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American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security

Accredited by the American National Standards Institute

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National Committee on Radiation Instrumentation, N42

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Secretariat
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Abstract: Performance specifications, design criteria, and testing methods are provided for the evaluation of radiation detection instruments that are pocket sized and carried on the body.
Keywords: alarming, design criteria, performance specifications, pocket-sized, personal radiation detectors, radiation, radiation detection, radiation instrumentation

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Introduction

(This introduction is not part of ANSI N42.32-2003, American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security.)

This standard is the responsibility of the Accredited American Standards Committee on Radiation Instrumentation, N42. The standard was approved on N42 letter ballot of July–August 2003.

Participants

At the time it approved this standard, the Accredited Standards Committee on Radiation Instrumentation, N42, had the following members:

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American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security

1. Overview

1.1 Scope

This standard describes design and performance criteria along with testing methods for evaluating the performance of instruments for homeland security that are pocket-sized and carried on the body for the purpose of detecting the presence and magnitude of radiation. This standard specifies the performance criteria for radiation detection and measurement instruments that may be used in a variety of environmental conditions. The performance criteria contained in this standard are meant to provide a means for verifying the capability of these instruments to reliably detect significant changes above background levels of radiation and alert the user to these changes.

1.2 Purpose

The purpose of this standard is to specify performance criteria and test methods used to evaluate self-reading, alarming radiation detection instruments that are pocket-sized, carried on the body and used to detect the presence of ionizing radiation.

1.3 Need

Methods and devices are needed to detect the presence of radioactive sources that may be illegally transported, deliberately placed, or dispersed to cause harm.

Radiation detection instruments are used to determine the presence and magnitude of radioactive material or respond to incidents involving the release of radiation. One of the methods employed to detect and measure radiation relies on the use of self-reading, alarming instruments that are pocket-sized and carried on the body. These instruments are required to alert the user to the presence of a source of radiation that is distinctly above the level of local background radiation. Dose or dose rate measuring instruments may also be carried to evaluate the potential for harmful biological effects of the radiation, but specifications and tests for these types of instruments are provided in other ANSI standards listed and in the Bibliography in Annex A.

1.4 Relationship to other standards

This standard is one of a group of standards along with ANSI N42.33-2003 [B11], ANSI N42.34-2003 [B12], and ANSI PN42.35 [B13][1] that deal with other radiation detection, measurement and identification instrumentation for Homeland Security applications. This standard is generally consistent with standards being developed by Subcommittee 45B (SC 45B) of IEC Technical Committee 45 (IEC TC45) on Nuclear Instrumentation and SC 2 of ISO TC 85 on Nuclear Energy, but it does not use the International Commission on Radiation Units and Measurements (ICRU) operational quantities given in those documents because they have not yet been adopted in the United States.

This standard does not apply to the performance of health physics instrumentation, which is covered in ANSI N42.17A-1989 [B16], N42.17C-1989 [B18] and N42.20-2003 [B19]. The instruments covered by this standard are not intended to measure the dose equivalent for radiation workers. This standard does not supersede ANSI N42.17A-1989, ANSI N42.17C-1989, and ANSI N42.20-2003.

1.5 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 “may” signifies an acceptable method or an example of good practice.
— The word “should” signifies a recommended specification or method.

2. References

This standard shall be used in conjunction with the following publications.

ANSI N42.22-1995 (R2002), American National Standard—Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control.[2]

ANSI N42.23-1996, American National Standard Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories.

IEC 61000-4, Electromagnetic Compatibility (EMC)—Part 4: Testing and Measurement Techniques. (All Sections.)[3]

3. Definitions

The following definitions apply for ANSI N42.32-2003, ANSI N42.33-2003 [B11], ANSI N42.34-2003 [B12], and ANSI PN42.35 [B13] that have been developed at the request of the Department of Homeland Security (DHS) for instruments to be used by DHS and emergency responders.

[1]The numbers in brackets correspond to those of the bibliography in Annex A.

[2]ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[3]IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

3.1 A-weighted sound level: The frequency weighting of an acoustic spectrum according to a standardized frequency response curve based on the frequency response of the human ear.

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

3.3 accepted ambient photon background: The background radiation as measured using a high pressure ionization chamber, an energy compensated Geiger-Mueller (G-M) tube, an energy compensated proportional counter, a tissue equivalent plastic scintillator, a scintillator with spectral compensation, or any other exposure rate meter having a nearly constant energy response (±30% in the energy range from 200 keV to 1.5 MeV).

3.4 accredited testing laboratory: Testing laboratory that has been accredited by an authoritative body with respect to its qualifications to perform verification tests on the type of instruments covered by this standard.

3.5 accuracy: The degree of agreement of the observed value with the conventionally true value of the quantity being measured.

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

3.7 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.

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

3.9 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.

3.10 check source: A not necessarily calibrated source that is used to confirm the continuing functionality of an instrument.

3.11 conventionally true value (CTV): The commonly accepted best estimate of the value of that quantity. This and the associated uncertainty will preferably be determined by a national or transfer standard, or by a reference instrument which 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 N42.22-1995 and ANSI N42.23-1996.)

3.12 decade: A range of values for which the upper value is a power of ten above the lower value.

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

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

3.15 effective center: For a given set of irradiation conditions, the point within a detector where the response is equivalent to that which would be produced if the entire detector were located at the point.

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

3.17 energy dependence: Variation in instrument response as a function of radiation energy for a constant radiation type and exposure rate referenced to air.

3.18 exposure: The measure of ionization produced in air by x or gamma radiation. The sum of electrical charges of all ions of either sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the roentgen per hour, abbreviated in this standard as R/h for exposure rate.

NOTE—In this standard, the International System (SI) units sievert (Sv) or gray (Gy) follow in parentheses the Roentgen value R, though the two units are not physically equivalent.

3.19 false alarm: Alarm NOT caused by a radioactive source under the specified background conditions.

3.20 functional check: A frequently used qualitative check to determine that an instrument is operational and capable of performing its intended function. Such checks may include, for example, battery check, zero setting, or source response check.

3.21 indicated value: **(A)** A scale or decade reading. **(B)** The displayed value of the readout. *See also:* **reading**.

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

3.23 influence quantity: Quantity that may have a bearing on the result of a measurement without being the subject of the measurement.

3.24 innocent alarm: An alarm resulting from an actual increase in radiation level, but for reasons that are not due to the detection of illicit radioactive materials.

