whether non-background radionuclides (e.g., ^{40}K, ^{232}Th series, ^{238}U series) are in the testing area. The neutron background should be measured using a neutron counter, dosimeter, or similar device that has the ability to measure low-level neutron radiation levels.

6.1.2 RID setup

An RID shall be set up based on the manufacturer's specifications. The operational settings (e.g., libraries, thresholds) shall be recorded. Once the RID is set up for testing, no changes shall be made unless required as part of a specific test.

The reference point as defined by the manufacturer shall be used when establishing source to detector distances. The orientation of the RID relative to a radiation source for testing and use should be defined by the manufacturer. The orientation used during testing shall be recorded and photographed.

6.1.3 Dynamic and static test method

During testing, the source shall be placed or moved in a configuration that provides no shielding around the source other than that required for a specific test. For dynamic tests, unless otherwise stated, the movement speed shall be 0.5 m/s (search speed). For static tests, the measurement time shall be stated by the manufacturer or 2 min, whichever is shorter.

6.1.4 Reference radiation and exposure rate determination for identification testing

The radiation sources used for testing are listed in Table 4. Due to the inherent difficulties with using an instrument to measure low exposure rates (e.g., 50 μR/h), other methods may be used including Monte Carlo codes [e.g., Monte Carlo N-Particle Transport Code (MCNP)] or calculation. When calculating an exposure rate to determine the appropriate source to reference point distance, only use the photon emission energies from 40 keV to 3 MeV. If an exposure rate measurement instrument is used, the energy response shall be known and used to correct the indicated readings as required. Corrections shall be described in the test record.

The levels used for detection and identification purposes are not indicative of the alarm set point(s) or overall detection capability of an RID.

6.1.5 SNM and other mass-based radiation sources

RIDs shall have the ability to identify depleted uranium (DU), highly enriched uranium (HEU), and weapons-grade plutonium (WGPu). This standard uses an exposure rate of 50 μR/h above background as the radiation level within a defined source-to-RID distance for verification of identification capabilities. As a result, the material form and shape (metal or oxide, plate or spherical) are not defined, although a complete description of the source including mass, form, shape, and spectrum shall be recorded. Table 2 provides the isotopic breakdown for the test sources. In order to establish the distance for test, the exposure rate should be determined using the guidance stated in 6.1.4.

For WGPu, depending on the amount of time since last separation, ^{241}Am may be a significant contributor to the exposure rate. In order to gain consistency in testing, the WGPu source shall be shielded to reduce the low-energy emissions from the 60 keV ^{241}Am line. The shielding shall reduce the 60 keV ^{241}Am net peak area count rate so that it is no more than a factor of 10 greater than the net peak area count rate of the 414 keV line from ^{239}Pu. For example, if the net peak area count rate for the 414 keV line is 100 counts per second (cps) then the net peak area count rate for the 60 keV line should not exceed 1000 cps. The factor 10 was determined from source material measurements. Copper alloy ASTM B152 or Cadmium is recommended as the shielding material. For the WGPu source, the exposure rate used for testing shall be obtained from the shielded source after the contribution of the 60 keV ^{241}Am gamma-ray line has been reduced.

Table 2—SNM and mass-based test sources

Materials	Isotopic composition
DU	0.2% ^{235}U
HEU	$\geq$ 90% ^{235}U
WGPu	$\leq$6.5% ^{240}Pu and >93% ^{239}Pu

6.2 False alarm

6.2.1 Requirements

While in a scan or search mode, the alarm rate providing an indication of radiation field changes shall be less than one alarm over a period of 1 h when tested in an area with a stable background (only natural fluctuations) at the levels stated in Table 1. The test method of two alarms over a time period of 5 h is based on a 95% upper confidence bound for a one-sided Poisson distribution.

NOTE—This test may be combined with the battery lifetime test described in step 5.11.

6.2.2 Test method

The test method to determine whether an RID meets the false alarms requirements is as follows:

a) Set up the RID in an area where the ambient background is stable and controlled.

b) Observe the RID over a period of 5 h and document any alarms or indications of changes in the ambient background.

c) The results are acceptable if there are no more than two alarms during the 5 h period.

6.3 Photon alarm or indication

6.3.1 Requirements

While searching, RIDs shall alarm or provide an indication when the radiation field changes from ambient background to that with a source present. For this test, the alarm or indication shall activate no later than 1 s after the RID passes through the test point (point of closest approach) or the test point moves past the RID. The radiation field at the test point shall be 10 μR/h and the transient speed 0.5 m/s.

6.3.2 Test method

The test method to determine whether an RID meets the photon alarm or indication requirements is as follows:

a) Set up a track-type system that has the ability to move either the test source or the RID from a position where the source is not detectable, through the test point, to a position where the source is again not detectable. The source assembly, movement device (i.e., track), and the RID shall be at least 1 m from any item or surface (e.g., storage cabinets, floor, ground surface).

b) Position the RID such that the rear surface of the RID is against the front surface of and centered on a polymethyl methacrylate (PMMA) phantom designed to represent the upper torso of a user. The phantom dimensions shall be 40 cm wide, 60 cm high, and 15 cm thick. If the RID requires the use of a hand phantom around its handle, the hand phantom shall be provided by the manufacturer and described in the test record. See Figure 1 for test setup. The RID's orientation for this test should be the same as the orientation when performing a scan or search, and shall be described in the test record.

   NOTE—The following steps are based on the source moving with the RID stationary.

c) Establish the 10 μR/h test point at a source to detector distance of 0.8 m to 1.2 m from the source to the reference point of the RID.

d) When the RID is ready and operating as it would for search or scan, move the ^{137}Cs source or RID through the test point at a speed of 0.5 m/s.

e) Observe the RID's response and record whether it alarms or provides an indication of the increased radiation field. The alarm shall activate no later than 1 s after the source passes through the test point (point of closest approach to the reference point).

f) Document the technique used by the RID to indicate an increasing or decreasing radiation field (e.g., waterfall display, time-based strip chart, audible tone). A digital image of the display or video record may be used.

g) Acknowledge the alarm (if applicable) and repeat the process nine additional times with a minimum of 10 s between each trial. Acceptable results are when the alarm or indication is activated 9 out of 10 trials.

h) Repeat the entire process using ^{241}Am and ^{60}Co.

