American National Standard Performance Specifications for Health Physics Instrumentation- Portable Instrumentation for Use in Extreme 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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Abstract: ANSI N42.17C-1989 American National Standard Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Extreme Environmental Conditions, describes the minimum acceptable performance criteria for health physics instrumentation for use under extreme environmental conditions for monitoring ionizing radiation fields. This standard supplements the basic performance specifications for portable health physics instrumentation presented in ANSI N42.17A-1989. Included in ANSI N42.17C are testing methods to be used to establish the acceptability of each type of instrumentation.

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Foreword

(This Foreword is not a part of ANSI N42.17C-1989, American National Standard Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Extreme 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 discussed. Performance criteria contained in this standard were tested for applicability under 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—Portable Instrumentation for Use in Extreme Environmental Conditions

1. Scope

This standard establishes minimum acceptable performance criteria for health physics instrumentation for use in ionizing radiation fields under extreme environmental conditions. 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. This standard supplements the basic performance requirements for health physics instrumentation as specified in ANSI N42.17A [2].[1] Specifications in this standard are expected to be called for by the user as required and should not be considered as general specifications.

1.1 Introduction

The object of this standard is to provide basic performance requirements for instruments used for radiation protection of personnel under extreme environmental conditions. The standard includes performance testing criteria for use in generic (type) tests of new instrument models.

As used in this standard, health physics instrumentation provides direct readout of dose or dose equivalent, rate,[2] or activity per unit area (i.e., effective probe area). 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 (equivalent) rate range of 0.1 mrad/h to 1000 rad/h (10^6 Gy/h to 10 Gy/h); 0.1 mrem/h to 1000 rem/h (10^6 Sv/h to 10 Sv/h); or activity per unit area

[1]The numbers in brackets correspond to those of the references listed in 1.2.
[2]Until conversion to SI units is complete, readout of exposure (R) or exposure rate (R/h) will be considered acceptable for exposure to photon radiation.

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ranges for surface contamination monitors of 50 dpm/cm^2 to 10- dpm/cm^2 (0.83 Bq/cm^2 to 167 Bq/cm^2) for beta/photon radiation and 1dpm/cm^2 to 10- dpm/cm^2 (0.02 aq/cm^2 to 167 Bq/cm^2 for alpha radiation.

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, and 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 occupational-type air monitoring instrumentation are discussed in ANSI N42.17B-1989 [3]. Requirements and testing criteria related to evaluation of portable radiation protection instrumentation under normal environmental conditions are covered in ANSI N42.17A-1989 [2].

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 N13.4-1971 (R1983), Specification of Portable X- or Gamma-Radiation Survey Instruments.[3]

[2] ANSI N42.17A-1989, Performance Specifications for Health Physics Instrumentation—Portable Instrumentation.

[3] ANSI N42.17B-1989, Performance Specifications for Health Physics Instrumentation—Occupational Airborne Radioactivity Monitoring Instrumentation.

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

[5] IEC Publication 68-2-27 (1987), Part 2, Test Ea and Guidance: Shock.[5]

[6] IEC Publication 278:1968, Documentation to be Supplied With Electronic Measuring Apparatus.

[7] Mil-Std 810D, 31 Jul 1983, Environmental Test Methods and Engineering Guidelines.[6]

2. Definitions

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

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

acceptance testing: Evaluation or measurement of the operational status of selected 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. Accuracy includes linearity, zero drift, and hysterisis.

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

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.

[3]ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.
[4]ANSI/IEEE publications are available from the Institute of Electrical and Electronics Engineers, Service Center, 445 Hoes Lane, Piscataway, NJ 08855-1331, or the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.
[5]IEC publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.
[6]Mil-Std publications are available from Global Engineering Documents, 1990 M Street, NW Suite 400, Washington DC 20036.

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

beta cut-off energy: The minimum energy required for 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/x) (100)].

condensing environment: Exposure to cycles of cool and warm humid atmospheres that cause condensation equipment.

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 which 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.

detection limit: The extreme of detection or 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.

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

durability: A cycle of temperature, humidity, shock and vibration to simulate environmental exposure in an accelerated mode.

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 monoenergetic radiation field of the same energy.

energy dependence: A change in instrument response with respect to radiation energy for a constant exposure or exposure 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.

extreme environment: An environment likely to occur in health physics practice but beyond the scope of routine conditions with regard to the physical or radiation environment exposure.

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 reading or displayed value.

