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American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security

Accredited by the American National Standards Institute

Sponsored by the
National Committee on Radiation Instrumentation, N42

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Secretariat

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Approved 9 February 2004

American National Standards Institute

Abstract: This standard describes the performance requirements for portal monitor instruments. The requirements stated are based on instruments used in support of efforts associated with the United States Department of Homeland Security.
Keywords: homeland security, instrument test, portal monitors, radiation detectors

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American National Standard

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Introduction

(This introduction is not part of ANSI N42.35-2004, American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in 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 3 October 2003.

Participants

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

At the time this standard was approved, Subcommittee N42.RPI had the following members:

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Contents

American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security

1. Overview

1.1 Scope

This standard provides the testing and evaluating criteria for Radiation Detection Portal Monitors to detect radioactive materials that could be used for nuclear weapons or radiological dispersal devices (RDDs). Portal monitors may be used in permanent installations, in temporary installations for short-duration detection needs, or as a transportable system. These systems are used to provide monitoring of people, packages, and vehicles to detect illicit radioactive material transportation, or for emergency response to an event that releases radioactive material.

1.2 Purpose

The purpose of this standard is to specify performance criteria and test methods used to evaluate portal monitors for use in homeland security.

1.3 General

1.3.1 Evaluation of monitors

Performance testing is performed under a set of test conditions to determine if a portal monitor meets the requirements of this standard. Special application, which could include the monitor's operation under extreme weather conditions, shall require additional testing.

Evaluation of portal monitors provides information to government agencies and other users on the capability of radiation detection portal monitors for reliably detecting specified amounts of unshielded radioactive material.

1.3.2 Meeting performance specifications

Obtaining operating performance that meets or exceeds the specifications of the evaluation tests rests upon properly installing the monitor at an appropriate location, establishing appropriate operating parameters, providing security for the systems, maintaining monitor calibration, implementing a suitable response testing and maintenance program, auditing compliance with quality requirements, and providing proper training for operating personnel. The evaluation uses essentially unshielded test sources; hence, results are based on detecting the entire gamma-ray and/or neutron spectrum of the sources.

1.4 Units

For the purposes of this standard, the radiological unit rem/h will be assumed to be interchangeable with the unit R/h, and the quantity dose equivalent will be assumed to be interchangeable with the quantity exposure for x-ray and gamma-ray radiation. For neutron radiation measurements, the rem and its submultiples will be used, with 10 μrem/h being equal to 0.1 μSv/h.

Conventional units are given with SI units in parentheses. If uncertainties are not specified they are set to 10%.

NOTE—A ^{137}Cs point source whose x-rays and gamma-rays produce an exposure rate of 10 μR/h in air would produce a dose equivalent of 0.0878 μSv/h (or 8.78 μrem/h) measured at the location. For sources emitting x-rays and gamma-rays from 10 keV to 2 MeV this conversion factor varies between 0.0876 μSv/h to 0.0879 μSv/h.

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.[1]

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.)[2]

[1]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/).

[2]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. Definitions

The following definitions apply for ANSI N42.32-2003 [B11], ANSI N42.33-2003 [B12], ANSI N42.34-2003 [B13], and ANSI N42.35-2004 that have been developed at the request of the Department of Homeland Security (DHS) for instruments to be used by DHS and emergency responders.

3.1 General definitions

3.1.1 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.

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

3.1.3 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 operator, or any other exposure rate meter having a nearly constant energy response (±30% in the energy range from 200 keV to 1.5 MeV).

3.1.4 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.

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

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

3.1.7 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.

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

3.1.9 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.

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

3.1.11 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.)

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

3.1.13 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.

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

3.1.15 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.

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

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

3.1.18 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 Standard International (SI) unit Sievert, or Sv, follows in parentheses the Roentgen value R, though the two units are not physically equivalent.

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

3.1.20 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.

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

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

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

3.1.24 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.

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

3.1.26 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).

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

3.1.28 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.

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

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

3.1.31 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.

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

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

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

3.1.35 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.

3.1.36 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.

3.1.37 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%.

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

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

3.1.39 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.

3.1.40 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.

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

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

3.1.43 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).

3.1.44 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.

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

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

3.1.47 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.

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

3.1.49 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.

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

3.2 Definitions of particular relevance to ANSI N42.35-2004

3.2.1 alarm assembly: Equipment designed to indicate visually or audibly or both that the measured quantity exceeds a certain value.

3.2.2 detection zone: A plane that is equivalent in width to the entire detection assembly and in height, as described in 5.1 (minimum height corresponds to the detection assembly dimension), placed at a distance from the detection assembly as listed in Table 1. Annex D shows a diagram of the detection zone.

3.2.3 evaluation distances: The distance between an evaluation test source and the exterior face(s) of the portal monitor unit(s), which corresponds to the surface of the detection assembly, during a trial (see 5.10.3).

3.2.4 manufacturer and purchaser: The term *manufacturer* includes the designer of the equipment. The term *purchaser* includes the user of the equipment.

3.2.5 monitored volume: The volume between detectors for multiple detector systems, or the volume defined from ground level to a height given by the detector's upper end of the assembly, the width of the detection assembly, and the distance from the detection assembly given by the evaluation distance for single detector systems (see Table 1).

3.2.6 portal monitor: Radiation detection system that measures radiation intensity, compares it to alarm criteria, and produces an alarm if the measured radiation intensity exceeds the criteria.

3.2.7 radioactive material: In this standard, radioactive material includes both special nuclear and radioactive material, unless otherwise specifically noted.

3.2.8 radiological dispersal device (RDD): A device containing radioactive material that is designed to expose people to radiation or disperse the material in order to contaminate an area.

3.2.9 reference point of the detection zone: The reference point of the detection zone is that point that is at the center of the detection zone in both axes (horizontal and vertical) at a distance from the detection assembly based on the monitor type given by the evaluation distance (see Table 1).

3.2.10 reference position of an assembly: The reference position of a detection assembly is located at the centered in the height and width of the entire detection assembly or it is a physical mark on the detection assembly to be used for determining the performance of the equipment.

3.2.11 standard test sources: A set a check sources required to perform an evaluation and periodic operational testing.

4. Test nomenclature

— *Acceptance test:* Test to ensure that the instrument meets individual conditions of its specification. These tests may be performed with the customer present at the manufacturer's facility.
— *Routine test:* Test applied to each individual instrument in order to ascertain compliance with specified criteria.
— *Supplementary test:* Test intended to provide supplementary information on certain characteristics of the assemblies.
— *Type test:* Conformity test that is performed on two or more units of an instrument model. This test may be done at the manufacturer's facility or after receipt by the customer.

