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American National Standard for Portable Radiation Detection Instrumentation for Homeland Security

Accredited by the American National Standards Institute

Sponsored by the
National Committee on Radiation Instrumentation, N42

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Secretariat

The Institute of Electrical and Electronics Engineers, Inc.

Approved 23 December 2003

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Abstract: This standard describes design criteria, performance requirements and performance tests for portable radiation survey instruments.
Keywords: design criteria, performance requirements, performance tests, portable radiation detectors

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Introduction

(This introduction is not part of ANSI N42.33-2003, American National Standard for Portable Radiation Detection Instrumentation 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

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Contents

American National Standard for Portable Radiation Detection Instrumentation for Homeland Security

1. Overview

1.1 Purpose

The purpose of this standard is to specify technical performance requirements and performance testing requirements for those purchasing and using portable radiation survey meters and portable radiation detectors for Homeland Security applications.

1.2 Scope

This standard establishes design and performance criteria, test and calibration requirements, and operating instruction requirements for portable radiation detection instruments. These instruments are used for detection and measurement of photon emitting radioactive substances for the purposes of detection and interdiction and hazard assessment. The informative annexes of this standard provide reference information.

The standard covers portable instruments used for:

- Detection of radioactive substances on or in people, containers, and vehicles, including:
  - Photon (gamma- and x-ray) emitting radionuclides.
  - Other types of radiation and radionuclides will be considered in other standards.
- Determination of exposure rate with alarming capability for Homeland Security personnel including:
  - Fire fighters,
  - Police,
  - Customs and border officials,
  - Additional emergency personnel.
- This standard includes:
  - Design and performance requirements for specific instrument types and applications;
  - Type testing and certification requirements for these instruments;
  - Calibration and test intervals;
  - Required calibration standards; and
  - Required documentation, including the instrument instruction manual.

1.3 Applicability

This standard is to be used as part of a comprehensive Homeland Security radiation detection and protection program. The comprehensive program shall include a field manual that specifies when, where, and how the instruments shall, should, or may be used to detect and quantify the radiation or radioactive material of concern. The comprehensive program shall include a training manual that specifies how users shall become proficient on the use of the instruments for their intended purposes.

This standard may not be universally applicable to all programs. When selecting instrumentation the buyer and user should exercise professional judgment in the application of these requirements and should explicitly document the detection and protection objectives and the reasons for any exceptions to the requirements of this standard.

1.4 Relationship to other standards

This standard is one of a family of standards along with ANSI N42.32-2003 [B11], ANSI N42.34-2003 [B12] and ANSI PN42.35 [B13][1] that deal with other radiation detection, measurement and radionuclide 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 apply to the performance of portable health physics instrumentation that is also covered in ANSI N42.17A-1989 [B16], N42.17C-1989 [B18] and N42.20-2003 [B19]. The instruments covered by this standard are intended to measure exposure rate and are not intended to measure the dose equivalent rates for radiation workers. This standard does not supersede ANSI N42.17A-1989, ANSI N42.17C-1989, and ANSI N42.20-2003.

This standard does not include instruments for spectroscopic identification of radionuclides or devices that are covered in ANSI N42.34-2003 or portal monitors that are covered in N42.35-2004. It also does not include personnel dosimeters for Homeland Security that are covered in ANSI N42.32-2003. It does not include personnel dosimeters for legal dose of record, electronic versions of which are covered in ANSI N42.20-2003. It does NOT include integrated exposure measurements.

Other related standards are listed in the bibliography in Annex A. Document numbers for all relevant standards, federal guidance documents, and regulatory requirements are identified. Included are ANSI N323A-1997 [B20], ANSI N323B-2003 [B21], ANSI N42.17A-1989 and ANSI N42.17C-1989.

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.

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

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 [B11], ANSI N42.33-2003, 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.

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 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).

3.4 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.

[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.

3.9 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 Standard International (SI) unit Sievert, or Sv, follows 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%.

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

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

Table 1 summarizes the general applications and salient performance requirements of portable radiation detection instruments covered by this standard for Homeland Security. The critical applications are Type 1 for Detection and Interdiction and Type 2 for Hazard Assessment. Annex B illustrates how specific instruments may address identified portions of the broad range of radiation exposure rates of concern. The tests in this standard are to be considered as Type Tests (see Table C.1) 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.

Table 1—Summary of applications and general requirements

Class	Application	Purpose	Salient performance requirement
Type 1	Detection and interdiction	Detect the presence of radioactive material.	Detect levels of radiation at and above background.
Type 2	Hazard assessment	Quantify the exposure rate.	Have a wide dynamic range for gamma radiation.

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 2. Acceptable testing ranges for these quantities as given in Table 2 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 2—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 (68 °F)	18 °C to 22 °C (64 °F to 72 °F)
Relative humidity	65%	50% to 75%
Atmospheric pressure	101.3 kPa (29.9 inches of mercury at 0 °C)	70 kPa to 106.6 kPa (20.7 to 31.5 inches 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
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

Table 2—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)
Radiation background	Less than ambient exposure rate of 25 μR/h (0.25 μSv/h) in air	Ambient exposure rate of 10 μR/h (0.1 μSv/h) in air or less if practical
Contamination by radioactive elements	Negligible	Negligible
Reference photon radiations	^{241}Am, ^{137}Cs, ^{60}Co	^{241}Am, ^{137}Cs, ^{60}Co
Reference beta radiations	$^{90}Sr/^{90}Y$	$^{90}Sr/^{90}Y$
Reference neutron radiation	^{252}Cf	^{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 μrem/h will be assumed to be interchangeable with the unit μR/h and the quantity dose equivalent will be assumed to be interchangeable with the quantity exposure for photon irradiation. For neutron irradiation, the unit μrem/h will be used. Conventional units are given with SI units in parentheses.