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

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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.

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) which will change the ability of the instrument to meet the required test parameters.

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

photon: Ionizing electromagnetic radiation, irrespective of origin.

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.

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

reading: The indicated value of the readout.

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

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 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.

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

temperature shock: A rapid and large temperature change.

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.

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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. A summary of the test characteristics with variations of influence quantities is given in Appendix A.

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

Warm-up time	<10 minutes
Relative humidity	Ambient ±10% up to maximum of 75%
Ambient temperature	20°C to 24°C
Atmospheric pressure	70 to 106 kPa
Line voltage*	Nominal voltage ±1%
Frequency*	60Hz±0.5Hz
ac power supply waveform*	Sinusoidal with total harmonic distortion≤1%
Angle of incidence of radiation	Direction stated ± 5°
Background radiation	≤2.5% of full scale or decade of the scale or decade under test
Nonionizing electromagnetic field of external origin	<0.5 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 *5
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 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

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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 probabilities of saying there is a difference when there is no true difference, and of saying that there is no difference when there is a true difference, are both equal to 0.05. Listed are the percentage differences 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.

The interval between instrument readings shall be at least three times the response time in order to ensure that the readings are statistically independent.

Table 2—Number of Instrument Readings Required to Detect True Differences (95% Confidence Level) Between Two Sets of Instrument Readings On the Same Instrument

True Differences Between Readings (%)	Coefficient of Variation of Readings (%)	Number of Readings Required (%)
5	<1.0	1
5	2.0	4
5	3.0	9
5	4.0	16
5	5.0	25
5	7.5	56
5	10.0	99
5	12.5	154
5	15.0	223
5	20.0	396
10	<2.0	1
10	3.0	3
10	4.0	34
10	5.0	6
10	7.5	14
10	10.0	24
10	12.5	37
10	15.0	53
10	20.0	94
15	<3.0	1
15	4.0	2
15	5.0	3

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True Differences Between Readings (%)	Coefficient of Variation of Readings (%)	Number of Readings Required (%)
15	7.5	6
15	10.0	10
15	12.5	10
15	15.0	23
15	20.0	40
20	<4.0	1
20	5.0	2
20	7.5	3
20	10.0	6
20	12.5	9
20	15.0	12
20	20.0	1

NOTE — This table is derived under the assumption that the probability of saying that 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.

4. General Characteristics

4.1 General

Specifications for readout units, scaling and zero set, decontamination, and alarm threshold remain the same as specified in ANSI N42.17A-1989 [2].

4.2 Markings

4.2.1 Requirements

4.2.1.1 General

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

4.2.1.2 Exterior Markings

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

1) manufacturer and model number;
2) unique serial number;

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3) location of the effective center(s) or area(s) of detection;
4) function designation for controls, switches, and adjustments;
5) “Suitable for Use in Extreme Environments”

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

4.2.1.3 Readout Markings

Analog displays shall be provided with scale markings. For linear analog readouts, major scale divisions shall be at 0% and 100% of full scale and at 4 or 9 equally spaced points in between (e.g, 0.2, 0.4, 0.6, and 0.8 of full scale). Logarithmic scales shall have each decade marked, with at least 4 but not more than 12 approximately equally spaced (e.g., 1, 1.5, 2.5, 3, 4, 5, 6, 7, 8, 9, 10) major division markings between the limits of the decade. The instrument shall indicate the readout units. Followed by the operational specifications (i.e., temperature: 40°C and + 70 °C).

4.2.2 Test

Verify by inspection.

4.3 Operability of Controls

4.3.1 Requirements

All operator controls shall retain freedom of operation under the specified conditions even with the operator encumbered by heavy gloves.

4.3.2 Test

Verify by testing with welder's gloves and ski mittens.

4.4 Battery Power

4.4.1 Requirements

Battery requirements for operation under specific extreme conditions shall be stated by the manufacturer. Any special precautions such as battery warming or limitations on operational time under extreme conditions shall be stated by the manufacturer. Batteries shall provide a minimum operational period of 4 hours and should provide an operational period of 10 hours.

4.4.2 Test

The instrument shall be equipped with fresh disposable or freshly charged batteries, as applicable. All functional circuits shall be switched on and shall remain on during the duration of the test. An exposure shall be made to a suitable source of ionizing radiation sufficient in strength to produce approximately a midscale deflection. Following a warm-up time specified by the manufacturer, an initial scale reading shall be taken followed by readings at approximately one-hour intervals. Battery lifetime shall be considered to have been exceeded when the ratio of the scale reading at any time relative to the reading taken initially falls outside the range of 0.9 to 1.1. The test shall be performed at the temperature extremes stated in this standard using batteries and conditions specified by the manufacturer.

