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

Sponsor

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

Secretariat

The Institute of Electrical and Electronics Engineers, Inc.

Reaffirmed January 4, 2005

American National Standards Institute

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.

Copyright © 1990 by

The Institute of Electrical and Electronics Engineers, Inc.

345 East 47th Street, New York, NY 10017-2394, USA

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS

Not for Resale

American National Standard

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

CAUTION NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of publication. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

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.

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

Louis Costrell, *Chair*
Sue Vogel, *Administrative Secretary*

American Conference of Governmental Industrial Hygienists ..... Jesse Lieberman
Battelle Pacific Northwest Laboratories ..... Jack M. Selby
Health Physics Society ..... J. B. Horner Kuper
Jack M. Selby *(Alt)*
Institute of Electrical and Electronics Engineers ..... Louis Costrell
David C. Cook *(Alt)*
Julian Forster *(Alt)*
Anthony J. Spurgin *(Alt)*
Lawrence Berkeley Laboratory ..... Lee J. Wagner
Lawrence Livermore National Laboratory ..... Paul L. Phelps
Nuclear Suppliers Association ..... Kenneth F. Sinclair
Oak Ridge National Laboratory ..... Hugh R. Brashear
UCLA Center for the Health Sciences ..... James E. McLaughlin
US Department of the Army ..... Edward Groeber
US Department of Commerce, National Institute of Standards and Technology ..... Louis Costrell
US Department of Energy ..... Gerald Goldstein
US Federal Emergency Management Agency ..... Carl R. Siebentritt
US Nuclear Regulatory Commission ..... Edward C. Wenzinger, Sr.
Members-at-Large ..... Joseph G. Bellian
David C. Cook
Ernesto A. Corte
John M. Gallagher
Dick A. Mack
Edward J. Vallario
Sanford Wagner

At the time this standard was approved, Subcommittee N42.1 had the following members:

Jack M. Selby, *Chair*

J. G. Bellian
Edmond Goodale
J. D. Henderson
R. L. Kathren
William Klein
H. W. Patterson
C. R. Siebentritt
E. J. Vallario

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

The working group for this standard had the following members:

J. M. Selby, *Chair*
J. L. Kenoyer, *Vice Chair*

B. V. Anderson*	J. N. Little	C. K. Brown‡
J. G. Bellian	R. B. Neel	A. L. Cucchiara‡
M. V. Federline†	G. J. Oliver	L. M. Earls‡
J. A. Flanigan	R. D. Terry	J. G. Flaherty‡
D. M. Fleming	R. P. Ulman	R. L. Kathren‡
J. A. Jones*		K. L. Swinth‡

* Deceased

† Replaced by another NRC representative

‡ Consultant

The following persons were on the balloting committee that approved this document for submission to the Accredited Standards Committee N42:

J. G. Bellian	G. Goldstein	C. R. Siebentritt
H. R. Brashear	E. Groeber	K. F. Sinclair
D. C. Cook	J. B. Horner Kuper	A. J. Spurgin
L. Costrell	J. Lieberman	E. J. Vallario
J. Forster	D. A. Mack	L. J. Wagner
J. M. Gallagher	J. E. McLaughlin	E. C. Wenzinger, Sr.
	J. M. Selby	

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

CLAUSE PAGE

1. Scope 1

1.1 Introduction 1
1.2 References 2

2. Definitions 3

3. General Test Procedures 5

3.1 Applicability of Tests 5
3.2 Standard Test Conditions 5
3.3 Statistical Fluctuations 6

4. General Criteria 8

4.1 Classification of Ambient Radioactivity Monitors 8
4.2 Sampler Design 9
4.3 Units of Readout 11
4.4 Markings 11
4.5 Alarm Threshold 12
4.6 Protection of Switches and Controls 12
4.7 Power 12
4.8 Battery Status Indication 14
4.9 Alteration and Modification 14

5. Electronic Criteria 14

5.1 Alarms 14
5.2 Stability 15
5.3 Response Time 16
5.4 Coefficient of Variation 16
5.5 Line Noise Susceptibility 17

6. Radiation Response 18

6.1 Minimum Detectable Activity 18
6.2 Accuracy 18
6.3 Beta-Photon Radiation Overload 19
6.4 Radiation Type and Energy 19
6.5 Response to Unwanted Radiations 20

7. Interfering Responses 21

7.1 Radio Frequency (RF) Fields 21
7.2 Microwave Fields 21
7.3 Electrostatic Fields 22
7.4 Magnetic Fields 22

8. Environmental Criteria 23

8.1 Temperature 23
8.2 Humidity 23

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

CLAUSE PAGE

8.3 Ambient Pressure 24

9. Air Circuit Criteria 24

9.1 Flow or Flowrate Meter Accuracy 24
9.2 Air In-Leakage 24
9.3 Flowrate Stability 25
9.4 Filter Pressure Drop 25
9.5 Power-Supply Voltage Effect on Flowrate 25
9.6 Power Supply Frequency Effect on Flowrate 26
9.7 Particle Collection 26
9.8 Gas Collection 27

10. Documentation 28

10.1 Type-Test Report 28
10.2 Certificate 28
10.3 Operation and Maintenance Manual 28

11. Bibliography 28

Annex A (Informative) 29

--`,,```,,,-`-`,,`,,`,`,,`---

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

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

Copyright © 1990 IEEE All Rights Reserved

--`,,`,,,,-`-`,,`,,`,`,,`---
Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

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]

---

[1]The numbers in brackets correspond to those of the references in 1.2.
[2]ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.
[3]ANSI/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.
[4]NUREG publications are available from the Superintendent of Documents, US Government Printing Office, P.O. Box 37082, Washington, D.C., 20013-7082.
[5]IEC publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

 Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

[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.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

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 actor 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.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

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.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

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 ±10%, not to exceed 75%
Ambient temperature	20 °C to 24 °C
Atmospheric pressure	70–106 kPa
Line voltage*	Nominal ±1%
Frequency*	60Hz±0.5Hz
AC power-supply waveform*	Sinusoidal with total harmonic distortion ≤5%
Background ambient photon radiation (external)	≤2.5% of full scale of range or decade under test, but nominally should not exceed 50 μrd/h (0.5 μGy/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.

--`,,```,,,,`-`-`,,`,,`,`,,`---
Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

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	0.5	1
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	0.5	1
10	1.0	1
10	2.0	1
10	3.0	3
10	4.0	4
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	0.5	1
15	1.0	1
15	2.0	1
15	3.0	1
15	4.0	2
15	5.0	3
15	7.5	6
15	10.0	10

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

True Differences Between Readings (%)	Coefficient of Variation of Readings (%)	Number of Readings Required
15	12.5	10
15	15.0	23
15	20.0	40
20	0.5	1
20	1.0	1
20	2.0	1
20	3.0	1
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	21

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 Criteria

4.1 Classification of Ambient Radioactivity Monitors

Ambient radioactivity monitors comprise a large group of instruments for which no standard or commonly accepted classification exists. Thus, a universal classification scheme is probably impossible because of the wide variety of detectors, measurement protocols, and applications that exist. The categories put forth in this standard are based largely on the measurement capabilities of the instrument.