5. Performance requirements

This clause specifies mechanical, electrical and electronic, radiological, and environmental performance requirements.

5.1 Mechanical

The mechanical design specifications insure that instruments designed for specific purposes outlined in the scope conform to this standard. The requirements for instruments to meet more rigorous mechanical and other required specifications are listed as under extreme conditions.

5.1.1 Appearance

The instruments specified and covered by this standard are portable survey meters. Each instrument should have an easy-to-read display for users and a minimum of switches and adjustable controls.

5.1.2 Size and dimensions

Type 1 instruments should fit into a storage space of less than 1728 in^3 (1 ft^3) excluding extendable probes. Type 2 instruments should fit into a storage space of less than 200 in^3 (0.12 ft^3) excluding extendable probes.

5.1.3 Weight

The weight of type 1 instruments should be less than 10 pounds (4.55 kg). The weight of type 2 instruments should be less than 6 pounds (2.7 kg).

5.1.4 Case construction

5.1.4.1 Type 1 instruments

The outer instrument case shall be rigid, shock resistant, splash proof and dust resistant. A user-friendly handle may be provided and attention should be given to the orientation of the display and alarms for the user.

5.1.4.2 Type 2 instruments

The outer instrument case shall be rigid, shockproof, waterproof (blowing rain) and dust proof. A user-friendly handle may be provided and attention should be given to the orientation of the display and alarms for the user. Type 2 instruments shall be supplied with field carrying cases to minimize damage.

5.1.5 Reference point marking

Instruments with detectors contained inside the instrument case shall have markings indicating the location of the effective center of detection in two planes, such as on the front and bottom, or on the front and on one side of the instrument.

5.1.6 Ease of radioactive decontamination and cleaning

The instrument case shall be constructed of materials that provide easy decontamination for radioactive materials and other potential surface contaminants.

5.2 Electrical and electronic

The electrical and electronic specifications for radiological instruments or survey meters are presented in 5.2.1 through 5.2.6.

5.2.1 Instrument display

The display may be digital, analog or a hybrid of the two types, and shall show units of exposure rate. The display shall be clearly visible to the user under normal and extreme conditions. The display may be illuminated.

5.2.2 Exposure rate range

The expected exposure rates are:

— *Type 1: Detection and interdiction*—from 0 μR/h to 1 mR/h (0 nSv/h to 10 μSv/h) (3 decades).
— *Type 2: Hazard assessment*—from 100 μR/h to 1000 R/h (1 μSv/h to 10 Sv/h) (7 decades).

5.2.3 Effective indicated range of measurement

The manufacturer shall state the effective range of the displayed indication for the instrument.

Some instruments use more than one detector for measurement over the complete specified ranges of those instruments. The manufacturer shall document that the slopes of response for the multiple detectors are the same.

The tests of this standard shall be performed for all detectors.

5.2.4 Switches

External switches shall be adequately protected from unintended operation. Switches shall be operable with gloved hands and through plastic bags used for contamination control.

5.2.5 Alarms

Alarms shall be configured such that they can only be set and reset by the appropriate controlling authority such as facility management or the radiation protection officer. Instruments covered by this standard shall be equipped with one or more adjustable alarms to alert the user or others. The alarms should be combinations of audible, visual, vibrating, or of other types appropriate to the application. For example, they may send a telemetric signal to a remote location. Alarms shall be readily recognized by the user.

5.2.5.1 Exposure rate alarms

For Type 1 instruments it should be possible to set alarms at levels of multiples of natural background in the applicable survey location. For example, if the natural background is 10 μR/h (100 nSv/h) in the location being surveyed, the controlling authorities should be able to set the instruments to alarm at, for example, 20 or 30 μR/h (200 or 300 nSv/h).

For Type 2 instruments it shall be possible to set these alarms to any value over the complete effective range of measurement of the instrument.

5.2.5.2 Alarm outputs

Alarms shall be of the audible, visual, vibrating or other appropriate types to warn the user.

— For Type 1 instruments the presence of radioactive material is indicated by an increase in the measured radiation level. This means that the user must first determine the natural background exposure rate in the location of the survey.
— For Type 2 instruments that are used to assess hazardous or potentially hazardous radiation levels, the alarms should be located where the user can readily observe a visual alarm such as a red light, hear an audible alarm, or feel a vibrating alarm. These alarms should be discernible to the user even under extreme conditions. For extreme conditions with the Type 2 instrument in a plastic bag and the user wearing gloves, the vibrating alarm and/or the audible alarm with the user wearing headphones may be most appropriate.

For audible alarms the frequencies shall be between 1,000 and 4,000 Hz. For intermittent alarms, the signal interval shall not exceed 2 seconds. The audible volume of the alarm shall exceed 75 dB(A) at the ears of the user or 85 dB(A) at one foot (30cm).

5.2.5.3 Additional indications

Both Type 1 and 2 instruments shall give indication of faulty instrument operating conditions, such as low battery supply, detector failure or high exposure rate levels.

5.2.6 Batteries

Facilities shall be provided to test the battery or batteries under maximum load conditions expected during use. Provision shall be made to indicate when the battery condition is no longer adequate for the instrument to meet the requirements of this standard. Primary batteries may be connected in any designed manner with correct polarity clearly indicated on the instrument by the manufacturer.

5.2.6.1 Primary battery requirements

a) The capacity of these batteries shall be such that after 24 hours of continuous operation under standard test conditions, the response of the instrument shall meet the requirements of 5.3.9 of this standard.