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4.5 Battery Power Indicator

4.5.1 Requirements

When the battery power indicator first shows a failure, the instrument reading shall be within ±10 of the reference reading.

4.5.2 Test

The batteries shall be replaced by a stable dc power supply producing a voltage equivalent to the voltage produced by a set of fresh disposable batteries of the type recommended by the manufacturer. The instrument is then exposed to a suitable source of ionizing radiation sufficient in strength to produce a midscale deflection on a suitable scale. A reference reading is then taken and the voltage decreased until the battery power indicator initially shows the voltage is too low. Another reference reading is then taken which shall be within 0.9 to 1.1 of the initial reading.

5. Electronic and Mechanical Requirements and Test

5.1 Check Circuits

5.1.1 Requirements

If the instrument is equipped with a check circuit or alarm, the circuit shall remain operational over the range of extreme conditions.

5.1.2 Test

Test circuit under extreme conditions of temperature per manufacturer's specifications for the check circuits and alarm circuits.

5.2 Stability

5.2.1 Requirements

Drift under constant conditions of temperature and pressure, and under environmental extremes shall be within 6% of the initial mean reading over a period of 2 h for battery-powered instruments and 24 h for ac-powered instruments. A preliminary stabilization period per the manufacturer's recommendations is permitted.

5.2.2 Test

Instruments shall be switched on and allowed a stabilization period per the manufacturer's recommendations. The detector shall be exposed to a suitable radiation field producing a midscale reading on an appropriate scale or decade. For survey meters, readings shall be recorded every 20 min for 2 h or every hour for 24 h for ac-powered instruments. Tests shall be performed at the temperature extremes stated in this standard: Category I (−20°C and +60°C), Category 2 (−40°C and +70°C).

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5.3 Response Time

5.3.1 Requirements

Instrument response time for increasing exposure rates for beta-photon and neutron dose rate readouts shall be in accordance with Table 3. Instruments suitable for both neutron and photon or neutron, beta, and photon shall meet the less restrictive value specified in Table 3.

Instrument response time for count rate readout (i.e., contamination monitors) should be less than 30 s for gas-flow units and less than 10 s for other type units (e.g., air proportional, scintillation). Instruments with variable response times shall be tested on the fastest response time available for each scale or decade.

Table 3—Instrument Response Time vs. Scale or Decade Maximum for Increasing Exposure Rates

Scale or Decade Maximum		
Beta-Photon Instruments (rad/h or rem/h)	**Neutron Instruments, (rem/h)**	**Maximum Response Time (s)**
$>10^{-4}$ to $\leq 10^{-3}$	$<5 \times 10^{-2}$	30
$>10^{-3}$ to $\leq 10^{-2}$	5×10^{-2} to $\leq$	10
$>10^{-2}$ to $\leq 10^{-1}$	>1	5
$>10^{-1}$ to ≤ 1		3
>1		2

NOTE — Response times with respect to increasing and decreasing exposure rates shall be stated by the manufacturer.

5.3.2 Test

The equilibrium reading of the instrument shall be established by exposing the detector in a reproducible geometry to an acceptable source of ionizing radiation of sufficient intensity to produce a mean reading between mid and full scale or decade. Remove the radiation field quickly and allow the instrument reading to stabilize. Renew the original radiation field and record the time for the instrument reading to move from 10% to 90% of the previously established equilibrium reading. Remove the source and record the time for the instrument to move from 90% to 10% of the previously established equilibrium reading. Repeat these two steps until a sufficient number of data points have been obtained. This test shall be done for all applicable scales or decades specified in Table 4 at the same temperature extremes stated in this standard: Category I (-20°C and 60°C), Category 2 (-40°C and 70°C).

