

N42.35

American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security

Accredited by the American National Standards Institute

Sponsored by the
National Committee on Radiation Instrumentation, N42



Published by
The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

11 February 2004

Print: SH95206
PDF: SS95206

American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security

Sponsor

National Committee on Radiation Instrumentation, N42

Accredited by the

American National Standards Institute

Secretariat

The Institute of Electrical and Electronics Engineers, Inc.

Approved 9 February 2004

American National Standards Institute

Abstract: This standard describes the performance requirements for portal monitor instruments. The requirements stated are based on instruments used in support of efforts associated with the United States Department of Homeland Security.

Keywords: homeland security, instrument test, portal monitors, radiation detectors

TERMS OF USE

Please Read Carefully

The Institute of Electrical and Electronics Engineers, Inc., (“IEEE”) owns the copyright to this Document in all forms of media. Copyright of the text retrieved, displayed, or output from this Document is owned by IEEE and is protected by the copyright laws of the United States and by international treaties. The IEEE reserves all rights not expressly granted to the user.

Except as allowed by the copyright laws of the United States of America, applicable international treaties, or any license or agreement the user or the user’s employer may have entered into with the IEEE or one of its authorized distributors, the user may not copy and/or distribute copies of this Document, nor significant portions of the document, in any form, nor may the user post this document on any intranet, website, or database without prior written permission from the IEEE.

Permission and/or requests for licenses should be directed to:

Manager, Standards Licensing and Contracts
+1-732-562-3804

or in writing at:

IEEE Standards Association
Manager, Standards Licensing and Contracts
445 Hoes Lane
Piscataway, NJ 08854

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2004 by the Institute of Electrical and Electronic Engineers, Inc.
All rights reserved. Published 11 February 2004. Printed in the United States of America.

Print: ISBN 0-7381-3942-5 SH95206
PDF: ISBN 0-7381-3943-2 SS95206

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

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 reviews 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 affirm, 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.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1-978-750-8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

(This introduction is not part of ANSI N42.35-2004, American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security.)

This standard is the responsibility of the Accredited American Standards Committee on Radiation Instrumentation, N42. The standard was approved on N42 letter ballot of 3 October 2003.

Participants

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

Louis Costrell, *Chair*
Michael P. Unterweger, *Vice Chair*
Sue Vogel, *Administrative Secretary*

<i>Organization Represented</i>	<i>Name of Representative</i>
American Conference of Governmental Industrial Hygienists	Jesse Lieberman
Bartlett Services	Morgan Cox
Canberra	Larry Darken
Chew, M.H.	Jack M. Selby
Commerce Dept, U.S., NIST	Michael P. Unterweger
	Louis Costrell (Alt.)
Consultant	Frank X. Masse
Entergy-ANO	Ron Schwartz
Femo-TECH Inc.	Richard Straub
Gamma-Metrics	Ernesto A. Corte
General Activities Inc.	Karl Reinitz
Health Physics Society	Joseph Stencel
Institute of Electrical & Electronics Engineers, Inc.	Louis Costrell
	Julian Forster (Alt.)
	Anthony Spurgin (Alt.)
	Michael P. Unterweger (Alt.)
Lawrence Berkeley National Laboratory	Edward J. Lampo
Lawrence Livermore National Laboratory	Gary Johnson
NASA, GFSC	H. Sachidananda Babu
Nuclear Standards Unlimited	Al N. Tschaeche
Oak Ridge National Laboratory	Peter J. Chiaro, Jr
	Charles L. Britton (Alt.)
Ortec Corp.	Ronald M. Keyser
Overhoff Technology Corp.	Mario Overhoff
Pacific NW Laboratories	Joseph C. McDonald
Swinth Associates	Kenneth L. Swinth
Tennessee, University of	William M. Bugg
Thermo-electron	Richard P. Oxford
Translucent	G. Laurie Miller
U. S. Army	Edward Groeber
Wisconsin Public Service Group	Tim Martinson
Members-At-Large	Joseph G. Bellian
	Edward Fairstein
	Paul L. Phelps
	Lee J. Wagner