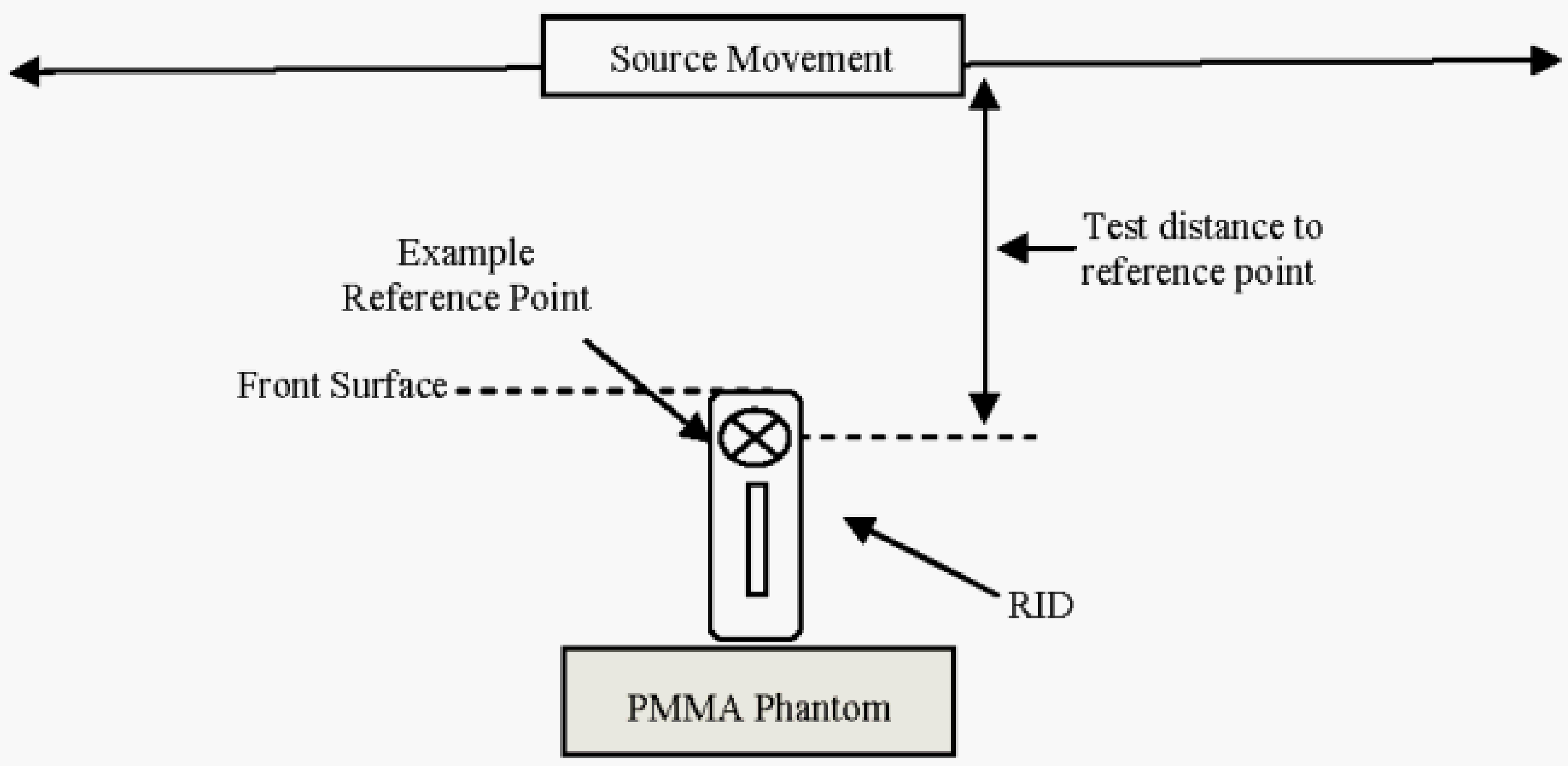

Figure 1—Test setup

6.4 Neutron alarm

6.4.1 Requirement

NOTE—This requirement is not applicable to RIDs that do not have neutron indication capabilities.

Neutron detection capable RIDs shall alarm or provide an indication when the neutron radiation field changes from ambient to that with a neutron source present. This requirement is verified using a 20 000 (±20%) neutrons/s ^{252}Cf source (Table 4) surrounded by a 4-cm thick high density polyethylene (HDPE) with the center of the moderator placed at a distance of 25 cm from the reference point of the RID. For this test, the alarm or indication shall activate no later than 1 s after the RID passes through the test point (point of closest approach) or the test point moves past the RID.

Testing shall be performed in a location where neutron scatter is kept to a minimum. The source assembly, movement device (i.e., track), and the RID shall be at least 1 m from any item or surface (e.g., storage cabinets, floor, ground surface). One meter was determined to be sufficient to keep scatter to a minimum for this source configuration.

6.4.2 Test method

NOTE—Testing should not deviate from use of the prescribed phantom or ^{252}Cf source. No hydrogenous material (e.g., foam, plastic) should be used in the test setup.

The test method to determine whether an RID meets the neutron alarm requirement is as follows:

a) Position the RID as done when performing the steps in 6.3.

b) Set up a track-type system that has the ability to move either the RID or moderated ^{252}Cf source from a position where the source is not detected, through the test point, to a position where the source is again not detected. The point of closest approach shall be 25 cm (center of source to the reference position of the RID).

   NOTE—The following steps are based on the source moving with the RID stationary.

c) When the RID is ready and operating as it would for search or scan, move the ^{252}Cf source/moderator assembly or RID through the test point at a speed of 0.5 m/s.

d) Observe the response and record whether the RID indicates the presence of neutrons. The indication shall activate no later than 1 s of the source passing through the test point (distance of closest approach). Document the technique used by the RID to indicate the presence of neutrons (e.g., waterfall display, time-based strip chart, audible tone, flashing light). A digital image of the display or video record may be used.

e) Acknowledge the alarm and repeat the process nine additional times. Acceptable results are when the indication is activated in 9 out of 10 trials.

6.5 Exposure or ambient dose equivalent rate accuracy

6.5.1 Requirements

If the RID displays the exposure rate or ambient dose equivalent rate [H*(10)], the displayed readings shall meet the accuracy requirements (±10% of the conventionally true value) for photon dose-rate instruments as stated in ANSI N42.17A, American National Standard for Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Normal Environmental Conditions, for exposure rates from 0.1 mR/h to the manufacturer-stated maximum response of the instrument.

The manufacturer shall provide calibration results as part of their report.

6.5.2 Test method

Verification testing shall be performed in accordance with the accuracy section of ANSI N42.17A using ^{137}Cs.

6.6 Over-range test

6.6.1 Requirements

If an RID is exposed to a radiation field that is greater than the manufacturer-stated maximum when performing measurements, an alarm indicating for example "over-range" or "high counts" shall be activated and shall remain activated until the radiation field is reduced or the alarm is reset or acknowledged by the user.

If the alarm is reset or acknowledged by the user without the radiation field being reduced, a visual indication shall be provided indicating that the radiation field is still present.

The time required to return to non-alarm condition after the radiation field is returned to background levels without any user interaction (other than acknowledging an audible alarm) shall not be greater than 1 min. If the maximum rate is not provided by the manufacturer, testing is not possible.

6.6.2 Test method

The test method to determine whether an RID meets the over-range requirements is as follows:

a) Review the manual to verify that the required information is provided. If the maximum exposure rate is not provided, testing is not possible. Record the results indicating that the maximum exposure rate was not provided to end the test.

b) Using ^{137}Cs determine the source to the RID reference point distance to obtain an exposure rate that is 150% of the manufacturer-stated maximum exposure rate.

c) With the RID in a stable background and operating as it would for search or scan, expose the RID to the radiation field from step b) for 1 min.

d) The RID shall alarm and remain in alarm for the exposure period.

e) Before reducing the field back to background, acknowledge or reset the audible alarm to verify that the visual indication remains activated.

f) Reduce the field to the pre-test level and verify that the RID recovers within 1 min without any user interaction other than acknowledging an audible alarm.

g) Repeat step c) through step f) two additional times for a total of three trials and record the results.

h) The results are acceptable when the RID performs as required for all three trials.

6.7 Neutron indication in the presence of photons

6.7.1 Requirements

NOTE 1—This requirement is not applicable to RIDs that do not have neutron indication capabilities.

Gamma radiation at exposure rates of up to 10 mR/h from ^{137}Cs shall not cause a neutron detection capable RID to indicate the presence of neutrons or activate a neutron alarm. In addition, the RID shall be able to detect the presence of neutrons or activate a neutron alarm while being exposed to the 10 mR/h gamma radiation field.