The instrument shall meet this specification in fields of:

1) 1 μR/h to 1,000 μR/h (10 nSv/h to 10 μSv/h) for Type 1 instruments, and
2) 100 μR/h to 1,000 R/h (1 μSv/h to 10 Sv/h) for Type 2 instruments.

b) Immediately after new batteries are installed the instrument shall be capable of operating for at least fifteen (15) minutes with all alarms in operation (e.g., flashing, sounding, and vibrating), as appropriate.

c) The primary batteries should be easily removed without use of a special tool or method.

d) Consumable batteries should be commercially available off the shelf from retail suppliers.

5.2.6.2 Secondary (rechargeable) battery requirements

These requirements shall be tested with gamma radiation.

a) When power is supplied by secondary batteries, the capacity of these batteries shall be such that after at least 12 (twelve) hours of continuous use under standard test conditions, the response of the instrument shall meet the requirements of 5.3.9.

1) Type1 instruments shall meet this specification in radiation fields of 1 μR/h up to 1,000 μR/h (10 nSv/h to 10 μSv/h), and
2) Type 2 instruments shall meet this specification from 100 μR/h to 1,000 R/h (1 μSv/h to 10 Sv/h).

b) Immediately after recharging the batteries, the instrument shall be capable of operating for at least 15 (fifteen) minutes with all alarms in operation. It should be possible to fully recharge these batteries within 12 (twelve) hours.

5.3 Radiological

This subclause presents radiological specifications.

5.3.1 Nature of the tests

Unless otherwise specified in 5.3.2 through 5.3.12, all tests described in this standard are to be considered as type tests. Parts of some tests may be considered as acceptance tests by the user.

5.3.2 Reference conditions and standard test conditions

Reference conditions are listed in Table 2. The test described in this standard shall be performed under standard test conditions unless otherwise specified. For those tests not performed under standard test conditions, the values of temperature, pressure and relative humidity at the time of test shall be documented and the appropriate corrections applied to equal or simulate the response under reference conditions.

For those tests intended to determine the effects of variations in the quantities given in Table 3, all other quantities should be maintained within the limits of standard test conditions given in Table 3, unless otherwise specified in the applicable test procedure.

Table 3—Radiated RF emission limits

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

5.3.3 Position of instrument for testing

For all radiation tests the reference point of the instrument shall be placed at that point where the value of the quantity to be measured is known with an uncertainty less than ±10%, and in the orientation with respect to the direction of the radiation field as indicated by the manufacturer.

5.3.4 Accuracy of radiation fields

For the purpose of this test the value of the exposure rate at the point of test shall be known with an uncertainty less than ±10%. The test shall be performed with the appropriate radiation source selected from Table 2. If the complete range of exposure rates is not available from a single source of radiation, several sources may be used with activities that produce dose (for beta and neutron radiations) or exposure rate ranges that overlap to cover the entire range of interest.

5.3.5 Low exposure rates

For the measurement of low exposure rates as with the Type 1 instruments it is necessary to account for the contribution of natural background to the exposure rate at the point or exact location of the test. Other contributing effects such as electronic noise or radioactive material inherent in instrument construction materials must also be considered.

5.3.6 Reference radiations

All tests involving radiation sources should be carried out using the type (s) specified in Table 2, unless otherwise specified in individual tests. The nature, construction, and conditions of use of the reference radiation sources shall be in accordance with the recommendations of ISO 4037-1:1996 [B25], ISO 4037-2:1997 [B26], ISO 8529-1:2001 [B27], and ISO 8529-2:2000 [B28], or NIST SP 250-98 ED [B29], as appropriate.

5.3.6.1 Reference gamma radiation

The reference gamma radiation sources should be ^{137}Cs and ^{241}Am. ^{60}Co may also be used with corrections needed to relate the response to that of ^{137}Cs.

5.3.7 Instrument accuracy, precision, and linearity

Under standard test conditions with calibration controls adjusted according to the instructions of the manufacturer, the relative error of indication of the instrument shall not exceed ±30% over the entire effective range of exposure rates.

Instruments should be tested for accuracy at approximately 25% and 75% of each range or decade over the entire effective range of the instrument.

5.3.8 Response time requirements for exposure rate monitors

The time required for an instrument to respond to and recover from a step change in radiation levels from 10% to 90% and 90% to 10% of the radiation level is the response time. The response time(s) for each type of instrument shall be stated by the manufacturer. When the instrument is subjected to an increase or decrease in exposure rate, the display shall indicate the new exposure rate with a relative error of indication of less than 20% within 4 seconds. For Type 1 instruments this requirement shall apply above exposure rates of 10 mR/h (100 nSv/h). For Type 2 instruments this requirement shall apply to exposure rates above 10 mR/h (100 μSv/h).

5.3.9 Photon energy response

In the calibration direction the response to incident photon radiation between 60 keV and 1.33 MeV shall not vary by more than ±30% from the response to the ^{137}Cs (0.662 keV) reference gamma radiation source. The 60 keV represents photons from ^{241}Am or filtered x-rays and the 1.33 MeV photons are emitted by ^{60}Co. This requirement applies only to Type 2 instruments.

5.3.10 Variation of response with angle of incidence for photon radiation requirements

The manufacturer shall state the directional or angular dependence of Type 2 instruments.

5.3.11 Response to other types of radiation

The manufacturer shall describe how the Type 1 and Type 2 instruments respond to alpha, beta, and neutron radiations.

5.3.12 Over-range characteristics requirements

For exposure rates greater than that corresponding to the maximum value of the upper decade and up to two times the maximum indication, the instrument readout shall remain “off scale” at the higher end of the display and shall remain so while in that radiation field. The manufacturer shall state the time required for instruments to return to the appropriate “on scale” reading following irradiation to this overexposure.

5.4 Environmental effects

This subclause presents specifications for resistance to environmental effects.

