

Recognized as an
American National Standard (ANSI)

IEEE Std 309™-1999
N42-3-1999(R2006)
(Revision of IEEE Std 309-1970
ANSI N43-1969)

IEEE Standard Test Procedures and Basis for Geiger-Mueller Counters

Sponsor

Nuclear Instruments and Detectors Committee
of the
IEEE Nuclear and Plasma Sciences Society

Approved 12 May 1999

American National Standards Institute

Reaffirmed 30 March 2006

Approved 18 March 1999

IEEE-SA Standards Board

Abstract: Test procedures for Geiger-Mueller counters that are used for the detection of ionizing radiation are presented so that they have the same meaning to both manufacturers and users. Also included is information on bases (i.e., connections) for the counters.

Keywords: gas counter, Geiger-Mueller, radiation detectors

The Institute of Electrical and Electronics Engineers, Inc.
347 East 47th Street, New York, NY 10017-2394, USA

Copyright © 1999 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 4 June 1999. Printed in the United States of America.

Print: ISBN 0-7381-1656-4 SH94739
PDF: ISBN 0-7381-1657-2 SS94739

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.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

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; (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 IEEE Std 309-1999/ANSI N42.3-1999, IEEE Standard Test Procedures and Bases for Geiger-Mueller Counters.)

This standard is a revision of the 1970 version. It presents standard test procedures for Geiger-Mueller counters that are used for the detection of ionizing radiation. Also included is information on standard and typical bases for the counters. This revision has been approved by the Nuclear Instruments and Detectors Committee (NIDCom) of the IEEE Nuclear and Plasma Sciences Society and by the Accredited Standards Committee N42 on Nuclear Instrumentation of the American National Standards Institute (ANSI) for which the IEEE serves as the Secretariat.

These detectors, originally announced by Geiger and Müller in 1928, represented a major step forward in the detection and counting of individual radioactive events. The amplitude of the output signal is independent of the energy of the event. Therefore, when only the counting of radioactive events is required, without regard for the type of radiation or its energy, Geiger-Mueller counters are useful. The output signal is large enough to operate a scaler without additional amplification, the regulation requirements of the power supply can be far less than that required for the solid state detectors, and, unlike germanium detectors, no cryostat is required.

The principal attributes of the Geiger-Mueller counters are their low cost and simplicity, which accounts for their wide usage in many applications. Ionization chambers and the subsequently developed scintillation counter and semiconductor radiation detectors are capable of distinguishing between different types of radiation and their energies and can therefore be used for spectroscopy as well as for counting. The scintillation and semiconductor detectors, because they are solid rather than a gas, are highly efficient for the detection of gamma rays. The principal attributes of the scintillation counters are high efficiency and moderate energy resolution; whereas, the semiconductor detectors have outstanding energy resolution.

Ionization chambers, scintillation counters, and semiconductor detectors are dealt with in other standards publications.

An excellent description of Geiger-Mueller counters and their operation is provided in Chapter 7 of Glenn F. Knoll's book, Radiation Detection and Measurement. (See Knoll [B4] in Annex A.)

Participants

At the time this standard was completed, the working group of the Nuclear Instruments and Detectors Committee had the following membership:

David J. Allard, *Project leader*
Louis Costrell, *Project leader*
Carl R. Siebentritt, *Project leader*

David Barclay
Joseph G. Bellian
Peter Burgess
Edward Fairstein

M. R. Farukhi
James K. Hesch
Joseph C. McDonald
Donald E. Stilwell

Kenneth L. Swinth
Al N. Tschaeche
Michael Unterweger
Sanford Wagner

At the time this standard was completed, the Nuclear Instruments and Detectors Committee had the following membership:

Donald E. Stilwell, Chair
Michael Unterweger, Vice Chair
Louis Costrell, Secretary

David J. Allard
 Joseph G. Bellian
 William M. Bugg
 Christopher Cox
 Larry Darken
 W. Kenneth Dawson

Edward Fairstein
 Erik H. M. Heijne
 Ronald M. Keyser
 Frederick A. Kirsten
 Glenn F. Knoll
 G. Laurie Miller
 Klaus D. Mueller

Dennis E. Persyk
 Paul L. Phelps
 Carl R. Siebentritt
 Kenneth L. Swinth
 Sanford Wagner
 John Walter

When the IEEE-SA Standards Board approved this standard on 18 March 1999, it had the following membership:

Richard J. Holleman, Chair
Donald N. Heirman, Vice Chair
Judith Gorman, Secretary

Satish K. Aggarwal
 Clyde R. Camp
 James T. Carlo
 Gary R. Engmann
 Harold E. Epstein
 Jay Forster*
 Thomas F. Garrity
 Ruben D. Garzon