NOTE 2—The exposure rate of 10 mR/h was selected based on typical exposure rates produced by medical sources that may be seen during use. ^{137}Cs was selected due to its photon energy being close to the maximum photon energy emission from some of the commonly used medical radionuclides (e.g., ^{131}I).

6.7.2 Test method

The test method to determine whether an RID meets the neutron indication in the presence of photons requirements is as follows:

a) Set up the RID to operate as it would for a search or scan.

b) Expose the RID to the moderated neutron source used in the performance of 6.4 placed at the distance stated in 6.4 and record the neutron response (e.g., count rate, alarm activation).

c) Remove the neutron source and using ^{137}Cs, increase the ambient gamma-ray exposure rate by 10 mR/h as measured at the reference point of the RID for a minimum of 30 s.

d) Record the neutron response (e.g., count rate, alarm activation). Remove the ^{137}Cs source and allow the RID to return to normal operation.

e) Simultaneously expose the RID to the 10 mR/h gamma-ray exposure rate and the moderated neutron source as stated in step b) and record the neutron response (e.g., count rate, alarm activation).

f) The results are considered acceptable if there is no observable change in the neutron response when exposed to the 10 mR/h ^{137}Cs source and if the RID is able to respond in the same manner to the neutron source while being exposed to the ^{137}Cs source.

NOTE—Due to the likely low count rate from the neutron source, statistical analysis is not required.

6.8 Radionuclide identification

6.8.1 General requirements

The general requirements for radionuclide identification are as follows:

a) An indication shall be displayed (e.g., "not identified") if the RID indicates the presence of a source but is not able to identify a radionuclide.

b) The RID should indicate if the exposure rate is too low or too high for radionuclide identification.

c) An indication should be displayed as to the confidence of the radionuclides identified. The indication should be numeric (e.g., 1 to 10). The manufacturer shall state the basis of the value.

NOTE—Identification requirements are based on the sources and source configurations defined in this standard. When an RID is used operationally, the configuration of a source or object being analyzed is typically unknown which may cause other radionuclides or isotopes to be identified.

6.8.1.1 Test method

The test method to determine whether an RID meets the general requirements for radionuclide identification is as follows:

a) Expose the RID to a radionuclide that is not included in the library and verify that it provides an indication such as "not identified." The radionuclide used should have at least one gamma line that is within the energy range of the RID. A radionuclide (agreed on with the manufacturer) may be temporarily removed from the library to perform this verification test. Record the results.

b) Indication that the exposure rate is too low for identification is verified through the performance of 6.10.

c) Perform a radionuclide identification to verify that a confidence indicator is provided. Review the manual to verify that the basis of the confidence indication is defined. Record the results.

6.8.2 Radionuclide identification library

6.8.2.1 Requirement

NOTE—IAEA Safety Guide No. RS-G-1.9 contains a list of radionuclides and categories.

The manufacturer shall state the radionuclides that the RID can identify. The list of radionuclides and materials shall include those listed in Table 3, as a minimum. Verification testing shall include those radionuclides listed in Table 4, except for ^{252}Cf.

Table 3—Radionuclide library

^{241}Am	^{137}Cs	^{40}K	^{232}Th	DU
^{133}Ba	^{67}Ga	^{99m}Tc	^{235}U	HEU
^{57}Co	^{131}I	^{201}Tl	^{238}U	WGPu
^{60}Co	^{192}Ir	^{226}Ra	^{239}Pu	RGPu

Table 4—Test sources

^{241}Am	^{99m}Tc
^{133}Ba	^{201}Tl
^{60}Co	^{226}Ra
^{137}Cs	^{232}Th
^{252}Cf	DU
^{67}Ga	HEU
^{131}I	WGPu

6.8.2.2 Test method

Verify that the requirement is met by review of manufacturer's provided information and the direct observation of the RID library.

6.8.3 Single radionuclide identification

6.8.3.1 Requirements

An RID shall be able to identify the radionuclides listed in Table 4 (except for ^{252}Cf) at an exposure rate of 50 µR/h above background established at the reference point of the RID within an integration time of 2 min or that stated by the manufacturer whichever is shorter.

The medical radionuclides (^{99m}Tc, ^{67}Ga, ^{131}I, and ^{201}Tl) shall be surrounded by 8 cm of PMMA for test purposes as a means to represent in-vivo conditions. Due to the short half-life of medical radionuclides, 6.8.3 and 6.9 testing should occur together to the extent possible.

NOTE—The actual activities for medical radionuclides given to patients are much greater than those required in this standard. For ^{99m}Tc stress tests, normal dispensed quantities are typically between 3 mCi and 5 mCi; bone scans with ^{99m}Tc are 20 mCi and 25 mCi; diagnosis using ^{131}I between 10 µCi and 30 µCi; therapy with ^{131}I between 29 mCi and 300 mCi; ^{201}Tl stress tests approximately 4 mCi; and for ^{67}Ga between 2 mCi and 5 mCi.

6.8.3.2 Test method

The test method to determine whether an RID meets the single radionuclide identification requirements is as follows:

a) Position the reference point of the RID 1m from the floor or ground surface.

b) According to the manufacturer's instructions, set up the RID to perform fixed object or static measurements. This may require the user to perform some action to manually initiate a measurement.

c) Position the ^{241}Am source from Table 4 at the source to reference position distance needed to produce 50 µR/h above background (see 6.1.4).

d) Initiate a measurement for the specified static measurement time.

e) At the end of the measurement, record the identification results and the confidence indicator(s).

f) Without moving the source, repeat the process stated in step d) and step e) for a total of 10 trials.

g) Repeat the process stated in step c) through step f) for each source listed in Table 4, except for ^{252}Cf.

h) Analyze the results using the technique described in Annex B, step B.2.3, and Annex C.

i) The results are acceptable when they are complete and correct in at least 9 of 10 trials.

6.8.4 Identification of shielded sources

6.8.4.1 Requirement

RIDs shall be able to identify ^{137}Cs and ^{60}Co while those sources are shielded by a 5 mm steel plate.

NOTE—RIDs are commonly used to identify radioactive sources surrounded by many different types and amounts of material making it difficult to establish a single requirement to cover all possible shielding configurations. Because of this, the requirement for shielded sources is limited to only include 5 mm of steel as the shielding. The thickness and associated attenuation is based on the total attenuation from material that could be surrounding a source that is in a vehicle or shipping container. The test method could be used for other shielding configurations.

6.8.4.2 Test method

The test method to determine whether an RID meets the identification of shielded sources requirement is as follows:

a) Position the reference point of the RID 1m from the floor or ground surface.

b) According to the manufacturer's instructions, set up the RID to perform fixed object or static measurements. This may require the user to perform some action to manually initiate a measurement.

c) Position the ^{137}Cs source from Table 4 at the source to reference position used in 6.8.3.2.

d) Center a 5 mm thick steel plate that is at least 10 cm by 10 cm between the RID and source at a distance of 10 cm from the source.

e) Initiate a measurement for the specified static measurement time.

f) At the end of the measurement, record the identification results and the confidence indicator(s).

g) Without moving the source, repeat the process stated in step e) and step f) for a total of 10 trials.

h) Repeat the process stated in step c) through step g) using the ^{60}Co source.

i) Analyze the results using the technique described in Annex B, step B.2.3, and Annex C.

j) The results are acceptable when they are complete and correct in at least 9 of 10 trials.