4.1.1 Direct Radiation Monitors

Direct radiation monitors are those that provide monitoring of ambient airborne radioactivity by measurement of the external radiation field associated with the airborne radioactivity. Direct radiation monitors may thus find application for quantifying radionuclide concentrations from noble gases or other sources where the external exposure from immersion in a cloud is the primary or limiting condition. Provisions shall be taken to ensure that the measurement of airborne radioactivity is not adversely affected by dose rates from other sources with intensities less than 100 μrd/h (1 μGy/h), referenced to air.

4.1.2 Gaseous Radioactivity Monitors

Gaseous radioactivity monitors are devices that continuously or at pre-established intervals sample a quantity of air and measure the radioactivity present in the gaseous state. Such instruments commonly use ion chambers or similar

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

detectors through which a quantity of air is continuously pulled; these are often referred to as flow-through chambers. Depending on the design features, such instruments may respond to any radiation present or may be responsive only to a specific range of energies or to energies above a specified cutoff or lower level. Unless appropriate precautions are taken, flow-through and similar types of gaseous monitors will also measure radioactivity present in or on solid particles suspended in air, and they will also respond to ambient external radiation fields and to free ions produced by non-radioactive sources (i.e., nebulizers). Gaseous radioactivity monitors should be equipped with provisions such as filters to remove interferences from particulate radioactivity and shall be capable of operation without adverse effects on measurement capability in ambient external photon fields of up to 100 μrd/h (1 μGy/h), referenced to air. The specific radioactive gases for which monitoring capability is claimed shall be stated.

4.1.3 Particulate Radioactivity Monitors

Particulate radioactivity monitors measure only the radioactivity present in or on particulates suspended in the ambient air, ordinarily by filtering, precipitating, or otherwise removing the particulates from a measured volume of air and continuously or periodically measuring the radioactivity in the material removed. This standard applies to both fixed- and moving-filter particulate radioactivity monitors; it does not apply to other sampling devices such as electrostatic precipitators or to air sampling devices without monitoring capability.

4.1.4 Radioiodine Monitors

For some applications, particularly around nuclear reactors, measurement of airborne radioiodines may be required Monitoring of radioiodines may be accomplished in a variety of ways, but consideration shall be given to the chemical and physical state of the radioiodine. Specifically, the applicability of the instrument for molecular iodine, methyl iodide, and particulate iodines shall be addressed and stated by the manufacturer.

4.1.5 Activity Fractioning Monitors

A single monitoring system may be used for measurement of more than one type of radioactivity in air by separation or fractioning the activity by physical or radiological means. The specific limitations of the monitoring system with regard to each of the radioactivities detected shall be stated. 4.1.1 to 4.1.4 shall apply, as necessary, to activity fractioning monitors.

4.2 Sampler Design

The following characteristics shall be considered and shall be agreed upon between the instrument manufacturer and the user. All requirements shall be verified by inspection.

4.2.1 Sampling Lines

4.2.1.1 Construction Materials

4.2.1.1.1 Requirements

The type of material used for the sampling lines shall be such that electrostatic and chemical effects are minimized. Sampling lines of electrical conducting materials shall be used whenever possible to mitigate electrostatic deposition of particles. Copper sampling lines shall not be used if the monitor is designed to measure radioiodines.

Materials that minimize absorption, adsorption, or permeation of gases of interest shall be used.

4.2.1.1.2 Test

Verify by inspection.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

4.2.1.2 Distance Between Inlet and Collection Medium or Detector

4.2.1.2.1 Requirements

The distance between the inlet to the air monitoring system and the collection medium or detector shall be kept as short as possible to minimize deposition and resuspension of particles and also to minimize particle-gas or gas-gas interactions.

4.2.1.2.2 Test

Verify by inspection.

4.2.1.3 Sampling Line Dimensions and Bends

4.2.1.3.1 Requirements

The sampling line cross section, air flow characteristics, and number and angles of bends in the line shall be such that deposition of particles on the walls of the line is minimized (ANSI N13.1-1969 (R1982) [2]).

4.2.1.3.2 Test

Verify by inspection.

4.2.2 Air (or Gas) Pump

4.2.2.1 Requirements

The air or gas pump should be of the constant-displacement type and shall be capable of continuous operation. The air mover shall be located downstream from the filter or sampling chamber.

4.2.2.2 Test

Verify by inspection.

4.2.3 Particle Collection Filters

4.2.3.1 Sampling Geometries

The filter moving device shall be independent of the air mover and shall be equipped with some means to indicate that the filter is moving. The amount of deposition both on the sampling head and in the housing should be minimized and shall be stated by the manufacturer.

4.2.3.1.1 Test

Verify by inspection.

4.2.3.2 Collection Medium

4.2.3.2.1 Requirements

The type of collection medium to be used with the monitoring system shall be stated by the manufacturer. For units that measure alpha radiation with a detector viewing the collection medium, the amount of absorption of the alpha radiation by the collection medium shall be minimized and stated by the manufacturer.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

4.2.3.2.2 Test

Verify by inspection.

4.2.4 Ease of Decontamination

4.2.4.1 Requirement

The sampling head or chamber, the radiation detector, and the associated lines shall be easily removed to facilitate decontamination. The remaining components of the sampler should be designed so as to minimize internal contamination to the electronic components.

4.2.4.2 Test

Verify by inspection.

4.2.5 Air In-Leakage

The design of the sampler shall be such that in-leakage of air that would allow air flow to bypass the collection medium or that allows air from other than the desired sampling of the sample head shall be eliminated.

4.3 Units of Readout

4.3.1 Requirements

Readings of airborne radioactivity should be expressed in units of activity per unit volume (e.g., Bq/m^3, μCi/cc, or multiples or submultiples thereof) when calibration for the instrument in terms of activity and airflow exists. If such a calibration does not exist, readings should be in units of directly measured quantities (e.g., c/min, A).

4.3.2 Test

Verify by inspection.

4.4 Markings

4.4.1 Requirements

4.4.1.1 General

All instrument controls, displays, and adjustments, both internal and external, shall be identified as to function.

4.4.1.2 Exterior Markings

The following markings shall appear on the exterior of the instrument or each major subassembly as appropriate.

