

American National Standard Performance Specifications for Health Physics Instrumentation — Portable Instrumentation for Use in Normal Environmental Conditions

**National Committee on Radiation Instrumentation, N42
accredited by the American National Standards Institute**

Secretariat

The Institute of Electrical and Electronics Engineers, Inc.

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Foreword

(This Foreword is not a part of ANSI N42.17A-1989, American National Standard Performance Specifications for Health Physics Instrumentation — Portable Instrumentation for Use in Normal Environmental Conditions.)

This standard is the responsibility of the Accredited Standards Committee N42 on Radiation Instrumentation. Committee N42 delegated the development of the standard to its Subcommittee N42.1. Drafts were reviewed by Committee N42, Subcommittee N42.1, and other interested parties, and the comments received were utilized in producing the standard as finally approved and issued. The standard was approved by Committee N42 letter ballot of April 18, 1988.

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American National Standard Performance Specifications for Health Physics Instrumentation — Portable Instrumentation for Use in Normal Environmental Conditions

1. Scope and References

This standard establishes minimum acceptable performance criteria for health physics instrumentation for use in ionizing radiation fields. Included are testing methods to establish the acceptability of each type of instrumentation. This standard does not specify which instruments or systems are required, nor does it consider the number of specific applications of such instruments.

1.1 Introduction

The object of this standard is to provide basic performance requirements and verification test methods for instruments used for radiation protection of personnel.

As used in this standard, health physics instrumentation provides direct readout of or readout relatable to dose or dose equivalent, rate,¹ or activity per unit area (i.e., effective probe area). Included are portable rate and integrating devices for beta, photon, and neutron radiations and monitors for surface contamination (alpha, beta, and photon). Instruments used to measure the presence of low-energy beta emitters (i.e., less than 200 keV maximum energy) are not addressed in this standard. Personnel dosimeters; instruments designed to be used as individual or personal monitors, or warning devices; environmental monitoring instruments; and air monitors are outside the scope of this standard. Special purpose instrumentation, such as emergency post-accident radiological monitors, may also fall under the scope of one or more related ANSI standards, and this standard is intended to supplement rather than replace these. In general, health physics instrumentation is considered to cover the dose and dose-equivalent rate ranges for survey meters of 0.1 mrd/h to 1000 rd/h (10^{-6} Gy/h to 10 Gy/h) and 0.1 mrem/h to 1000 rem/h (10^{-6} Sv/h to 10 Sv/h).² It covers activity-per-unit-area ranges for surface contamination monitors of 50 disintegrations per minute (dpm)/cm² to 10⁴ dpm/cm²

¹Until conversion to SI units is more advanced, readout of exposure (R) or exposure rate (R/h) will be considered acceptable for exposure to photon radiation.

²See footnote 1 above.

(0.83 Bq/cm² to 167 Bq/cm²) for beta/photon radiation and 1 dpm/cm² to 10⁴ dpm/cm² (0.02 Bq/cm² to 167 Bq/cm²) for alpha radiation.

For specific characteristics, test requirements will vary with the use of the instrument. For example, the temperature range for a laboratory instrument is not as demanding as the requirement for an instrument to be used out-of-doors. Table A-1 in the appendix lists the characteristics in the standard, and when multiple ranges for influence quantities are listed, the appropriate range shall be used. Where more stringent requirements may be necessary, they should be specified.

This standard specifies general characteristics; general test procedures; radiation characteristics; and electrical, mechanical, safety, and environmental characteristics. Throughout this standard, three verbs have been used to indicate the degree of rigor intended for each specific criterion. The word *shall* is used to denote a requirement, the word *should* to denote a recommendation, and the word *may* to denote a permissible practice.

If the operational conditions for an instrument are less severe than the requirements of this standard, then the instrument performance specifications may be agreed upon by the instrument manufacturer and the purchaser; however, the instrument should be tested using the testing protocol of this standard.

1.2 Classes of Instruments

1.2.1 Class A Instruments

Class A instruments shall meet all of the applicable requirements listed in this standard.

1.2.2 Class B Instruments

Class B instruments shall meet all the applicable requirements of Sections 4., 5., 6., 7.1, 8.1, 8.2, 8.3, and such others as the manufacturer shall so designate and the purchaser so specify.

