Radon Diffusion Coefficient In Radon Proof Membranes

Laboratory measurements of radon fluxes and radon concentration profiles were conducted to characterize the effectiveness of multilayer cover systems for uranium tailings. The cover systems utilized soil and clay materials from proposed disposal sites for the Vitro, Durango, Shiprock, Grand Junction and Riverton tailings piles. Measured radon fluxes were in reasonable agreement with values predicted by multilayer diffusion theory. Results obtained by using air-filled porosities in the diffusion calculations were similar to those obtained by using total porosities. Measured diffusion coefficients were a better basis for predicting radon fluxes than were correlations of diffusion coefficient with moisture or with air porosity. Radon concentration profiles were also fitted by equations for multilayer diffusion in the air-filled space. Layer-order effects in the multilayer cover systems were examined and estimated to amount to 10 to 20 percent for the systems tested. Quality control measurements in support of the multilayer diffusion tests indicated that moisture absorption was not a significant problem in radon flux sampling with charcoal canisters, but that the geometry of the sampler was critical. The geometric design of flux-can samplers was also shown to be important. Enhanced radon diffusion along the walls of the test columns was examined and was found to be insignificant except when the columns had been physically disturbed. Additional moisture injected into two test columns decreased the radon flux, as expected, but appeared to migrate into surrounding materials or to be lost by evaporation. Control of moisture content and compaction in the test columns appeared to be the critical item affecting the accuracies of the experiments.

In the book Radon, some segments of modern research from a wide range of issues related to radioactive gas radon are presented. The purpose of this book is to emphasize the importance of the existence of the radioactive gas radon in the environment and to make this natural phenomenon a top issue because radon is included in class A human carcinogenesis. The chapters of the book show physical and chemical properties of radon and radon progeny; concentration, emanation, and transport of radon in ambient environments; detection of radon and radon progeny in different environments; passive and active radon measurement techniques; and calibration of a dosimeter for the detection of radon. This book will be of great importance to scientists from a wide range of research area on the phenomenon of radon and will be useful to those who are beginners in this

area as well. Due to the impact of radon gas on health, the content of this book will be interesting to a wider audience.
CLIFFORD K. HOAND STEPHEN W. WEBB Sandia National Laboratories, P. O. Box 5800, Albuquerque, NM 87185, USA Gas and vapor transport in porous media occur in a number of important applications in cludingdryingofindustrialandfoodproducts,oilandgase xploration,environm- tal remediation of contaminated sites, and carbon sequestration. Understanding the fundamental mechanisms and processes of gas and vapor transport in porous media allows models to be used to evaluate and optimize the performance and design of these systems. In this book, gas and vapor are distinguished by their available states at stan- ? dard temperature and pressure (20 C, 101 kPa). If the gas-phase constituent can also exist as a liquid phase at standard temperature and pressure (e. g. , water, ethanol, toluene, trichlorothylene), it is considered a vapor. If the gas-phase constituent is non-condensable at standard temperature and pressure (e. g. , oxygen, carbon di- ide, helium, hydrogen, propane), it is considered a gas. The distinction is important because different processes affect the transport and behavior of gases and vapors in porous media. For example, mechanisms specific to vapors include vapor-pressure lowering and enhanced vapor diffusion, which are caused by the presence of a g- phase constituent interacting

with its liquid phase in an unsaturated porous media. In addition, the “heat-pipe” exploits isothermal latent heat exchange during evaporation and condensation to effectively transfer heat in designed and natural systems.

"Transport Modeling for Environmental Engineers and Scientists, Second Edition, builds on integrated transport courses in chemical engineering curricula, demonstrating the underlying unity of mass and momentum transport processes. It describes how these processes underlie the mechanics common to both pollutant transport and pollution control processes"--Provided by publisher.