5. Design requirements

5.1 General characteristics

The equipment addressed by this standard is a warning assembly designed to detect radiation from gamma and/or neutron emitters contained in objects, containers, or vehicles, or carried by a pedestrian, that activates an alarm when the signal from the detection system exceeds an alarm threshold. Measurement occurs when the object passes through the detection zone (dynamic mode) or is placed for some period of time within the detection zone (static mode).

According to their use, monitors are classified as:

— Pedestrian
— Package (conveyor)
— Vehicle (which includes containerized cargo)
— Rail vehicle

NOTES

1—Monitoring systems used in cranes are not addressed in this standard.

2—A monitor may be used in two or more classifications. However, its associated detection zone shall be appropriate for each classification.

The “detection zone” is a plane that is equivalent in width to the entire detection assembly and in height as described in the following sections (the minimum height corresponds to the vertical dimension of the detection assembly) placed at a distance from the detection assembly as specified in Table 1.

Table 1—Evaluation distances for different applications

Category	Monitor type	Distance between detection assemblies	Evaluation distance
A	Single-sided vehicle monitors (includes containerized cargo)	N/A	Source 6 m from assembly
B	Multiple-sided vehicle monitors (includes containerized cargo)	Monitors 5 m apart	Centered between detection assemblies
C	Single-sided pedestrian or package monitors	N/A	Source 1 m from detector
D	Fixed-dimension pedestrian or package monitors	N/A	Centered between detection assemblies
E	Multiple-sided pedestrian or package monitors	Monitors 1 m apart	Centered between detection assemblies
F	Single-sided rail vehicles monitors	N/A	Source 6 m from assembly
G	Multiple-sided rail vehicle monitors	Monitors 6 m apart	Centered between detection assemblies

Monitors shall not be installed farther apart than the distance at which they have proven to be effective. If installation requires other distances from those tested, testing or scaling to the required distance should be made prior to installation. Monitors should be demonstrated to be effective (by being fully evaluated) at greater distances or speeds for specific applications.

As an example: single sided pedestrian monitors are evaluated at a distance of 1 m, but if they are evaluated and pass requirements at a distance of 1.5 m they may be used at this distance.

The “reference position” is located at the evaluation distance listed in Table 1 and centered in both the height and width orientations of the entire detection assembly.

NOTE—Annex D provides a diagram of a typical mounting system.

5.1.1 Pedestrian

Pedestrian monitors shall provide a detection zone to ensure that personnel are monitored properly. As a minimum, the height of the detection zone shall be from ground (or base surface) to 2 m above ground or the top end of the detection assembly whichever is higher. The width is based on the width of the detection assembly.

Monitors may use a single detection assembly (single-sided) or multiple opposing detection assemblies with or without detectors across the top and/or bottom part of the detection assembly. For monitors with a restricted passage height, the height of the detection zone shall be from ground to the fixed manufactured dimension. The distance between detection assemblies for evaluation purposes is listed in Table 1, or is given by the fixed manufactured dimension.

For dynamic monitors, the passage speed should be the speed listed in Table 2.

Table 2—Speed of moving sources

Monitor type	Source speed
Vehicle monitors (except rail)	8 km/h
Pedestrian monitors	1.2 m/s
Package or conveyor monitor	1 m/s
Rail vehicle monitors	8 km/h

5.1.2 Vehicle (includes road transported containers)

Vehicle monitors shall provide a detection zone that ensures that the entire vehicle is monitored during passage. As a minimum, the height of the detection zone shall be from ground (or base surface) to 5 m above ground or the top end of the detection assembly whichever is highest. For monitors with a restricted passage height, the height of the detection zone shall be from ground to the fixed manufactured dimension. The distance between vertical monitors for evaluation purposes is listed in Table 1 or is given by the fixed manufactured dimension.

For dynamic monitors, the passage speed should be the speed listed in Table 2.

5.1.3 Rail vehicle (includes rail transported containers)

Rail vehicle monitors shall provide a detection zone that ensures that the entire rail vehicle is monitored during passage. As a minimum the height of the detection zone is from 0.25 to 5 m above base surface or the top end of the detection assembly whichever is higher. For monitors with a restricted passage height, the height of the detection zone shall be from ground to the fixed manufactured dimension. The distance between vertical monitors for evaluation purposes is listed in Table 1 or is given by the manufactured dimension.

For dynamic monitors, the passage speed should be the speed listed in Table 2.

5.1.4 Package (or conveyor monitor)

Package or conveyor monitors shall provide a detection zone that ensures that items moving through the detection zone are monitored properly. Monitors may use a single detection assembly (single-sided) or multiple opposing detection assemblies with or without detectors across the top and/or bottom part of the detection assembly (multi-sided).

As a minimum, the height of the detection zone shall be 1) from the base surface to 1 m above the base surface (that surface which corresponds to the ground or conveyor bottom surface) for detectors mounted below the base surface, or 2) from the base surface to the face of the detection assembly for detectors mounted above the base surface. For monitors with a restricted passage height, the height of the detection zone shall be from the base surface to the fixed manufactured dimension. The distance between vertical monitors for evaluation purposes is listed in Table 1 or is given by the fixed manufactured dimension.

For dynamic monitors, the passage speed should be the speed listed in Table 2.

5.2 Configuration

The detection assembly for monitoring both road and rail vehicles may be designed as a measurement assembly connected to one or several detection assemblies, which may be contiguous to the measurement assembly or placed at a distance from it.

A detection assembly generally contains one or more detectors linked to a measurement assembly.

The system containing several detection assemblies placed around the detection zone is called the “detection system.”

The detection assemblies shall pass the performance test for environmental testing specified in 6.6 of this standard.

Enclosure(s) provided for outdoor assemblies shall be designed so monitors will not deteriorate during a period of five years under field conditions.

The detection assemblies for road and rail vehicle monitoring may be subjected to vibration due to the weight of vehicles being monitored. Mounting techniques (i.e. concrete pads) which are not described here shall be designed to prevent normal vibrations and shocks of vehicle traffic from interfering with the operation of the detection system.

Controls and adjustments which affect calibration and alarm settings shall be designed so that access to them is limited to authorized persons.

Provisions shall be made to permit testing of visual or sound warning indicators.

The monitoring system shall have the ability to communicate signals from each detector or detection assembly.

The monitoring system shall continuously indicate that it is in an operational or non-operational condition. Fault detection such as loss of high voltage, low count-rate, high count-rate, calibration expired, or other electronic failures shall be indicated.

Testing throughout the standard shall be performed with encapsulated, but otherwise, unshielded point sources. The source mounting apparatus should be simple and designed with minimum mass.

5.3 Indication features

The monitoring system shall communicate, save, and store time history data for later retrieval including background readings prior to and/or after an alarm, and the alarm information shall include time and date. Communication capabilities may be accomplished, for example, by providing outputs for recorders or computers, or be internal to the measurement assembly. Data transfer techniques and format methods shall be fully described by the manufacturer and should be based on available technology.