1) Instrument function or classification or both
2) Manufacturer and model number
3) Unique serial number
4) Function designation for controls, switches, and adjustments
5) Markings for proper location of detector

Markings shall be in appropriate units or terms, shall be easily readable, and shall remain permanently affixed under normal conditions of use.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

4.4.1.3 Readout Markings

Analog meters shall be provided with scale markings. For linear readouts, major scale divisions shall be at zero 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, 2.5, 3, 4, 5, 6, 7, 8, and 10) major division markings between the limits of the decade. All readouts, analog or digital, shall prominently display the readout units. Units or abbreviations for units shall, wherever possible, be consistent with ANSI Y1.1-1972 (R1984) [9]. Ancillary or secondary readouts such as printers, strip chart recorders, and similar devices should conform to the provisions of this paragraph; conformance may be achieved by appropriately marked charts or paper.

4.4.2 Test

Verify by inspection.

4.5 Alarm Threshold

4.5.1 Requirements

Instruments may be equipped with audible or visible alarms or both. For instruments equipped with an alarm, the alarm threshold shall be capable of adjustment to any point within the specified range of the instrument. This threshold shall be stated or indicated as either a percentage of the range in use or in absolute values of the units of measurement.

4.5.2 Test

Verify by inspection.

4.6 Protection of Switches and Controls

4.6.1 Requirements

Switches and other controls shall be protected to prevent inadvertent deactivation or improper operation of the system. The manufacturer shall state what action has been taken to meet this requirement.

4.6.2 Test

Verify by inspection.

4.7 Power

4.7.1 AC Power Supply Instruments

4.7.1.1 Requirements

The operating power requirements shall be stated for instruments and shall include the operating voltage range and current requirements. Instruments powered by ac shall operate over the range of 117 ± 15 V, single phase ac, or 208 ± 30 V single phase ac at a nominal frequency of 60 Hz (i.e., 57–61 Hz).

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

4.7.1.2 Tests

4.7.1.2.1 AC Supply Voltage

The detector shall be exposed to a source of radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. The supply voltage shall be changed in 5. V increments over the applicable range given in 4.7.1.1, and a sufficient number of readings shall be obtained at each voltage in accordance with 3.3 to achieve an accurate statistical basis for comparison. Alternatively, the test may be made at the extremes and midpoint of the appropriate voltage range. The mean response of the instrument at any point over the voltage range shall not differ by more than 5% from the mean response observed at the reference operating voltage as specified by the manufacturer.

4.7.1.2.2 AC Supply Frequency

The detector shall be exposed to a source of radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. In the case of flow-through or other internal detectors, an external source of radiation may be used. While the instrument is operating at the nominal voltage as stated by the manufacturer, the frequency of the input voltage shall be varied in 1. Hz increments over the applicable range given in 4.7.1.1, and a sufficient number of readings shall be recorded at each frequency in accordance with 3.3. The mean response of the instrument at any point over the frequency range shall not differ by more than 5% from the mean response observed at the reference operating frequency as specified by the manufacturer.

4.7.2 DC Power Supply Instruments

4.7.2.1 Requirements

Instruments with a self-contained, nonrechargeable power supply, either as the primary power source or as a backup power source, shall use readily available batteries meeting the requirements put forth in ANSI C18.1-1986 [1]. Battery lifetimes and operating temperature range for continuous operation and normal storage under all conditions shall be stated by the manufacturer of the instrument. The manufacturer shall state the minimum voltage required to produce satisfactory operation of the instrument where satisfactory operation is defined as a less than a 10% change in instrument response compared to the response with fresh batteries. The low battery indication shall be no lower than the minimum voltage.

4.7.2.2 Test

The instrument shall be equipped with fresh batteries meeting the specifications put forth in ANSI C18.1-1986 [1], as applicable. All functional circuits, alarms, and speakers excluded shall be switched on and shall remain on during the test. An exposure shall be made to a source of ionizing radiation sufficient in strength to produce approximately a midrange or middecade reading on an appropriate range or decade, and a sufficient number of readings shall be taken initially and then at predetermined times in accordance with 3.3. Battery lifetime shall be considered to have been exceeded when the ratio of the mean reading at any time relative to the mean reading taken initially falls outside the range 0.9 to 1.1. The battery lifetime shall be stated as the longest time in hours at which the ratio of the mean reading to the initial mean reading falls within this range.

4.7.3 AC- and DC-Powered Instruments

4.7.3.1 Requirements

Instruments with both ac and dc capability shall meet the requirements of 4.7.1.1 and 4.7.2.1 unless the dc power is for emergency or backup use, in which case only the provisions of 4.7.1.1 apply. In this case, the instrument shall not be considered to have true dc capability, and such capability shall not be claimed.

Copyright © 1990 IEEE All Rights Reserved

--`,,```,,,,````-`-`,,`,,`,`,,`---

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

4.7.3.2 Test

Refer to 4.7.1.2 or 4.7.2.2 or both as they apply.

4.8 Battery Status Indication

4.8.1 Requirements

Battery-powered instruments shall be equipped with a test circuit with visual direct indication of battery condition for each battery circuit. A metering indication is preferred, but single valued indicators may also be used.

4.8.2 Test

Verify by inspection.

4.9 Alteration and Modification

Instruments that have been altered, changed, or modified by the manufacturer in any manner that could affect the capability of the instrument to meet the specifications provided in this standard shall be re-evaluated to ensure conformance with the provisions of this standard and to determine changes in the response. All such changes shall be documented along with the results of the re-evaluation.

5. Electronic Criteria

5.1 Alarms

5.1.1 Requirements

5.1.1.1 Alarm Reset

Instruments may be provided with various audible or visual alarms or both that operate in one of the following modes:

1) Latching, in which the alarm remains activated until manually reset (i.e., acknowledged)
2) Nonlatching, in which the alarm deactivates or clears automatically on reduction of exposure rate below the alarm level

Alarms shall normally continue to operate in radiation fields greater than the selected alarm points. However, it should be possible to interrupt or deactivate the audible alarm manually without interrupting the visual alarm.

5.1.1.2 Alarm Threshold Drift

Under standard test conditions, the actual exposure rate trip level shall not deviate from the set point level by more than ± 10% over a period of 24 h and ± 20% over a period of 500 h.

5.1.1.3 Fault Alarm

A fault-alarm capability should also be provided that gives an appropriate notification when the system is incapable of monitoring radiation or if a failure occurs in any component or circuit that would affect the accuracy of the readout. This alarm shall sound different from the radiation alarm.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

5.1.1.4 Audible Alarm Intensity

The intensity of an audible alarm shall be at least 75 dB in the frequency range 500–3000 Hz at a distance of 15 cm (6 in) from the exterior case of the instrument over a solid angle of 15°.

5.1.1.5 Visual Alarms

Visual alarms may be flashing or steady state.

5.1.2 Tests

5.1.2.1 Latching and Nonlatching Reset

The detector shall be exposed to a suitable source of radiation with an intensity sufficient to activate the alarm(s). The instrument shall be permitted to operate for at least 5 min in the alarm condition. If the instrument design permits manual interruption of the audible alarm without interrupting the visual alarm, this action shall be performed and the result observed. The exposure shall then be terminated. Latching alarms shall remain activated for at least 5 min after termination of the exposure. The meter indication of readout shall fall to background, and the latching alarm shall be deactivated only by manual activation of the acknowledgment or reset switch. Nonlatching alarms shall deactivate and the readout shall fall to background with no action required upon termination of the exposure. The time for this to occur shall not exceed 30 s.