Relationships of Radon Diffusion Coefficient with Saturated Hydraulic Conductivity, Fines Content and Moisture Saturation of Radon

Studies of underground miners have provided a wealth of data about the risk of lung cancer from exposure to radon's progeny elements, but the application of the miner data to the home environment is not straightforward. In Comparative Dosimetry of Radon in Mines and Homes, an expert committee uses a new dosimetric model to extrapolate to the home environment the risk relationships found in the miner studies. Important new scaling factors are developed for applying risk estimates based on miner data to men, women, and children in domestic environments. The book includes discussions of radon dosimetry and the uncertainties concerning other risk factors such as age and smoking habits. The book also contains a thorough technical discussion of the characteristics of radioactive aerosols in domestic environments, the dose of inhaled radon progeny to different age groups, identification of respiratory tract cells at the greatest risk of carcinogenesis, and a complete description of the new lung dose model being developed by the International Commission on Radiological Protection as modified by this committee.

This book addresses the basics of interval/fuzzy set theory, artificial neural networks (ANN) and computational methods. It presents step-by-step modeling for application problems along with simulation and numerical solutions. In general, every science and engineering problem is inherently biased by uncertainty, and there is often a need to model, solve and interpret problems in the world of uncertainty. At the same time, exact information about models and parameters of practical applications is usually not known and precise values do not exist. This book discusses uncertainty in both data and models. It consists of seven chapters covering various aspects of fuzzy uncertainty in application problems, such as shallow water wave equations, static structural problems, robotics, radon diffusion in soil, risk of invasive alien species and air quality quantification. These problems are handled by means of advanced computational and fuzzy theory along with machine intelligence when the uncertainties involved are fuzzy. The proposed computational methods offer new fuzzy computing methods that help other areas of knowledge construction where inexact information is present. Disposal Facilities for uranium mill tailings have been constructed as required by the Uranium Mine Tailing Radiation Control Act (UMTRCA) of 1978. Nearly all of these facilities rely on a low-permeability, compacted clay surface cover to control the rate at which contaminants migrate in the gas and water phase from the tailings into the environment. The primary engineered component of the surface cover is typically referred to as the “low permeability Radon barrier, (or Rn Barrier). The Rn Barrier is designed to have low hydraulic conductivity and low gaseous diffusivity to effectivity control the emission of Radon and other contaminants into the environment. Several of the UMTRCA sites are over 20 years of service life. It is well understood that near-surface clay covers can experience significant structure development (e.g., cracking) due to process related to environmental exposure, including seasonal wetting and drying and bio-intrusion from vegetation and animal activity. Over many seasons, there is the potential that the Rn Barrier system may not contain contaminants as well as when the barrier was initially constructed. Studies conducted on

UMTRCA sites have indicated significant variability in Radon Flux (Rn Flux) emanating through the top of the Rn Barrier (e.g., from as little as 0.3 pCi/m2-s to as much as 200 pCi/m2-s) (CNWRA 2012). When UMTRCA was first passed, the intended service life of cover systems was 1,000 years and Rn Flux was stipulated to not exceed 20 pCi/m2-s. This study first seeks to develop and calibrate alternative measurement techniques for accurately and reliably measuring Rn Flux at UMTRCA field sites. The study is motivated partly to address limitations in current regulatory measurement techniques, where Radon surface flux is measured using Activated Carbon (AC) placed directly on the cover surface and Radon is measured by passive sorption. Advances in Radon measurement technologies have led to the development of continuous, electronic Radon monitors. These monitors are capable of measuring Radon concentration at user-specified intervals and thus can be used to measure the buildup of Radon inside a closed sampling chamber placed on the cover system over time. Continuous data afforded by this approach provides significant advantages for measuring Rn flux over the historical AC measurement approach. The calibration effort of this study employed an electronic RAD7 Radon detection system (Durridge Company Inc.) to measure Rn flux emanating from two Radon sources in the laboratory (granite aggregate and a poured concrete slab).