5.4.1 Ambient temperature requirements

The mean instrument response shall not vary by more than ±15% from a set of reference readings taken at a temperature of 50 °C or –20 °C when the instrument is taken from either of these temperatures to a temperature of 20 °C and allowed to stabilize at that temperature.

NOTE—These temperature limits are not sufficient for use in all parts of the country. Local extreme temperatures should be specified in those cases where the range of –20 °C to 50 °C does not cover the possible temperatures that can be encountered.

5.4.2 Temperature shock requirements

The mean instrument response shall not vary by more than ±30% from a set of reference readings taken at a mean temperature of 20 °C when the instrument is taken from 20 °C to 50 °C and from 20 °C to –20 °C, each in less than 5 minutes.

NOTE—The temperature range determined from 5.4.1 should be substituted for –20 °C to 50 °C if the local extreme temperatures exceed those specified temperatures.

5.4.3 Relative humidity requirements

The variation in the indication due to the effect of relative humidity from 40% to 93% non-condensing shall be within ±15%.

5.4.4 Sealing or moisture proofing

The mean response shall not vary more than ±15% from the mean set of reference readings after being subjected to water spray in accordance with 6.4.3 of this standard.

5.4.5 Rain

The instrument shall be operational without degradation in specified performance and shall sustain no physical damage during periods of precipitation. The instrument design shall permit no leakage to wind driven rain at a maximum rate of 5 inches per hour. The maximum horizontal wind velocity for this test shall be 40 miles/hour. This test procedure is listed in 6.4.4 of this standard.

5.4.6 Dust

The instrument shall withstand exposure to fine dust particles with wind speed of 17.3 knots or 1750 feet/minute in both operating and non-operating conditions. This test procedure is listed in 6.4.5.

5.4.7 Explosive atmospheres

The manufacturer shall specify the performance of the instrument in explosive atmospheres. This applies primarily to air ionization chambers or other radiation detectors that could emit an electrical spark. The manufacturer shall test the instrument in accordance with UL-913-2002 [B3].

5.4.8 Atmospheric pressure

The atmospheric pressure at which all tests are performed shall be stated. The manufacturer shall state the effects of atmospheric pressure over the range from ~520 to 720 mmHg (70 to 101.3 kPa) on instrument response.

5.4.9 External magnetic fields

Special precautions must be taken into account in the design of instruments to present correct indications in the presence of external magnetic fields (EMF) and radio frequency (RF) fields.

5.4.9.1 General requirements

A warning by the manufacturer shall be given in the operational manual if the indication of the instrument may be influenced by the presence of external magnetic fields. If the manufacturer states that the instrument is insensitive to electromagnetic fields, the types, the range of frequencies and intensities of the electromagnetic radiation in which the instrument has been tested shall be stated by the manufacturer.

5.4.9.2 Specific requirements

The instrument should not be affected by RF fields over the frequency range of 20 MHz to 1000 MHz at an intensity of 10 volts per meter (V/m). The instrument shall function correctly and alarm at a change in ambient background of 50 μR h^{-1} (0.5 μSv/h). For instruments with a digital display, (see 5.2.1) the instrument shall display a reading within ±15% of the conventionally true value, CTV, while being exposed to the RF radiation. For instruments with a non-digital indication, (see 5.2.1) that indication shall not have changed during the exposure and no alarms shall occur as a result of the RF radiation alone.

5.4.9.3 Conducted immunity

The instrument should not be affected by RF fields that can be conducted onto the instrument through an external conducting cable. Instruments that do not have at least one external conducting cable are excluded.

5.4.9.4 Electrostatic discharge requirements

The variation in response shall not be greater than ±15% when the instrument is exposed to an electrostatic discharge across the case of 6 kV with energy of 2 mJ on a grounded chassis and with a minimum of 10 seconds between individual discharges.

5.4.9.5 Magnetic fields

When exposed to direct current (DC) magnetic fields in two 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 (0.5 μSv/h). For instruments with a digital display, 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, that indication shall not have changed during the exposure and no alarms shall occur as a result of the DC magnetic field alone.

5.4.9.6 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 3.

6. Performance tests

Subclauses 6.1 through 6.4 describe the specific tests to be performed as portions of type tests, acceptance tests and periodic performance tests.

6.1 Mechanical tests

The type test and acceptance test should both include a physical inspection of the instrument to determine its compliance with the manufacturer's stated specifications with regard to appearance, dimensions and weight. The physical inspection should identify any abnormalities that may affect instrument operation, including broken parts, loose or missing screws, misaligned controls, knobs or access holes, circuit cards not secured, loose wires, loose connectors, or loose components, testing moving parts, and ensuring that fresh batteries are properly installed. The inside of the instruments should be dust-free and sealed via gaskets or some other mechanical method to exclude moisture.

The tests described in 5.1.1 and 5.1.2 are intended to determine the effects of mechanical handling of the instrument on its current or stored indications of dose or dose rate equivalent.

6.1.1 Drop test

Instruments shall be dropped from a height of one meter on all six sides onto a flat wooden surface mounted on a concrete base. Type 1 instruments shall be dropped in their respective shipping containers. Type 2 instruments shall be dropped in their respective field carrying cases. A check of accuracy using the reference radiation in Table 2 shall indicate satisfactory performance after the drop has been performed. The accuracy shall be within ±15% of the reference value.

6.1.2 Vibration test

The instrument shall be subjected to harmonic loadings of at least 2 g_n for 15 minutes in the range of frequencies of 10–30 Hz in each of three orthogonal directions. An accuracy check using the reference radiation in Table 3 shall indicate satisfactory performance after all vibration tests have been performed. The accuracy shall be within ±15% of the reference value.