5.1.2.2 Alarm Threshold Drift

The alarm threshold shall be set to approximately midrange or middecade and the detector exposed to a suitable source of radiation with sufficient intensity to activate the alarm on an appropriate range or decade. The mean exposure rate required to activate the alarm shall be determined initially, every hour for the first 8 h, at the end of 24 h, and then periodically until 500 h have elapsed.

5.1.2.3 Fault Alarm

Tests of failure alarm(s) against appropriate instrument malfunctions shall be performed by agreement between the manufacturer and the user.

5.1.2.4 Audible Alarm Intensity

The detector shall be exposed to a suitable source of radiation sufficient in intensity to activate the audible alarm. The intensity of the alarm shall be measured at a distance of 15 cm from the alarm over a solid angle of 15°.

5.1.2.5 Visual Alarm

The detector shall be exposed to a suitable source of radiation sufficient in intensity to activate the visual alarm and the required observations made.

5.2 Stability

5.2.1 Requirements

The mean instrument response at constant temperature and pressure shall not vary more than 6% from the mean of a set of reference readings over a period of 24 h for ac-powered units and 3 h for survey meters, after a warmup period specified by the instrument manufacturer. A maximum change of 15% over a period of 500 h is allowed for ac-powered units.

Copyright © 1990 IEEE All Rights Reserved

--`,,`,,,,-`-`,,`,,`,`,,`---

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

5.2.2 Test

Instruments shall be switched on and allowed an appropriate warmup period. The detector shall be exposed to a suitable source of radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. A sufficient number of readings shall be recorded in accordance with 3.3 immediately after the recommended warmup period has elapsed and then after 1 h, 10 h, 100 h, 200 h, and 500 h have elapsed. No adjustments are to be made to the unit during the test, and corrections for changes in temperature and ambient pressure are to be made when appropriate, as well as corrections for radioactive decay of the source. All equipment including air pumps is to be operated during the testing.

5.3 Response Time

5.3.1 Requirements

The instrument response time shall be stated by the manufacturer for each scale or decade of the unit.

5.3.2 Test

The equilibrium reading of the instrument shall be established by exposing the detector in a reproducible geometry to an appropriate source of ionizing radiation of sufficient intensity to produce a mean reading between mid- and full scale or decade. The radiation field shall be removed and the instrument reading allowed to stabilize. The original radiation field shall quickly be renewed and the time recorded for the instrument reading to move from 10% to 90% of the previously established equilibrium reading. These two steps shall be repeated until a sufficient number of data points to establish statistical confidence at the 95% confidence level have been obtained in accordance with 3.3. This test shall be performed on all scales or decades, if possible.

An acceptable alternate test method is to use a pulser instead of a radioactive source for the measurements. The same steps as stated above shall be performed on all scales or decades.

5.4 Coefficient of Variation

5.4.1 Requirements

The coefficient of variation of 20 instrument readings shall not be more than 10% for detectors exposed to radiation intensities greater than or equal to 2000 dpm. When the detector is exposed to radiation intensities less than 2000 dpm, the coefficient of variation shall not be more than 15%. This test shall be performed on all scales or decades.

5.4.2 Test

The detector shall be exposed in a reproducible geometry to a suitable radiation source of sufficient intensity to produce a reading between 25–75% of full scale or full decade. Twenty successive readings shall be made, and the time interval between readings shall not be less than that corresponding to three times the response time for the scale or decade on which the readings are made. The test should be made on each scale or decade. The mean, the standard deviation, and the coefficient of variation of the instrument readings shall be calculated for each scale or decade. Reference sources are specified in Table 3.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

Table 3—Reference Sources for Coefficient of Variation and Accuracy Tests

Radiation Type	Acceptable Reference Source
Alpha	^{23O}Th, ^{239}Ptu, ^{Nat}U
Beta	^{90}Sr–^{90}Y in equilibrium, filtered through 50 mg/cm^2 of a material with $Z \leq 13$
Photon	^{137}Cs filtered to remove ≥90% of the betas and associated Ba X rays

NOTE — Z = atomic number

5.5 Line Noise Susceptibility

5.5.1 Requirements

The mean instrument response of ac-powered units shall vary not more than 15% from the mean of a set of reference readings during or after subjection to voltage sags, surges, and transients on the power line. System alarms shall not be triggered by sags, surges, or transients.

5.5.2 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 [10].

Table 4—Power Transients

Number of Pulses	Rise Time (ms)	Duration (ms)	Decay (ms)	Pulse Amplitude and Sign % of Nominal RMS Voltage
Surges				
10	10	10	10	+40%
10	10	500	10	+20%
Sags				
10	10	10	10	-100%
10	10	500	10	-40%
Transients				
5	0.0005	100 kHz	—	6 kV
5	0.0012	(ring wave)	0.05	6 kV
10	0.0005	100 kHz	—	2.5 kV
10	0.0012	(ring wave)	0.05	2.5 kV

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

6. Radiation Response

6.1 Minimum Detectable Activity

6.1.1 Requirements

The MDA for specific radionuclides or radiation types over a given energy range shall be stated by the manufacturer. Radionuclides and background conditions that are to be used in testing shall be agreed upon between the instrument manufacturer and the user.

6.1.2 Test

The minimum detectable activity for specific radionuclides under different radiation background conditions shall be determined using the following equation [11]:

$$\mathrm{MDA} = \frac{4.65 S_b}{K} \tag{1}$$

where

S_b = the standard deviation of the count rate
K = a conversion factor, typically in units of c/min/μCi

A minimum of 20 readings for background shall be taken to calculate S_b. The MDA shall be calculated and verified for the different radionuclides agreed upon between the instrument manufacturer and the user and may include calculations and measurements for ^{85}Kr, ^{133}Ba, ^{133}Xe, $^{\mathrm{Nat}}$U, ^{99}Tc, ^{137}Cs, ^{131}I, and ^{239}Pu.

6.2 Accuracy

6.2.1 Requirements

The ratio of the indicated value to the conventionally true value shall fall within the range of 0.60 to 1.40 at the 95% confidence level, or

$$0.60 \le \frac{\bar{r}_i}{CTV_{\mathrm{ref}}} \le 1.40 \tag{2}$$

where

$\bar{r}_i$ = the mean indicated value
CTV_{ref} = the conventionally true value

6.2.2 Test

The instrument shall be exposed to (a) standard source(s) of the appropriate reference energy or energies with sufficient intensity to produce readings of approximately 25% and 75% of each scale or decade, and the readings shall be recorded. A sufficient number of readings should be made in accordance with 3.3. Determine the ratios of the observed value to the conventionally true values. Acceptable reference sources are specified in Table 3.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

6.3 Beta-Photon Radiation Overload

6.3.1 Requirements

When exposed to radiation levels greater than that corresponding to the highest scale or decade maximum, the instrument shall continue to operate, and the readout of an analog instrument shall be off scale or at the higher end of the scale or decade and shall remain so until the radiation field is reduced to below full-scale or -decade value. Digital readouts shall convey that the radiation levels present exceed the upper detection limit of the instrument in a manner described by the manufacturer. When the radiation field is removed, the instrument reading shall return to the correct downscale reading within the time interval stated by the instrument manufacturer.