6.9 Simultaneous radionuclide identification

6.9.1 Requirement

RIDs shall be able to identify a minimum of two radionuclides simultaneously within an integration time of 2 min or that stated by the manufacturer, whichever is shorter.

6.9.2 Test method

The test method to determine whether an RID meets the simultaneous radionuclide identification requirement is as follows:

a) Perform the test using the following source combinations. Except for NORM, the sources used are those listed in Table 4. Source combinations shall be configured such that one source does not shield the other.

   1) ^{137}Cs + DU

   2) ^{99m}Tc+ HEU

   3) ^{201}Tl+ HEU

   4) ^{67}Ga+ HEU

   5) ^{131}I+ WGPu

   6) NORM + HEU

   7) NORM + WGPu

b) Position the reference point of the RID approximately 1m from the floor or ground surface.

c) According to the manufacturer's instructions, set up the RID to perform fixed object or static measurements. This may require the user to perform some action to manually initiate a measurement.

d) Position the ^{137}Cs source from the ^{137}Cs + DU source combination at the source to reference point distance used for the identification test (see 6.8.3.2). The adjusted distances determined during the performance of 6.8.3.2 may be used.

e) Position the DU source from ^{137}Cs + DU source combination at the source to reference point distance used for the identification test (see 6.8.3.2).

f) Initiate a measurement for the static measurement time.

g) At the end of the measurement, record the identification results and the confidence indicator(s).

h) Repeat step f) and step g) for a total of 10 trials.

i) Repeat step b) through step h) for each remaining combination, except for NORM.

j) To verify the requirement utilizing NORM, perform the following steps to prepare the NORM source configuration.

   1) Assemble the surrogate bulk NORM by surrounding the ^{226}Ra source and the ^{232}Th source from Table 4 with 9 cm of PMMA. The sources shall be configured such that neither source shields the other and be placed at a height that is approximately 1 m from the floor or ground surface.

   NOTE—Point sources are used for this test to help improve reproducibility in the test process.

   2) To replicate the existence of the 1460 keV photo peak that may be present in NORM found in commerce, co-locate the source combination from step j1) with 25 kg of KCl-containing material such as ice melt.

   3) Position the reference point of the RID 1 m from the floor or ground surface.

   4) According to the manufacturer's instructions, set up the RID to perform fixed object or static measurements. This may require the user to perform some action to manually initiate a measurement.

   5) Position each shielded NORM surrogate source at the source to reference position distance used for the identification test (see 6.8.3.2).

   6) Position the HEU source at the source to reference position distance used for the identification test (see 6.8.3.2).

   7) Initiate a measurement for the static measurement time.

8) At the end of the measurement, record the identification results and the confidence indicator(s).

9) Repeat step j7) and j8) for a total of 10 trials.

10) Repeat step j3) through step j9) for the NORM+WGPu combination.

k) Analyze the results using Annex B, step B.2.3, and Annex C.

l) The results are acceptable when they are complete and correct in at least 9 of 10 trials.

6.10 False identification

6.10.1 Requirement

RIDs shall not identify a radionuclide that is not present when operated in a stable and low ambient radiation background.

6.10.2 Test method

The test method to determine whether an RID meets the false identification requirement is as follows:

a) Establish a position where the background is not more than 25 µR/h.

b) Place the RID at the location and allow it to update background.

c) When it is ready, initiate a static measurement.

d) If naturally occurring radionuclides such as ^{40}K are identified, actions should be taken (e.g., placing the RID in a shielded box or enclosure, removal of NORM containing material) to reduce or eliminate the source prior to obtaining 10 results. If the identified naturally occurring radionuclide cannot be removed, the identified radionuclide shall be considered an expected identification.

e) When ready, perform step c) for a total of 10 trials.

f) The results are considered acceptable when the RID identifies only expected naturally occurring radionuclides, does not identify a source, or indicates that an identification is not possible in nine out of 10 consecutive trials.

7. Environmental performance requirements

NOTE 1—The following environmental performance requirements and test methods are derived from the "handheld" portions of IEC 62706, Radiation protection instrumentation – Environmental, electromagnetic and mechanical performance requirements.

NOTE 2—The tolerance for each temperature is ±2 °C. For RH, the tolerance is ±5% RH.

7.1 Ambient temperature influence

7.1.1 Requirements

RIDs shall be able to function (including having a readable display) over an ambient temperature range from −20 °C to +50 °C. Additional testing and verification should be agreed upon between the manufacturer and customer if the manufacturer claims a broader range of operation (for example, an operating temperature range of −40 °C to +60 °C).

7.1.2 Test method

This test should be carried out in an environmental chamber. Humidity levels should be low enough to prevent condensation (<65% RH) and the temperature change rate shall not exceed 10 °C per hour. The RID shall be observed during the entire temperature test to verify it functions properly and any functional changes recorded (e.g., alarms, fault indications).

NOTE 1—A power supply placed outside of the chamber may be used to perform the test as batteries may not last for the duration of the test.

NOTE 2—Some RIDs use spectral components in the ambient background for stabilization. Although not expected, background levels within an environmental chamber may need to be raised using a NORM source to allow those RIDs to stabilize.

The test method to determine whether an RID meets the ambient temperature influence requirements is as follows:

a) Place the RID in the test chamber and allow 2 h for stabilization at the nominal temperature and relative humidity of 22 °C and <65% RH.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

   NOTE—Phantom(s) or moderation is not required for this test.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Decrease the temperature at a rate of 10 °C/h to the low temperature test point (−20 °C).

h) Maintain the low temperature test point for 16 h.

i) During the 16 h period, obtain the RID's response as described in step b), step c), and step d) at the beginning, middle, and end of the 16 h period with each source in the same position as that used to establish the acceptance range.

j) Following the low temperature exposure, increase the temperature at the 10 °C/h rate to −10 °C.

k) Allow the RID to remain at that temperature for 1 h. During the last 20 min, obtain the RID's response as described in step b), step c), and step d).

l) Increase the temperature at the 10 °C/h rate and repeat step k) at 0 °C and +40 °C.

m) Increase the temperature to the upper temperature test point (50 °C) at 10 °C/h.

n) Maintain the upper temperature test point for 16 h. Obtain the RID's response as described in step b), step c), and step d) at the beginning, middle, and end of the 16 h period.

o) Following the upper temperature exposure, return the temperature to the nominal value at the 10 °C/h rate, and after a 2 h stabilization period obtain the RID's response as described in step b), step c), and step d).

p) Analyze the results based on Annex B, step B.2, and Annex C.

7.2 Temperature shock

7.2.1 Requirements

The RID shall be fully functional within 1 h of exposure to rapid temperature changes from 22 °C to –20 °C, –20 °C to 22 °C, 22 °C to 50 °C, and 50 °C to 22 °C with each change being made in less than 5 min. The RID shall provide an indication if it is not fully functional.

7.2.2 Test method

NOTE—Some RIDs use spectral components in the ambient background for stabilization. Although not expected, background levels within an environmental chamber may need to be raised using NORM to allow those RIDs to stabilize.