For auto-ranging instruments, where the instrument stabilizes on a different scale or decade than the one measured with the radiation source, the use of a second position of the radiation source or a second acceptable source of ionizing radiation of sufficient intensity to produce a mean reading in the lower half of the scale or decade to be tested shall be used to pre-bias the instrument. The original radiation field shall be renewed and the time determined for the instrument reading to move from 10% to 90% of the difference between the minimum reading of the scale or decade to be tested and the predetermined equilibrium value. (This value in the case of two sources is the sum of the individual sources and should be determined prior to making the test to ensure being on the scale or decade desired for the test). The source shall be removed and the time determined for the instrument to move from 90% to 10% of the difference between the minimum reading of the scale or decade to be tested and the predetermined equilibrium value. These two steps shall be repeated until a sufficient number of data points have been obtained in accordance with the guidance in 3.3 of ANSI N42.17A-1989 [2]. This test shall be done for all applicable scales or decades specified in Table 3.

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5.4 Line Noise Susceptibility

5.4.1 Requirements

The mean instrument response of line-powered units shall not vary more than 15% from the mean of a set of reference readings while or after being subjected to voltage sags, surges, and transients on the power line.

5.4.2 Test

The detector shall be exposed in a reproducible geometry to an acceptable source of ionizing radiation of sufficient intensity to minimize the effect of the statistical fluctuations of the instrument readings and to produce a response of approximately midscale or middecade. The mean instrument response shall be determined. If the instrument is equipped with an alarm, it shall be set 15% higher than the mean reading. The power line disturbances listed in Table 4 shall be applied to the system randomly in relation to the power line phase. Changes in instrument response or inadvertent triggering of alarms shall be noted. Transients noted in Table 4 shall comply with ANSI/IEEE C62.41-1980 [4].

Table 4—Power Line Disturbances

Number of Pulses	Rise Time (ms)	Duration (ms)	Decay (ms)	Pulse Amplitude As a Percent of Nominal (or Voltage)
Surges				
10	10	10	10	+60%
10	10	500	10	+25%
Sags				
10	10	20	10	–100%
10	10	500	10	–40%
Transients				
10	0.0005	100 kHz	—	6 kV
10	0.0012	(ring wave)	0.05	6 kV
15	0.0005	100 kHz	—	2.5 kV
15	0.0012	(ring wave)	0.05	2.5 kV

6. Radiation Response

6.1 Accuracy, Precision Energy Dependence

6.1.1 Requirements

Any deviations in accuracy, precision, or energy dependence following or during exposure to extreme environmental conditions shall be stated by the manufacturer. Tests shall be performed for the energies stated in ANSI N42.17A-1989 [2] or for specific ranges as agreed between the manufacturer and purchaser. Under no circumstances shall the accuracy be derated so that the ratio of the mean indicated value to the conventionally true value falls outside the range 0.80 to 1.20 at the 95% confidence level or

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$$0.80 \leq \frac{\bar{r}_i}{CTV_{\text{ref}}} \leq 1.20$$

in which $\bar{r}_i$ the mean indicated value, and CTV_{ref} is the conventionally true value of the reference radiation and still consider the instrument operational under the extreme conditions.

6.1.2 Test

If the manufacturer states specific exceptions, the tests shall verify that the manufacturer's specifications are met under the extreme environmental conditions. Test methods shall be as arranged between the manufacturer and the user.

6.2 High-Energy Photons

6.2.1 Requirements

The response of a photon survey instrument to high-energy photons (i.e., up to 7.5 MeV) relative to the response of the instrument at a lower ^{137}Cs) shall be stated by the manufacturer. The following energy condition shall be met:

$$0.8 \leq \frac{(\bar{r}_{\text{en}_i}/CTV_{\text{en}_i})}{(\bar{r}_{\text{ref}}/CTV_{\text{ref}})} \leq 1.5$$

where $\bar{r}_{\text{en}_i}$ = the mean indicated reading of the ion chamber to photon energy *i*

$\bar{r}_{\text{ref}}$= the mean indicated reading to the reference photon energy

CTV_{en_i} = the conventionally true value of the photon radiation of energy *i*

CTV_{ref}= the conventionally true value of the reference photon energy

6.2.2 Test

The instrument shall be exposed to a known intensity of photons from a high energy source (e.g., ^{16}N, ^{19}F(P, $\alpha\gamma$)^{16}0). The field shall be well characterized in terms of the photon energy spectra and the number of electrons present. The instrument shall also be exposed to an appropriate ^{137}C source and the ratio of the response calculated.

7. Interfering Responses

7.1 Nonlonizing Electromagnetic Radiations

7.1.1 Requirements

The instrument shall be unaffected by pulsed or modulated continuous radiofrequency fields ≤400 V/m and pulsed or continuous microwave fields of ≤ 200 W/m2.