1.2.3 Class C Instruments

Class C instruments shall meet requirements as specified by the purchaser or the user group and shall be tested in accordance with the guidance in this standard.

1.3 References

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

[1] ANSI N13.4-1971 (R1983), American National Standard for the Specification of Portable X- or Gamma-Radiation Survey Instruments.³

[2] ANSI/IEEE C62.41-1980, IEEE Guide for Surge Voltages in Low-Voltage AC Power Circuits.⁴

[3] ICRU Report 12-1968, Certification of Standardized Radioactive Sources.⁵

[4] IEC 278-1968, Documentation to Be Supplied With Electronic Measuring Apparatus.⁶

³ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

⁴ANSI/IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, Piscataway, NJ 08855-1331, or from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

⁵ICRU publications are available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814.

⁶IEC publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

[5] ISO 6980-1984, Reference Beta Radiations for Calibrating Dosimeters and Doseratemeters and for Determining Their Response as a Function of Beta Radiation Energy.⁷

[6] NCRP Report 38-1971, Protection Against Neutron Radiation.⁸

[7] Shleien, Bernard, and Terpilak, Michael S., eds. *The Health Physics and Radiological Health Handbook*. Olney, Maryland: Nucleon Lectern Associates, 1984.

2. Definitions

For the purpose of this document, the following definitions apply:

acceptable source: Source of radiation listed in the appropriate reference source table in this standard.

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

accredited testing laboratory: A 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.

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

adjust: To alter the response by means of a variable, built-in control such as a potentiometer.

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

angular dependence: Response of the detector as a function of the angle of incidence of the radiation being detected and a reference orientation.

beta cutoff energy: The minimum energy required of a beta particle for that particle to travel a specific distance through a known media.

calibrate: To adjust or determine or both: (1) the response or reading of an instrument relative to a series of conventionally true values; or (2) the strength of a radiation source relative to a standard or conventionally true value.

coefficient of variation: The standard deviation, expressed as a percentage of the mean [i.e., standard deviation/ $\bar{x}$] • (100) %.

contamination meter: An assembly, including one or several radiation detectors and associated subassemblies, designed to measure (alpha, beta, alpha-beta) activity per unit surface area associated with the contamination of the examined object.

conventionally true value of a quantity: The commonly accepted best estimate of the value of that quantity. This and its associated uncertainty will normally be determined by a national or transfer standard, or by a reference instrument that has been calibrated against a national or transfer standard, or by measurement quality assurance (MQA) with a national laboratory or qualified secondary laboratory.

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

detection axis: A specified imaginary line through the effective center of the detector to which the radiation field direction can be referenced.

⁷ISO publications are available from the Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

⁸NCRP publications are available from the National Council on Radiation Protection and Measurements, 7910 Woodmont Avenue, Suite 800, Bethesda, MD 20814.

detection limit: The extreme of quantification for the radiation of interest by the instrument as a whole or an individual readout scale or decade. The lower detection limit is the minimum quantifiable instrument response or reading. The upper detection limit is the maximum quantifiable instrument response or reading. Quantifiable, in this case, means within the specified accuracy.

detector: That portion of an instrument system sensitive to and used for the quantification of ionizing radiation.

drift: Change in readout, usually gradual, without concomitant change in the influence quantity.

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

effective energy: The energy used to characterize a heterogeneous radiation field that behaves under specified conditions as if it were a mono-energetic radiation field of the same energy.

energy dependence: A change in instrument response with respect to radiation energy for a constant dose equivalent or dose-equivalent rate.

evaluation: Interpretation of measurements and observations, including determination of compliance with applicable specifications.

extracameral: Pertaining to that portion of the instrument exclusive of the detector.

geotropism: A change in instrument reading with a change in instrument orientation as a result of gravitational effects.

homogeneity coefficient: The ratio of the first to second half-value layers; usually applied to a heterogeneous X-ray beam.

indicated value: A scale or decade reading or displayed value.

influence quantity: A radiation field, electromechanical condition, or environmental condition that may produce a response.