6.3.2 Test

The detector or instrument shall be placed in (an) appropriate radiation field(s) or exposed to a source with a conventionally true value 10 times the intensity required to produce a full scale or decade reading on the highest scale or decade and the response observed for 1 min. The radiation source shall be removed and the instrument reading shall be observed for 2 min or for the time interval specified by the manufacturer. This test shall be performed for all detectors in the instrument and for all scales or decades.

6.4 Radiation Type and Energy

6.4.1 Requirements

The radiation type and energy range that the instrument measures shall be stated by the manufacturer. Instruments for the measurement of gross beta activity shall be responsive to betas with energies from 0.08 to 3 MeV. For these instruments, curves of detector efficiency or versus maximum beta energy shall be provided. This curve shall be based on measurements of efficiency made with the sources listed in Table 5. The source-to-detector distance shall not exceed 10 cm. Instruments for measurement of specific nuclides or beta-energy ranges shall be tested for those nuclides or ranges and the results stated. Instruments for gross alpha activity shall respond to alpha particles with energies greater than 3.5 MeV. Alpha sources that may be used for testing include ^{239}Pu and ^{230}Th. Reference photon sources that may be used include ^{137}Cs and ^{60}Co. Sources to be used for radioiodine monitors shall be agreed upon between the submitter and the testing facility.

6.4.2 Test

Instruments shall be exposed to the appropriate sources as described in the requirements and under standard test conditions. A sufficient number of instrument readings shall be taken in accordance with 3.3. Test methods shall be agreed upon between the instrument submitter and the testing facility. Calculations of efficiency shall be as follows:

$$E_{\mathrm{en}_i} = \frac{\bar{r}_{\mathrm{en}_i}}{CTV_{\mathrm{en}_i}} \tag{3}$$

where

E_{en_i} = the efficiency of the detector at energy i
$\bar{r}_{\mathrm{en}_i}$ = the mean detector response to the radiation of energy i
CTV_{en_i} = the conventionally true value of the radiation of energy i

Alternatively, the efficiency may be expressed as a percent, obtained by multiplying the right-hand side of the above equation by 100.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

Table 5—Beta Sources for Use in Determining Beta Efficiency [13][6]

Source	Half-Life (yr)	Maximum Beta Energies (MeV)	Filtration Required
^{14}C	5730	0.156	
^{147}Pm	2.62	0.224	
or			
^{99}Tc	2.14×10	0.292	
^{36}Cl	3.01×10	0.710	
or			
^{204}Tl	3.78	0.763	
^{210}Pb-Bi+	20.4	0.016	5 mg/cm^2
daughters		0.061	($Z \leq 15$)
		1.161	
^{90}Sr–^{90}Y	27.7	0.546	40 mg/cm^2
		2.27	($Z \leq 15$)
or			
^{238}U+	4.51×10	0.100	40 mg/cm^2
daughters		0.191	($Z \leq 15$)
		2.29	

NOTE — Z = atomic numbers

6.5 Response to Unwanted Radiations

6.5.1 Requirements

The ability of the instrument to reject unwanted ionizing radiations, including natural background, shall be stated along with the method used for testing. The response of the instrument to ionizing radiations other than those for which measurement capability is claimed shall be stated. If the air monitoring system uses multiple detectors, then the possible problem of "cross talk" between detectors shall be investigated. If the air monitoring system uses a radiation background-subtract circuit or process, the operation of such shall be evaluated and documented.

6.5.2 Test

Test methods shall be agreed upon between the instrument manufacturer and the user.

[6]Adapted from the journal *Health Physics* by permission of the Health Physics Society.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

7. Interfering Responses

7.1 Radio Frequency (RF) Fields

7.1.1 Requirement

The mean instrument response for each detector, obtained when the instrument is exposed to an RF field that is ≤100 V/m in intensity in the frequency range of 0.3 MHz to 35 MHz or at a nominal 140 MHz[7] or both shall not vary more than 15% from the mean instrument response obtained with no radio frequency field present. Alternatively, the manufacturer shall specify in the documentation that the instrument may be sensitive to and not operate properly in such fields. Special requirements for other frequencies may be determined by the instrument manufacturer and the user. The tests for these requirements may be performed on a single instrument.

7.1.2 Test

7.1.2.1 60 Hz and 400 Hz Electric Fields

The instrument shall be exposed under standard test conditions to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade and the mean instrument reading determined. The instrument shall be additionally exposed to 60 Hz and 400 Hz electric fields with peak intensities of 100 V/m and the mean instrument reading determined.

7.1.2.2 0.3 to 35 MHz RF Field

The instrument shall be exposed under standard test conditions to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. A sufficient number of instrument readings shall be obtained in accordance with 3.3. The mean instrument reading shall be determined. The instrument shall then be additionally exposed to a 0.3 MHz RF field with a peak intensity of 100 V/m, and the instrument reading shall be observed and recorded. The instrument reading shall be observed while the frequency is increased to 35 MHz at a rate not to exceed 10 kHz/s from the 0.3 MHz to 2 MHz range and 100 kHz/s over the 2 MHz to 35 MHz range. The field intensity is to be maintained at 100 V/m during this frequency scan.

7.1.2.3 Nominal 140 MHz RF Field

The instrument shall be positioned in an RF field generation system or near a portable communication transmission and receiving unit with the field at zero intensity. The instrument shall be exposed in a reproducible geometry to a source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. A sufficient number of instrument readings shall be obtained in accordance with 3.3. The mean instrument reading shall be determined. The instrument shall then be exposed to an RF field that is 100 V/m in intensity and a nominal 140 MHz in frequency (i.e., the most commonly used frequency for portable communication transmission and receiving units), and the mean instrument reading shall be determined again.

7.2 Microwave Fields

7.2.1 Requirements

Exposure to microwave fields ≤100 W/m^2 in intensity at 915 MHz or 2450 MHz shall not alter the mean response of the instrument to ionizing radiation by more than 15% from the mean response of the instrument obtained when there is no field present. Alternatively, the manufacturer shall specify in the documentation that the instrument may be sensitive to and not operate properly in such fields. The test for this requirement may be performed on a single instrument.