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

3.26 instrument-hour: The number of operating instruments multiplied with the amount of time they are operating (e.g. 8 instruments operating for 3.75 hours is equivalent to 30 instrument hours).

3.27 interdiction: Stopping the illicit or inadvertent movement of radioactive material that has been discovered as a result of radiation detection or measurement.

3.28 monitoring: Means provided to continuously indicate the state or condition of a system or assembly.

NOTE—The real time measurement of radioactivity or radiation level.

3.29 overload response: The response of an instrument when exposed to radiation intensities greater than the upper measurement limit.

3.30 performance test: An evaluation of the performance of an instrument in response to a given influence quantity.

3.31 point of measurement: Place at which the conventionally true values are determined and at which the reference point of the instrument is placed for test purposes.

3.32 precision: Degree of agreement of repeated measurements of the same parameter.

3.33 range: All values lying between the detection limit and the upper measurement limit.

3.34 reading: The indicated or displayed value of the readout.

3.35 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 some influence quantity.

3.36 reference point of an instrument: 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.

3.37 relative error (ε_{REL}): The difference between instrument's reading, *M*, and the conventionally true value, *CTV*, of the quantity being measured divided by the conventionally true value multiplied by 100%.

$$\varepsilon_{\mathrm{REL}} = [(M - CTV)/(CTV)] \times 100\%$$

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

3.39 response time: The time interval required for the instrument reading to change from 10 percent to 90 percent of the final reading or vice versa, following a step change in the radiation field at the detector.

3.40 restricted mode: An advanced operating mode that can be accessed by an expert user (e.g.: 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, etc.). May be called the "advanced" or "expert" mode.

3.41 routine test: Test that applies to each independent instrument to ascertain compliance with specified criteria

3.42 standard deviation: The positive square root of the variance.

3.43 standard instrument or source: **(A)** National standard—a standard determined by a nationally recognized competent authority to serve as the basis for assigning values to other standards of the quantity concerned. In the U.S., this is an instrument, source, or other system or device maintained and promulgated by the National Institute of Standards and Technology (NIST). **(B)** Primary standard—a standard that is designated or widely acknowledged as having the highest metrological qualities and whose value is accepted without reference to other standards of the same quantity. **(C)** Secondary standard—a standard whose value is assigned by comparison with a primary standard of the same quantity. **(D)** Reference standard—a standard, generally having the highest metrological quality available at a given location or in a given organization, from which measurements made there are derived. **(E)** Working standard—a standard that is used routinely to calibrate or check material measures, measuring instruments, or reference materials. A working standard is traceable to NIST (see ANSI N42.22-1995 and ANSI N42.23-1996).

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

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

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

3.47 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.

3.48 upper measurement limit (UML): The UML is the maximum level at which the instrument meets the required accuracy.

3.49 variance (σ^2): A measure of dispersion, which is the sum of the squared deviation of observations from their mean divided by one less than the number of observations.

$$\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

4. General considerations

The tests in this standard are to be considered as Type Tests (see Table B.1 in Annex B) unless otherwise stated. The specifications given are evaluated by the tests given in this standard. For tests to conform to this standard, they shall be performed using the same conditions with any accessories included with the instruments. Where no test is specified, it is understood to mean that the characteristic can be verified by observation or consultation of the manufacturer's specifications. The user may employ certain parts of the standard as Acceptance Tests.

4.1 Reference conditions and standard test conditions

The required standard test conditions for environmental quantities, such as temperature and pressure, as well as those for other quantities that may influence the performance of instruments, are given in Table 1. Acceptable testing ranges for these quantities as given in Table 1 shall be met, except where the effect of the condition or quantity itself is being tested. Environmental quantities, such as temperature and humidity, are referred to as influence quantities. Measurements or calibrations should be carried out under reference conditions. Since this is not always achievable or convenient, a small interval around the reference values can be used. In general, corrections to the reference conditions are made.

Table 1—Reference conditions and standard test conditions

Influence quantity	Reference conditions (unless otherwise indicated by the manufacturer)	Standard test conditions (unless otherwise indicated by the manufacturer)
Stabilization time	≤ 1 min	≤ 1 min
Ambient temperature	20 °C	18 °C to 22 °C
Relative humidity	65%	50% to 75%
Atmospheric pressure	101.3 kPa (760 mm of mercury at 0 °C)	70 kPa to 106.6 kPa (525 to 800 mm of mercury at 0 °C)
Battery voltage	Nominal voltage	Battery used up to half of its useful life
Reference Point	Effective center as marked	Effective center as marked

Table 1—Reference conditions and standard test conditions *(continued)*

Influence quantity	Reference conditions (unless otherwise indicated by the manufacturer)	Standard test conditions (unless otherwise indicated by the manufacturer)
Electromagnetic field of external origin	Negligible	Negligible
Magnetic induction of external origin	Negligible	Negligible
Instrument controls	Set up for normal operation	Set up for normal operation
Radiation background	Less than ambient photon exposure rate of 25 μR/h	Ambient photon exposure rate of 10 μR/h or less if practical
Contamination by radioactive elements	Negligible	Negligible
Reference photon radiations		^{241}Am, ^{137}Cs, ^{60}Co
Reference neutron radiation		^{252}Cf
NOTE—The characteristics of, and dosimetry methods for, the reference photon radiations are given in ISO 4037-1:1996 [B25] and ISO 4037-2:1997 [B26] and the characteristics of, and dosimetry methods for, the reference neutron radiations are given in ISO 8529-1:2001 [B27] and ISO 8529-2:2000 [B28]. The calibrations of these sources shall be traceable to NIST (see ANSI N42.22-1995 and ANSI N42.23-1996).		

For the purposes of this standard, the radiological unit μGy will be assumed to be interchangeable with the unit μR, and the quantity air kerma will be assumed to be interchangeable with the quantity, exposure, for photon irradiation, since for the photon energies of interest are not significantly different. For neutron irradiation, the unit s^{-1} cm^{-2} will be used. Conventional units are given with SI units in parentheses.

5. Performance requirements

5.1 General requirements

Instruments addressed by this standard are carried on the body and are used to detect and indicate the presence and magnitude of ionizing radiation. These devices are not primarily intended to provide a measurement of dose equivalent rate. However, their indication can provide an approximate value of exposure rate that should be reasonably accurate. Health physics instruments that are primarily intended to provide a measurement of dose equivalent, or dose equivalent rate, should be tested using ANSI N42.17A-1989 [B16] and ANSI N42.20-2003 [B19].