Field	Intensity
Radiofrequency	400 V/m
Microwave	200 W/m^2

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While in these fields, the instrument shall correctly respond to all appropriate source of radiation (Table 5, ANSI N42.17A-1989 [2]) of intensity sufficient to provide approximately a half scale or decade reading.

During exposure the fields shall be pulsed or modulated to attempt to cause a response. Testing shall be performed at commonly expected frequencies such as 60 Hz, 500-2000 kHz, 3-15 MHz and 80-200 MHz, as agreed between the manufacturer and user.

7.1.2 Test

The instrument shall be exposed to an appropriate radiation source of intensity sufficient to produce a midscale reading on the most sensitive scale. A reference reading is established and the instrument is exposed to a pulsed or modulated rf(400 V/m) or microwave (200 W/m^2) fields at several orientations relative to the reference orientation. The response at specific frequencies, as agreed between the manufacturer and the user, shall vary ±15% from the reference response.

8. Environmental Factors

8.1 Temperature

8.1.1 Requirements

The temperature range over which the mean instrument response shall not vary more than 20% from the mean instrument response at 22 °C shall be stated by the manufacturer. The mean instrument response shall (Category 1) not vary more than 20% from the mean response at 22 °C from –20 °C to 60 °C and should not vary more than 20% from the mean response at 22 °C from –40 °C to 70°C (Category 2). Corrections to instrument readings for air density changes shall be made when appropriate (e.g., for vented ionization chambers).

NOTE — The manufacturer shall specify if the rate of change of temperature may cause damage to the detector.

8.1.2 Test

The instrument shall be exposed in a reproducible geometry in an environmental chamber to an acceptable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. The mean instrument reading at 20 °C shall be determined. The temperature inside the chamber shall be raised or lowered at a rate of approximately 10°C/h until the temperature extremes.[7] [8] Sufficient data shall be recorded at the extremes; the instrument shall be permitted to come to thermal equilibrium at each temperature level before data are taken.

NOTE — The rate of change of the temperature may have to be less than 100 .C/h for some types of detectors to prevent damage [e.g., NaI(TI) detectors]

8.2 Extreme Temperature Shock (Method 1)

8.2.1 Requirements

The mean instrument response shall not vary more than 15% rom a set of reference readings taken at a nominal temperature of 22 °C when the instrument is cycled between 70 °C and –40 °C in less than 5 minutes.

NOTE — This test should not be performed with detectors that may be damaged during the test [e.g., NaI(T1) detectors].

[7]The instrument shall be held at the maximum temperature of 60 °C for 4 h with readings taken at 2 and 4 h.
[8]The instrument shall be held at –40 °C for 4 h with readings at 2 and 4 h. Stabilization periods of i h shall be permitted and readings taken at -30 °C and -20°C.

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8.2.2 Test

The instrument shall be exposed to a suitable source of radiation in a reproducible geometry to establish a reference reading (standard conditions). The instrument shall then be placed in an environmental chamber at 70 °C (+0 °, –2 °)C for a period of 2 h and then transferred to a chamber at –40 °C (0°, +2 °)C within 5 min for a two-hour exposure period. The instrument will then be cycled back to the high and the low-temperature environments three times for two-hour periods following which the instrument will be permitted to stabilize in the standard laboratory environment. The instrument shall be at each temperature four times. Following stabilization, the instrument will again be exposed to a suitable source of radiation in the controlled geometry established prior to temperature cycling. The variation in pre- and postexposure readings shall be <15%.

8.3 Temperature Shock (Method 2)

8.3.1 Requirements

Instruments shall withstand sudden changes (<2 min) in temperature from a nominal 22 °C to 70°C or to -40°C with ≤20% change in response. Instruments shall also withstand excursions from –40 °C and 70 °C to 22 °C with ≤20% change in response. Response changes shall be referenced to 22 °C.

NOTE — This test should not be performed with detectors that may be damaged during the test [e.g., NaI(Tl) detectors.