[7]Approximate frequency of a portable transceiver unit.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

7.2.2 Test

The instrument shall be exposed under standard test conditions to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade, and a sufficient number of instrument readings shall be obtained in accordance with 3.3. The mean instrument reading shall be determined. The instrument shall then be exposed to 915 MHz microwave fields 100 W/m^2 in intensity at 915 MHz and 2450 MHz. The mean instrument reading shall be determined for each and compared with the value obtained under standard test conditions.

7.3 Electrostatic Fields

7.3.1 Requirements

Exposure to electrostatic fields ≤5000 V/m in intensity shall not alter the mean response of the instrument toionizing radiation by more than 15% from the mean response of the instrument obtained when there is no field present. Alternatively, the manufacturer may specify in the documentation that the instrument may be sensitive to and not properly operate in such fields. The test for this requirement may be performed on a single instrument.

7.3.2 Test

Under standard test conditions, the instrument shall be exposed to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade and a sufficient number of readings shall be taken in accordance with 3.3. The mean instrument reading shall be determined. The instrument shall then be exposed to an electrostatic field 5000 V/m in intensity. The mean instrument reading shall be determined again and compared with the reference value obtained under standard test conditions.

7.4 Magnetic Fields

7.4.1 Requirements

Exposure to magnetic fields ≤800 A/m (~10 Oe) shall not alter the mean response of the instrument by more than 15% from the mean response of the instrument obtained when there is no field present. Alternatively, the manufacturer may specify in the documentation that the instrument may be sensitive to and not operate properly in such fields. The test for this requirement may be performed on a single instrument.

7.4.2 Test

Under standard test conditions, the instrument shall be exposed to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade, and a sufficient number of instrument readings shall be taken in accordance with 3.3. The mean instrument reading shall be determined. The instrument shall then be exposed to a magnetic field 800 A/m (~10 Oe) in intensity, and the mean instrument reading shall be determined again and compared with the reference value obtained under standard test conditions.

The instrument shall be tested in a second orientation such that the detector to magnetic field lines orientation is changed 90° from the first orientation.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

8. Environmental Criteria

8.1 Temperature

8.1.1 Requirements

The mean instrument response shall not vary more than 15% in the temperature range of 10 to 40 °C and shall not vary more than 20% in the temperature range of -20 °C to 50 °C from the mean instrument response at 22 °C. Corrections to instrument readings for air density changes are to be made when appropriate. The instrument shall have the capability to withstand changes in temperature of 10 °C/h.

8.1.2 Test

The instrument shall be exposed in a reproducible geometry to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. A sufficient number of instrument readings shall be taken in accordance with 3.3. The mean instrument reading at 20 °C shall be determined. The temperature shall be raised or lowered at a rate of approximately 10 °C/h until the temperature extremes have been reached. Sufficient data shall be recorded at least at 10° increments; the instrument shall be permitted to come to thermal equilibrium at each temperature level before data are taken. The results should be plotted or stated as a temperature coefficient or inclusive range.

NOTE — A rate of the temperature change of 10 °C/h may damage certain detectors [e.g., NaI(Tl) detectors].

8.2 Humidity

8.2.1 Requirements

The mean instrument response shall not vary more than 15% over the relative humidity (RH) range of 40–95% noncondensing and a temperature of 22 ± 2° C from the mean instrument response at 40% RH and ~22 ± 2 °C.

8.2.2 Test

The instrument shall be exposed to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. A sufficient number of instrument readings shall be taken in accordance with 3.3. The mean instrument reading at 40 ± 2% RH and temperature of 22 ± 2 °C shall be determined after a minimum exposure period in this atmosphere of 4 h. The RH inside the chamber shall be increased to 95% +0, -2 RH while the temperature is kept at 22 ± 2 °C and maintained at that level for a minimum of 8 h. The mean instrument reading shall then be determined under these environmental conditions. The relative humidity shall be decreased to 40 ± 2% while the temperature is kept at 20 ± 5 °C and then maintained at that level for a minimum of 4 h. The mean instrument reading shall then be determined.

Although it is preferable to test the instrument systems as a whole, this may be impractical in some instances. In such cases, the response of components or portions of the instrument may be checked individually providing that all portions of the instruments, including cables and connectors, are evaluated and each portion meets the requirements of 8.2.1.

Copyright © 1990 IEEE All Rights Reserved

--`,,```,,,-`-`,,`,,`,`,,`---

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

8.3 Ambient Pressure

8.3.1 Requirements

The mean instrument response shall not vary more than 15% from the mean instrument response at 101 kPa over the ambient pressure range of 70–106 kPa. Corrections to instrument readings for air density changes are to be made when appropriate.

8.3.2 Test

The instrument shall be exposed to a suitable source of ionizing radiation of sufficient intensity to produce a response of approximately midscale or middecade on an appropriate scale or decade. A sufficient number of instrument readings shall be taken in accordance with 3.3. 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. The mean instrument reading shall be obtained at 106, 10, 92, 84, 75, and 70 kPa after the instrument has been permitted to equilibrate at the specific pressure, and the results shall be compared.

9. Air Circuit Criteria

9.1 Flow or Flowrate Meter Accuracy

9.1.1 Requirements

Air flowrate meters shall be accurate to within ± 15% of the conventionally true flowrate values.

9.1.2 Test

A volumetric measuring device or flowmeter, standardized under the measuring conditions and having an accuracy better than 2%, shall be used in this test. The device or flowmeter shall be inserted in series directly upstream to the flowmeter to be tested with the upstream end of the device or flowmeter open to the atmosphere. A sufficient number of instrument readings shall be taken in accordance with 3.3. The mean flowrates at a minimum of three different flowrates (e.g., at 25%, 50%, and 75% of full scale) shall then be determined and compared.

9.2 Air In-Leakage

9.2.1 Requirements

The leakage of air into the monitoring unit upstream of the flowrate meter shall be less than 10% of the nominal flowrate.

9.2.2 Test

After the accuracy of the flowrate meter has been verified (i.e., with the test in 9.1), the leakage of air into the monitoring unit upstream of the flowrate meter shall be determined by placing a calibrated volumetric measuring device or flowmeter on the inlet to the air monitoring system. This device shall have an accuracy better than 2%. The air monitor shall be operated with a clear filter medium, flow-through chamber, or clean cartridge in place at the desired flowrate. The flowrate measured by the system flowrate meter shall be compared to that measured by the inlet device. A sufficient number of instrument readings shall be taken in accordance with 3.3. If the mean system flowrate meter reading is greater than the mean reading of the inlet device by more than 10%, adjustments to the system (e.g.,

Copyright © 1990 IEEE All Rights Reserved

--`,,`,,,,-`-`,,`,,`,`,,`---

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

air-line fittings, o-ring seals, filter placement) shall be made in an attempt to reduce the air in-leakage. If these attempts do not reduce the leakage to less than 10% of the nominal flowrate, then the unit shall fail the test.