There are a number of general requirements for instruments to be tested using this standard, described in 5.1.1 through 5.1.3.

5.1.1 Controls

Controls shall be clearly identified, easily operable under conditions of expected use, and have provisions to reduce the possibility of inadvertent changes in controls.

5.1.2 Procedure instructions

Manufacturers shall provide instructions for procedures, or functional checks, used to verify proper operation of the instrument in addition to the documentation described in Clause 7 of this standard.

5.1.3 Displays and alarms

Displays and alarms shall provide the user with an instantly recognizable indication of the fact that the magnitude of radiation present has exceeded the alarm set point. Methods used to display readings and annunciate alarms shall be appropriate to the conditions of expected use. Displays shall be readable in low-light conditions as provided, for example, by backlit liquid crystal displays or light emitting diodes that enable readings in low-light conditions.

For use in potentially explosive atmospheres, instruments shall comply with UL 913-2002 [B3].

5.2 Mechanical requirements

These mechanical design specifications are given to ensure that instruments designed for the specific purposes outlined in the scope of this standard are tested.

5.2.1 Size

The overall dimensions of the instruments, excluding any clip, retaining device or external alarm, should not exceed 8 in (20 cm) in length, 4 in (10 cm) in width and 2 in (5 cm) in thickness, unless it is incorporated into another device.

5.2.2 Weight

The weight of the complete instrument should not exceed 0.9 lb (400 g).

5.2.3 Case construction

The instrument case should be smooth, rigid, resistant to mechanical shock, dust resistant and water resistant. Means shall be provided to securely affix the instrument to the user (for example, a clip, ring, or lanyard), with attention given to the necessary orientation of the detector, alarm type, and display.

5.2.4 Reference point marking

The instrument when tested should have markings indicating the position of the reference point on both the front, or back, and side of the instrument. The reference orientation with respect to the wearer should also be marked on the instrument.

5.2.5 Resistance to contamination

The instrument case should be constructed of materials that are easily decontaminated, or the instrument should be operable within a plastic enclosure that can be discarded.

5.2.6 Mechanical shock requirements

After being subjected to drops on each of its six surfaces from a height of 1.5m onto a concrete floor, the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1}(0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the conventionally true value, CTV after each drop. For instruments with a non-digital indication, that indication shall not have changed as a result of the mechanical shock.

5.2.7 Vibration requirements

After the instrument has been subjected to vibration within the range of 10 Hz to 500 Hz with a maximum acceleration of 33 ft·s^{-2} (10 m·s^{-2}) applied in each of three orthogonal directions, the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display, the instrument shall display a reading within ±30% of the conventionally true value, CTV. For instruments with a non-digital indication, that indication shall not have changed as a result of the test.

5.3 Electrical and electronic requirements

The electrical and electronic specifications of instruments are given in 5.3.1 through 5.3.7.

5.3.1 Scale indication

The scale indication shall be clearly visible to the user under conditions of expected use (i.e. backlit liquid crystal or light-emitting diode display). If a scale change is made by the user, or automatically by the instrument, a clear indication of the effective range of the new scale should be provided.

5.3.2 Quantity displayed

If an instrument measures radiation quantities (μR h^{-1}, μGy h^{-1}, or μSv h^{-1}) the quantity displayed shall be clearly indicated by, or on, the instrument.

5.3.3 Effective range of measurement or indication

The effective range of measurement or indication shall be appropriate for the conditions of expected use.

5.3.4 Switches

Any external switches shall be adequately protected from accidental or unauthorized operation. Any switches shall be operable with gloved hands, through a plastic bag, or other enclosure used for contamination control.

5.3.5 Batteries

If replaceable batteries are used, they shall be commercially available and field replaceable. The batteries shall be capable of powering the alarm of the instrument continuously for 30 minutes.

A low battery indicator should indicate when there are less than 4 (four) hours of use (without alarm) remaining. Until the time the low battery indicator turns on, the instrument shall meet the performance requirements in 5.4 of this standard.

5.3.6 Alarms

5.3.6.1 Alarm characteristics

a) *Location*—The alarm shall be located such that when the instrument is worn on the body, the alarm will alert the wearer to its output.

b) *Alarm type*—The frequency of an audible alarm should be within the range of 1000–4000 Hz. Where an intermittent alarm is provided, the signal interval shall not exceed 2 s. The alarm volume at a distance of 12 in (30 cm) from the alarm source shall be at least 85 dB (A). The A-weighted sound level shall not exceed 100 dB (A) at 12 in (30 cm) from the alarm source. Where ambient noise levels would make the alarm inaudible or when a silent alarm is necessary, a visual, vibratory, or other additional signal shall be provided.

Indication should be given of conditions that render the instrument incapable of alarming at the level set or reading inaccurately, such as: low battery, detector failure or an overrange condition.

5.3.7 Electromagnetic and electrostatic interference

While the instrument is being exposed to the non-ionizing radiations described in 5.3.7.1, 5.3.7.2 and 5.3.7.3, it shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading that is within ±30% of the conventionally true value, CTV, while being exposed to the non-ionizing radiation. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed while being exposed to the non-ionizing fields described in 5.3.7.1, 5.3.7.2 and 5.3.7.3, and no alarms shall occur as a result of the non-ionizing fields alone.

5.3.7.1 Electrostatic discharge

During exposure to electrostatic discharges at intensities of up to 6 kV for contact and 8 kV for air, the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1}(0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the conventionally true value, CTV while being exposed to the electrostatic discharge. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the exposure and no alarms shall occur as a result of the electrostatic discharge alone.

5.3.7.2 Radio frequency

The instrument should not be affected by radio frequency (RF) fields over the frequency range of 20 MHz to 1000 MHz at an intensity of 10 volts per meter (V/m). When exposed to these RF fields, the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the conventionally true value, CTV, while being exposed to the RF radiation. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the exposure and no alarms shall occur as a result of the RF radiation alone.

5.3.7.3 Magnetic fields

When exposed to direct current (DC) magnetic fields in all three mutually orthogonal orientations relative to a 10 gauss (1 mT) magnetic field, the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the conventionally true value, CTV, while being exposed to the DC magnetic field. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the exposure and no alarms shall occur as a result of the DC magnetic field alone.

5.3.7.4 Radiated emissions

RF emissions from an instrument shall be less than that which can interfere with other equipment located in the area of use. The emission limits are given in Table 2.