8.3.2 Test

The instrument shall be placed in a controlled environment of approximately 20 °C and allowed to stabilize for a minimum of 60 min. The instrument shall be exposed in a reproducible geometry to an acceptable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. The mean instrument reading shall be determined. The instrument and radioactive source shall be removed from this environment and placed directly into an environmental chamber such that the same exposure geometry is established and the temperature near the instrument is 70 °C (+0 °, –2 °) C. This procedure shall be performed in less than 5 min. The mean instrument reading shall be determined then and every 15 min for 2 h if the instrument fails the test within the first hour. If the instrument does not fail the test within the first hour, data does not need to be taken during the second hour; however, the instrument should remain in this environment during the period to reach temperature equilibrium. The instrument and radioactive source shall be removed from the environmental chamber and returned to the first environment such that the same exposure geometry is established and the temperature near the instrument is 22 ± 2 °C.This procedure shall be performed in less than 5 min. The mean instrument reading shall be determined then and every 15 min for 2 h if the instrument fails the test within the first hour. If the instrument does not fail within the first hour, data does not need to be taken during the second hour; however the instrument should remain in this environment during the period to reach temperature stabilization.

The test shall be repeated with the temperature inside the environmental chamber near the instrument at –40 °C (+2 °, –0 °) C.

8.4 Humidity and Temperature

8.4.1 Requirements

The mean instrument response shall not vary more than 15% over the relative humidity range of 3% to 99% referenced to 60 °C. components should be protected against both high- and low-humidity extremes.

8.4.2 Test

The instrument shall be exposed in an environmental chamber to an appropriate reference radiation source of sufficient strength to give a midscale reading on any scale or decade. The instrument shall be allowed to equilibrate for 24 h at

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40 ° ± 2 ° and 50 ± 5% relative humidity, and the reading noted. The relative humidity shall be raised to approximately 95 ± 5% and held for 24 h, and the instrument reading recorded. The humidity shall be maintained at 95 ± 5% and the temperature raised to 60 °C. The instrument shall be held under these conditions for 24 h. The instrument reading shall be noted and then humidity will be lowered to 5 ± 5% for 24 h and the reading is noted. The temperature shall be reduced to 40 °C with 5 ± 5% relative humidity and maintained for 24 h. After noting the reading, the instrument will be returned to ambient conditions and the reading shall be recorded for comparison with preexposure conditions.

8.5 Mechanical Shock

8.5.1 Requirements

Survey instruments shall be able to withstand, without damage, mechanical shocks from all directions with magnitude up to 100 g and the instrument response shall vary ≤ 15% from a set of reference readings taken prior to the shock.

8.5.2 Test

The instrument shall be subjected to an acceleration of 100 G for a time interval of 6 ms. Refer to IEC Publication 68-227 (1987), Part 2., [4]. The instrument shall be exposed to a suitable source of radiation producing a midscale or middecade reading on an appropriate range or decade in a reproducible geometry prior to and following the test. If the mean instrument reading deviates from the before test condition by greater than 15% following the test, the instrument shall be considered to have failed the test. The test shall be performed on each of three orthogonal axes.

8.6 Vibration

8.6.1 Requirements

The mean instrument response shall vary ≤15% from a set of reference readings following extended (15 min) harmonic loadings of 3.5 g applied for 15 min in each of three mutually orthogonal axes in the frequency range of 15 to 200 Hz.

NOTE — Transportation or use of instruments in helicopters or propeller-driven aircraft may require more severe vibration testing (Mil-Std 810D 31 Jul 1983[5]).

8.6.2 Test

The instrument shall be subjected to harmonic loadings of 3.5 g for 15 minutes in each of three mutually orthogonal axis at the following nominal frequencies: 15, 30, 60, 100, 200 Hz. While the instrument is mounted, the vibration frequencies shall be slowly (15 min) swept from 10-200 Hz three times with forces less than 3.5 g. The instrument shall be exposed to a suitable source of radiation producing a midscale or middecade reading on an appropriate range or decade in Q-reproducible geometry prior to and following the test. If the mean instrument reading deviates from the before test reading by greater than 15% following the test, the instrument shall be considered to have failed the test. The test shall be performed on each of three orthogonal axes.

8.7 Ambient Pressure

8.7.1 Requirements

The instrument response shall change ≤15% from the mean instrument response at 101 kPa over a pressure range of 55 to 150 kPa. Corrections to instrument readings for air density changes are to be made when appropriate (e.g., for vented ionization chambers). This requirement does not apply to gas or air proportional instruments.

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8.7.2 Test

The instrument shall be exposed in a reproducible geometry to an acceptable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. The mean instrument reading at 101 kPa shall be determined. The ambient pressure shall be changed at a rate not greater than 20 kPa/min Data shall be obtained at 150, 101, 80, 65, and 55 kPa; the instrument shall be permitted to stabilize at each pressure before data are taken. The instrument shall be considered to have failed the test if the mean response varies by greater than 15% over the range tested. Corrections to instrument readings are to be made for air density changes when appropriate (e.g., vented ionization chambers).