6.2 Electrical and electronic tests

6.2.1 Battery lifetimes-primary and secondary batteries

New primary batteries or fully charged secondary batteries of the types specified by the manufacturer shall be used in these tests.

a) The instrument shall be exposed to a photon radiation field sufficient to provide a suitable indication on the display. The instrument shall be maintained in this field for a period or periods specified in 5.2.6, as appropriate, and the reading at the end of each period noted. Each reading shall conform within the requirements of 5.2.6, as appropriate.

b) This following test item will not be required for Type 1 instruments that do not have alarming capability. Type 2 instruments shall be set to alarm below 100 mR/h (1 mSv/h). The instrument shall be subjected to an exposure rate of 100 mR/h (1 mSv/h) until the appropriate alarms (audible, visual and others) are activated. After 10 (ten) minutes of continuous exposure all appropriate alarms shall continue to respond.

6.2.2 Audible alarm intensity

The audible alarm of the instrument shall be activated with an appropriate radiation source near the instrument. The A-weighted sound level at a distance of 30 cm shall be measured and compared with the specifications in 5.2.5.1 and 5.2.5.2.

6.2.3 Vibrating alarm intensity

The vibrating alarm intensity shall be such that an operator can definitely feel the alarm condition with the instrument in a plastic bag or other anti-contamination container and through several pairs of protective gloves. Several people should be used to test this type of alarm to reduce subjectivity.

6.2.4 Miscellaneous types of alarms

Other types of alarms may include telemetric alarms with alarms signals sent from the instrument to a remote or central location. This type of alarm shall be tested under the conditions specified by the manufacturer and agreed upon by the user. Similarly, if dose rate data are transmitted remotely, then this data transmission method and program shall be tested as agreed upon between the manufacturer and the user.

6.3 Radiological tests

The reference radiation sources to be used for the tests described in this subclause shall be selected from those listed in Table 2. The instruments to be tested shall be mounted on a low-scattering, low atomic number (Z) stand or fixture.

6.3.1 Precision

The instrument shall be exposed to an appropriate source selected from Table 2 at an exposure rate of approximately 25% and 75% of each range or decade of the instrument. At each exposure rate test level, a minimum of ten readings shall be taken, and no individual reading shall exceed ±30% of the average of the readings.

6.3.2 Accuracy and linearity

The instrument shall be exposed to an appropriate source selected from Table 2 at an exposure rate of approximately 25% and 75% of each range or decade of the instrument. The relative error of indication shall be within ± 30% of the true value of the exposure rate.

6.3.3 Energy response

Type 2 instruments shall be tested at the following energies:

a) ^{241}Am or filtered x-rays of approximately 60 keV,

b) Gamma (γ) radiation from ^{137}Cs at 0.662 MeV,

c) ^{60}Co at 1.17 MeV and 1.33 MeV.

The response to incident photon radiation between 60 keV and 1.33 MeV shall not vary by more than ±30% from the response to the ^{137}Cs (0.662 keV) reference gamma radiation source.

It is desirable that these tests be conducted at the same exposure rate at all radiation energies. As this may not be possible, the indicated exposure rates may be corrected for the relative error of indication at that indicated exposure rate for the reference gamma radiation source.

Type 1 instruments shall only be tested with ^{137}Cs photons.

6.3.4 Over-range response

The instrument shall be irradiated for 10 minutes to an exposure rate of two (2) times the exposure rates given in 5.2.2. The indication of the instrument shall remain at the maximum of the range, and an over-range indication shall be shown.

6.3.5 Response to other types of radiation

The instruments covered in this standard, intended for measuring only photons, shall be tested for the influence of other types of radiation. A source of radiation that the instrument is not designed to measure shall be selected from Table 2. The beta source(s) should provide dose equivalent rates of 1 mrad/h (10 μGy/h) for Type 1 instruments and 1 rad/h (10 mGy/h) for Type 2 instruments. The neutron source(s) should provide dose equivalent rates of 1mrem/h (.01 mSv/h) for Type 1 instruments and 1 rem/h (10 mSv/h) for Type 2 instruments. The indicated response to these radiations shall result in a reading in R/h of less than 2.5% of the dose equivalent rates presented (i.e., 25 μR/h above indicated background for Type 1 instruments and 25 mR/h for Type 2 instruments).

NOTE—For use in this standard the Gray (Gy) and the Sievert (Sv) are considered equal and the Roentgen (R), the rem (Roentgen equivalent man) and the rad (Roentgen absorbed dose) are also considered equal.

6.4 Environmental condition tests

This subclause specifies tests for environmental conditions.

6.4.1 Temperature

For these tests the instrument shall be irradiated with a reference photon source to provide a measurable indication under standard test conditions.

a) A series of exposure rate readings shall be performed and the readings recorded at the reference temperature of 20 °C ±2 °C, at the upper and lower temperature limits of +50 °C and –20 °C (+122 °F and –4 °F), and at each 10 °C soak temperature (–10, 0, 10, 30, and 40 °C). Temperature ramp rates shall be 10 °C/hr and soak times shall be 1.5 hrs for each 10 °C soak interval. The test temperature shall be maintained at the extreme values for at least four (4) hours and the displayed indication of the instrument shall be measured during the last thirty (30) minutes of this period. The limits of variation of indication shall be within the value in Table 4.