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

Morgan Cox, *Co-Chair*
Jack M. Selby, *Co-Chair*

Dru Carson
Peter J. Chairro, Jr.
Jack Cooley
Leo Faust
Edward Groeber

Jerry Hiatt
Mark M. Hoover
Ron Keyser
Joseph C. McDonald
Robert Murphy
Cheryl Olson

Mario Overhoff
Scott Rogers
Michael P. Unterweger
Ed Walker
Chuan-Fu Wu

At the time this standard was approved, the ANSI 42.35 Working Group had the following members:

Brian Rees, *Chair and Project Leader*

Dan Archer
Stephen Bennett
Jeff Cunningham
Arthur Desrosiers
Paul Fehlau

Al Frymire
Philip Getske
John Gutman
Bill Huckabee

Adam Hutter
Leticia Pibida
Mitchell (Mick) Truitt
Eric Wagner
Ray Warner

Andrew Ickowicz
IEEE Standards Project Editor

Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
1.3 General	1
1.4 Units	2
1.5 Special word usage	2
2. References	2
3. Definitions	3
3.1 General definitions	3
3.2 Definitions of particular relevance to ANSI N42.35-2004	6
4. Test nomenclature	7
5. Design requirements	7
5.1 General characteristics	7
5.2 Configuration	10
5.3 Indication features	10
5.4 Speed control	11
5.5 Moisture protection	11
5.6 Markings	11
5.7 Power supply	11
5.8 Protection of switches	11
5.9 Effective range of measurement	12
5.10 Evaluation of portal monitors	12
6. Test procedures	14
6.1 General test conditions	14
6.2 Radiation characteristics	15
6.3 Background effects	18
6.4 Electrical characteristics	19
6.5 Mechanical characteristics	19
6.6 Environmental characteristics	20
6.7 Electromagnetic compatibility	22
7. Documentation	25
7.1 Type test report	25
7.2 Certification	25
7.3 Operation and maintenance manual	25
Annex A (informative) Bibliography	26
Annex B (informative) Detector tests	29
Annex C (informative) Timing circuit for false alarm test	30
Annex D (informative) Diagram of mounting dimensions for portal detectors	31

American National Standard for Evaluation and Performance of Radiation Detection Portal Monitors for Use in Homeland Security

1. Overview

1.1 Scope

This standard provides the testing and evaluating criteria for Radiation Detection Portal Monitors to detect radioactive materials that could be used for nuclear weapons or radiological dispersal devices (RDDs). Portal monitors may be used in permanent installations, in temporary installations for short-duration detection needs, or as a transportable system. These systems are used to provide monitoring of people, packages, and vehicles to detect illicit radioactive material transportation, or for emergency response to an event that releases radioactive material.

1.2 Purpose

The purpose of this standard is to specify performance criteria and test methods used to evaluate portal monitors for use in homeland security.

1.3 General

1.3.1 Evaluation of monitors

Performance testing is performed under a set of test conditions to determine if a portal monitor meets the requirements of this standard. Special application, which could include the monitor's operation under extreme weather conditions, shall require additional testing.

Evaluation of portal monitors provides information to government agencies and other users on the capability of radiation detection portal monitors for reliably detecting specified amounts of unshielded radioactive material.

1.3.2 Meeting performance specifications

Obtaining operating performance that meets or exceeds the specifications of the evaluation tests rests upon properly installing the monitor at an appropriate location, establishing appropriate operating parameters, providing security for the systems, maintaining monitor calibration, implementing a suitable response testing and maintenance program, auditing compliance with quality requirements, and providing proper training for operating personnel. The evaluation uses essentially unshielded test sources; hence, results are based on detecting the entire gamma-ray and/or neutron spectrum of the sources.

1.4 Units

For the purposes of this standard, the radiological unit rem/h will be assumed to be interchangeable with the unit R/h, and the quantity dose equivalent will be assumed to be interchangeable with the quantity exposure for x-ray and gamma-ray radiation. For neutron radiation measurements, the rem and its submultiples will be used, with 10 μ rem/h being equal to 0.1 μ Sv/h.