The test method to determine whether an RID meets the temperature shock requirements is as follows:

a) Place the RID in the test chamber, or if the ambient conditions are acceptable, use the existing test space and allow 2 h for stabilization at the nominal temperature and relative humidity of 22 °C and <65% RH.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of three radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the three-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Move the RID into a 50 °C environment or change the temperature to 50 °C within a time of 5 min and observe the response.

h) Every 15 min for a total of 2 h, perform step b), step c), and step d).

i) Following the temperature stabilization period of 2 h, move the RID back to the 22 °C environment or change the temperature to 22 °C within a time of 5 min, observe the response, and repeat step h).

j) Following the 22 °C stabilization period of 2 h, move the RID into a −20 °C environment or change the temperature to −20 °C within a time of 5 min and observe the response.

k) Every 15 min for a total of 2 h, perform step b), step c), and step d).

l) Following the 2 h −20 °C exposure, move the RID back to the 22 °C environment or change the temperature to 22 °C within a time of 5 min, observe the response, and repeat step h).

m) The results are acceptable if after 1 h the RID correctly identifies each radionuclide in two out of three trials and the mean indicated gamma-ray exposure rate from each test point is within the acceptance range determined in step f).

7.3 Relative humidity

7.3.1 Requirement

The RID shall be fully functional when operated in relative humidity levels of up to 93% relative humidity (RH) at 35 °C.

7.3.2 Test method

NOTE—A power supply may be used to perform the test as batteries may not last for the entire duration of the test.

The test method to determine whether an RID meets the relative humidity requirement is as follows:

a) Place the RID in the test chamber and allow 2 h for stabilization at 22 °C and 40% RH.

   NOTE—Some RIDs use spectral components in the ambient background for stabilization. Although not expected, background levels within an environmental chamber may need to be raised using NORM to allow those RIDs to stabilize.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Increase the temperature at a rate not exceeding 10 °C/h to 35 °C. Once the temperature is attained, increase the humidity at a rate not exceeding 10% RH per hour until attaining 93% RH ± 3% RH.

h) Maintain the RH test point for 16 h.

i) During the 16 h period, obtain the RID's response as described in step b), step c), and step d) at the beginning, middle, and end of the 16 h period with each source in the same position as that used to establish the acceptance range.

j) Following the 16 h high-humidity exposure, reduce the humidity to 40% at the 10% RH per hour rate while maintaining the temperature at 35 °C ± 2 °C.

k) Allow the RID to stabilize for 2 h, then obtain the RID's response as described in step b), step c), and step d).

l) Following the 2 h stabilization period, return the temperature to 22 °C at the 10 °C/h rate while maintaining 40% RH. After a 2 h stabilization period, obtain the RID's response as described in step b), step c), and step d).

m) Analyze the results based on Annex B, step B.2.

7.4 Dust and moisture protection

7.4.1 Requirements

RIDs shall be protected from the ingress of dust and spraying water (rain). Dust shall not penetrate in a quantity to interfere with satisfactory operation of the instrument or to impair safety, and water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects. This is equivalent to IP Code 53 from IEC 60529.

7.4.2 Test method—Dust

The test method to determine whether an RID meets the dust protection requirement is as follows:

a) Set up the dust test chamber as needed. Talcum powder with a maximum particle diameter of 75 microns shall be used. The amount of talcum powder to be used is 2 kg/m^3 of the test chamber volume. The talc shall not have been used for more than 20 tests.

b) With the RID in position in the dust chamber, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

NOTE—The radiation sources are used to obtain relative measurements for comparison throughout the test. It is necessary that the same sources are used and that they are placed in the same position when obtaining each series of readings.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Expose the RID to the dust environment for a period of 1 h.

h) Stop the dust exposure after 1 h, allow the dust to settle, and repeat step b), step c), and step d).

i) Remove the RID from the dust chamber and inspect the unit to determine the extent of dust ingress. Particular attention shall be made to the battery compartment, display, and any other easily accessed portions of the RID.

j) Analyze the results based on Annex B, step B.2.

7.4.3 Test method—Moisture

The test method to determine whether an RID meets the moisture protection requirement is as follows:

a) Prior to positioning the RID for test, turn on the water flow to the spray nozzle. The spray nozzle should be that shown in IEC 60529:2013, Figure 4 or Figure 5 for characteristic numeral 3.

b) Turn on the water flow to the spray nozzle.

c) Adjust the water flow rate according the spray nozzle.

d) Adjust the water temperature to be not more than 5 K from the temperature of the RID under test.

e) Turn off the water and position the RID as required based on the spray nozzle.

f) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

g) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

h) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

i) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step g) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

j) Establish the acceptance range using the technique defined in Annex B, step B.1.

k) Expose all sides of the RID to the water spray starting with the nozzle directly pointed to the center of the side being exposed at a distance of 1 m. The spray nozzle or RID shall be moved during the test such that the water direction is changed between +60° and −60° in two orthogonal orientations relative to each side of the RID. The test duration shall be based on the spray nozzle used.

l) Observe the response of the RID while being exposed to the water spray and record any functional changes that may occur (e.g., alarms, fault indications).

m) When complete, repeat step f), step g), and step h).

n) Inspect the unit to determine the extent of water ingress. Particular attention shall be made to the battery compartment, display, and any other easily accessed portions of the RID.

o) Analyze the results based on Annex B, step B.2.

7.5 Extreme temperature startup

7.5.1 Requirement

RIDs shall be able to operate when switched on at the cold temperature limit (−20 °C) or high temperature limit (50 °C).

7.5.2 Test method

The test method for extreme temperature startup is as follows:

a) Place the RID in the test chamber and allow 2 h for stabilization at the nominal temperature and relative humidity of 22 °C and <65% RH.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf, respectively. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Switch off the RID

h) Decrease the temperature in the chamber at a rate of 10 °C/h to −20 °C.

i) Allow the temperature to stabilize for a period of 4 h.

j) Switch on the RID and after the manufacturer's specified warm-up period repeat step b), step c), and step d).

k) Remove the sources and switch off the RID.

l) Increase the temperature to 22 °C at a rate of 10 °C/h and allow the temperature to stabilize for a period of 4 h.

m) Switch on the RID and, after the manufacturer's specified warm-up period, repeat stepb), step c), and step d). Then switch off the RID.

n) Increase the temperature in the chamber at a rate of 10 °C/h to 50 °C.

o) Allow the temperature to stabilize for a period of 4 h.

p) Switch on the RID and after the manufacturer's specified warm-up period repeat step b), step c), and step d).

q) Remove the sources and switch off the RID.

r) Decrease the temperature in the chamber at a rate of 10 °C/h to 22 °C.

s) Allow the temperature to stabilize for a period of 4 h.

t) Switch on the RID and, after the manufacturer's specified warm-up period, repeat stepb), step c), and step d).

u) Analyze the results based on Annex B, step B.2.

8. Electromagnetic performance requirements

NOTE—The following electromagnetic performance requirements and test methods are derived from the "handheld" portions of IEC 62706, Radiation protection instrumentation – Environmental, electromagnetic and mechanical performance requirements.

8.1 Radio frequency

8.1.1 Requirement

An RID should not be affected by radio-frequency (RF) fields over the frequency range of 80 MHz to 2500 MHz. The field intensity shall be 10 V/m over the frequency range from 80 MHz to 1000 MHz. For frequencies over 1000 MHz, the intensity shall be 3 V/m.

NOTE—Wireless interface technologies may not work in the presence of RF.

8.1.2 Test method

The susceptibility test shall be performed with and without radiation sources (background only). Statistical requirements are not used for background-only testing.

a) Place the RID in the test chamber oriented with the display facing the RF emission source. Stands or other supports shall be used when necessary to prevent accidental grounding of the RID. Although polystyrene is not recommended for use when testing with neutrons, it is permitted and recommended for RF testing since the response from testing is relative to the response with the RF field present.