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

laboratory certified instrument: An instrument or specific type of instrument that has been certified by a third-party accredited testing laboratory as meeting the requirements of this standard.

manufacturer certified instrument: An instrument that has been certified and warranted by the manufacturer as meeting the requirements of this standard.

manufacturing run: A normal quantity of any item built on a single job order. This is also referred to as an economic quantity.

mean instrument reading: The arithmetic average of a series of readings.

model run: That number of a specific type of instrument from first manufacture to the first design change (or any design change to the subsequent design change) that will change the ability of the instrument to meet the required test parameters.

overload response: The behavior of the instrument where the response is less than full scale or decade (i.e., maximum scale or decade reading) when exposed to radiation intensities greater than the upper limit.

photon: Ionizing electromagnetic radiation, irrespective of origin.

probe sensitivity: The magnitude of the instrument with a given probe for a uniform area source.

portable: Capable of being carried by hand to a specific facility or location for use and usually less than a nominal 22.5 kg in weight.

portable survey meter: An instrument intended to be operated while being carried by a person.

precision: The degree of agreement of repeated measurements of the same parameter.

rad: As used herein, the word *rad* (abbreviated *rd*) refers to dose in air unless otherwise stated.

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

reading: The indicated value of the readout.

readout: The device that conveys visual information regarding the measurement to the user.

reference orientation: The orientation in which the instrument is normally intended to be operated as stated by the manufacturer.

response: The instrument indication produced as a result of some influence quantity.

response time: The time interval required for the instrument reading to change from 10% to 90% of the final reading (or vice versa) following a step change in the radiation field (i.e., signal) at the detector.

scale: A subrange of the total range of measurement.

standard (instrument or source):

- 1) **National Standard.** An instrument, source, or other system or device maintained and promulgated by the U.S. National Institute of Standards and Technology (NIST).
- 2) **Transfer Standard.** A physical measurement standard that has been compared directly or indirectly with the national standard. This standard is typically a measurement instrument or a radiation source used as a laboratory standard.
- 3) **Laboratory Standard.** An instrument, source, or other system or device calibrated by comparisons with a standard other than a U.S. National Standard.

subassembly: An assembled unit designed to be incorporated with other units in a finished product.

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

type testing: Evaluation or measurement of all identified performance characteristics of a representative sample of production model instruments.

uncertainty: The estimated bounds of the deviation from the mean value, generally expressed as a percent of the mean value. Ordinarily taken as the sum of (1) the random errors at the 95% confidence level and (2) the estimated upper limit of the systematic error.

useful energy range: The set or range of continuous energies for a specific type of radiation in which the instrument meets specified criteria.

3. General Test Procedures

3.1 Applicability of Tests

Tests to determine compliance with the specifications given in Sections 4. through 8. are provided after each specification.

3.2 Standard Test Conditions

Acceptable ranges for environmental conditions during testing are given in Table 1 and shall be met except where the effect of the condition itself is being tested.

Table 1—Standard Test Conditions

Influence Quantities	Acceptable Range for Standard Test Conditions
Warmup time	≤ 10 min
Relative humidity	Ambient $\pm 10\%$ up to maximum of 75%
Ambient temperature	20 °C to 24 °C
Atmospheric pressure	70 to 106 kPa
Line voltage *	Nominal voltage $\pm 1\%$
Frequency	60 Hz ± 0.5 Hz
AC power supply waveform	Sinusoidal with total harmonic distortion $\leq 1\%$
Angle of incidence of radiation	Direction stated $\pm 5^\circ$
Background radiation	$\leq 2.5\%$ of full scale or decade of the scale or decade under test
Nonionizing electromagnetic field of external origin	Less than 50% of the lowest value that causes interference
Magnetic induction of external origin	Less than twice the induction due to the earth's magnetic field
Orientation of assembly	State orientation $\pm 5^\circ$
Controls	Set for normal operation per manufacturer
Contamination by radionuclides	Negligible
Reference point	Effective center

*Applicable only to ac-powered instruments.

3.3 Statistical Fluctuations

For any test involving the use of radiation, the magnitude of the statistical fluctuations of the reading from the random nature of radiation alone may be a significant fraction of the variation of the mean reading permitted in the test. A sufficient number of readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient precision to demonstrate compliance or noncompliance with the test requirement. Table 2 provides guidance on the number of instrument readings required to determine true differences between two sets of instrument readings at the 95% confidence level. This table is derived from the assumption that the probability of saying there is a difference when there is no true difference and the probability of saying that there is no difference when there is a true difference are both equal to 0.05. Listed are the percentage difference between the means, the coefficient of variation of the sets of readings (assumed to be equal for each set), and the number of instrument readings required.