Conventional units are given with SI units in parentheses. If uncertainties are not specified they are set to 10%.

NOTE—A ^{137}Cs point source whose x-rays and gamma-rays produce an exposure rate of 10 μ R/h in air would produce a dose equivalent of 0.0878 μ Sv/h (or 8.78 μ rem/h) measured at the location. For sources emitting x-rays and gamma-rays from 10 keV to 2 MeV this conversion factor varies between 0.0876 μ Sv/h to 0.0879 μ Sv/h.

1.5 Special word usage

The following word usage applies:

- The word “shall” signifies a mandatory requirement (where appropriate a qualifying statement is included to indicate that there may be an allowable exception).
- The word “may” signifies an acceptable method or an example of good practice.
- The word “should” signifies a recommended specification or method.

2. References

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

ANSI N42.22-1995 (R2002), American National Standard—Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control.¹

ANSI N42.23-1996, American National Standard Measurement and Associated Instrumentation Quality Assurance for Radioassay Laboratories.

IEC 61000-4, Electromagnetic Compatibility (EMC)—Part 4: Testing and Measurement Techniques. (All Sections.)²

¹ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

²IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

3. Definitions

The following definitions apply for ANSI N42.32-2003 [B11], ANSI N42.33-2003 [B12], ANSI N42.34-2003 [B13], and ANSI N42.35-2004 that have been developed at the request of the Department of Homeland Security (DHS) for instruments to be used by DHS and emergency responders.

3.1 General definitions

3.1.1 A-weighted sound level: The frequency weighting of an acoustic spectrum according to a standardized frequency response curve based on the frequency response of the human ear.

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

3.1.3 accepted ambient photon background: The background radiation as measured using a high pressure ionization chamber, an energy compensated Geiger-Mueller (G-M) tube, an energy compensated proportional counter, a tissue equivalent plastic scintillator, a scintillator with spectral operator, or any other exposure rate meter having a nearly constant energy response ($\pm 30\%$ in the energy range from 200 keV to 1.5 MeV).

3.1.4 accredited testing laboratory: Testing laboratory that has been accredited by an authoritative body with respect to its qualifications to perform verification tests on the type of instruments covered by this standard.

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

3.1.6 adjust: To alter the reading of an instrument by means of a built-in variable (hardware or software) control.

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

3.1.8 calibrate: To adjust and/or determine the response or reading of a device relative to a series of conventionally true values.

3.1.9 calibration: A set of operations under specified conditions that establishes the relationship between values indicated by a measuring instrument or measuring system, and the conventionally true values of the quantity or variable being measured.

3.1.10 check source: A not necessarily calibrated source that is used to confirm the continuing functionality of an instrument.

3.1.11 conventionally true value (CTV): The commonly accepted best estimate of the value of that quantity. This and the associated uncertainty will preferably be determined by a national or transfer standard, or by a reference instrument which has been calibrated against a national or transfer standard, or by a measurement quality assurance (MQA) interaction with the National Institute of Standards and Technology (NIST) or an accredited calibration laboratory. (See ANSI N42.22-1995 and ANSI N42.23-1996.)

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

3.1.13 detection limits: The extremes of detection or quantification for the radiation of interest. The lower detection limit is the minimum statistically quantifiable instrument response or reading. The upper detection limit is the maximum level at which the instrument meets the required accuracy.

3.1.14 detector: A device or component designed to produce a quantifiable response to ionizing radiation normally measured electronically.

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

3.1.16 effective range of measurement: Range of measurements within which the requirements of this standard are met.

3.1.17 energy dependence: Variation in instrument response as a function of radiation energy for a constant radiation type and exposure rate referenced to air.

3.1.18 exposure: The measure of ionization produced in air by x or gamma radiation. The sum of electrical charges of all ions of either sign produced in air when all electrons liberated by photons in a volume element of air are completely stopped in air, divided by the mass of the air in the volume element. The special unit of exposure is the roentgen per hour, abbreviated in this standard as R/h for exposure rate.