8.8 Condensing Atmospheres

8.8.1 Requirements

Survey instrument response, to an appropriate source, shall vary ≤15% during and following exposure to condensing environments over a period of 8 h.

8.8.2 Test

Place the instrument in an environmental chamber with an appropriate check source that provides a midscale reading on an appropriate scale. Cool the instruments to 5 °C and then rapidly raise the humidity (95% RH) and temperature to 30 °C. After 1 h, check the response of the instrument and recool to 5 °C. Repeat this sequence every 2 h for 8 h, with I h time to equilibrate at 5 °C. The instrument shall be considered to have failed the test if the mean response varies by more than 15% of the response under standard conditions. Corrections to instrument readings are to be made for air density changes when appropriate (e.g., vented ionization chambers).

8.9 Instrument Durability

8.9.1 Requirements

Following five cycles of accelerated aging, the instrument response shall vary ≤15% at the 95% confidence level.

8.9.2 Test

The instrument shall be exposed to a suitable radiation source in a reproducible geometry to establish a reference reading. The instrument shall then be exposed to a 50 °C environment for a period of 24 h with humidity cycled every 6 between 40% RH and 95% RH The instrument shall then be subjected to harmonic loadings of 2 g in the frequency range from 20-30 Hz for 15 min. Any suitable orientation can be used. The instrument will next be submitted to a peak acceleration (shock) of 50 g (half-sine wave pulse) with a period of 18 ms. Following exposure to five shock pulses in any orientation, the instrument will then be tested in the reference exposure geometry. This cycle (temperature, vibration, shock, test exposure) will then be repeated an additional four times and the final test exposure must vary from the reference reading <15% at the 95% confidence level.

8.10 Radiation Resistance

8.10.1 Requirements

Following a radiation dose to air of 10^4 rads referenced to air of photon radiation, the instrument response shall vary ≤15%.

NOTE — After this test, the instrument should be retired from service.

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8.10.2 Test

A reference reading shall be established for the instrument in a reproducible geometry. The instrument shall then be exposed to a ^{137}Cs or ^{60}Co radiation field with a maximum intensity of 10^3 rad/h until the instrument receives an exposure of 10^4 rad. The instrument will then be exposed in the reference geometry and the reading shall vary <15%.

8.11 Drop Test

8.11.1 Requirements

Instruments shall continue to operate after a fall of 1.0 meters onto a concrete surface. Instrument response shall vary ≤15% after a series of five tests. The cause of failure shall be noted.

8.11.2 Test

The instrument shall be exposed to a suitable source of radiation in a reproducible geometry to establish a reference reading on an appropriate range or decade. Next, the instrument will be dropped five times from the reference orientation ±10° onto a concrete surface from a height of 1.0 m. Following each drop, the instrument will be tested in the reference geometry until five drops have been accomplished. Any other physical damage shall be noted.

8.12 Moisture Exposure (Rain)

8.12.1 Requirements

Survey instrument response to an appropriate source shall vary ≤15% during and following exposure to lightly falling rain (1/4 inch per h) for a period of 2 h at 20 °C. If required by the user, salts can be added to the liquid to simulate salt spray exposure.

8.12.2 Test

Place the instrument in a rain chamber with a check source providing a midscale reading on an appropriate range. Maintain temperature near 22 °C and expose instrument to rain environment for 2 h periodically checking (30-minute intervals) for operability. If requested, add salts to moisture to test simulated salt spray response. After exposure, dry instrument and test with check source. If the instrument response varies more than 15%, the instrument shall be considered to have failed the test. Inspect interior for moisture and record observations.

NOTE — The source should be protected.

8.13 Moisture Exposure (Fog)

8.13.1 Requirements

Survey instrument response to an appropriate source shall vary ≤15% during and following exposure to a fog over a period of 6 h at 22 °C. If required by the user, salts can be added to the liquid to simulate salt spray exposure.

8.13.2 Test

Place the instrument in a fog chamber and expose it to an appropriate source which provides a midscale reading on an appropriate range or decade. Obtain a reference reading prior to fog exposure and obtain readings every hour for 6 h after initiation of exposure. If requested, add salts to moisture to simulate salt fog exposure. After exposure (6 h) dry instrument and test with reference source. If the instrument response varies more than 15%, the instrument shall be considered to have failed the test. Inspect interior for moisture and record observations.