Table 2—Radiated RF emission limits

Emission frequency range (MHz)	Field strength (μV/m)
30–88	100
88–216	150
216–960	200
Above 960	500

5.4 Radiological

5.4.1 Radiation detection and alarms

The instruments to be tested using this standard shall possess the following characteristics: a large response to low levels of radiation, the ability to quickly alert the user to any radiation level increases, and a low occurrence of false alarms.

5.4.2 Response and time to alarm

The instrument's mean time to alarm shall be no more than 2 seconds once the radiation intensity at the instrument's reference point is increased by 50 μR h^{-1} (0.5 μGy h^{-1}) in a period of not more than 0.5 seconds. The test will be conducted at three different ambient background levels of 20, 60, and 100 μR h^{-1} (0.2, 0.6, and 1.0 μGy h^{-1}) using each of the reference photon radiations listed in Table 1.

5.4.3 Detection of gradually increasing radiation levels

The instrument's alarm should be triggered with a 95% confidence level when the radiation intensity at the instrument's reference point is increased gradually in a period of 5 ± 1 seconds to 30 μR h^{-1} (0.3 μGy h^{-1}) above a 20 μR h^{-1} (0.2 μGy h^{-1}) ambient background level of radiation using a ^{137}Cs source. The mean time to alarm should be less than 2 seconds after the 50 μR h^{-1} (0.5 μGy h^{-1}) rate is achieved.

5.4.4 Rate of false alarms

The mean time to false alarm should be greater than 1 hour in all ambient background radiation levels used in 5.4.2 (e.g., 20, 60, and 100 μR h^{-1}) (0.2, 0.6, and 1.0 μGy h^{-1}) when the test specifications are identical to those used in 5.4.2 to test alarms.

5.4.5 Accuracy

For instruments that display a numerical value, or if its display is proportional to a numerical value, the reading shall be accurate to within ±30% of the conventionally true value of the quantity of radiation to which the instrument has been exposed using a reference radiation of ^{137}Cs whose calibration is traceable to the National Institute of Standards and Technology (NIST) (see Table 1).

5.4.6 Detection of neutrons

If the manufacturer specifies that the instrument has a neutron-sensing capability, the instrument shall respond within 2 s, with a 95% confidence level, when placed at the center of the surface (facing the radiation source) of a 30 cm × 30 cm × 15 cm polymethylmethacrylate phantom. The neutron source given in Table 1 shall have an unscattered neutron fluence rate of 2.5 s^{-1} cm^{-2} at the instrument's reference point in a low-scatter environment, and the value of the fluence rate shall be traceable to NIST (see ANSI N42.22-1995 and ANSI N42.23-1996).

5.4.7 Overrange response

When exposed to a radiation intensity of two times the maximum of the highest range specified by the manufacturer, the indication of the instrument shall remain at the maximum of that range, and an overload indication shall be displayed.

5.5 Environmental

It is necessary to demonstrate that the variations in environmental conditions to which an instrument is exposed will not substantially affect its operation in the conditions of expected use.

5.5.1 Temperature requirements

— *Primary specification:* Over the range of temperature from –20 ºC to +50 ºC, the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the conventionally true value. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the temperature test and no alarms shall occur as a result of the temperature changes alone.
— *Secondary specification:* If the manufacturer has stated a wider operational temperature range, the instrument's ability to perform correctly over that range shall be tested, and the primary specifications shall be met over the extended temperature range.

5.5.2 Humidity requirements

Over the range of relative humidity up to 93% at 95 ºF (35 ºC), the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the conventionally true value (CTV). For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the test and no alarms shall occur as a result of the humidity change alone. If the manufacturer claims correct operation over a wider range of humidity, the test shall be performed over that range.

5.5.3 Moisture resistance requirements

After being subject to water spray described in 6.5.3 of this standard, the instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the conventionally true value. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the test and no alarms shall occur as a result of the water spray alone.

Instruments that are specified to be resistant to salt water spray shall exhibit this same performance after being subjected to a salt water spray in accordance with 6.5.3.

6. Performance tests

6.1 General performance test information

Subclauses 6.2 through 6.5 describe the specific tests to be performed as part of the type tests, performance tests, or acceptance tests. A subset of these tests should be used for periodic performance testing.

6.2 Mechanical tests

The requirements in 5.2.1 through 5.2.5 regarding size, weight, case construction, reference point marking, and resistance to contamination can be verified by inspection of the instrument, and instruments that do not meet the specifications described need not be tested using this standard. The following tests are intended to determine the effect of mechanical handling of the instrument upon its response.

6.2.1 Mechanical shock test

The instrument shall be dropped from a height of 1.5 m onto a concrete surface on each of its six surfaces. After each drop, the instrument shall be exposed to a ^{137}Cs source producing an exposure rate of 50 μR h^{-1} (0.5 μGy h^{-1}) over the ambient background level of radiation. The instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the CTV. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the test and no alarms shall occur as a result of the mechanical shock alone. There shall be no visible external damage to the instrument, and all control functions shall be verified to be operating correctly.

6.2.2 Vibration test

The instrument shall be subjected to vibration with a frequency that is swept, or delivered at chosen intervals, within the range of 10 Hz to 500 Hz and a maximum acceleration of 33 ft.·s^{-2} (10 m·s^{-2}) applied in each of three orthogonal directions. The instrument shall then be exposed to a ^{137}Cs source producing an exposure rate of 50 μR h^{-1} (0.5 μGy h^{-1}) over the ambient background level of radiation. The instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the CTV. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the test and no alarms shall occur as a result of the vibration alone.

6.3 Electrical and electronic tests

The requirements in 5.3.1 through 5.3.4 regarding scale indication, quantity displayed, effective range of measurement or indication, and switches can be verified by inspection of the instrument or supplied documentation. Instruments that do not meet the specifications described need not be tested using this standard. The tests described in 6.3.1 through 6.3.3 are intended to determine the electrical and electronic properties of the instrument and effects upon its response.

6.3.1 Battery lifetime

New batteries of the type indicated by the manufacturer shall be used for each of these tests. If the instrument uses rechargeable batteries, they shall be fully charged before the start of the tests. Instruments shall be placed under laboratory reference conditions, switched on and allowed a stabilization and background detection period specified by the manufacturer's recommendations.

The instrument shall be exposed to an ambient background radiation intensity of 50 μR h^{-1} (0.5 μGy h^{-1}) to initiate an alarm. The instrument's alarm will be kept sounding continuously for 30 minutes.