b) The instrument shall be placed in a temperature of 20 °C ±2 °C and allowed to stabilize for at least one (1) hour. The instrument shall be exposed in a reproducible geometry to a photon source of sufficient intensity to minimize the effects of statistical fluctuations and to produce a response in approximately the middle of the second least significant decade. For Type 1 instruments this point on the range of the instrument is approximately 50 μR/h (500 nSv/h). For Type 2 instruments this point on the range is approximately 0.50 mR/h (500 μSv/h). The mean instrument reading shall be determined after a sufficient number of readings are taken to reduce statistical fluctuations. The instrument and source shall then be placed directly into an environmental chamber where the exact exposure geometry is established and the temperature is now 50 °C (±2 °C) or the temperature specified by the purchasing agency. This procedure shall be completed within five (5) minutes. The mean reading shall be determined then, and every fifteen (15) minutes thereafter for two (2) hours. If the instrument does not fail the test during the first hour, then the test is completed satisfactorily. The instrument shall remain at this temperature for the second hour. The instrument and source shall be removed from the environmental chamber and returned to the first environment with the same exposure geometry established and the temperature at the instruments is 20 °C ±2 °C. This procedure shall be performed in less than five (5) minutes. The mean instrument reading shall be taken then and every fifteen (15) minutes thereafter for two (2) hours. If the instrument does not fail the test in the first hour, data do not need to be taken during second hour. The instrument should remain in this environment for the second hour to reach temperature stability.

This test shall be repeated inside the environmental chamber with the temperature set at –20 °C (± 2 °C) at the instrument or the temperature specified by the purchasing agency.

Table 4—Tests performed with variations of influence quantities

Characteristic under test or influence quantity	Range of values of influence quantity	Limits of variation of indication
Relative intrinsic error	Effective range of measurement	Exposure rate ±20%
Response time	5 s	< ±20%
Accuracy of alarm levels	All settings	Exposure rate ±20%
Photon High-energy beta Neutron	50 keV to 1.5 MeV Emax = 3.5 MeV Thermal to 15 MeV	±30% ±50% ±50%
Angle of incidence Neutron Photon	0° to ±75° 0° to ±75°	±30% ±30% for ^{137}Cs ±50% for ^{241}Am
Retention of reading	24 h after loss of power supply	±5%
Exposure rate dependence	Up to 100 R/h (1 Sv/h)	< ±20%
Other ionizing radiation response	At 1 R/h equivalent (10 mSv/h)	< 2.5% full scale
Overload	Two times maximum range	Indication greater than full scale
Power supply voltage Primary batteries Secondary batteries	 > 100 h continuous use > 10 h continuous use	 ±15% ±15%

6.4.2 Humidity

This test shall be performed at a single temperature of 35 °C (±2 °C) in an environmental chamber. The reference source shall be in contact with the instrument being tested, and providing a sufficient response under standard test conditions for the test to be performed. The humidity will be maintained at the extreme values each for at least four (4) hours. The indication on the instrument shall be documented during the final thirty (30) minutes of this period. The permitted variation of ±15% in the indication is in addition to the variations due to temperature alone.

6.4.3 Moisture resistance

The instrument shall be exposed in a reproducible geometry to a source of ionizing radiation selected from Table 2, of sufficient intensity to reduce the effects of statistical fluctuations of the instrument and to produce a response approximately in the middle of the range of the instrument. For Type 1 instruments this is a value of approximately 100 μR/h (1 μSv/h) and for Type 2 instruments this is a value of approximately 500 mR/h (5 mSv/h). The mean instrument reading shall be determined after a sufficient number of readings are taken. The instrument shall then be exposed for two (2) minutes to a fine water spray at a flow rate of about four (4) liters/minute. The spray nozzle shall be about 2 meters from the instrument. The instrument shall respond to radiation during and after the test. The temperature of the water shall be 20 °C (±2 °C).

6.4.4 Rain test procedure

For instruments that can be used in extreme environmental conditions, the following test procedure shall be used as the basis for testing the water tightness of the instrument being tested.

a) With the instrument being tested in the normal operating position, the rainfall rate shall be adjusted to 2 inches per hour for 10 minutes. The rate shall be adjusted to 5 inches per hour for 5 minutes. The rate shall then be adjusted to 2 inches per hour for 15 minutes. The sealed instrument being tested shall be raised to a temperature above that of the rainwater, or the rainwater shall be cooled. The tested instrument shall then be restored to its normal operating configuration as before testing.

b) The wind speed shall be initiated at 40 miles per hour 5 minutes after the start of the test and maintained for at least 15 minutes. The wind source shall then be turned off.

c) If an operational check is required, the tested instrument shall be operated for the last 10 minutes of the test.

d) The instrument being tested shall then be exposed to the rain source on any other side of the test item that could be exposed to rain during the deployment cycle.

e) Steps a) through d) shall be repeated until all possible variations are tested.

f) The tested instrument shall be examined in the test chamber if possible or the instrument shall be given a visual inspection outside of the test chamber. If noticeable water has penetrated the test instrument, then judgment shall be exercised before the instrument is operated. It may be necessary to empty the water, and the water volume shall be measured.

g) The tested instrument shall then be operated normally.

h) The results shall be documented.

6.4.5 Blowing dust test procedure

For instruments that can be used in extreme environmental conditions, the following test procedure shall be used as the basis for collecting the necessary data concerning performance of the instrument in a dusty environment.

a) With the instrument to be tested in the chamber, the temperature shall be adjusted to 23 °C (73 °F and the relative humidity shall be maintained to less than 22% throughout this test.

b) The air velocity shall be adjusted to 1750 feet per minute ±250 feet per minute.

c) The dust feed control shall be adjusted for a dust concentration of 10.6 grams/meter^3 (0.3 ±0.2 grams/foot^3.

d) These conditions shall be maintained for at least 6 hours with the test instrument not operating.

e) The dust feed shall then be stopped and the air velocity reduced to 300 ±200 feet per minute and the temperature shall be raised to 50 °C.

f) Step e) shall be maintained until stabilization is reached.

g) The air velocity shall be adjusted to that in step b) and the dust feed shall be restarted to maintain the dust concentration as in step c).

h) All chamber controls shall be turned off and the tested instrument returned to ambient conditions.

i) All accumulated dust shall be removed from the tested instrument and care taken to avoid introduction of additional dust into the tested instrument.

j) The tested instrument will be operated as normally.

k) Results of this test shall be documented.