Results were used to develop an experimental protocol for field measurements and to identify and characterize variables that affect the measurements. AC canisters were placed into chambers containing the Radon sources in tandem with the electronic radon monitors so that radon concentrations measured using the two approaches could be directly compared. The AC to RAD7 Rn Concentration ratio averaged 0.58 (+/- 0.07) for five tests under the same conditions. A second suite of experiments was conducted to examine the effects of process variables on the measurements, including relative humidity, chamber size, exposure duration, and Rn flux. Similar differences in the two techniques were observed. The lab analysis properly corrected varying levels of exposure to RH before Rn exposure to the same Rn concentration (198.5 +/- 23.8 Bq/m3), but that concentration consistently averaged 0.60 (+/- 0.07) in the AC to RAD7 Rn Concentration Ratio. Varying chamber size, Rn flux, and exposure time all failed to produce statistically significant trends with R2 = 0.73, 0.42, and 0.28 respectively. Field measurements were conducted at a uranium mill tailings disposal cell located in Falls City, Texas. Continuous (RAD7) and passive (AC canisters) Radon detectors were deployed at six test pits that were excavated to expose the Rn barrier at the site and to measure radon flux at locations representative of different site conditions. Test pit locations were selected to compare varying vegetation conditions, Rn barrier thicknesses, and underlying tailings activities. Rn flux measured at the top of the barrier within the six test pits ranged from 0.06 - 24.74 pCi/m2-s. Radon flux measurements were also conducted directly on top of the tailings layer, which was exposed by excavating through the Rn Barrier. Radon flux from the tailings layer was measured as high as 1148.07 pCi/m2-s. Results from this suite of measurements were used to assess performance of the alternative Radon measurement approaches in a typical field application. The AC to RAD7 Rn concentration ratio was consistent with the laboratory measurements, averaging 0.59 with a variance of 0.07. Corresponding ratio of Rn flux between the two devices was 0.60-0.93 depending on the size of the chamber and length of the test. Finally, a laboratory procedure was developed to simulate desiccation and structure development inside compacted clay samples and the associated effects on gaseous Radon diffusion coefficient. Experiments were conducted in a modified flexible wall permeameters to measure Radon diffusion coefficients through several wetting and drying cycles. Results were used to understand how structure develops in different types of clays that may be considered representative of compacted cover materials and to quantify the associated effects on Radon diffusivity. Measured

Rn diffusion coefficients across all clays ranged from a maximum of 3.98e-7 m2/s to a minimum of 1.24e-09 m2/s. These values fall within the expected diffusion coefficients boundaries of air (1e-5 m2/s) and water (1e-9 m2/s).

The release of 222Radon to the atmosphere is controlled by the rate of its gas transport through earthen materials. Of the many soil-related parameters, radon diffusion coefficient is the key parameter that characterizes this transport. We compared the radon diffusion coefficients measured at the laboratories for the UMTRA Project with simple empirical correlations developed by others. The empirical correlations predict the radon diffusion coefficient based on the fraction of moisture saturation and porosity. One of the more recent correlations agrees reasonably well with the measurements. In addition, by using a series of correlation curves, we studied the empirical relationships of the. radon diffusion coefficient with the saturated hydraulic conductivity, the fines content, and the moisture saturation in soil. The results reveal that a reliable determination of the long-term moisture and porosity is essential in the design of an adequate radon barrier with respect to the radon diffusion coefficient.

The Safe Drinking Water Act directs the U.S. Environmental Protection Agency (EPA) to regulate the quality of drinking water, including its concentration of radon, an acknowledged carcinogen. This book presents a valuable synthesis of information about the total inhalation and ingestion risks posed by radon in public drinking water, including comprehensive reviews of data on the transfer of radon from water to indoor air and on outdoor levels of radon in the United States. It also presents a new analysis of a biokinetic model developed to determine the risks posed by ingestion of radon and reviews inhalation risks and the carcinogenesis process. The volume includes scenarios for quantifying the reduction in health risk that might be achieved by a program to reduce public exposure to radon. Risk Assessment of Radon in Drinking Water, reflecting research and analysis mandated by 1996 amendments to the Safe Drinking Water Act, provides comment on a variety of methods to reduce radon entry into homes and to reduce the concentrations of radon in indoor air and in water. The models, analysis, and reviews of literature contained in this book are intended to provide information that EPA will need to set a new maximum contaminant level, as it is required to do in 2000.

This volume gathers the proceedings of the 3rd International RILEM Workshop on Concrete Durability and Service Life Planning (ConcreteLife’20), held in Haifa, Israel in January 2020. The papers cover a range of topics in concrete curing, cracking in concrete structures, corrosion of steel in concrete, thermal and hygral effects, concrete in cold climates and under high temperatures, recycling, alkali-silica reactions, chloride and sulfate attacks, marine structures, transport phenomena, durability design, microstructure of concrete and volume changes, and life cycle assessment. The book also explores future trends in research, development, and practical engineering applications related to durable concrete construction, and focuses on the design and construction of concrete structures exposed to various environmental conditions and mechanical loading. Given its scope, it offers a valuable asset for all researchers and graduate students in the areas of cement chemistry, cement production, and concrete design.