A low battery indicator should indicate when there are less than 4 (four) hours of use (without alarm) remaining. The instrument shall be operated continuously until the low battery indicator is activated. At that time, the tests described in 6.4.2.1 and 6.4.2.2 of this standard shall be performed.

6.3.2 Alarm acoustic intensity

The audible alarm of the instrument shall be activated with an appropriate radiation source that may be placed as close to the instrument as practical. The A-weighted sound level at a distance of 12 in (30 cm) shall be measured and compared to the specifications given in 5.3.6.1. The alarm acoustical intensity in the frequency range from 1000–4000 Hz shall be at least 85 dB(A). The A-weighted sound level shall not exceed 100 dB(A) at 12 in (30 cm) from the alarm source.

6.3.3 Electromagnetic and electrostatic interference

The instrument shall be exposed to an exposure rate of 50 μR h^{-1} (0.5 μGy h^{-1}) of the appropriate ionizing radiation, depending upon the intended use, selecting from the reference sources given in Table 1, and the instrument's reading noted. While the instrument is indicating the presence of this ionizing radiation, the tests described in 6.3.3.1 through 6.3.3.4 will be performed.

6.3.3.1 Electrostatic discharge

The "contact discharge" technique for conductive surfaces and coupling planes, and the "air discharge" technique for insulating surfaces shall be used. Discharge points shall be selected based on user accessibility (see IEC 61000-4[4]).

There shall be ten discharges per discharge point with a one-second-recovery time between each discharge. The maximum intensity of each discharge is based on the technique used (6 kV for contact, and 8 kV for air discharge). The instrument shall then be exposed to a ^{137}Cs source producing an exposure rate of 50 μR h^{-1} (0.5 μGy h^{-1}) over the ambient background level of radiation. The instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the CTV. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the exposure and no alarms shall occur as a result of the non-ionizing fields alone.

6.3.3.2 Radio frequency

Expose the instrument to a ^{137}Cs source producing an exposure rate of 50 μR h^{-1} (0.5 μSv h^{-1}) over the ambient background level of radiation. Place the instrument and source in a RF controlled environment and expose it to a RF field of 20 V/m as measured without an instrument present in the test cell over a frequency range of 20 MHz to 1000 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 not greater than 1% of the fundamental.

NOTE—20 V/m is selected so that the test can be performed in one orientation. If susceptibility is indicated, the test should be repeated at the frequencies of susceptibility at 10 V/m in at least three orientations relative to the emission source. The indication shall not have changed during the exposure and no alarms shall occur as a result of the non-ionizing fields alone.

[4]Information on references can be found in Clause 2.

6.3.3.3 Magnetic fields

Place the instrument in a 10 gauss (1 mT) magnetic field. The instrument shall then be exposed to a ^{137}Cs source producing an exposure rate of 50 μR h^{-1} (0.5 μGy h^{-1}) over the ambient background level of radiation. The instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μGy h^{-1}). For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the CTV. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed during the exposure to the magnetic field and no alarms shall occur as a result of the non-ionizing fields alone. The test shall be repeated for all three mutually orthogonal orientations of the instrument with respect to the magnetic field.

6.3.3.4 Radiated emissions (see IEC 61000-4)

Place the instrument in an RF shielded room or chamber, as appropriate. Place the antenna three meters from the assembly. With the instrument off, collect a background spectrum using a narrow bandwidth as specified in Table 3.

Table 3—Emitted frequency distribution

Frequency (Hz)	Bandwidth (Hz)
1k–50k	100
50k–500k	400
500k–1M	2k
1M–10M	10k
10M–1G	50k

Switch the instrument on and perform a narrow bandwidth scan. Repeat the test with the instrument turned on and detecting a radioactive source. Document the frequency and level of emissions as indicated.

6.4 Radiological tests

6.4.1 General test information

For all tests described in this subclause, radionuclide sources shall be calibrated by, or be traceable to, an accredited calibration laboratory or to NIST. The reference point of the instrument shall be placed at the point of measurement. The instrument shall be oriented with respect to the direction of the radiation field as indicated by the manufacturer. If the instrument requires a background radiation measurement, it will be allowed to acquire the data in a manner specified by the manufacturer.

6.4.2 Background radiation determination

For all tests described in this subclause, radionuclide sources are selected from Table 1. For each ambient photon exposure rate in 5.4.2 the accepted ambient photon background will be measured at the detector test location, and a ^{137}Cs source should be used to increase the accepted ambient exposure to be within ±30% of the required ambient photon exposure rate (e.g., 20, 60, and 100 μR h^{-1}) (0.2, 0.6, and 1.0 μGy h^{-1}). Using an instrument capable of measuring the accepted ambient photon background, several readings (more than three) should be taken and averaged until the absolute value of the difference between the required appropriate ambient photon exposure rate and the measured ambient photon exposure rate is smaller than 20% of the appropriate ambient photon exposure rate minus the square root of the variance of the measurements.

The ambient exposure rate shall be rechecked regularly and tests accepted only when the ambient exposure rate is constant to within the stated uncertainty both before and after the test. The ^{137}Cs source shall be used to alter the photon background only after the post-test photon background has been determined.

The instrument to be tested shall be placed under standard test conditions, switched on, setup as per instructions from the manufacturer, and allowed a stabilization and background detection period specified by the manufacturer's recommendations. The entire process from the time the detector is turned on should not exceed the stabilization time in of 1 minute (see Table 1). When the detector is displaced for ambient photon background verifications and adjustments, it should be allowed a similar setup and stabilization period if required. The detector setup procedure for any given required ambient photon exposure rate must be the constant to within the stated uncertainty when the tests described in 6.4.2.1, 6.4.2.2, and 6.4.2.3 are performed.

6.4.2.1 Response and time to alarm

The radiation intensity at the instrument's reference point will be increased by 50 μR h^{-1} (0.5 μGy h^{-1}) in a period of not more than 0.5 seconds. The test will be conducted at three different ambient background levels of 20, 60, and 100 μR h^{-1} (0.2, 0.6, and 1.0 μGy h^{-1}) using each of the reference photon radiations listed in Table 1. The instruments will be allowed to stabilize at each ambient background level of radiation for at least 2 minutes prior to the test. The actual mean time to alarm will be recorded as a performance indicator.