NOTE—In this standard, the Standard International (SI) unit Sievert, or Sv, follows in parentheses the Roentgen value R, though the two units are not physically equivalent.

3.1.19 false alarm: Alarm NOT caused by a radioactive source under the specified background conditions.

3.1.20 functional check: A frequently used qualitative check to determine that an instrument is operational and capable of performing its intended function. Such checks may include, for example, battery check, zero setting, or source response check.

3.1.21 indicated value: (A) A scale or decade reading. (B) The displayed value of the readout. *See also:* reading.

3.1.22 indication: Displayed signal from the instrument to the user conveying information such as scale or decade, status, malfunction or other critical information.

3.1.23 influence quantity: Quantity that may have a bearing on the result of a measurement without being the subject of the measurement.

3.1.24 innocent alarm: An alarm resulting from an actual increase in radiation level, but for reasons that are not due to the detection of illicit radioactive materials.

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

3.1.26 instrument-hour: The number of operating instruments multiplied with the amount of time they are operating (e.g. 8 instruments operating for 3.75 hours is equivalent to 30 instrument hours).

3.1.27 interdiction: Stopping the illicit or inadvertent movement of radioactive material that has been discovered as a result of radiation detection or measurement.

3.1.28 monitoring: Means provided to continuously indicate the state or condition of a system or assembly.

NOTE—The real time measurement of radioactivity or radiation level.

3.1.29 overload response: The response of an instrument when exposed to radiation intensities greater than the upper measurement limit.

3.1.30 performance test: An evaluation of the performance of an instrument in response to a given influence quantity.

3.1.31 point of measurement: Place at which the conventionally true values are determined and at which the reference point of the instrument is placed for test purposes.

3.1.32 precision: Degree of agreement of repeated measurements of the same parameter.

3.1.33 range: All values lying between the detection limit and the upper measurement limit.

3.1.34 reading: The indicated or displayed value of the readout.

3.1.35 readout: The portion of the instrument that provides a visual display of the response of the instrument or the displayed value, with units, displayed and/or recorded by the instrument as a result of the instrument's response to some influence quantity.

3.1.36 reference point of an instrument: Physical mark, or marks, on the outside of an instrument used to position it at a point where the conventionally true value of a quantity is to be measured, unless the position is clearly identifiable from the construction of the instrument.

3.1.37 relative error (ϵ_{REL}): The difference between instrument's reading, M , and the conventionally true value, CTV , of the quantity being measured divided by the conventionally true value multiplied by 100%.

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

3.1.38 response: Ratio of the instrument reading to the conventionally true value of the measured quantity.

3.1.39 response time: The time interval required for the instrument reading to change from 10 percent to 90 percent of the final reading or vice versa, following a step change in the radiation field at the detector.

3.1.40 restricted mode: An advanced operating mode that can be accessed by an expert user (e.g.: via password) to control the parameters that can affect the result of a measurement (i.e., radionuclide library, routine function control, calibration parameters, alarm thresholds, etc.). May be called the "advanced" or "expert" mode.

3.1.41 routine test: Test that applies to each independent instrument to ascertain compliance with specified criteria

3.1.42 standard deviation: The positive square root of the variance.

3.1.43 standard instrument or source: (A) National standard—a standard determined by a nationally recognized competent authority to serve as the basis for assigning values to other standards of the quantity concerned. In the U.S., this is an instrument, source, or other system or device maintained and promulgated by the National Institute of Standards and Technology (NIST). (B) Primary standard—a standard that is designated or widely acknowledged as having the highest metrological qualities and whose value is accepted without reference to other standards of the same quantity. (C) Secondary standard—a standard whose value is assigned by comparison with a primary standard of the same quantity. (D) Reference standard—a standard, generally having the highest metrological quality available at a given location or in a given organization, from which measurements made there are derived. (E) Working standard—a standard that is used