

Calibration of Electret-Based Integral Radon Monitors Using NIST Polyethylene-Encapsulated $^{226}\text{Ra}/^{222}\text{Rn}$ Emanation (PERE) Standards

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The recently developed ^{222}Rn emanation standards that are based on polyethylene-encapsulated ^{226}Ra solutions were employed for a first field-measurement application test to demonstrate their efficacy in calibrating passive integral radon monitors. The performance of the capsules was evaluated with respect to the calibration needs of electret ionization chambers (E-PERM[®], Rad Elec Inc.). The encapsulated standards emanate well-characterized and known quantities of ^{222}Rn , and were used in two different-sized, relatively-small, accumulation vessels (about 3.6 L and 10 L) which also contained the deployed electret monitors under test. Calculated integral ^{222}Rn activities from the capsules over various accumulation times were compared to the averaged electret responses. Evaluations were made with four encapsulated standards ranging in ^{226}Ra activity from approximately 15 Bq to 540 Bq (with ^{222}Rn emanation fractions of 0.388); over accumulation times from 1 d to 33 d; and with four different types of E-PERM detectors that were independently cali-

brated. The ratio of the electret chamber response E_{int} to the integral ^{222}Rn activity I_{Rn} was constant (within statistical variations) over the variables of the specific capsule used, the accumulation volume, accumulation time, and detector type. The results clearly demonstrated the practicality and suitability of the encapsulated standards for providing a simple and readily-available calibration for those measurement applications. However, the mean ratio $E_{\text{int}}/I_{\text{Rn}}$ was approximately 0.91, suggesting a possible systematic bias in the extant E-PERM calibrations. This 9 % systematic difference was verified by an independent test of the E-PERM calibration based on measurements with the NIST radon-in-water standard generator.

Key words: calibration; electret; emanation; environment; E-PERM[®]; ionization chamber; measurement; radium-226; radon-222; standards.

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1. Introduction

The National Institute of Standards and Technology (NIST) has over the past 3 to 4 years worked on the development of a new emanation standard for ^{222}Rn measurement calibrations as described by Collé et al. [1]. This new standard is based on a polyethylene-encapsulated ^{226}Ra solution that has been demonstrated to emanate a well-characterized and known quantity of ^{222}Rn when employed in an "accumulation mode." The encapsulated standard was intended to serve as a more

convenient, easier-to-use, alternative to the conventionally employed ^{226}Ra solution standards that have been disseminated by NIST for ^{222}Rn emanation measurements for the past 40 or more years [2–4]. The latter standards were, of course, only certified for the ^{226}Ra mass content or at later times (circa mid-1980s) the ^{226}Ra radioactivity content. The new encapsulated standards that are certified in terms of two parameters, both the ^{226}Ra activity and the ^{222}Rn emanation fraction, have,

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Zhe Xu



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Higher Education and Research in the Netherlands, 1968 *Mathematical Reviews*, 1973 *Biographical Dictionary of Mathematicians*, 1991 Vol 1 Neils Abel Ren Descartes Vol 2 Leonard Dickson Al Khwarizmi Vol 3 T homas Kirkman Isaac Newton Vol 4 Jerzy Neyman Niccol Zucchi Chronology Index The Radon Transform Sigurdur Helgason, 1999-08-01 The Radon transform is an important topic in integral geometry which deals with the problem of expressing a function on a manifold in terms of its integrals over certain submanifolds Solutions to such problems have a wide range of applications namely to partial differential equations group representations X ray technology nuclear magnetic resonance scanning and tomography This second edition significantly expanded and updated presents new material taking into account some of the progress made in the field since 1980 Aimed at beginning graduate students this monograph will be useful in the classroom or as a resource for self study Readers will find here an accessible introduction to Radon transform theory an elegant topic in integral geometry *The Universality of the Radon Transform* Leon Ehrenpreis, 2003-10-02 Written by a leading scholar in mathematics this monograph discusses the Radon transform a field that has wide ranging applications to X ray technology partial differential equations nuclear magnetic resonance scanning and tomography In this book Ehrenpreis focuses on recent research and highlights the strong relationship between high level pure mathematics and applications of the Radon transform to areas such as medical imaging The first part of the book discusses parametric and nonparametric Radon transforms Harmonic Functions and Radon transform on Algebraic Varieties nonlinear Radon and Fourier transforms Radon transform on groups and Radon transform as the interrelation of geometry and analysis The later parts discuss the extension of solutions of differential equations Periods of Eisenstein and Poincar and some problems of integral geometry arising in tomography Examples and proofs are provided throughout the book to aid the reader s understanding This is the latest title in the Oxford Mathematical Monographs which includes texts and monographs covering many topics of current research interest in pure and applied mathematics Other titles include Carbone and Semmes A graphic apology for symmetry and implicitness Higson and Roe Analytic K Homology Iwaniec and Martin Geometric Function Theory and Nonlinear Analysis Lyons and Qian System Control and Rough Paths Also new in paperback Johnson and Lapidus The Feynman Integral and Feynman s Operational Calculus Donaldson and Kronheimer The geometry of four manifolds *Radon Integrals* Bernd Anger, C. Portenier, 1992-02-07 In topological measure theory Radon measures are the most important objects In the context of locally compact spaces there are two equivalent canonical definitions As a set function a Radon measure is an inner compact regular Borel measure finite on compact sets As a functional it is simply a positive linear form defined on the vector lattice of continuous real valued functions with compact support During the last few decades in particular because of the developments of modern probability theory and mathematical physics attention has been focussed on measures on general topological spaces which are no longer locally compact e g spaces of continuous functions or Schwartz distributions For a

Radon measure on an arbitrary Hausdorff space essentially three equivalent definitions have been proposed As a set function it was defined by L Schwartz as an inner compact regular Borel measure which is locally bounded G Choquet considered it as a strongly additive right continuous content on the lattice of compact subsets Following P A Meyer N Bourbaki defined a Radon measure as a locally uniformly bounded family of compatible positive linear forms each defined on the vector lattice of continuous functions on some compact subset

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The Radon Transform and Some of Its Applications Stanley R. Deans,2007-10-01 Of value to mathematicians physicists and engineers this excellent introduction to Radon transform covers both theory and applications with a rich array of examples and literature that forms a valuable reference This 1993 edition is a revised and

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 - The Rise of Digital Reading Radon Integral In Tuitionism
 - Advantages of eBooks Over Traditional Books
2. Identifying Radon Integral In Tuitionism
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Radon Integral In Tuitionism
 - User-Friendly Interface
4. Exploring eBook Recommendations from Radon Integral In Tuitionism
 - Personalized Recommendations
 - Radon Integral In Tuitionism User Reviews and Ratings
 - Radon Integral In Tuitionism and Bestseller Lists
5. Accessing Radon Integral In Tuitionism Free and Paid eBooks
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 - Radon Integral In Tuitionism Compatibility with Devices
 - Radon Integral In Tuitionism Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Radon Integral In Tuitionism
 - Highlighting and Note-Taking Radon Integral In Tuitionism
 - Interactive Elements Radon Integral In Tuitionism
- 8. Staying Engaged with Radon Integral In Tuitionism
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Radon Integral In Tuitionism
- 9. Balancing eBooks and Physical Books Radon Integral In Tuitionism
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Radon Integral In Tuitionism
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Radon Integral In Tuitionism
 - Setting Reading Goals Radon Integral In Tuitionism
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Radon Integral In Tuitionism
 - Fact-Checking eBook Content of Radon Integral In Tuitionism
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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