The monitor shall be capable of providing a local indication and alarm signal, and of transmitting these signals to an additional remote station at a distance of at least 50 m. Local alarm signals should latch until reset by the operator. This additional remote station may be a portable computer or processing and display unit. The instrument performance should be unaffected by and completely independent of any operational mode or malfunction of the remote station.

5.4 Speed control

The performance of the equipment is dependent on the speed at which the object being monitored passes through the detection zone. The actual traffic speed should be less than the evaluation speed listed in Table 2. If operational constrains don't allow slowing traffic speed, scaling of the detector's performance and/or higher speed tests shall be made for the particular application.

5.5 Moisture protection

Instruments shall be designed to prevent water ingress from rain, condensing moisture, or high humidity. The manufacturer shall state design measures that address this requirement such as seals or gaskets.

5.6 Markings

5.6.1 General

All external instrument controls, displays, and adjustments shall be identified as to function. Internal controls shall be identified through markings on circuit boards and identification in technical manuals.

Markings shall be easily readable and permanently fixed under normal conditions of use (including use of normal decontamination procedures).

5.6.2 Exterior markings

The following markings shall appear on the exterior of the instrument or each major assembly (e.g., detector probe) as appropriate:

a) Manufacturer and model number.

b) Unique serial number.

c) Location of the effective center(s) or area(s) of detection.

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

5.7 Power supply

Line operated assemblies shall be designed to operate from single-phase a.c. supply voltage.

— 120 V for use in the United States.

The assemblies shall be capable of operating from a.c. lines with a supply voltage tolerance of +10%–15% and a supply frequency of 57–61 Hz where the nominal line frequency is 60 Hz.

5.8 Protection of switches

Switches and other controls should be designed to ensure that the instrument is operated properly while minimizing accidental switch operation.

5.9 Effective range of measurement

The effective gamma energy response range shall be stated by the manufacturer, and should be 60 keV to 2.6 MeV.

5.10 Evaluation of portal monitors

Alarm probability tests shall be performed with the monitor system set up with the following specifications.

5.10.1 Background radiation during testing

The evaluation shall be performed in an area with a nominal natural background environment that has only natural variation. The normal range of the natural background is from 5 μR/h to 20 μR/h.

The gamma-ray background intensity shall be measured using a pressurized ion chamber or similar environmental radiation measurement device that is calibrated with respect to NIST standards to provide gamma-ray exposure rate. If the monitor is equipped with neutron detectors the neutron background should be the natural background and it should not be artificially modified during testing.

5.10.2 Speed of moving sources

During testing the source shall be moved in a configuration that provides no shielding around the source and the source mounting shall provide minimum shielding. The source shall be moved at a speed specified in Table 2 for the specific type of monitor.

5.10.3 Evaluation distances

The detector response is determined by transporting the test sources through the portal monitors at the specified speed given in Table 2 and as described in 5.10.2. The setup or evaluation distances for different applications are given in Table 1; these distances are measured from the detector case or assembly.

Results (number of alarms and passages) are analyzed as a binomial experiment to give a confidence interval for the probability of detection. If the monitor can be operated in different modes, or at more than one distance between its detectors, it should be evaluated in each mode and at each distance.

5.10.4 Detector response

The evaluation of the detector response for the monitors shall be performed without the benefit of any radiation shielding against the natural background, except for that shielding which is a permanent feature of the monitor.

5.10.4.1 Response to gamma radiation

Detector response tests shall be performed with the monitor system set up per the above specifications. These specifications are listed in Tables 1 and 2 and include passage speed (dynamic mode) and detection assembly separation distance when two-, three-, or four-sided systems are used. For static mode detectors, the manufacturer shall specify the monitoring time.

At a background level of not more than 20 μR/h, an alarm shall be triggered when the exposure rate is increased due to the exposure of the monitor to the sources listed in Table 3 for a minimum duration specified by the manufacture for static-mode systems or at the test speed for dynamic-mode systems. The probability of detecting this alarm condition should be greater than or equal to 0.90 with 95% confidence, i.e. 59

alarms in 60 passages. This requirement shall be fulfilled over a continuous incident gamma energy range from 60 keV to 2.6 MeV (tested with ^{241}Am, ^{228}Th, ^{137}Cs, ^{133}Ba, ^{60}Co and ^{57}Co).

Test sources shall be traceable to NIST standard sources, and shall have appropriate documentation to demonstrate the traceability chain (see ANSI N42.22-1995 and ANSI N42.23-1996).

Table 3—Activity values for gamma-ray and neutron sources

Radionuclide	Type test and evaluation test source activity[a]
^{57}Co	93 μCi (3.5 MBq)
^{133}Ba	23 μCi (0.85 MBq)
^{137}Cs	16 μCi (0.6 MBq)
^{60}Co	4 μCi (0.15 MBq)
^{228}Th	7 μCi (0.26 MBq)
^{241}Am	462 μCi (17 MBq)
Neutron (^{252}Cf)	2×10^4 n/s ± 20%

NOTES
1—The actual activity of each source at the time of testing shall be within 20% of the value shown in Table 3. The uncertainty in the actual activity value shall be less than 10% (1σ).
2—The neutron source should be encapsulated in 1 cm steel but otherwise unshielded.
3—Units: 1 μCi = 37,000 Bq
4—These activity levels are for testing only and are not indicative of the alarm set point or overall sensitivity of the monitoring system, which are established based on the ambient background and acceptable false alarm rate.

[a]Source activity values are based on encapsulation in 0.25 mm wall thickness stainless steel. If the source is of a different construction it is required to have the same exposure rate as the listed source.

5.10.4.2 Response to neutron radiation

Detector response tests shall be performed with the monitor system set up per the specifications listed in Tables 1 and 2 and include passage speed (dynamic mode) and detection assembly separation distance when two-sided systems are used. For static mode detectors the manufacturer shall specify the monitoring time used. A neutron alarm shall be triggered whenever the neutron activity measured during a counting interval is greater than the alarm set point. The probability of detecting this alarm condition should be greater than or equal to 0.90 with 95% confidence, i.e. 59 alarms in 60 passages.

The neutron source should be encapsulated in 1 cm steel but otherwise unshielded.

6. Test procedures

6.1 General test conditions

6.1.1 Nature of tests

Unless otherwise specified, all tests enumerated in this standard are to be considered as “type tests.”

6.1.2 Reference conditions and standard test conditions

Reference and standard test conditions are given in Table 4. Reference conditions are those conditions to which the performance of the instrument is referred and standard test conditions indicate the necessary tolerances in practical testing. Except where otherwise specified, the tests in this standard shall be performed under the standard test conditions given in Table 4.