6.4.2.2 Detection of gradually increasing radiation levels

The reference point of the instrument shall be placed at the point of measurement and the instrument shall be exposed in a reproducible geometry to a source selected from Table 1. The radiation intensity at the instrument's reference point is increased gradually in a period of 5 ± 1 seconds to 30 μR h^{-1} (0.3 μGy h^{-1}) above a 20 μR h^{-1} (0.2 μGy h^{-1}) ambient background level of radiation. The instrument's time to alarm will be measured as the time from when the exposure is at full strength to the time the alarm activates. After any number of tests are performed (e.g., 20, or any larger number at the manufacturer's request), the mean time to alarm plus two times the square root of the variance shall be less than 2 seconds. The tests shall be conducted with each of the photon sources listed in Table 1 (e.g., ^{241}Am, ^{137}Cs and ^{60}Co).

6.4.2.3 Rate of false alarms

With a number of instruments agreed upon with the manufacturer of the same construction in the appropriate gamma background exposure rate, the detectors are exposed to the background radiation levels specified in 6.4.2.1 and monitored for at least 30 instrument-hours. The number of alarms during this period shall not exceed three.

6.4.2.4 Accuracy

If the instrument has a numerical display, or if its display is proportional to a numerical value, the instrument shall be placed at the point of measurement and the instrument shall be exposed in a reproducible geometry to a ^{137}Cs source of known intensity. The radiological quantity used for this test shall be determined by the quantity displayed by instruments' readout, or by the quantity that the manufacturer specifies for the instruments' reading. At least five measurements shall be taken over the interval from 50 μR h^{-1} (0.5 μGy h^{-1}) to 75% of the display range of the instrument, and no reading shall have a relative error larger then 30%. The measurements shall include values near both extremes of reading [within 20 μR h^{-1} (0.2 μGy h^{-1}) of the lower reading and within 10% of the maximum instrument reading].

6.4.2.5 Detection of neutrons

If the instrument has a neutron-sensing capability, neutron measurements shall be taken in a low scatter irradiation facility (see ISO 8529-1:2001 [B27]). The detector shall be placed at the center of the surface facing the radiation source, of a 30 cm × 30 cm × 15 cm polymethylmethacrylate phantom. There shall be no other significant masses of plastic or any other high hydrogen content materials close to the detector (see ISO 8529-1:2001 [B27] for irradiation details).

The fluence rate at the instrument's reference point shall be raised to 2.5 n s^{-1} cm^{-2} over a 2.0 ± 0.5 second or less time and the instrument's time to alarm will be measured as the time from when the fluence rate is at full strength to the time the alarm activates. After any number of tests (e.g. 20, or any larger number at the manufacturer's request) the mean time to alarm plus two times the square root of the variance shall be less than three seconds.

6.4.2.6 Overrange response

If the instrument has a numerical readout, the instrument shall be irradiated as described in 6.4.2.4 using a radiation intensity of two times the maximum of the highest range specified by the manufacturer. The indication of the instrument shall remain at the maximum of that range, and an overload indication shall be displayed.

6.5 Environmental tests

6.5.1 Temperature tests

a) *Shock Test—Room Temperature to High Temperature Limit:* Audible or vibratory alarms shall be turned off for this test. The instrument shall be placed in an environment with a temperature of 20 ºC ± 2 ºC for a period of 30 minutes. The instrument shall then be placed in a test chamber that has equilibrated to a temperature of +50 ºC ± 5 ºC. A ^{137}Cs radiation source shall be placed in the test chamber with, or near, the instrument at a distance from the reference point of the instrument such that the instrument produces a constant reading. Reading changes, as a function of time during the first 30 minutes shall be recorded. The reading at the end of the 30-minute interval shall be recorded. The reading of the instrument shall not have changed by more than ±30%. If the instrument displays non-digital readings, the reading shall change by not more than one unit of indication.

b) *Shock Test—Room Temperature to Low Temperature Limit:* Audible or vibratory alarms shall be turned off for this test. The instrument shall be placed in an environment with a temperature of 20 ºC ± 2 ºC for a period of 30 minutes. The instrument shall then be placed in a test chamber that has equilibrated to a temperature of – 20 ºC ± 2 ºC. A ^{137}Cs radiation source shall be placed in the test chamber with, or near, the instrument at a distance from the reference point of the instrument such that the instrument produces a constant reading. Readings, as a function of time during the first 30 minutes, shall be recorded along with the final reading at the end of 30 minutes. At the end of this part of the test, the instrument and the ^{137}Cs radiation source shall be placed in the laboratory at a temperature of 20 ºC ± 2 ºC for a period of 30 minutes. The radiation source to reference point distance shall be maintained in order not to change the reading of the instrument. The reading of the instrument at the end of the 30-minute interval shall be recorded. The reading of the instrument at the end of the 30-minute interval at the low temperature extreme, and the reading at the end of the 30-minute interval at the laboratory temperature shall not have changed by more than ± 30%. If the instrument displays non-digital readings, the reading shall not change by more than one unit of indication.

c) *Temperature Ramp—Room Temperature to High Temperature Limit:* Audible or vibratory alarms shall be turned off for this test. The instrument shall be placed in a test chamber at a temperature of 20 ºC ± 2 ºC along with a ^{137}Cs radiation source placed in the test chamber with, or near, the instrument at a distance from the reference point of the instrument such that the instrument produces a constant reading. The temperature shall then be linearly increased to +50 ºC ± 2 ºC at a rate of approximately 10 ºC/h. Any reading changes occurring during this time period shall be recorded. The temperature of the test chamber shall be maintained at +50 ºC ± 2 ºC for 30 minutes and the reading of the instrument shall be recorded. The reading of the instrument shall have changed by not more than ± 30%. If the instrument displays non-digital readings, the reading shall change by not more than one unit of indication.

d) *Temperature Ramp—Room Temperature to Low Temperature Limit:* Audible or vibratory alarms shall be turned off for this test. The instrument shall be placed in a test chamber at a temperature of 20 ºC ± 2 ºC along with a ^{137}Cs radiation source placed in the test chamber with, or near, the instrument at a distance from the reference point of the instrument such that the instrument produces a constant reading. The temperature shall then be linearly decreased to –20 ºC ± 2 ºC at a rate of approximately 10 ºC/h. Any reading changes occurring during this time period shall be recorded. The temperature of the test chamber shall be maintained at –20 ºC ± 2 ºC for 30 minutes and the reading of the instrument shall be recorded. The reading of the instrument shall not have changed by more than ± 30%. If the instrument displays non-digital readings, the reading shall have change by not more than one unit of indication.

6.5.2 Humidity

The humidity tests may be performed along with the temperature tests, if the environmental chamber can provide the appropriate settings for both tests.