   NOTE 1—The test orientation is based on where an RID may be most likely susceptible to RF. Other orientations may be selected based on a physical inspection of the RID case, e.g., cable connections, switch locations.

   NOTE 2—Some RIDs use spectral components in the ambient background for stabilization. Although not expected, background levels within an environmental chamber may need to be raised using NORM to allow those RIDs to stabilize.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{137}Cs and ^{252}Cf, respectively. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

e) Establish the acceptance range using the technique defined in Annex B, step B.1.

f) Set up the RF generation system to produce the required intensity at the reference position over a frequency range of 80 MHz to 2500 MHz that is 80% amplitude modulated with a 1 kHz sine wave. The test should be performed using an automated sweep at a frequency change rate ≤1% of the fundamental (previous) frequency. Dwell time at each frequency should be chosen based on the monitor's response time, but should be ≥3 s.

g) With the sources in position, expose the RID to the RF field.

h) Observe the response of the RID during the RF exposure. Record any functional changes that may occur (e.g., alarms, fault indications) and the frequency ranges where the gamma or neutron response went outside of the acceptance range.

i) Without changing the positions of the source(s) or RID, repeat the RF exposure over the frequency ranges where the response was outside of the acceptance range to verify susceptibility, as needed.

j) Remove the sources and repeat step f) through step h). Due to the low response levels, the use of an acceptance range is not required.

k) For the background-only test, the results are acceptable if no reproducible alarms, spurious indications, or repeatable changes in response occur during RF exposure.

l) For the test performed using sources, analyze the results based on Annex B, step B.2.

8.2 Radiated emissions

8.2.1 Requirement

The electromagnetic (EM) fields emitted by the RID at 3 m shall be less than what is shown in Table 5.

Table 5—Emission frequency limits

Emission frequency range (MHz)	Field strength (µV/m at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
>960	500

8.2.2 Test method

The method of testing for radiated emissions is as follows:

a) Place the RID in an area with a low and controlled RF environment.

b) Position an antenna 3 m from the RID in an orientation where RF emissions may be likely (e.g., openings, cable penetrations, display). A distance of 1 m may be used with the emission levels adjusted accordingly.

NOTE 1—The device under evaluation may be rotated using a turntable while monitoring the RF spectrum to identify the location of RF emissions.

NOTE 2—Some RIDs use spectral components in the ambient background for stabilization. Although not expected, background levels within an environmental chamber may need to be raised using NORM to allow those RIDs to stabilize.

c) With the RID turned off, collect a background RF spectrum using a scanning bandwidth of 120 kHz over a range from 30 MHz to 1000 MHz.

d) Once the RID is operational, perform an RF scan with the antenna in the vertical orientation.

e) Record emissions that are greater than the values stated in Table 5.

f) If no RF emissions are observed, proceed to step g). If observed RF emissions are greater than the values stated in Table 5, additional testing is not required.

g) Rotate the antenna to the horizontal orientation and repeat step d) and step e).

8.3 Magnetic field

8.3.1 Requirements

The RID shall be fully functional when exposed to a 100 A/m (1.3 G) 60 Hz magnetic field. The indication of the magnitude of the radiation field as well as any spectral response shall not change while being exposed in three mutually orthogonal orientations relative to the magnetic field. The test shall be performed with radiation sources and without radiation sources (background only).

8.3.2 Test method

The method of testing to determine whether an RID meets the magnetic field requirements is as follows:

a) Place the RID in the magnetic field generator.

b) Expose the RID to the required magnetic field, observe the response, and record whether any alarms, spurious indications, or reproducible changes in response occur.

c) Repeat the test for each orientation as stated in the requirements.

d) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

e) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

f) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series.

g) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step e) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

h) Establish the acceptance range using the technique defined in Annex B, step B.1.

i) With the ^{133}Ba, ^{60}Co, and ^{252}Cf sources in position, expose the RID to the magnetic field as required.

j) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series.

k) Repeat step j) in each orientation.

l) Analyze the results based on Annex B, step B.2.

8.4 Electrostatic discharge

8.4.1 Requirement

The RID shall not be affected by exposure to electrostatic discharges (ESDs) at intensities of up to ±6 kV using the contact discharge technique.

8.4.2 Test method

The method of testing to determine whether an RID meets the electrostatic discharge requirement is as follows:

a) Prior to proceeding with the test, identify three appropriate discharge points. Discharge points should be selected based on user accessibility (e.g., handle, user buttons, maintenance access points).

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in sections 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Using the contact discharge technique as described in IEC 61000-4-2, expose the RID to 10 positive and 10 negative 6 kV discharges per each of the three discharge points with a 1 s recovery time between each discharge. The current return path should be established by attaching the discharge device ground clip to the RID.

h) Observe the response, and record whether any reproducible changes (e.g., alarms, spurious indications) occur.

i) When the test is complete, repeat step b), step c), and step d).

j) Analyze the results based on Annex B, step B.2.

9. Mechanical performance requirements

NOTE—The following mechanical performance requirements and test methods are derived from the "handheld" portions of IEC 62706, Radiation protection instrumentation – Environmental, electromagnetic and mechanical performance requirements [B6].

9.1 Vibration

9.1.1 Requirements

RIDs shall withstand exposure to vibrations associated with the operation of handheld or hand-carried equipment. The physical condition and functionality of an RID shall not be affected during or after the exposure (e.g., solder joints shall hold, nuts and bolts shall not come loose).

The test conditions chosen are based on a review of MIL-STD 810 and IEC 60721-3-7, "Classification of groups of environmental parameters and their severities – Portable and non-stationary use."

9.1.2 Test method

The method of testing to determine whether an RID meets the vibration requirements is as follows:

a) Set up the test equipment and position the RID as required. The test is performed in three orthogonal orientations. It is recommended that the first orientation be with the handle facing up and the opposite side against the shock table. The second orientation to have the long side of the instrument resting on the table and the last orientation having the short side against the table.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Subject the RID to a random vibration at 0.01 g^2/Hz (spectral density) using 5 Hz and 500 Hz as the frequency endpoints for a period of 1 h.

h) Observe the response and record whether any alarms or changes in response occur.

i) At 30 min into the 1 h vibration, perform step b) and step c) with the sources placed in the same position as used prior to the vibration and without stopping the vibration.

j) After the 1 h vibration interval, stop the vibration and repeat step b), step c), and step d) with the sources in the same position relative to the RID.

k) Repeat step g) through step j) for the remaining two orthogonal orientations.

l) When complete and with the vibration stopped, repeat step b), step c), and step d).

m) Inspect the RID for mechanical damage and loose components. If internal inspection is not possible, check for loose components by gently shaking the RID. Document the results from the inspection.

n) Analyze the results based on Annex B, step B.2.

9.2 Mechanical shock

9.2.1 Requirements

RIDs shall function properly after exposure to shock pulses of 50 g peak acceleration, each applied for a nominal 11 ms in each of three mutually orthogonal axes.

The physical condition of an RID shall not be affected by these shocks (e.g., solder joints shall hold; nuts and bolts shall not come loose).