Table 4—Reference 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	15 min	> 15 min
Ambient temperature	20 °C	–30 °C to +55 °C
Relative humidity	65%	10% to 93%
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)
Reference point	Effective center as marked.	Effective center as marked.
Electromagnetic field of external origin	Negligible.	Less than the lowest value that causes interference.
Magnetic induction of external origin	Negligible.	Less than twice the value of the induction due to earth’s magnetic field.
Instrument controls	Set up for normal operation.	Set up for normal operation.
Contamination by radioactive elements	Negligible.	Negligible.
Reference photon radiations	See Table 3.	^{57}Co, ^{60}Co, ^{133}Ba, ^{137}Cs, ^{228}Th, ^{241}Am.
Reference neutron radiation	See Table 3.	^{252}Cf

6.1.3 Tests performed under standard test conditions

For these tests the value of temperature, pressure, and relative humidity at the time of the test shall be recorded with the appropriate corrections made to give the response under the reference conditions.

6.1.4 Tests performed with variation of influence quantities

For those tests intended to determine the effects of variations in the influence quantities, all other influence quantities shall be maintained within the limits for the standard test conditions unless otherwise specified in the applicable test procedure.

6.1.5 Statistical fluctuations

For any test involving the use of radiation, if the magnitude of the statistical fluctuations of the indication arising from the random nature of radiation alone is a significant fraction of the variation of the indication permitted in the test, then sufficient readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient accuracy to demonstrate compliance with the test in question.

The interval between such readings shall be sufficient to ensure that the readings are statistically independent.

6.2 Radiation characteristics

NOTE—The “reference point” is located at the reference distance as listed in Table 1 (single side = 1 m for pedestrian monitors or 5 m for vehicle monitors), and centered in both orientations of the height and width of the detection assembly.

6.2.1 Reference gamma radiation

Unless otherwise stated, tests involving the use of gamma radiation shall be carried out using the reference gamma radiation, ^{137}Cs, with activity values specified in Table 3. Tests requiring the use of ^{241}Am, ^{228}Th, ^{137}Cs, ^{133}Ba, ^{60}Co and ^{57}Co sources shall be so noted.

6.2.2 False alarm test

6.2.2.1 Requirements

False alarms can stem from counting statistics, background intensity variations, and equipment malfunction. At a background level not less than 5 μR/h, the false alarm rate shall be less than 1 per 1,000 occupancies of a system. The occupancy shall be based on the application of the system. The speed given in Table 2, and a dimension of 0.5 m for pedestrians, 10 m for vehicles, 15 m for rail vehicles, or 1 m for packages shall be used to calculate occupancy time unless a time is otherwise specified.

False alarm testing should be at least partially completed before sensitivity tests are begun. If the emerging result for false alarm probability is too high, the cause shall be determined and the monitor readjusted, modified, or repaired. After repair or readjustment, any previously obtained false alarm and sensitivity results are not applicable.

False alarm testing should take place only during periods of time when background is free of man-made variations. Records of background intensity during test periods should be checked for unexpected man-made variations.

The manufacturer shall provide an estimate of the background level at which the monitor will no longer meet these requirements.

6.2.2.2 Method of test

Alarms are recorded by an event marker or by other means. After each test alarm, the monitor may automatically reset itself so that testing can continue. During actual use, alarms should latch.

The accumulated number of false alarms divided by the total number of passages determines the false alarm probability. The false alarm probability shall be less than 0.001 per passage, which corresponds to the false alarm rate mentioned above of 1 alarm per 1,000 passages. The number of passages may depend on whether the monitor operates in a "dynamic" or "static" mode.

False alarm probability testing addresses all types of portal monitors and is conducted as described in 6.2.2.2.1 and 6.2.2.2.2.

6.2.2.2.1 Portal monitor with occupancy sensor

Automatic data collection shall be performed with a system that cycles the monitor alternately through a group of simulated passages and a background update while recording the background intensity and each of its alarms.

For false alarm testing, the monitor should be automatically cycled through at least 100 test periods, each of which is comprised of 10 to 30 simulated passages followed by a full background update.

6.2.2.2.2 Portal monitors without an occupancy sensor

Automatic data collection shall be performed for a time period equal to an occupancy period, for at least 1000 passages based on the size of the detector and the speed of testing specified in Table 2 while recording the background intensity and each of its alarms.

For monitors without occupancy sensors, the monitor is operated for a time period approximately equal to occupancy times for that type of monitor using its passage time and physical dimensions, as given in 6.2.2.1.

6.2.3 Detector response to gamma radiation

6.2.3.1 Requirements

An alarm shall be triggered when the measured count rate is greater than the alarm setting. This requirement shall be fulfilled over a continuous incident gamma energy range from 60 keV to 2.6 MeV (tested with ^{241}Am, ^{228}Th, ^{137}Cs, ^{133}Ba, ^{60}Co and ^{57}Co). Source activities for this test are given in Table 3.

For test purposes, the probability of detecting this alarm condition shall be greater than or equal to 95%.

6.2.3.2 Method of test

Expose the monitor to the sources listed in Table 3 at the evaluation distance for the type of detector being tested. The ^{137}Cs source shall be placed at the reference point of the detection zone.

For static type monitors the exposure period shall be the duration specified by the manufacturer. For dynamic type monitors, the exposure period is established by moving the source through the reference point at the passage speed listed in Table 2.

The test is considered acceptable when an alarm occurs in 59 out of 60 trials.

Place the source at the base surface (or at ground level) as described in 5.1 and repeat the test. Reposition the source at the maximum testing height as described in 5.1 and repeat the test. Then reposition the source halfway between the base surface and the reference point as well as at halfway between the reference point and the maximum height and repeat the test at those positions. The diagram in Annex D shows the testing positions.

Repeat the test with ^{241}Am, ^{228}Th, ^{133}Ba, ^{60}Co and ^{57}Co sources. Source activities for this test are given in Table 3.

NOTE—These are gamma radiation levels for testing only. They are not indicative of the alarm set point or overall sensitivity of the monitoring system that is established based on the ambient background and acceptable false alarm rate.

6.2.4 Detector response to neutron radiation

6.2.4.1 Requirements

An alarm shall be triggered when the monitor is exposed to a ^{252}Cf neutron emission rate of 20,000 n/s for a duration specified by the manufacture or at the passage speed as appropriate for the monitor type being tested.

6.2.4.2 Method of test

Expose the monitor to neutron emissions from a ^{252}Cf source that produces an emission rate of 20,000 n/s placed at the reference point of the detection zone.

The exposure period shall be specified by the manufacture for static type monitors. For dynamic type monitors, the exposure period is established by moving the source through the reference position at the passage speed stated for that particular type of monitor in Table 2 (see also Annex C).