Audible or vibratory alarms shall be turned off for this test. An instrument, or group of instruments, shall be placed along with a ^{137}Cs radiation source placed in the test chamber with the instrument at a distance from the reference point of the instrument such that the instrument produces a constant reading. The environmental chamber shall be set at a temperature of 20 ºC ± 2 ºC and relative humidity of approximately 40% and allowed to stabilize for two hours. Any reading changes occurring during this time period shall be recorded. The reading of the instrument shall not have changed by more than ±30%. If the instrument displays non-digital readings, the reading shall change by not more than one unit of indication.

The temperature and relative humidity shall then be linearly increased to +30 ºC and 93%, respectively, at a rate of approximately 10% relative humidity per hour. The reading of the instrument shall not have changed by more than ±30%. If the instrument displays non-digital readings, the reading shall change by not more than one unit of indication.

The relative humidity shall then be reduced to 10%, at the rate given above, while maintaining the temperature at +30 ºC. Any reading changes occurring during this time period shall be recorded. The reading of the instrument shall have changed by not more than ±30%. If the instrument displays non-digital readings, the reading shall have change by not more than one unit of indication.

6.5.3 Water resistance

The instrument shall be exposed for 2 minutes to a fine water spray at a flow rate of approximately 1 gal/min (4 L/min). The spray nozzle should be located approximately 6.5 ft (2 m) from the instrument. The instrument shall then be exposed to a ^{137}Cs source producing an exposure rate of 50 $\mu R\ h^{-1}$ (0.5 $\mu Gy\ h^{-1}$) over the ambient background level of radiation. For instruments with a digital display (see 5.1.3), the instrument shall display a reading within ±30% of the CTV. For instruments with a non-digital indication (see 5.1.3), that indication shall not have changed as a result of the water spray and no alarms shall occur as a result of the water spray alone. The temperature of the water and the instrument shall be 20 ºC ±5 ºC.

For instruments that are designed for use in salt water spray environments, the test shall be conducted using a salt water mixture approximating mean standard ocean water by the following ingredients: 96.5% by weight H_2O and 3.5% NaCl by weight, having a specific gravity of approximately 1.025 at 20 ºC ± 2 ºC.

7. Documentation

This clause specifies the requirements for documentation.

7.1 Type test report

The manufacturer shall provide a report covering the type tests performed in accordance with the requirements of this standard.

7.2 Certificate

The manufacturer shall provide a certificate or other documentation containing at least the following information:

- Contacts for the manufacturer including, but not limited to, name, address, telephone number, fax number, e-mail address, etc.
- Type of instrument, detector, and types of radiation the instrument is designed to measure.
- Range of exposure rates the instrument is designed to measure.
- Reference points and reference orientation for radiation source used for calibration.
- Location and dimensions of the sensitive volumes of the detectors.
- Response of the instrument to different appropriate radiation energies.
- Results of tests for accuracy, linearity, and lower limit of detection.
- Weight and dimensions of the instrument.
- Power supply (battery) requirements.
- Results of tests under environmental conditions.
- Results of electrical and mechanical tests.

7.3 Operation and maintenance manuals

The manufacturer shall supply an operational and maintenance manual containing at least the following information for the user:

- Operating instructions and restrictions.
- Schematic electrical diagrams plus spare parts list and specifications.
- Troubleshooting guide.

Annex A

(informative)

Bibliography

A.1 General

[B1] IEC 60068-2, Basic Environmental Testing Procedures—Part 2: Tests. (All Sections.)

[B2] IEEE Std C62.41™-1991, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.[5, 6]

[B3] UL 913– 2002, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations.[7]

A.2 Detectors

[B4] ANSI N42.12-1994, American National Standard for Calibration and Usage of Thallium-Activated Sodium Iodide Detector Systems for Assay of Radionuclides.

[B5] ANSI N42.13-1986 (R1993), American National Standard for Calibration and Usage of "Dose Calibrator" Ionization Chambers for the Assay of Radionuclides.

[B6] ANSI N42.14-1999, American National Standard for Calibration and Use of Germanium Spectrometers for the Measurement of Gamma-Ray Emission Rates of Radionuclides.

[B7] ANSI N42.31-2003 American National Standard – Measurement Procedures for Resolution and Efficiency of Wide-Bandgap Semiconductor Detectors of Ionizing Radiation.

[B8] IEEE Std 300™-1988, IEEE Standard Test Procedures for Semiconductor Charged-Particle Detectors.

[B9] IEEE Std 309™-1999/ANSI N42.3-1999, IEEE Standard Test Procedures and Bases for Geiger-Mueller Counters.

[B10] IEEE Std 325™-1996 (R2002), IEEE Standard Test Procedures for Germanium Gamma-Ray Detectors

A.3 Detection and identification instruments

[B11] ANSI N42.33-2003, American National Standard for Portable Radiation Detection Instrumentation for Homeland Security.

[5]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).

[6]The IEEE standards referred to in Annex A are trademarks belonging to the Institute of Electrical and Electronics Engineers, Inc.

[7]UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (http://global.ihs.com/).

[B12] ANSI N42.34-2003, American National Standard Performance Criteria for Hand-held Instruments for the Detection and Identification of Radionuclides.

[B13] ANSI PN42.35, Draft American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security.[8]

[B14] IEC WD62327, Radiation Protection Instrumentation—Hand-held Instruments for the Detection and Identification of Radioactive Isotopes and additionally for the Indication of Ambient Dose Equivalent Rate from Photon Radiation (Draft).[9]

[B15] ISO/DIS 22188:2002, Monitoring for Inadvertent Movement and Illicit Trafficking of Radioactive Material.[10]

A.4 Radiological protection instruments

[B16] ANSI N42.17A-1989 (R1994), American National Standard Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Normal Environmental Conditions.

[B17] ANSI N42.17B-1989 (R1994), American National Standard Performance Specifications for Health Physics Instrumentation—Occupational Airborne Radioactivity Monitoring Instrumentation.

[B18] ANSI N42.17C-1989 (R1994), American National Standard Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Extreme Environmental Conditions.

[B19] ANSI N42.20-2003, American National Standard Performance Criteria for Active Personnel Radiation Monitors.

[B20] ANSI N323A-1997, American National Standard Radiation Protection Instrumentation Test and Calibration Portable Survey Instruments.

[B21] ANSI N323B-2003, American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instrumentation for Near Background Operation.[11]

[B22] IEC 60395 (1972), Portable X or Gamma Radiation Exposure Rate Meters and Monitors for Use in Radiological Protection.