6.4.6 Radio frequency

The instrument shall be exposed to a ^{137}Cs source producing an exposure rate of 50 μR/h (0.5 μSv/h) 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 measured without an instrument present in the irradiation area 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.

6.4.7 Conducted immunity

A ^{137}Cs source shall be placed in a location that provides a exposure rate of 50 μR/h at the detector and expose the instrument to a conducted RF field over the frequency range of 150 kHz to 80 MHz at an intensity of 140 dB 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. No alarms or other spurious indications shall occur and the indicated exposure rate should remain within ± 30% of the initial indicated value throughout the RF exposure.

6.4.8 Magnetic fields

The instrument shall be placed 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 (0.5 μSv/h) over the ambient background level of radiation. The instrument shall function correctly and alarm at a change in ambient background of 50 μR/h (0.5 μSv/h). For instruments with a digital display (see 5.2.1), the instrument shall display a reading within ±30% of the conventionally true value (CTV). For instruments with a non-digital indication (see 5.2.1), 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 after orienting the instrument at an orthogonal position with respect to the magnetic field.

6.4.9 Radiated emissions (see IEC 61000-4)

The instrument shall be placed 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 5.

Table 5—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.

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 volume of the detectors.
— Thickness of walls and other materials between the source and detector in milligrams per centimeter squared (mg/cm^2).
— Response of the instrument to different appropriate radiation energies.
— Response of the instrument as a function of angle of incidence.
— 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.

7.4 Training manual

A detailed training manual or instructions for operators and users shall be prepared as agreed upon between the ANSI National Committee on Radiation Instrumentation, N42, and the ANSI National Committee on Radiation Protection, N13.

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.[4, 5]

[B3] UL 913– 2002, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations.[6]

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.

[4]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/).

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

[6]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.[7]

[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).[8]

[B15] ISO/DIS 22188:2002, Monitoring for Inadvertent Movement and Illicit Trafficking of Radioactive Material.[9]

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.[10]

[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.[11, 12]

[7]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/).

[8]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/).

[9]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/).

[10]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.

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

[12]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.[13]

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

Annex B

(informative)

Considerations for the selection of instruments to address the radiation exposure rates of concern

Figure B.1 shows the exposure-rate ranges of concern for Type 1 and Type 2 instruments. Because the exposure rate ranges are large, more than one instrument may be required to cover the complete ranges of interest.

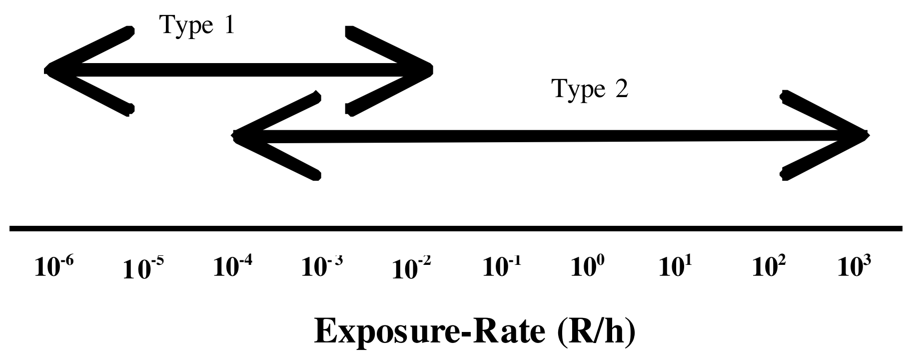

Figure B.1—Exposure rate ranges of interest for Type 1 and Type 2 instruments

Annex C

(informative)

A comprehensive test program

This annex presents a programmatic overview and delineates the tests that comprise a comprehensive program. Table C.1 provides a summary of instrument tests that would comprise a comprehensive design, development, test, and documentation program. As shown in Table C.1, such a program would include tests that are performed only once (typically on new instruments) such as type testing production control tests, and acceptance testing, as well as tests that are performed repeatedly such as calibration, functional checks, maintenance and recalibration, and periodic performance testing.

As illustrated in Table C.2, each class of test would comprise individual tests from four general categories: mechanical, electrical and electronic, radiological, and environmental conditions. Details of these performance requirements and test requirements are presented in Clauses 5 and 6 of this standard.

C.1 Classes of tests

This annex subclause describes the general considerations of tests that are presented in Table C.1.

C.1.1 Development and prototype testing

These tests are performed by the manufacturer during the design phase to determine the likelihood that a specific instrument design will meet the intended specifications. Understanding the expected conditions of use and monitoring objectives allows the manufacturer to develop an instrument that is likely to pass the other tests described in C.1.

C.1.2 Type testing

To fully define the performance characteristics of the instrument, portable radiation detection instruments shall be type tested in accordance with this standard. Type testing shall be performed on two or more production models of each instrument to fully characterize the performance and limitations of the instrument. Variation in radiation energy, radiation direction, temperature, humidity, instrument stability, etc., can affect the accuracy of measurements in the field. The instrument characteristics, as defined by a series of tests, will document for the user how accurately the instrument can be expected to detect and quantify the radioactivity of concern under variable operational conditions.

C.1.3 Production control testing

These tests are performed by the manufacturer in accordance with documented procedures.

C.1.4 Acceptance testing

Acceptance testing should be performed on each new instrument before initial use. Acceptance testing should test each instrument against specific characteristics identified as critical or indicative of overall instrument performance. The purpose of acceptance testing is to demonstrate that each instrument meets certain stated specifications and contractual requirements.