The test is considered acceptable when an alarm occurs 59 out of 60 trials.

Place the source at the base surface (or at ground level) as describe in 5.1 and repeat the test. Reposition the source at the maximum testing height as described in 5.1 and repeat the test. Then reposition the source halfway between the base surface and the reference point as well as at halfway between the reference point and the maximum height and repeat the test at those positions. The diagram in Annex D shows the testing positions.

6.2.5 Testing considerations

Parts of the evaluation use specific values or measurements that can alter the testing outcome if not done properly. For example, an improperly measured background intensity that is actually much higher or lower than stated in 5.10.1 will bias the results of the test.

The presence of sources other than natural background during false alarm testing can be discovered by recording the output of a background monitor or the output of the monitor’s radiation detection circuits. A strip-chart recorder, data logger, or computer-generated displays are convenient ways to record background data.

The number of alarms shall be recorded during false alarm testing. The value of the alarms should be recorded as an aid to troubleshooting.

A timing device that provides a sequence of periodic or random (but not overlapping) occupancy signals and subsequent background update periods is needed for false alarm determination.

Annex C gives one example of a timing circuit for this purpose.

Automatically cycling the monitor for false alarm testing requires the monitor’s alarm to automatically reset itself. If it does not, a means to generate an alarm-reset signal is usually easy to provide. For example, the alarm signal can operate a solenoid that depresses the alarm-reset push-button.

6.2.6 Overload characteristics

6.2.6.1 Requirements for exposure during a monitoring cycle

The indication of the assembly shall stay in alarm and shall remain so if it is exposed to a radiation field that is greater than the maximum response as stated by the manufacturer during a monitoring cycle.

The manufacturer shall state the time required by the assembly to return to non-alarm condition after exposure is removed and the doserate is returned to background. This time shall be not greater than 1 min.

6.2.6.2 Method of test

With the monitor operating normally in a stable background, initiate a monitoring cycle. Simultaneously, increase the ambient background by approximately 10 mR/h as measured at the surface of the detection assembly. This can be achieved by placing a 16 μCi (0.6 MBq) ^{137}Cs source (see Table 3) at a distance of 2 cm from the face of the detector. The monitor shall alarm and remain in alarm until the radiation field is reduced back to the pre-test level. After a period of 1 min, the monitor shall return to the pre-test count rate. The system shall alarm and recover successfully in 30 successive tests.

6.2.7 Neutron indication in the presence of photons

NOTE—If the system uses non-scintillation based detectors, this test is not required.

6.2.7.1 Requirements

The neutron alarm shall not be triggered when the monitor is exposed to gamma radiation at gamma exposure rates up to 100 μR/h as measured at the surface of the detection assembly.

The instrument shall not indicate the presence of neutron radiation because of the presence of gamma radiation.

6.2.7.2 Test method

Increase the ambient gamma exposure rate by placing a 4 μCi (0.15 MBq) ^{60}Co source (see Table 3) at a distance of 20 cm from the face of the detector. There shall be no neutron alarms.

Indication of neutron detectors to gamma radiation is confirmed if no neutron alarms are triggered in 60 successive trials.

6.3 Background effects

6.3.1 Requirement

The monitoring system shall provide a warning indication when there is a step or gradual change in background that is great enough to cause a substantial change in alarm probability. The indication shall be visual and audible, and shall be different than monitoring alarms.

The manufacturer shall provide an estimate of the background level at which the monitor will no longer meet the requirements of 6.2.2.

6.3.2 Method of test

With the monitor system monitoring the background radiation levels, expose the monitor to a step change in the ambient background level that is approximately 10 times that of the measured ambient background level without activating a monitoring cycle. The step change shall be performed over a period of not more than 5 seconds. The monitor shall indicate that the background has changed.

If the monitor indicates that it is operational, perform a gamma sensitivity test as stated in 6.2.3 for ^{137}Cs only. If the monitor does not meet the sensitivity requirements as stated in 6.2.3, reduce the background as needed to a level where the requirements of 6.2.3 are met. This level shall be within 20% of the maximum value as stated by the manufacturer.

6.4 Electrical characteristics

NOTE—Electrical, mechanical and environmental tests shall be performed with ^{137}Cs and ^{252}Cf (if the monitor is equipped with neutron detectors) sources from Table 3 unless otherwise stated.

6.4.1 AC line operation

6.4.1.1 Requirements

Line operated assemblies shall be designed to operate from single-phase a.c. supply voltage.

— 120 V for use in the United States.

The assemblies shall be capable of operating from a.c. lines with a supply voltage tolerance of +10%–15% and a supply frequency of 57 Hz–61 Hz where the nominal line frequency is 60 Hz. The indications of the radiation quantities shall vary by not more than 15% over this range of supply voltage and frequency.

The test stated in 6.4.1.2 is not necessary if the monitor is designed with a power supply that permits the input of various voltages and frequencies.

6.4.1.2 Method of test

The radioactive source defined in 6.2.1 shall be placed at a suitable reference point. With the supply voltage at its nominal value determine the mean of sufficient readings from each detector.

The count rates given by the device shall be recorded.

Sufficient readings shall be taken with the supply voltage 10% above the nominal value and sufficient readings with the supply voltage 15% below the nominal value. The mean radiation values shall not differ from those obtained with nominal supply voltage by more than 15%.

These above tests shall be repeated, but instead of changing the voltage, the frequency shall be changed from 57 Hz to 61 Hz, and the readings at these frequencies shall vary by not more than the values stated above compared to the readings at 60 Hz.

6.5 Mechanical characteristics

Components used outdoors near pedestrian traffic will typically not be exposed to mechanical environments such as shock and vibration other than when shipped to the location. Equipment designed for use as road and rail vehicle monitoring devices (including containers) unless mounted on bridges or onto other handling devices, such as cranes, will most likely not be exposed to shock or vibration environments. The requirements described in 6.5.1 and 6.5.2 are for all types of monitors regardless of use.

6.5.1 Mechanical shocks

Detection assemblies should be able to withstand, without affecting their performance, mechanical shocks (half-sine) from all directions at an acceleration of 300 m/s^2 over a time interval of 6 ms (see IEC 60068-2-27 [B1]). During this test, the assembly should be operating.

6.5.2 Vibration test

6.5.2.1 Requirements

a) *Frequency scanning:* No alarms or other changes in operation shall occur during the vibration exposure.

b) *Durability against vibration:* The indication of the equipment shall not vary more than 15% from a correspondent set of reference readings. The physical condition of the equipment shall not be affected by this vibration test (e.g., solder joints shall hold, nuts and bolts shall not come loose).

6.5.2.2 Method of test

The detection assembly shall be exposed to a source of photon radiation having sufficient intensity to minimize the effect of statistical fluctuations of the equipment readings, such as a radioactive source listed in Table 3 at a distance of 50 cm from the reference position of the detection assembly.