9.3 Flowrate Stability

9.3.1 Requirements

The manufacturer shall state the nominal flowrate for the type of filter that is used. After the warm-up time specified by the manufacturer for the monitoring unit, the measured flowrate shall not vary more than 5% from the nominal flowrate.

9.3.2 Test

A volumetric measuring device or flowmeter, standardized under the measuring conditions and having an accuracy better than 2%, shall be incorporated in the airflow circuit at the inlet of the unit. The unit shall be turned on and the flowrate measured after the warm-up time specified by the manufacturer and at 1 h, 5 h, 10 h, and 100 h of operation. A sufficient number of instrument readings shall be taken in accordance with 3.3. The mean flowrates obtained at these times shall not vary more than 5% from the nominal flowrate.

9.4 Filter Pressure Drop

9.4.1 Requirements

The minimum pressure drop that causes a 10% decrease from the nominal airflow under standard conditions shall be stated by the manufacturer, and the pressure drop measured during testing shall not be below that stated by the manufacturer.

9.4.2 Test

A calibrated vacuum measurement device shall be fitted downstream of the filter at a point identified by the manufacturer. This instrumentation shall provide a direct indication of the pressure drop obtained by inserting a variable restrictor (e.g., a valve, a clamp) between the flowmeter and the filter. A volumetric measuring device or flowmeter, standardized under the measuring conditions and having an accuracy better than 2%, shall be incorporated in the airflow circuit at the inlet of the unit. The unit shall be turned on and allowed to operate for a warm-up period stated by the manufacturer. A sufficient number readings shall be taken in accordance with 3.3. The variable restrictor shall then be adjusted until a mean flowrate that is 10% below the nominal flowrate under standard test conditions is observed. The pressure drop shall be measured under these conditions and compared to the minimum pressure drop stated by the manufacturer for the specific filter media.

9.5 Power-Supply Voltage Effect on Flowrate

9.5.1 Requirements

The mean flowrate under testing conditions shall not vary more than 5% from the mean flowrate under reference conditions when the power-supply voltage is varied between +10% to -12% of the reference operating voltage as stated by the manufacturer. This test requirement is only for instruments with self-contained pumps or active flow regulators.

9.5.2 Test

A volumetric measuring device or flowmeter, standardized under the measuring conditions and having an accuracy better than 2%, shall be incorporated in the airflow circuit at the inlet of the unit. A sufficient number of instrument readings shall be taken in accordance with 3.3. The unit shall be turned on and the mean flowrate determined after the

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

warm-up time specified by the manufacturer with the air monitoring system operating at the reference operating voltage. The mean flowrates shall be determined when the system is operating at operating voltages that are 12% below and 10% above the manufacturer's recommended operating voltage. The mean flowrates under these testing conditions shall then be compared to the flowrate obtained under reference conditions.

9.6 Power Supply Frequency Effect on Flowrate

9.6.1 Requirements

The mean flowrate under testing conditions shall not vary more than 10% from the mean flowrate under reference conditions when the frequency is varied from 57 Hz to 61 Hz. This test requirement is only for instruments with self-contained pumps or active flow regulators.

9.6.2 Test

A volumetric measuring device or flowmeter, standardized under measuring conditions and having an accuracy better than 2%, shall be incorporated in the airflow circuit at the inlet of the unit. A sufficient number of instrument readings shall be taken in accordance with 3.3. The unit shall be turned on and the mean flowrate determined after the warm-up time specified by the manufacturer with the air monitoring system operating at the reference operating voltage (i.e., recommended ac voltage by the manufacturer at 60 Hz). The mean flowrates shall be determined when the unit is operating at 57 Hz and 61 Hz and shall be compared to the mean flowrate observed under reference conditions.

9.7 Particle Collection

9.7.1 Requirements

The percentage of particles collected by the air monitoring system for measurement of particulates shall be stated by the manufacturer. This is defined as the ratio of concentrations of radioactivity, as represented by the collection media (e.g., filters), to the concentration of radioactivity in the air supplied to the inlet of the sampling equipment, expressed as a percentage. Therefore, this includes losses of particles to walls of the sampling pipe and head, etc.

The particle diameter and range of sizes used in the measurement of the percentage of particles collected by the sampling system shall be agreed upon between the manufacturer and the purchaser (e.g., dependance upon the diameter of the aerosol to be monitored, collection efficiency of the filter medium versus particle size, etc.)

The type of aerosol used in testing shall be agreed upon between the manufacturer and the user. Various types of aerosols are suitable for use in particle collection tests and include:

1) Nonradioactive aerosols with particles that have a fluorescent tracer
2) Nonradioactive aerosols composed of latex or polystyrene spheres
3) Radioactive aerosols

9.7.2 Test

The percentage of particles collected by the air monitoring system shall be tested by introducing into the inlet sampling pipe a sample of air containing monodisperse particles of the appropriate aerodynamic equivalent diameter. The sampling equipment shall be operating under known test conditions, (e.g., flowrate, temperature).

The total amount entering the air monitoring system is given by:

$$C_T = C_M + C_U + C_D \quad (4)$$

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

where

C_T = the total amount, as activity, mass, or number of particles
C_M = the amount deposited on the collection medium
C_U = the amount recovered from internal surfaces of the air circuit upstream of the collection medium
C_D = the amount collected downstream of the sampling medium

The percentage of particles collected by the system (E_{PS}) is given by:

$$E_{PS} = \frac{(C_M + C_U)}{C_T}(100) = \left(1 - \frac{C_D}{C_T}\right)(100) \quad (5)$$

If the total amount of particulates entering the air monitoring system, the amount of particulate material deposited upstream of tile collection medium, and the amount deposited on the collection medium can be determined accurately, then the calculation of E_{PS} is straightforward. This calculation is also straightforward if the total amount of particulates entering the monitoring system and the amount of material downstream of the sampling medium can be directly measured or determined. The measurement of the aerosol concentration entering the inlet pipe can be determined by various instrumental techniques (e.g., spectrophotometer, particle analyzer, etc.) or by calculation of the output of the aerosol generator minus the quantity of aerosol lost prior to delivery or the amount of material being delivered to the air monitoring system. The value of C_M shall be determined by analytical techniques (i.e., chemical or radioactive).

If the determination of the total amount of particulates is not feasible, then after shutdown of the sampling equipment, the following shall be determined:

1) The amount of aerosol collected on the sampling medium (i.e.,C_M)
2) The amount of aerosol collected on the internal surfaces of the inlet pipe and other surfaces of the air circuit upstream of the collection medium (i.e., C_U)
3) The amount of aerosol downstream of the collection medium (i.e.,C_D).

C_T can be calculated by summing these three values, and then E_{PS} determined.

9.8 Gas Collection

9.8.1 Requirements

The percentage of a specific gas collected by the air monitoring system shall be stated by the manufacturer. This is defined as the ratio of the concentration of radioactivity, as represented by the collection medium, to the concentration of radioactivity in the air supplied to the inlet of the sampling equipment, expressed as a percentage. Therefore, this includes any absorption into or adsorption onto the walls of the sampling line, etc. This requirement shall not apply to flow-through type on other direct reading (i.e., nonremoval systems).