From long-standing worries regarding the use of lead and asbestos to recent research into carcinogenic issues related to the use of plastics in construction, there is growing concern regarding the potential toxic effects of building materials on health. Toxicity of building materials provides an essential guide to this important problem and its solutions. Beginning with an overview of the material types and potential health hazards presented by building materials, the book goes on to consider key plastic materials. Materials responsible for formaldehyde and volatile organic compound emissions, as well as semi-volatile organic compounds, are then explored in depth, before a review of wood preservatives and mineral fibre-based building materials. Issues related to the use of radioactive materials and materials that release toxic fumes during burning are the focus of subsequent chapters, followed by discussion of the range of heavy metals, materials prone to mould growth, and antimicrobials. Finally, Toxicity of building materials concludes by considering the potential hazards posed by waste based/recycled building materials, and the toxicity of nanoparticles. With its distinguished editors and international team of expert contributors, Toxicity of building materials is an invaluable tool for all civil engineers, materials researchers, scientists and educators working in the field of building materials. Provides an essential guide to the potential toxic effects of building materials on health Comprehensively examines materials responsible for formaldehyde and volatile organic compound emissions, as well as semi-volatile organic compounds Later chapters focus on issues surrounding the use of radioactive materials and materials that release toxic fumes during burning

A new method was developed to measure the effectiveness of water in reducing the release of radon emanating from 226 Ra-bearing sand into air. Fick's law on diffusion was used to model the transport of radon in water including the impact associated with radioactive decay. A multi-region, one-dimensional, steady-state transport model was used to analyze the movement of radon through a sequential column of air, water and air. An effective diffusion coefficient was determined by varying the thickness of the water column to predict the transport of 222Rn through particular thickness of water. A one-region, one-dimensional transient diffusion equation was developed to investigate the build up of radon at the end of the water column until a steady-state, equilibrium condition was achieved. This build up with time is characteristic of the transport rate of radon in water and established the basis for estimating the effective diffusion coefficient for 222Rn in water. The results suggest that convective forces other than molecular diffusion impact the transport of 222Rn through the water barrier. An effective diffusion coefficient is defined that includes effects of molecular diffusion and convection to describe the transport of radon in water. Several experimental arrangements were evaluated to examine the influence of physical parameters on the radon transport. The effective diffusion coefficients measured in these experiments are 6.8x10?4 +- 28% and 3.5x10?4 +- 34% cm 2 sec?1 for the steady-state and transient diffusion approaches, respectively. Water barriers ranging in thickness from 30 - 50 cm reduce the amount of radon released from the radium-bearing source

material by a factor of 0.3 - 0.1, respectively.
This handbook focuses on residential radon exposure from a public health point of view and provides detailed recommendations on reducing health risks from radon and sound policy options for preventing and mitigating radon exposure. The material in the handbook reflects the epidemiological evidence that indoor radon exposure is responsible for a substantial number of lung cancers in the general population. Information is provided on the selection of devices to measure radon levels and on procedures for the reliable measurement of these levels. Discussed also are control options for radon in new dwellings, radon reduction in existing dwellings as well as assessment of the costs and benefits of different radon prevention and remedial actions. Also covered are radon risk communication strategies and organization of national radon programs.--Publisher's description.
In recent years, the perception of indoor radon as a relatively minor health issue has been radically altered: observations in Sweden, Canada, and the U.S. have revealed the high incidence of elevated radon levels in ordinary houses and the extreme hazard of inhaling radon decay products. These findings have lead to a wide range of activities and intensive research aimed at limiting human exposure to radon. This is one of the few books to provide a comprehensive, insightful analysis of the radon

problem. Papers reflecting the most current research critically review all major aspects of this issue, each providing sufficient detail to be accessible to those who are technically trained but lack prior direct experience. Coverage includes the generation and migration of radon in source material, the physical and chemical behavior of radon, current evidence on the health effects and risk of exposure, and the strategic and tactical aspects of controlling exposures.