The count rates given by the equipment shall be recorded. The mean correspondent readings shall be determined.

a) *Frequency scanning:* The detection assembly shall be subjected to harmonic loadings of $0.5g_n$ whose frequency gradually increases from 10 Hz to 33 Hz and decreases from 33 Hz to 10 Hz in each of three orthogonal directions (one minute cycle is recommended). The mean correspondent equipment readings shall be recorded during the vibration.
b) *Durability against vibration:* The detection assembly shall be subjected to harmonic loadings of $2g_n$ for 15 min in each of three orthogonal directions at one or more frequencies in each of the following ranges: 10–21 Hz and 22–33 Hz.

However, if any mechanical resonance is found [in item a) of 5.5.2.2], the test frequency should be chosen among the resonance frequencies. After each 15 min vibration interval, the mean correspondent equipment readings shall be determined in the same exposure geometry as used initially and compared to the pre-vibration correspondent set of readings.

The equipment shall be inspected and the physical condition shall be documented.

6.6 Environmental characteristics

6.6.1 Ambient temperature

6.6.1.1 Requirements

The monitor shall be able to operate over an ambient temperature range from –30°C to +40°C, although higher temperatures may occur in enclosed cabinets, especially detector component cabinets. Because of the possibility of these higher temperatures, the test shall be performed over the temperature range from –30 °C to +55 °C (see IEC 60068-2-1 and IEC 60068-2-2, respectively [B1]). Acceptable operation is indicated by a <15% change in detector count rate with that measured at +20 °C.

The use of devices to control temperature within individual assemblies is acceptable.

6.6.1.2 Method of test

This test shall include measurements of count rate induced by ambient background, and measurements of count rate induced by radioactive sources as defined in 6.2.1 and 5.10.1.

This test shall normally be carried out in an environmental chamber. It is not, in general, necessary to control the humidity of the air in the chamber unless the monitor is particularly sensitive to changes of humidity. Humidity levels should be low enough to prevent condensation (<50%). The rate of change of temperature shall not exceed 10 °C per hour.

The temperature shall be maintained at each of its extreme values for a minimum of 16 h and the indication of the assembly measured every 30 min during this period. The limits of variation of indications shall be within the value given in this subclause.

Portions of the system that are intended for installation in a controlled environment may be excluded from this test.

6.6.2 Relative humidity

6.6.2.1 Requirements

The monitor shall be able to operate during and after exposure to relative humidity (RH) levels of up to 93% at an ambient temperature of +40 °C (see IEC 60068-2-56 [B1]). Acceptable operation is indicated by a <15% change in detector count rate with that measured at +20 °C and 65% RH, both during and after exposure. There also shall not be any observable effects from the exposure.

6.6.2.2 Method of test

The test shall be carried out at a single temperature of 40 °C using an environmental chamber. For this test the detection assembly shall be switched on and exposed to a reference gamma and neutron radiation (if the monitor is equipped with neutron detectors) as defined in 6.2.1 and 6.2.4. The humidity shall be maintained at its extreme values for a minimum of 16 h and the indications of the assembly noted every hour during this period. The permitted variation in the indications as specified is in addition to the permitted variations due to temperature alone. Following exposure, each assembly shall be inspected for corrosion or other affects caused by humidity.

Portions of the system that are intended for installation in a controlled environment may be excluded from this test.

6.6.3 Sealing

6.6.3.1 Requirements

The manufacturer shall state the precautions that have been taken to prevent the intrusion of moisture.

6.6.3.2 Method of test

All components that are intended for outdoor use shall be exposed to a rain test of 3 mm/min for a minimum of 15 min (see IEC 60068-2-18 [B1]). After exposure, each component shall be inspected to determine if moisture penetrated the installed seals.

6.6.4 External magnetic fields

6.6.4.1 Requirements

The manufacturer shall provide a warning in the instruction manual if an assembly may be influenced by external magnetic fields.

6.6.4.2 Method of test

This shall be subject to agreement between the manufacturer and the purchaser. The following is provided as a recommendation only.

Set the magnetic field intensity for continuous fields to 30 A/m at a frequency of 50 Hz or 60 Hz.

Expose the assembly to at least two orientations (0° and 90°) relative to the field lines.

NOTE—1 A/m is equivalent to a free space induction of 1.26 mT.

Compliance shall be checked by recording count rates from each detector channel and by monitoring the operational status during exposure. The count rate shall not vary by more than 15% of the rate under standard test conditions. There shall be no change in the operational status.

6.6.5 Occupancy sensor requirements

6.6.5.1 Requirements

The occupancy (or presence) sensors shall operate reliably under all expected weather conditions where used and for all types of expected vehicles.

6.6.5.2 Method of testing

A test shall be developed to ensure that the occupancy sensor operates reliably. The test shall be based on the type of sensor used to detect occupancy or initiate a count cycle. The test shall consist of 100 consecutive occupancies. A 99% reliability is required for acceptance.

6.7 Electromagnetic compatibility

6.7.1 Radio frequency

6.7.1.1 Requirements

The maximum spurious variation in the count rate from the detectors (both transient and permanent) due to electromagnetic fields shall be less than 15% of the rate under standard test conditions.

No alarms or other outputs should be spuriously activated when the assembly is exposed to the electromagnetic fields.

6.7.1.2 Method of test

Compliance with the performance requirements shall be checked by recording detector count rates and operating settings with and without the presence of the radio frequency field around the complete system (for the purpose of this test, and subsequent tests, the equipment can be collected together in a compact fashion and, provided all the operational functions can be exactly simulated, the equipment can be reduced to a single detection assembly where more than one would normally be used).

The field strength shall be 10 V/m over the frequency range from 20 MHz to 1 GHz in steps of 1% (severity level 3 as described in IEC 61000-4-3) of the fundamental frequency. The test can be performed using a field strength of 20 V/m to reduce the amount of measurements needed to show compliance with this requirement. If any change in count rate greater than 15% of the count rate under standard test conditions is observed, additional tests between ±5% around the frequency of susceptibility in steps of 1% with a field strength of 10 V/m shall be carried out with the equipment in all three orientations.

There shall be no change in the operational setting at any frequency.

6.7.2 Conducted disturbances induced by bursts and radio frequencies

6.7.2.1 Requirements

The maximum spurious variation in the count rate from the detectors (both transient and permanent) due to conducted disturbances induced by bursts and radio frequencies shall be less than 15% of the rate under standard test conditions.

No alarms or other outputs should be activated when the assembly is exposed to the field.

The test applies to devices used in the presence of radio-frequency transmitters in the frequency range of 150 kHz–80 MHz. Monitors that do not have at least one conducting cable (line supply, signal line, or earth connection) are excluded.