An acceptance test should consist of:

— Physical inspection
— General operational tests
— Radiological response tests
— Initial calibration

C.1.4.1 Physical inspection

A physical inspection is an inspection identifying any physical abnormalities that may effect instrument operation, for example, inspecting instruments for broken parts, loose or missing screws, loose or misaligned knobs, calibration potentiometers not aligned with access holes, circuit boards not secured, loose wires, loose connectors, and loose components; testing moving parts; or ensuring that batteries are fresh and properly installed. Physical inspections shall be performed on each instrument.

C.1.4.2 General operations test

A general operations test is a determination of non-radiological operating functions, for example, checking battery condition, verifying mechanical zero, testing the meter zero potentiometer, and checking liquid crystal display elements, if applicable. General operations tests shall be performed on each instrument.

C.1.4.3 Radiological response tests

Radiological response characteristics that may be tested during acceptance testing include radiological response such as energy response or energy dependence, overload response, measurement range and stability.

C.1.5 Initial calibration

The initial instrument calibration is part of the acceptance test and should include a comparison of the instrument linearity and overload response against specifications.

C.1.6 Functional checks

A functional check is a check, often qualitative, 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. This check shall be performed at least daily, or prior to each intermittent use, whichever is less frequent.

C.1.7 Periodic maintenance and calibration

Maintenance, calibration, performance tests, and functional checks shall be performed periodically on all instruments to assure that the instruments continue to meet the required accuracy for field measurements. The calibration interval should not exceed a period of one year or as recommended by the manufacturer. Periodic calibration is different from a functional check or simple evaluation with a check source. Calibration should be performed by the manufacturer or other qualified calibration facility. Sources used for calibration shall be traceable to NIST (see ANSI N42.22-1995 and ANSI N42.23-1996).

Maintenance shall be performed using components and recommendations at least equivalent to those specified by the manufacturer. Replacement components shall be specified by the manufacturer or be equivalent.

Repairs made using unapproved instructions or components that may affect instrument performance constitute an instrument modification and shall render invalid any type tests made on the instrument model as applied to the specific instrument. Modified instruments shall have their performance tested and documented prior to issuance for field use. If the user can document that the modification does not affect the instrument performance, additional testing is not required.

C.1.8 Periodic performance test

As appropriate based on experience and anticipated modes of failure, the purchaser should test or arrange to test a representative number of units against selected specifications from the type test to verify that the instrument continues to meet relevant specifications.

Table C.1—Summary of instrument tests and test requirements

Name of test	Purpose of test	Test frequency	Units to be tested	Specifications to be tested	Responsibility
Development test	To aid in the development of a prototype that is likely to meet certain specifications.	As needed.	Individual components and assemblies.	As selected by the manufacturer; or requested by the purchaser/user.	The manufacturer.
Prototype test	To demonstrate that the design of the instrument is likely to meet certain specifications.	As needed prior to start of production.	One or more prototype units.	As selected by the manufacturer; or requested by the purchaser/user.	Generally the manufacturer. Occasionally the purchaser/user.
Type test	To demonstrate that the design of the instrument as manufactured meets certain specifications.	A minimum of once prior to full production.	Two or more initial production units.	All specifications from the relevant standard, or as agreed upon between manufacturer and purchaser/user.	Generally the manufacturer. Occasionally the purchaser/user.
Production control test	To control production, avoid defects, and confirm instrument compliance with selected specifications.	Depending on the acceptable failure rate agreed upon between manufacturer and purchaser/user.	As determined by the manufacturer or as agreed upon between manufacturer and purchaser/user.	As selected by the manufacturer, or requested by the purchaser/user.	Manufacturer.
Acceptance test	To demonstrate compliance with selected specifications.	After the units are received and prior to their initial use.	As agreed upon between manufacturer and purchaser/user.	As selected by the purchaser/user.	Purchaser/user.
Initial calibration	To establish a traceable calibration relevant to expected conditions of use.	Prior to initial use.	Each unit.	Selected instrument parameters and responses.	Designated calibration staff of the users' organization (or selected vendor).

Table C.1—Summary of instrument tests and test requirements *(continued)*

Name of test	Purpose of test	Test frequency	Units to be tested	Specifications to be tested	Responsibility
Functional check	To provide indications that the instrument is operational.	Before each use and periodically during use.	Each unit.	As appropriate for the instrument being used.	User.
Periodic maintenance and calibration	To provide preventive maintenance, make necessary repairs, and re-establish a traceable calibration.	At a frequency, such as annually, based on the design and reliability history of the instrument.	Each unit.	As appropriate for the instrument.	Designated maintenance staff of the user's organization (or selected vendor).
Periodic performance test	To verify that the instrument continues to meet relevant specifications.	As appropriate based on experience and anticipated modes of failure.	A representative number of units.	Selected specifications from the type test.	As arranged by the purchaser.

Table C.2—Example matrix of instrument tests and test requirements[a]

Class of test	Test categories and requirements			
	Mechanical	Electrical and electronic	Radiological	Environmental conditions
Type test	5.2.1/5.2.3	5.2.4	5.2.5	Table 2
Production control test				Table 2
Acceptance test	5.2.2	5.2.4		Table 2
Calibration				Table 2
Functional check			5.3	Table 2
Maintenance and recalibration	5.4.2	5.4.2	5.4 and 5.4.1	Table 2
Periodic performance test				

[a]The test requirements refer to Table C.1 plus the clauses/subclauses and tables of this standard as indicated.

Annex D

(informative)

Detector tests

This standard and ANSI N42.32-2003 [B11], ANSI N42.34-2003 [B12], and ANSI N42.35-2004 [B13] utilize some of the following types of detectors:

— *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.