9.2.2 Test method

The method of testing to determine whether an RID meets the mechanical shock requirements is as follows:

a) Set up the test equipment and position the RID as required. The test is performed in three orthogonal orientations. It is recommended that the first orientation be with the handle facing up and the opposite side against the shock table. The second orientation to have the long side of the instrument resting on the table and the last orientation having the short side against the table.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Subject the RID to 10 pulses of peak acceleration of 50 g (half-sine-wave pulse), each applied for a time interval of approximately 11 ms. Additional setup information can be found in IEC 60068-2-27.

h) Observe the response and record whether any alarms, including type, or changes in response occur.

i) After each set of 10 shocks, repeat step b), step c), and step d) with the sources in the same position relative to the RID.

j) Repeat step g) through step i) for the remaining two orthogonal orientations.

k) When exposure to the mechanical shocks is complete, repeat step b), step c), and step d).

l) Inspect the RID for mechanical damage and loose components. If internal inspection is not possible, check for loose components by gently shaking the RID. Document the results from the inspection.

m) Analyze the results based on Annex B, step B.2.

9.3 Impact (microphonics)

9.3.1 Requirement

The RID's response, both gamma-ray and neutron, shall be unaffected by microphonic conditions such as those that may occur from low-intensity impacts from sharp contact with hard surfaces.

9.3.2 Test method

The method of testing to determine whether an RID meets the impact requirement is as follows:

a) Set up the test equipment and position the RID as required.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Using an appropriate test device (i.e., spring hammer), expose each side and the top and bottom of the RID to three 0.2 J intensity impacts each.

h) Observe the response and record whether any alarms, including type, or changes in response occur.

i) After the impacts, repeat step b), step c), and step d) with the sources in the same position relative to the RID.

j) Analyze the results based on Annex B, step B.2.

9.4 Drop

9.4.1 Requirements

Handheld instruments such as RIDs may be dropped during normal use. As a result, RIDs should be designed to withstand being dropped from a height of 1 m onto a concrete surface.

9.4.2 Test method

The test method for drop is as follows:

a) Set up the test equipment and position the RID as required.

b) With the RID in position for test, expose it to a gamma-ray and neutron radiation field (when applicable) using ^{133}Ba and ^{60}Co simultaneously, and ^{252}Cf. Each source should be located at distances that are similar to those used in 6.8.3 and 6.4, respectively. The goal is to produce a similar response to that obtained when the tests in the referenced subclauses were performed.

c) Record 10 readings (i.e., exposure rates, count rates) with the source(s) present.

d) Perform a series of 10 radionuclide identifications with ^{133}Ba and ^{60}Co, and record the identification results including the confidence indicators. Collect at least one spectrum from the 10-trial series. Remove the sources.

e) Calculate and record the mean, standard deviation, and coefficient of variation (COV) for data obtained in step c) only. The COV should be less than or equal to 12% for the gamma channel. If the COV from the gamma readings is greater than 12%, the radiation level should be increased to reduce the variation between readings. Due to the possible low response of the neutron detector, a COV > 12% is acceptable for the neutron channel.

f) Establish the acceptance range using the technique defined in Annex B, step B.1.

g) Drop the RID from a height of 1 m onto concrete. The drop shall be controlled to cause the RID to land on its bottom surface and not topple following the drop.

h) After the drop, repeat step b), step c), and step d).

i) Inspect the RID for mechanical damage and loose components. If internal inspection is not possible, check for loose components by gently shaking the RID. Document the results from the inspection.

j) Analyze the results based on Annex B, step B.2.

10. Documentation

10.1 Report

The manufacturer shall provide the following information, as a minimum:

a) Contact information for the manufacturer including name, address, telephone number, fax number, e-mail address, etc.

b) Model name or number, serial number, and software and firmware version numbers.

c) Type of radiation detector(s) used (e.g., NaI, CZT, HPGe, ^{3}He). If pressurized detectors are used (e.g., ^{3}He), the manufacturer shall state the size, pressure, and volume of the detector.

d) Size and weight (with batteries installed).

e) Manufacturer's website information.

f) Battery requirements.

g) Recommended operational parameters such as detector response, false alarm probability, alarm thresholds, operating parameters, and radionuclide library(s).

h) Static measurement time.

i) Complete description of the RID.

j) Case specification classification.

k) Inclusion of any hazardous material that may require additional regulation (such as radionuclide check source, pressurized gases, corrosive materials).

l) List of radionuclides that are identified by the RID.

m) Description of the confidence level indication.

n) Exposure or dose-equivalent rate range.

o) Exposure or dose-equivalent rate calibration results.

p) Over-range exposure rate values for gross counting and identification.

q) Energy range.

r) Full width-half max (FWHM) value for ^{137}Cs

10.2 Operation and maintenance manual

The manufacturer shall supply an operation and maintenance manual (paper or electronic) containing the following information for the user:

a) Operating instructions and restrictions

b) Functional verification process

c) Spare parts list

d) Troubleshooting guide

e) Description and protocol for communication methods of transmitting and receiving data

f) Photos or schematic drawings that describe the location of the detector(s) and associated reference point(s)

Annex A

(informative)

Bibliography

Bibliographical references are resources that provide additional or helpful material but do not need to be understood or used to implement this standard. Reference to these resources is made for informational use only.

[B1] ANSI C63.4, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.[7]

[B2] ANSI N42.22, American National Standard—Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control.

[B3] ANSI N42.23, American National Standard Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories.

[B4] FCC Rules, Code of Federal Regulations, Title 47, Part 15, Radio Frequency Devices.[8]

[B5] IAEA Safety Guide No. RS-G-1.9, Categorization of Radioactive Sources.[9]

[B6] IEC 62706, Radiation protection instrumentation – Environmental, electromagnetic and mechanical performance requirements.

[B7] ISO 8601 Data elements and interchange formats—Information interchange—Representation of dates and times.[10]

[B8] ISO/IEC 4037-3, X and Gamma Reference Radiation for Calibrating Dosemeters and Doserate Meters and for Determining the Response as a Function of Photon Energy—Part 3: Calibration of Area and Personal Dosemeters and Measurement of Their Response as a Function of Energy and Angle of Incidence.

[B9] MIL-STD-1472G, DoD Design Criteria Standard: Human Engineering.[11]

[7] ANSI C63® publications are available from the Institute of Electrical and Electronics Engineers (http://standards.ieee.org/) and the American National Standards Institute (http://www.ansi.org/).
[8] CFR publications are available from the U.S. Government Publishing Office (http://www.ecfr.gov/).
[9] IAEA publications are available from the International Atomic Energy Agency (http://www.iaea.org/).
[10] ISO publications are available from the International Organization for Standardization (http://www.iso.ch/). ISO publications are also available in the United States from the American National Standards Institute (http://www.ansi.org/).
[11] MIL publications are available from DLA Document Services (http://quicksearch.dla.mil/).

Annex B

(normative)

General test method

This annex provides information for test setup and execution.

B.1 Determination of test acceptance range for a confidence interval of 95%

The tests described in Clause 7, Clause 8, and Clause 9 use an acceptance range based on the mean value and standard deviation derived from a series of measurements (e.g., count rate, exposure rate). The range is typically ±15% adjusted to compensate for the standard deviation determined at nominal conditions. The following process is used to determine the acceptance range:

a) Position the test source(s) as required and collect 10 readings without moving the source(s). There should be a minimum of three update intervals between each reading enabling each reading to be independent.

b) Calculate and record the mean response and experimental standard deviation for the series of readings.

c) Use the following equation to calculate the 95% confidence interval (CI) for a sample size of n.

$$^{95\%}\mathrm{CI}_n = t_n \times \frac{s}{\sqrt{n}}$$

where

t_n is the two-sided Student's t value for 95% confidence interval for a sample size of 10 ($t_{10} = 2.26$)
s is the experimental standard deviation for the series of measurements
n is the number of measurements ($n = 10$)

d) Multiply the mean value by 15% and then add the value $^{95\%}\mathrm{CI}_n$.

e) Add the value from step d) to the mean value to establish the upper limit and subtract the value from step d) from the mean value to establish the lower limit. The upper and lower limits establish the acceptance range.