6.7.2.2 Method of test

Perform the following operations both with and without the presence of conducted disturbances induced by bursts (see IEC 61000-4-4) and conducted disturbances induced by radio-frequency fields (see IEC 61000-4-6) (the severity level shall in both cases be level 3), and with and without the presence of radiation sources as stated in 6.2.1 and 6.2.4.

a) Set the assembly to perform a measurement.

b) Set the frequency range of 150 kHz–80 MHz at an intensity of 140 dB (μV) 80% amplitude modulated with a 1 kHz sine-wave.

c) The test should be performed using an automated sweep at a rate not greater than 1.5×10^{-3} decades per second, or 1% of the fundamental.

Compliance shall be checked by recording count rates from each detector channel and by monitoring the operational status during exposure. The count rate shall not vary by more than 15% of the rate under standard test conditions. There shall be no change in the operational status.

6.7.3 Surges and oscillatory waves

6.7.3.1 Requirements

The tests apply to a.c. line-operated devices. The maximum spurious indications (both transient and permanent) of the display or data output due to surges or oscillatory waves shall be less than 15% of the count rate under standard test conditions.

No alarms or other outputs should be activated.

6.7.3.2 Method of test

Connect the a.c. line supply terminal via a coupling/decoupling network to the pulse generator in accordance with IEC 61000-4-5 and IEC 61000-4-12 (the severity level shall be level 3) and conduct the following operations, with and without the presence of radiation sources as stated in 6.2.1 and 6.2.4.

a) Ten pulses should be applied to the device with a minimum time between surges of one minute.

b) Each pulse should consist of a combination wave (1.2/50 μs – 8/20 μs) at an intensity of 2 kV.

c) Ring wave pulses should be not more than 2 kV.

Compliance shall be checked by recording count rates from each detector channel and by monitoring the operational status during exposure. The count rate shall not vary by more than 15% of the rate under standard test conditions. There shall be no change in the operational status.

6.7.4 Electrostatic discharge

6.7.4.1 Requirements

The maximum spurious indications (both transient and permanent) at the display or data output due to electrostatic discharge shall be less than 15% of the rate under standard test conditions.

No alarms or other outputs should be activated when the device is exposed to the discharges.

6.7.4.2 Method of test

User accessible components shall be placed close to a suitable discharge test generator as described in IEC 61000-4-2, and the following operations are performed, with and without the presence of radiation sources as stated in 6.2.1 and 6.2.4.

Set the assembly to perform a measurement.

Discharge at least five times to those various external parts of the complete equipment, which may be touched by the operator.

For assemblies with conductive surfaces and coupling planes, the contact discharge method shall be employed as described in IEC 61000-4-2. The electrostatic discharge shall be equivalent to that from a capacitor of 150 pF charged to a voltage of 6 kV, and discharged through a resistor of 330 Ω (severity level 3).

When assemblies with insulated surfaces are tested, the air discharge method with a voltage of 8 kV (severity level 3) shall be used.

Compliance shall be checked by recording count rates from each detector channel and by monitoring the operational status during exposure. The count rate shall not vary by more than 15% of the rate under standard test conditions. There shall be no change in the operational status.

7. Documentation

7.1 Type test report

The manufacturer shall make available, at the request of the purchaser, the report on the type tests performed to the requirements of this standard.

7.2 Certification

The manufacturer shall provide a certificate and evaluation report containing at least this information:

— Contact information for the manufacturer including name, address, telephone number, fax number, e-mail address, etc.
— Type of instrument, detector and types of radiation the instrument is designed to measure.
— Evaluated portal width.
— Sensitivity switch settings, detector bias level (lower level discriminator setting), and all significant calibration parameters such as ^{137}Cs 662 keV gamma-ray pulse height in scintillation detectors or neutron pulse height in ^{3}He proportional counters.
— Power supply requirements.
— Results of tests under environmental conditions.
— Results of electrical and mechanical tests.
— Recommended operational parameters such as: detector response and false alarm probability.
— Complete description of the evaluated monitor.

7.3 Operation and maintenance manual

The manufacturer shall supply an operational and maintenance manual containing the following information to the user:

— Operating instructions and restrictions.
— Schematic electrical diagrams, plus spare parts list and specifications.
— A troubleshooting guide.
— A detailed training manual or instructions for operators and users.
— Description and protocol for communication methods of transmitting and receiving data.

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.[3, 4]

[B3] UL 913– 2002, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations.[5]

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 N42.32-2003, American National Standard Performance Criteria for Alarming Personal Radiation Detectors for Homeland Security.

[3]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/).

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

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

[B12] ANSI N42.33-2003, American National Standard for Portable Radiation Detection Instrumentation for Homeland Security.

[B13] ANSI N42.34-2003, American National Standard Performance Criteria for Hand-held Instruments for the Detection and Identification of Radionuclides.

[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).[6]

[B15] ISO/DIS 22188:2002, Monitoring for Inadvertent Movement and Illicit Trafficking of Radioactive Material.[7]

A.4 Radiological protection instruments

[B16] ANSI N13.27-1981 (R1992), American National Standard Performance Requirements for Pocket-Sized Alarm Dosimeters and Alarm Ratemeters.

[B17] ANSI N42.17A-1989 (R1994), American National Standard Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Normal Environmental Conditions.

[B18] ANSI N42.17B-1989 (R1994), American National Standard Performance Specifications for Health Physics Instrumentation—Occupational Airborne Radioactivity Monitoring Instrumentation.

[B19] ANSI N42.17C-1989 (R1994), American National Standard Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Extreme Environmental Conditions.

[B20] ANSI N42.20-2003, American National Standard Performance Criteria for Active Personnel Radiation Monitors.

[B21] ANSI N323A-1997, American National Standard Radiation Protection Instrumentation Test and Calibration Portable Survey Instruments.

[B22] ANSI N323B-2003, American National Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instrumentation for Near Background Operation.[8]

[B23] IEC 60395 (1972), Portable X or Gamma Radiation Exposure Rate Meters and Monitors for Use in Radiological Protection.

A.5 Electromagnetic compatibility

[B24] 47 CFR 0-19: 2002, Telecommunication.[9, 10]

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[6]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/).

[7]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/).

[8]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.

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

[B25] IEC 61000-6-2 (1999), Electromagnetic Compatibility (EMC)—Part 6-2: Generic Standards—Immunity for Industrial Environments.

A.6 Units, quantities, calibrations

[B26] 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.

[B27] 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.

[B28] ISO 8529-1:2001, Reference Neutron Radiations—Part 1: Characteristics and Methods of Production."

[B29] ISO 8529-2:2000, Reference Neutron Radiations—Part 2: Calibration Fundamentals Related to the Basic Quantities Characterizing the Radiation Field.

