

American National Standard Performance Specifications for Health Physics Instrumentation-Occupational Airborne Radioactivity Monitoring Instrumentation

Sponsor

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Abstract: ANSI N42.17B-1989, American National Standard Performance Specifications for Health Physics Instrumentation-Occupational Airborne Radioactivity Monitoring Instrumentation, describes the minimum acceptable performance criteria for instrumentation used to monitor occupational exposure to airborne radioactive materials. Included in the standard are testing methods to establish the acceptability of each air monitor. Tests involve air sampling capability; power, electronic, and alarm capabilities; radiation and interfering responses; and environmental factors including temperature, humidity, and ambient pressure.

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Foreword

(This Foreword is not a part of ANSI N42.17B-1989, American National Standard Performance Specification for Health Physics Instrumentation—Occupational Airborne Radioactivity Monitoring Instrumentation.)

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 discussed. Performance criteria contained in this standard were tested for applicability under the sponsorship of the US Department of Energy and the US Nuclear Regulatory Commission. The standard was approved by Committee N42 letter ballot of February 6, 1989.

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American National Standard Performance Specifications for Health Physics Instrumentation—Occupational Airborne Radioactivity Monitoring Instrumentation

1. Scope

This standard specifies performance criteria and testing procedures for instruments and instrument systems designed to continuously sample and quantify concentrations of radioactivity in ambient air in the workplace. This standard does not specify which instruments or systems are required, nor does it address the specific locations or applications of such instruments.

1.1 Introduction

The objective of this standard is to provide basic performance criteria for instruments and instrument systems used to continuously sample and measure airborne radioactivity concentrations, i.e., continuous air monitors (CAMs). The standard includes performance testing criteria for use in generic (type) tests of new instrument models. This standard does not apply to routine or acceptance tests. However, selected tests as agreed between the manufacturer and the purchaser would be applicable for performing routine or acceptance tests.

Included in this standard are both gaseous and particulate gross radioactivity monitors, as well as monitors for specific radionuclides or groups of radionuclides used for radiation protection purposes. Instruments designed to divide the airborne radioactivity into two or more specific components or fractions and monitor each independently are included. An example of the latter is an instrument that independently monitors airborne particulate radioactivity, radioiodines, and beta-emitting isotopes of the noble gases. Such instruments are called activity fractioning monitors for the purposes of this standard.

Excluded from this standard are monitors used for other purposes, including effluent and process monitors and emergency postaccident monitors, and the class of special-purpose radiation protection instruments designed to measure working-level rather than activity concentration. Tritium and radon monitors are also excluded from this standard. Area monitors that are used to characterize ambient radiation levels are not included in this standard; however, area monitors that are used as part of the background circuitry for an air monitor shall be tested for that

purpose. Instruments excluded from this standard may fall under the scope of one or more related ANSI standards, including ANSI N42.18-1980 (R1985) [6],¹ N323-1978 (R1983) [8], and N317-1980 (R1985) [7]; this standard is intended to supplement rather than replace these.

This standard specifies criteria and test procedures for the following areas: general, electronic, radiation, interfering response, environmental, and air circuit criteria. 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.

Requirements and testing criteria to be used for the evaluation of portable radiation protection instruments under normal environmental conditions are covered in ANSI N42.17A-1989 [4]. Requirements and testing criteria related to the evaluation of portable radiation protection instrumentation under extreme environmental conditions are covered in ANSI N42.17C-1989 [5].

1.2 References

The following publications shall be used in conjunction with this standard. When standards in this document are referred to, the latest revision shall apply.

- [1] ANSI C18.1-1986, Specifications for Dry Cells and Batteries.²
- [2] ANSI N13.1-1969 (R1982), Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.
- [3] ANSI N13.4-1971 (R1983), Specification of Portable X- or Gamma-Radiation Survey Instruments.
- [4] ANSI N42.17A-1989, Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Normal Environmental Conditions.
- [5] ANSI N42.17C-1989, Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Extreme Environmental Conditions.
- [6] ANSI N42.18-1980 (R1985), Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluent.
- [7] ANSI N317-1980 (R1985), Performance Criteria for Instrumentation Used for In-plant Plutonium Monitoring.
- [8] ANSI N323-1978 (R1983), Radiation Protection Instrumentation Test and Calibration.
- [9] ANSI Y1.1-1972 (R1984), Abbreviations for Use on Drawings and in Text.
- [10] ANSI/IEEE C62.41-1980, Guide for Surge Voltages in Low-Voltage AC Power Circuits.³
- [11] BRODSKY, A. Accuracy and Detection Limits for Bioassay Measurements in Radiation Protection. NUREG-1156, US Nuclear Regulatory Commission, Washington, D.C., 1986.⁴
- [12] IEC Publication 278: 1968, Documentation to be Supplied With Electronic Measuring Apparatus.⁵

¹The numbers in brackets correspond to those of the references in 1.2.

²ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

³ANSI/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.

⁴NUREG publications are available from the Superintendent of Documents, US Government Printing Office, P.O. Box 37082, Washington, D.C., 20013-7082.

⁵IEC publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

[13] KATHREN, R. L. Standard Sources for Health Physics Instrument Calibration. *Health Physics*, vol. 29, 1975, pp. 143–153.

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.

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

activity fractioning monitor (AFM): An instrument that separates airborne radioactivity into two or more specific fractions and monitors each fraction.

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

aerosol: Suspension of solid or liquid particles in a gas.

airborne radioactivity: Radioactivity in any chemical or physical form that is dissolved, mixed, suspended, or otherwise entrained in air.

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

ambient air: The general air in the area of interest (e.g., the general room atmosphere) distinct from a specific stream or volume of air that may have different properties.

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)].

continuous air monitor (CAM): An instrument used to continuously sample and measure airborne radioactivity concentrations.

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 limit: The extreme of quantification for the radiation of interest by the instrument as a whole or by 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.

direct radiation monitors: Those monitors that provide monitoring of ambient airborne radioactivity by measurement of the external radiation field associated with the airborne radioactivity.

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 that point.

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

extreme environment: One in which ambient temperature or humidity or both fall outside a specified range of values.

indicated value: A scale reading or displayed value.

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

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

minimum detectable activity (MDA): That activity giving an indication corresponding to 4.65 times the standard deviation of the indication given by a specific background, divided by the appropriate conversion factor to result in units of activity.

monitor: An instrument that provides a continual measurement of one or more parameters and generates a signal to record or transmit that measurement.

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

photon: Ionizing electromagnetic radiation, irrespective of origin.

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

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 following a step change in the radiation field (i.e., signal) at the detector, or, for integrating monitors, 90% of the final value of the first derivative of the indication with respect to time (i.e., rate of change).

standard (instrument or source):

- 1) **National Standard.** An instrument, source, or other system or device maintained and promulgated by the US 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 US National Standard.

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

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

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

working level: Any combination of shortlived radon daughters in air that will result in the ultimate emission of 1.3×10^5 MeV of alpha-particle energy.

working level monitor: Monitors used to measure the alpha-energy deposition from the decay of radon daughters. Calibrated in units of working levels.

3. General Test Procedures

3.1 Applicability of Tests

Tests to determine compliance with the specifications given in Sections 4. through 9. are provided after each specification. Unless otherwise noted, tests enumerated in this standard are to be considered type tests. In addition, these and other tests may, by agreement between the manufacturer and the user, be considered acceptance tests. A summary of the test characteristics with variations of influence quantities is given in Appendix A.

Type testing shall be done on a minimum number of production instruments, as shown in the table below, except as otherwise noted. Selection of the instruments from the initial manufacturing run shall be performed in a random manner. A model run shall be considered to terminate if changes in components, construction, design, or assembly are made that could affect the capability of the instrument to meet the required testing parameters. Minor changes (i.e., electronic component substitution) shall be documented by the manufacturer via appropriate instruction-manual notation. Instruments selected for type testing shall be representative of routine production units. A type test is assumed to apply to all instruments of a particular model. Also, it is assumed that there are no variations or changes in components or construction among instruments of the same model. If components are changed by the manufacturer, retesting is not required if technical equivalence of the components can be demonstrated and documented in the model's certificate or operation and maintenance manual.

Number of Instruments in Initial Manufacturing Run	Minimum Number to Be Type Tested
< 3	All
≥ 3	3

3.2 Standard Test Conditions

Acceptable ranges for environmental conditions and influencing quantities 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	
Electronic devices	≤ 10 min
Air or gas circuit	≥ 60 min
Relative humidity	Ambient $\pm 10\%$, not to exceed 75%
Ambient temperature	20 °C to 24 °C
Atmospheric pressure	70–106 kPa
Line voltage*	Nominal $\pm 1\%$
Frequency*	60Hz ± 0.5 Hz
AC power-supply waveform*	Sinusoidal with total harmonic distortion $\leq 5\%$
Background ambient photon radiation (external)	$\leq 2.5\%$ of full scale of range or decade under test, but nominally should not exceed 50 μ rd/h (0.5 μ Gy/h), referenced to air
Nonionizing electromagnetic field 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
Controls	Set for normal operation per manufacturer's recommendations
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 arising 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 under 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.

Whenever possible during testing, exposure rates should be established such that the effect of the statistical fluctuation of the instrument readings is minimized. It may be necessary to make instrument readings midscale or middecade on the second or third most sensitive scale or decade in order to accomplish this.