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9. Documentation

9.1 Type Test Report

The manufacturer shall make available on request a report including results of the tests performed to determine compliance with the requirements of this standard.

9.2 Certificate

A certificate shall be provided with each certified instrument separate from the operation manual giving at]least the following information:

1) manufacturer's name and address
2) type and of instrument and detector(s) and serial numbers
3) a list of all test requirements not met
4) a statement of conformance to this standard shall be included (e.g. Conforms to ANSI N42.17C-1989 for measurement of ---- radiation), as well as the type of certification, instrument Class, and (for Class B instruments) sections of this Standard with which the instrument is in compliance. Where alternatives are given in this Standard, as in 4.10, the applicable alternatives shall be stated.
5) date of test(s)
6) certificate shall state which tests are a result of type tests and which are specific to the instrument, if any.

9.3 Operation and Maintenance Manual

Each instrument shall be supplied with an appropriate manual in accordance with ANSI N13.4-1971 [1] (R1983), and IEC Publication 278:1968 [6].

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Annex A

(Informative)

(This Appendix is not a part of ANSI N42.17C-1989, Performance Specifications for Health Physics Instrumentation—Portable Instrumentation for Use in Extreme Environmental Conditions, but is included for information only.)

Table A-1—Test Performed With Variation of Influence Quantities

Characteristics Under Test (Influence Quantity)	Range of Values of Influence Quantities	Limits of Variation	Method of Test (Section)
Temperature	1) -20 °C to 60 °C	20% Reference 22 °C	8.1.2
	2) -40 °C to 70 °C	20% Reference 22 °C	8.1.2
Temperature Shock:	70 °C from/to 20 °C	15% Measured at 22 °C	8.2.2
Method 1:	4 cycles between temperature		
Method 2:	1) -40 °C from/20°C	20% Reference 22 °C	8.3.2
	2) +70 °C from/to 20°C	20% Reference 22 °C	8.3.2
Humidity and Temperature	3%RH to 99%RH	15% Reference	8.4.2
	(T = 60 °C)	Standard Conditions	
Condensing Atmosphere	Cycle from 30 °C to 5 °C at 95%	15% Reference Standard	8.8.2
	RH four times	Conditions	
Vibration	Test on three orthogonal axis at 3.5 G for 15 min over frequency range of 15-200 Hz	15% Reference Standard conditions	8.6.2
rf Fields	400 V/M (frequency as required)	15% Reference Standard Conditions	7.1.2
Microwave Fields	200 W/m^2 (frequency as required	15% Reference standard conditions	7.1.2
Battery Power	1) 0-10 hours	10% Variation	4.4.2
	-20 °C, +16 °C		
Battery Power indicator	$V_{Battery = minimum}$	10% Variation	4.5.2
Stability	1) 0-1 hours -20 °C,+16°C	Per Table 3	5.3.2
	2) 0-2 hours -40 °C,+40 °C	Per Table 3	5.3.2
Response Time	1) Table 3 -20 °C,+60 °C	3%	5.2.2
	2) Table 3 -40 °C,+70 °C	3%	5.2.2
Accuracy, Precision, Energy Dependence	Range of Measurement	To be stated by manufacturer	6.1.2

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Characteristics Under Test (Influence Quantity)	Range of Values of Influence Quantities	Limits of Variation	Method of Test (Section)
High-Energy Photons	5–7 MeV	$0.8 \le \frac{(\bar{r}_{en_i}/CTV_{en_i})}{(\bar{r}_{ref}/CTV_{ref})} \le 1.5$	6.2.2
Durability	a) 50 °C(40% 90% RH	15% at Reference Conditions	8.9.2
	b) 2 G (20–30 Hz) Vibration		
	c) 50 G (18 ms sine) Shock 5 times		
	d) Repeat sequence 5 times		
Radiation Resistance	5 × 10 rad gamma	15% Reference Standard Conditions	8.10.2
Drop Test	1.0 m drop (5 times)	15% Reference Standard Conditions	8.11.2
Moisture Exposure:			
Rain	0.25.inch $^{-1}$ (2 h)	15 % Reference Standard	8.12.2
	(t = 20 °C)	Conditions	
Fog	6h	15% Reference Standard Conditions	8.13.2

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