[B30] NIST SP 250-98 ED, NIST Calibration Services User's Guide, 1998 Edition.[11]

A.7 Security monitors

[B31] ASTM C993-97 (2003), Standard Guide for In-Plant Performance Evaluation of Automatic Pedestrian SNM Monitors.[12]

[B32] ASTM C1112-99, Standard Guide for Application of Radiation Monitors to the Control and Physical Security of Special Nuclear Material.

[B33] ASTM C1169-97 (2003), Standard Guide for Laboratory Evaluation of Automatic Pedestrian SNM Monitor Performance.

[B34] ASTM C1189-02, Standard Guide to Procedures for Calibrating Automatic Pedestrian SNM Monitors.

[B35] ASTM C1237-99, Standard Guide to In-Plant Performance Evaluation of Hand-held SNM Monitors.

[10]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/).

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

[12]ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (http://www.astm.org/).

Annex B

(informative)

Detector tests

This standard and ANSI N42.32-2003 [B11], ANSI N42.33-2003 [B12], and ANSI N42.34-2003 [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.

Annex C

(informative)

Timing circuit for false alarm test

The circuit in Figure C.1 provides variable length occupied (false alarm testing) and unoccupied (background update) periods by using a recycle timer and recycling time delay relay. During false alarm testing, the recycle timer energizes the time delay to provide alternating timed periods of occupancy and vacancy.

If the monitor does not accept a relay closure as an occupancy signal, the relay can be used to control another device to cause occupancy. For example, the relay can operate a shutter to interrupt a light beam used as an occupancy sensor.

When the circuit is used with a wait-in portal, the time intervals used in the two devices should be carefully chosen to avoid the possibility of causing an alarm by de-energizing the time delay relay and prematurely vacating the monitor.

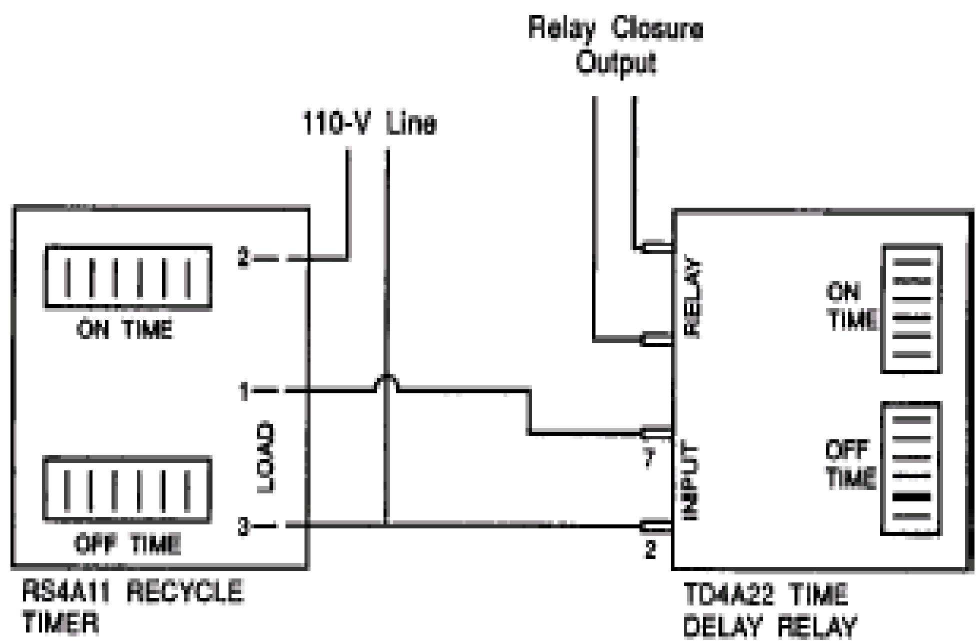
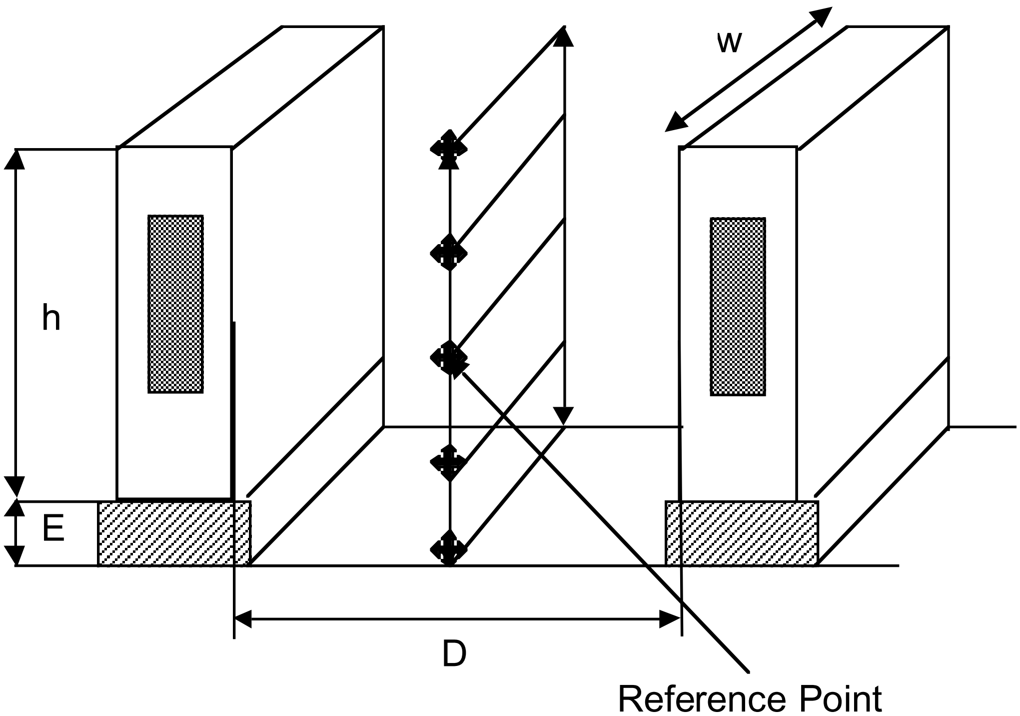


Figure C.1—A circuit providing alternating periods of unoccupied background update and cyclic occupancy for nuisance alarm testing

Annex D

(informative)

Diagram of mounting dimensions for portal detectors



where

- w is the width of the detection assembly
- h is the height of the detection assembly
- E is the height of detector mount
- D is the distance between detectors (measured from the detector's assembly or case)

The lines between the portal monitors represent the position at which the detector response test will be performed (see 6.2.3 and 6.2.4).

The plane between the monitors represents the detection zone.

Figure D.1—Mounting dimensions for portal monitors