9.8.2 Test

The percentage of a specific gas collected by the system shall be determined by introducing a known concentration of radioactive gas into the system at the design flowrate upstream of the gaseous removal system and measuring the concentration immediately downstream of the gaseous removal system.

The percentage of gas collected by the system (E_{GS}) is given by:

$$E_{GS} = \left(1 - \frac{C_D}{C_o}\right)(100) \quad (6)$$

where

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

C_D = The gas concentration downstream of the removal system
C_o = The inlet gas concentration

10. Documentation

10.1 Type-Test Report

The manufacturer shall make available a report including all test data on the type tests performed in accordance with the requirements of this standard.

10.2 Certificate

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

1) Manufacturer's name and address
2) Type of instrument, detector(s), and serial numbers
3) A list of all test requirements met
4) A statement of conformance to this standard (e.g., conforms to ANSI N42.17B-1989 for measurement of appropriate radiation)
5) Date of test(s)

10.3 Operation and Maintenance Manual

Each instrument shall be supplied with an appropriate manual in accordance with ANSI N13.4-1971 (R1985) [3] and IEC Publication 278-1968 [12].

11. Bibliography

[B1] IEC Publication 761:1983. Equipment for Continuously Monitoring Radioactivity in Gaseous Effluent, Parts 1–5.

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

Annex A

(Informative)

(This Appendix is not a part of ANSI N42.17B-1989, Performance Specifications for Health Physics Instrumentation–Occupational Airborne Radioactivity Monitoring Instrumentation, but is included for information only.)

Table A —Tests Performed With Variation of Influence Quantities

Characteristics Under Test (Influence Quantity)	Range of Values of Influence Quantities	Limits of Variation	Method of Test (Section)
	GENERAL CHARACTERISTICS		
AC power	102–132 V or 178–238 V	5%	4.7.1.2.1
Battery power	Minimum voltage as stated by manufacturer	10% change in instrument response	4.7.2.2
AC-powered instruments with battery backup	(1) Markings for units with rechargeable batteries	As stated by manufacturer	4.7.3.2
	(2) Test when battery condition indicator first shows failure	10%	4.7.3.2
	ELECTRONIC AND MECHANICAL TESTS		
Alarms, reset	Dose rate to activate alarm	As stated by manufacturer	5.1.2.1
Alarms, threshold drift	Dose rate to activate alarm	± 10% over 24 h	5.1.2.2
		± 20% over 500 h	
Audible alarm	≥ 75 dB at 15 cm	500–3000 Hz	5.1.1.4
Visual alarm	Flashing or steady-state	As stated by manufacturer	5.1.1.5
Stability	(1) Battery powered: 3 h	6% from reference initial reading	5.2.2
	(2) AC powered: 24 h	6% from reference initial reading	5.2.2
	(3) AC powered: 500 h	15% from reference initial reading	5.2.2
Response time	As stated by manufacturer	As stated by manufacturer	5.3.2
Coefficient of variation (1)	20 readings of radiation exposure ≥ 2000 dpm	10%	5.4.2
	(2) 20 readings of radiation exposure < 2000 dpm	15%	5.4.2
Line noise susceptibility	See Table 4	15% from reference readings	5.5.2
	RADIATION RESPONSE		
Minimum detectable activity	As stated by manufacturer		6.1.2
Accuracy	As stated by manufacturer	± 40% at 95% confidence level from conventionally true value	6.2.2

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS Not for Resale

Characteristics Under Test (Influence Quantity)	Range of Values of Influence Quantities	Limits of Variation	Method of Test (Section)
Beta-Photon radiation overload	10 times upper limit for 1 min	Correct response within 2 min or as stated by manufacturer	6.3.2
Beta energy dependence	0.08 to 3 McV	$E_{\mathrm{en}_i} = \frac{\bar{r}\mathrm{en}_i}{CTV_{\mathrm{en}_i}}$	6.4.2
Gross alpha activity	>3.5 MeV	$E_{\mathrm{en}_i} = \frac{\bar{r}\mathrm{en}_i}{CTV_{\mathrm{en}_i}}$	6.4.2
Response to unwanted radiations	As stated by manufacturer		6.5.2
	INTERFERING RESPONSE		
RF fields	(1) ≤100 V/m at 0.3 to 35 MHz	15% reference standard conditions	7.1.2.2
	(2) ≤100 V/m at ~140 MHz	15% reference standard conditions	7.1.2.3
	(3) ≤100 V/m at 60 Hz, 400 Hz	15% reference standard conditions	7.1.2.1
Microwave fields	(1) Per user requirements	15% reference standard conditions	7.2.2
	(2) ≤100 W/m^2 at 915 MHz, 2450 MHz	15% reference standard conditions	7.2.2
Electrostatic fields	(1) 5000 V/m	15% reference standard conditions	7.3.2
	(2) Per user requirements	15% reference standard conditions	7.3.2
Magnetic fields	(1) ≤ 800 A/m	15% reference standard conditions	7.4.2
	(2) Per user requirements	15% reference standard conditions	7.4.2
	ENVIRONMENTAL FACTORS		
Temperature	(1) 10–40 °C	15% of reference at 22 °C	8.1.2
	(2) -20–50 °C	20% of reference at 22 °C	8.1.2
Humidity	40% RH to 95% RH (Temperature = 22 ± 2 °C)	15% of reference at 40% RH	8.2.2
Ambient pressure	70–106 kPa	15 of reference at 101 kPa	8.3.2

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale

Characteristics Under Test (Influence Quantity)	Range of Values of Influence Quantities	Limits of Variation	Method of Test (Section)
	AIR CIRCUIT CRITERIA		
Flow or flowrate meter accuracy	Minimum of 3 mean flowrates (e.g., 25%, 50%, and 75% of full scale)	±15% of conventionally true flowrate values	9.1.2
Air in-leakage	—	<10% of nominal flowrate	9.2.2
Flowrate stability	Flowrate at 1 h, 5 h, 10 h, and 100 h	≤5% of nominal flowrate	9.3.2
Filter pressure drop	As stated by manufacturer	10% decrease	9.4.2
Power-supply voltage effect on flowrate	12% below and 10% above reference operating voltage	5% from mean flowrate	9.5.2
Power-supply frequency effect on flowrate	57–61 Hz	10% from mean flowrate	9.6.2
Particle collection	As stated by manufacturer		9.7.2
Gas collection	As stated by manufacturer		9.8.2

Copyright © 1990 IEEE All Rights Reserved

Copyright The Institute of Electrical and Electronics Engineers, Inc.
Provided by IHS under license with IEEE
No reproduction or networking permitted without license from IHS
Not for Resale