A.5 Electromagnetic compatibility

[B23] 47 CFR 0-19: 2002, Telecommunication.[12, 13]

[8]This ANSI standards project was not approved at the time this publication went to press. For information about obtaining a draft, contact the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/).

[9]This IEC standards project was not approved at the time this publication went to press. For information about obtaining a draft, contact the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iec.ch/).

[10]ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

[11]This approved ANSI standard will be available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (http://standards.ieee.org/), in early 2004.

[12]Supersedes FCC P15: 1976, Radio Frequency Devices.

[13]CFR publications are available from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, USA (http://www.access.gpo.gov/).

[B24] IEC 61000-6-2 (1999), Electromagnetic Compatibility (EMC)—Part 6-2: Generic Standards—Immunity for Industrial Environments.

A.6 Units, quantities, calibrations

[B25] ISO 4037-1:1996, X and Gamma Reference Radiation for Calibrating Dosemeters and Doserate Meters and for Determining their Response as a Function of Photon Energy—Part 1: Radiation Characteristics and Production Methods.

[B26] ISO 4037-2:1997, X and Gamma Reference Radiation for Calibrating Dosemeters and Doserate Meters and for Determining their Response as a Function of Photon Energy—Part 2: Dosimetry for Radiation Protection over the Energy Ranges from 8 keV to 1,3 MeV and 4 MeV to 9 MeV.

[B27] ISO 8529-1:2001, Reference Neutron Radiations—Part 1: Characteristics and Methods of Production."

[B28] ISO 8529-2:2000, Reference Neutron Radiations—Part 2: Calibration Fundamentals Related to the Basic Quantities Characterizing the Radiation Field.

[B29] NIST SP 250-98 ED, NIST Calibration Services User's Guide, 1998 Edition.[14]

[14]Information on NIST Special Publications may be obtained from the National Institute of Standards and Technology at http://www.nist.gov/.

Annex B

(informative)

Summary of test information

Table B.1 briefly describes the characteristics of the tests included in this standard and provides a summary of the important performance requirements for the instruments to be tested.

Table B.1—Instrument tests and requirements

Name of test	Purpose	Frequency	Units tested	Specifications tested	Performed by
Type test	Demonstrate design meets criteria.	Once for a particular design.	Two or more representative units.	All relevant specifications from standard.	Manufacturer or organization.[a]
Acceptance test	Confirm compliance with requirements.	Upon receipt, prior to use.	Representative group.	As relevant to purchaser	Organization.[a]
Functional check	Confirm unit is operational.	Before each use and as appropriate.	Each unit.	As appropriate to use.	User.
Periodic performance check	Verify stable operation.	As appropriate to use.	Representative group.	Selected type test specifications.	User or organization.[a]

[a]The organization may arrange to have certain tests performed by contractor or accredited testing laboratory.

Annex C

(informative)

Performance requirements

Table C.1—Summary of performance requirements

Parameter	Performance requirement or specification
Maximum size and weight	8 × 4 × 2 in (20 × 10 × 5 cm), 0.9 lb (400 g)
Mechanical shock and vibration	Correct operation after drop from (1.5 m) onto concrete surface. No visible damage and controls will operate correctly.
Battery life	Non-rechargeable lifetime: > than 100 hours using batteries readily available.
Alarm, acoustic	Audible frequency 1,000–4,000 Hz. Signal interval less than or equal to 2 s for intermittent alarm. Volume at 12 in (30 cm) > 85 dB(A); A-weighted sound level ≤ 100 dB(A) @ 12 in (30 cm).
EM-RF interference	Correct operation while exposed to 20–1000 MHz at 10 V/m, 6–8 kV discharge, 10 gauss (1 mT) magnetic field.
Time to alarm	< 2s
Alarm radiation level	50 μR h^{-1} (0.5 μGy h^{-1}) using ^{241}Am,^{137}Cs and ^{60}Co.
Rate of false alarms	Mean time to false alarm > 1 h.
Accuracy of digital indication	±30% relative to CTV for ^{137}Cs irradiation.
Operating temperature range	–20 ºC to +50 ºC, unless specified differently by manufacturer.
Operating humidity range	40% to 93% RH, unless specified differently by manufacturer.
Water resistance	Response stable after fine water spray of approximately 1 gal/min (4 L/min) for approximately 2 min at a distance of 6.5 ft (2 m). Salt water spray, if expected in use.

Annex D

(informative)

Detector tests

This standard and ANSI N42.33-2003 [B11], ANSI N42.34-2003 [B12], and ANSI PN42.35 [B13] utilize some of the following types of detectors:

— *Cesium Iodide (CsI) Scintillation detectors:* These detectors are used for their high efficiency of light output per photon incident. They are operated at room temperature and have moderate energy resolution. Test procedures for systems using scintillation detectors can be found in ANSI N42.12-1994 [B4].

— *Sodium Iodide (NaI) Scintillation detectors:* These detectors are available in large sizes such that they have both high efficiency and moderate energy resolution. They are operated at room temperature. Test procedures are given in ANSI N42.12-1994 [B4].

— *CZT Semiconductor detectors:* CZT and other wide-bandgap semiconductor detectors are semiconductor detectors that can be operated at room temperatures. At this time they are small physically and therefore have low efficiency. They have good energy resolution though somewhat poorer than that of Germanium detectors. Standard test procedures for these detectors are given in ANSI N42.31-2003 [B7].

— *Germanium Gamma-ray detectors:* These detectors have very high energy resolution and are currently of sufficient size to have also high efficiency. They must be operated at cryogenic temperatures. Test procedures for these detectors are given in IEEE Std 325-1996 [B10].

— *Semiconductor charged-particle detectors:* These detectors are capable of high resolution measurements of charged particles. Test procedures for these detectors are given in IEEE Std 300-1988 [B8].

— *Geiger-Mueller Counters:* These are widely used for radiation detection and intensity measurements. They are avalanche detectors, the output signals of which are independent of the radiation energy. Test procedures for these detectors are given in IEEE Std 309-1999/ANSI N42.3-1999 [B9].

— *Ionization chambers:* These are highly accurate detectors for gross measurement of radiation intensity. They are operated at room temperature. Test procedures for these detectors are given in ANSI N42.13-1986 [B5].

— *Plastic Scintillator detectors:* These detectors are particularly useful for portal monitors. Standards and standard measurement procedures have not yet been developed.

— *High-pressure ^{3}He proportional counters:* These are particularly useful for neutron detection and are commonly used in portal monitors.