B.2 Test result analysis

B.2.1 Functionality

The results are acceptable if there are no unexpected alarms or fault indications during the test.

B.2.2 Radiation response

Analyze the radiation response as follows:

a) Calculate the mean and standard deviation from each series of readings and determine the confidence interval for each series of readings as described in B.1.

b) Calculate the value $^{95\%}CI_n$ from step B.1.3.

c) Establish the confidence interval by adding and subtracting $^{95\%}CI_n$ from the mean.

d) If the entire interval is within the acceptance range, the response results are acceptable. If the entire interval is outside of the acceptance range, the response results are unacceptable. If the interval is partially within the acceptance range, the response results may be considered conditionally acceptable.

B.2.3 Identification results

For environmental or other similar tests, the identification results are acceptable if the complete and correct results at each test point from each series of identifications are the same as or better than the identification results obtained prior to the test. For example, if the 10-trial results prior to a test are complete and correct in 6 out of 10 trials, the complete and correct results at each test point shall be six or more.

B.2.4 Test-caused degradation (informative)

It is recommended that whenever multiple tests are performed, initial pre-test response values could be obtained and used to determine if there is a degradation of the RID as testing proceeds. The initial pre-test values may be obtained from each detector based on the design of the RID and availability of response data. A test position should be marked on the exterior of the RID to indicate where each source is placed ensuring reproducibility. The test position(s) may also be used to obtain pre-test readings when performing individual tests. For test-caused degradation, the sources may be different than those used to perform the test methods established in this standard. The critical item is position reproducibility.

The initial pre-test readings are obtained using the following technique:

a) Switch the RID on and allow it to start up in accordance with the manufacturer's instructions.

b) Determine a location that could be marked as the initial pre-test gamma response position and place the ^{137}Cs and ^{60}Co sources from Table 4 at that location. They may be in contact with the detector assembly case.

c) With the sources in position, collect a series of 10 gamma count rate readings and a spectrum.

d) Remove the gamma sources.

e) Determine a location that could be marked as the initial pre-test neutron response position and place the ^{252}Cf source assembly from Table 4 at that location.

f) Record a series of 10 neutron count rate readings.

g) Calculate and record the mean value and experimental standard for each series of readings.

h) Calculate $^{95\%}CI_n$ as defined in step B.1.3. The value $^{95\%}CI_n$ is added and subtracted to each mean value to establish the upper and lower limits.

   NOTE—This response range is for indication only and not for pass or fail determination.

i) Record the ranges for use during the testing process.

j) To determine if response changes may have occurred, place the sources in the reference positions established in step b) and step e) and perform the measurement process stated in step c) and step d), step f) and step g).

k) Compare the readings with the response range to determine if changes may have occurred.

l) To determine if spectral changes have occurred, compare the peak positions from the performance of step c) with the peak positions from the initial pre-test spectrum.

Annex C

(informative)

Guidance regarding identification performance

This annex is a summary of the definitions used to characterize identification results for spectrometric systems. The described technique was developed as a means to analyze results obtained from spectral injection studies at the International Atomic Energy Agency.

C.1 Complete and correct

— Source "X" identified as "X"

— Sources "X+Y" identified as "X+Y"

For example:

— $^{235}U \rightarrow {}^{235}U$

— $^{235}U \rightarrow {}^{235}U + {}^{40}K$

— $^{235}U \rightarrow {}^{235}U + {}^{40}K + {}^{232}Th$

— $^{235}U \rightarrow {}^{235}U + {}^{40}K + {}^{232}Th + {}^{226}Ra$

— $^{235}U + {}^{67}Ga \rightarrow {}^{235}U + {}^{67}Ga + {}^{40}K + {}^{232}Th + {}^{226}Ra$

Complete and correct may also include daughter(s) and impurities of the target radionuclide(s). Table C.1 provides a list of daughters and possible impurities.

C.2 Incomplete

— Source "X+Y" identified as "X" or "Y"

For example:

— $^{235}U + {}^{226}Ra \rightarrow {}^{226}Ra$

C.3 Incorrect

— Source "X" identified as "X + Y"

For example:

— $^{235}U \rightarrow {}^{235}U + {}^{237}Np$

— $^{67}Ga \rightarrow {}^{235}U + {}^{67}Ga$

C.4 Incomplete and incorrect

- Source "A" being identified as "C"
- Source "A+B" identified as "C+D"

For example:

- $^{235}U \rightarrow {}^{67}Ga$
- $^{235}U + {}^{137}Cs \rightarrow {}^{99m}Tc + {}^{133}Ba$

Table C.1—List of daughters and possible impurities

Radionuclide(s)/materials	Daughters and possible impurities
^{201}Tl	^{202}Tl
DU	^{235}U, ^{226}Ra
WGPu	^{242}Pu, ^{241}Pu, ^{240}Pu, ^{238}Pu, ^{241}Am, ^{237}U, ^{242}Pa, ^{233}U
HEU	^{238}U, ^{234m}Pa
^{99m}Tc	^{99}Mo
^{232}Th	^{228}Th, ^{232}U
^{226}Ra	^{214}Bi, ^{214}Pb

Annex D

(informative)

Guidance regarding adjudication and resolution of radiation alarms for state and local agencies

D.1 Scope of Annex D

This annex defines the data collection process as required by those who analyze RID spectral field measurement results and the composition of the required data package.

State and local agencies may implement similar procedures to adjudicate many radiation alarms at a local level. In certain cases, alarms should be adjudicated through National Level Reachback, in accordance with the guidance below.

Per the "National Detection Response Protocol," state and local agencies are expected to perform the procedures outlined below and contact National Level Reachback in a manner consistent with your local protocol in the event that:

a) Neutrons are detected and are not associated with properly licensed and/or manifested radiological material.

b) Special nuclear material is present, suspected, or cannot be ruled out and is not part of a legitimate shipment to and from authorized Nuclear Regulatory Commission (NRC) licensees.

c) A radiation source is suspicious or cannot be identified or authenticated.

d) Agencies are not able to adjudicate the event for some reason.

Operators should notify the local FBI Field Office in accordance with established protocols if any of the events in step a) through step d) are encountered.

D.2 Possible data collection process

Once the measurement position has been identified (e.g., after localization of the radioactive source), perform the following measurements:

a) Collect 5 min of background data at a distance where the radioactive object is not affecting the radiation background. Record the file name as required.

b) If a suitable calibration source is available, obtain a 5 min source measurement. Record the file name as required.

c) Position the RID as needed to obtain the most favorable response and collect a 5 min object measurement. Record the file name as required.

D.3 Data package content

This subclause defines what is needed from the operator and RID for analysis. The needed information could be obtained as a single package automatically generated by the RID or manually by the operator through e-mail or files attached to an e-mail. The individual file structure for each spectrum shall be in the ANSI N42.42 data format.

a) If the RID has the ability to directly send files, the file packet should only include the spectra obtained during the data collection process along with any supporting information.

b) Move the data collection process files from the RID to the transfer platform as required.

c) Verify that all collected information is included

    1) 5 min background data

    2) 5 min energy-calibration data

    3) 5 min object data

    4) Measurement specifics

        i) Name and contact information

        ii) Location

        iii) Time

        iv) Estimated source-to-detector distance

        v) Estimated detector height and source height (if known)

Consensus

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