James H. Gurney
 Jim D. Isaak
 Lowell G. Johnson
 Robert Kennelly
 E. G. "Al" Kiener
 Joseph L. Koepfinger*
 Stephen R. Lambert
 Jim Logothetis
 Donald C. Loughry

L. Bruce McClung
 Louis-François Pau
 Ronald C. Petersen
 Gerald H. Petersen
 John B. Posey
 Gary S. Robinson
 Hans E. Weinrich
 Donald W. Zipse

*Member Emeritus

Subsequently, the accredited American National Standards Committee N42 on Radiation Instrumentation also reviewed and approved this document. At the time of approval, it had the following membership:

Louis Costrell, Chair
Michael Unterweger, Vice Chair
Sue Vogel, Administrative Secretary

<i>Organization Represented</i>	<i>Name of Representative</i>
American Conference of Governmental Industrial Hygienists.....	Jesse Lieberman
Applied Safety Technology.....	Edward J. Vallario*
Battelle Pacific Northwest Laboratories	Joseph C. McDonald
Bicron.....	Joseph G. Bellian
Chew, M. H.	Jack M. Selby
Eberline Instrument Company	James K. Hesch
EG&G ORTEC	Sanford Wagner
Gamma-Metrics	Ernesto A. Corte
Health Physics Society.....	George Campbell
	Joseph R. Stencel (Alt.)
Institute of Electrical and Electronics Engineers.....	Louis Costrell
	Julian Forster (Alt.)
	Anthony J. Spurgin (Alt.)
Lawrence Berkeley Laboratory.....	Edward J. Lampo
Lawrence Livermore National Laboratory.....	Gary Johnson
Lovelace RR Institute.....	Morgan Cox
Massachusetts Institute of Technology, Bates Linear Accelerator Center	Frank X. Masse

NASA/GSFC, U.S.....	Donald E. Stilwell*
Nuclear Standards Unlimited.....	Al N. Tschaeché
Oak Ridge National Laboratory.....	Charles L. Britton
Swinth Associates	Kenneth L. Swinth
U.S. Army Center for EW/RSDA	Edward Groeber
U.S. Department of Commerce, National Institute of Standards and Technology	Louis Costrell Michael Unterweger (<i>Alt.</i>)
U.S. Department of Energy/PCSRD.....	Natesh Varma
U.S. Federal Emergency Management Agency	Carl R. Siebentritt
Members-at-Large.....	Paul L. Phelps Lee J. Wagner

*Deceased

Catherine K.N. Berger
IEEE Standards Project Editor

Contents

1.	Overview.....	1
1.1	Scope.....	1
1.2	Purpose.....	1
2.	References.....	1
3.	Definitions, symbols, abbreviations, and acronyms	2
3.1	Definitions.....	2
3.2	Symbols, abbreviations, and acronyms.....	5
4.	General.....	5
5.	Test conditions	6
5.1	Radiation background	6
5.2	Ambient temperature	6
5.3	Radiation sources	6
5.4	Photon sources	6
5.5	Alpha- and beta-ray sources.....	7
5.6	Geiger-Mueller counter test circuits	7
6.	Geiger-Mueller counter parameters	9
6.1	Background counting rate	9
6.2	Response to ionizing radiations	9
6.3	Geiger-Mueller threshold.....	10
6.4	Plateau characteristics	10
6.5	Life	10
6.6	Radial sensitivity of end-window counter	11
6.7	Longitudinal sensitivity of cylindrical counter	11
6.8	Temperature dependence	11
6.9	Hysteresis	11
6.10	Photosensitivity	12
7.	Measurements of Geiger-Mueller characteristics	12
7.1	Current mode	12
7.2	Pulse-shape	12
8.	Test equipment.....	14
8.1	Voltmeter	14
8.2	Ammeter	14
8.3	Oscilloscope	14
8.4	Counting system.....	15
8.5	Scaler.....	15
8.6	High-voltage supply	15
8.7	Capacitance bridge.....	15
8.8	Single-channel analyzer	15

9. Specifications of Geiger-Mueller counters	15
9.1 Geiger-Mueller counter construction.....	15
9.2 Standard connections	16
9.3 Anode resistors.....	16
Annex A (informative) Bibliography	17

IEEE Standard Test Procedures and Bases for Geiger-Mueller Counters

1. Overview

1.1 Scope

This standard applies to Geiger-Mueller (G-M) counters that are used for the detection and counting of individual particles.

1.2 Purpose

The purpose of this standard is

- a) To establish test methods and test procedures so that they have the same meaning to both manufacturers and users.
- b) To present additional information regarding G-M counters, such as information about the counters' bases.

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

ANSI N42.12-1994, American National Standard—Calibration and Usage of Thallium-Activated Sodium Iodide Detector Systems for Assay of Radionuclides.¹

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

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

¹ANSI N42 standards are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://www.standards.ieee.org/>).