Ionizing radiation can be found everywhere; in the Earth, inside buildings, in space, in the food we eat, and even inside our bodies. It is of much importance to know more about radiation and how it can improve human life, including how to make use of it and how to avoid its harm. This book covers several topics on ionizing radiation to enrich our knowledge about its applications and effects.

Diffusion coefficients for radon gas in earthen materials are required to design suitable radon-barrier covers for uranium tailings impoundments and other materials that emit radon gas. Many early measurements of radon diffusion coefficients relied on the differences in steady-state radon fluxes measured from radon source before and after installation of a cover layer of the material being tested. More recent measurements have utilized the small-sample transient (SST) technique for greater control on moistures and densities of the test soils, greater measurement precision, and reduced testing time and costs. Several of the project sites for the US

Department of Energy's Uranium Mill Tailings Remedial Action (UMTRA) Program contain radiologically contaminated subsurface material composed predominantly of cobbles, gravels andsands. Since remedial action designs require radon diffusion coefficients for the source materials as well as the cover materials, these cobbly and gravelly materials also must be tested. This report contains the following information: a description of the test materials used and the methods developed to conduct the SST radon diffusion measurements on cobbly soils; the protocol for conducting radon diffusion tests oncobbly soils; the results of measurements on the test samples; and modifications to the FITS computer code for analyzing the time-dependent radon diffusion data.

Radon migration in porous, earthen materials is characterized by diffusion in both the air and water components of the system as well as by the interaction of the radon between the air and water. The size distribution and configuration of the pore spaces and their moisture distributions are key parameters in determining the radon diffusion coefficient for the bulk material. A mathematical model is developed and presented for calculating radon diffusion coefficients solely from the moisture content and pore size distribution of a soil, reducing the need for resorting to radon diffusion measurements. The resulting diffusion coefficients increase with the median pore diameter of the soil and decrease with increasing widths of the pore size distribution. The calculated diffusion coefficients are suitable for use in simple homogeneous-medium diffusion expressions for predicting radon transport and compare well with measured diffusion coefficients and with empirical diffusion coefficient correlations.

A method was developed and used to determine radon diffusion coefficients in compacted soils by transient-diffusion measurements. A relative standard deviation of 12% was observed in repeated measurements with a dry soil by the transient-diffusion method, and a 40% uncertainty was determined for moistures exceeding 50% of saturation. Excellent agreement was also obtained between values of the diffusion coefficient for radon in air, as measured by the transient-diffusion method, and those in the published literature. Good agreement was also obtained with diffusion coefficients measured by a steady-state method on the same soils. The agreement was best at low moistures, averaging less than ten percent difference, but differences of up to a factor of two were observed at high moistures. The comparison of the transient-diffusion and steady-state methods at low moistures provides an excellent verification of the theoretical validity and technical accuracy of these approaches, which are based on completely independent experimental conditions, measurement methods and mathematical interpretations.

Naturally Occurring Radioactive Materials in Construction (COST Action NORM4Building) discusses the depletion of energy resources and raw materials and its huge impact not only on the building market, but also in the development of new synthetic building materials, whereby the reuse of various (waste) residue streams becomes a necessity. It is based on the outcome of

COST Action TU 1301, where scientists, regulators, and representatives from industry have come together to present new findings, sharing knowledge, experiences, and technologies to stimulate research on the reuse of residues containing enhanced concentrates of natural radionuclides (NORM) in tailor-made building materials. Chapters address legislative issues, measurement, and assessment of building materials, physical and chemical aspects, from raw materials, to residues with enhanced concentrations of natural radionuclides (NORM), processes, building products containing NORM, and end-of-life and reuse requirements. Presents a holistic approach in developing new reuse pathways involving experts on different (technical, chemical, physical, ecological, economical and radiological) aspects of materials Provides practical guidance that address questions and comments regarding the EU-BSS standards linked to the processing of NORM in building materials Investigates realistic legislative scenarios Primarily aimed at industry and actors linked to the industry, but also researchers Contains a strong international network of expert authors and internal reviewers for each chapter

Envirocare of Utah, Inc. operates a Low Level Radioactive Waste (LLRW) and 11e. disposal facility in the Utah west dessert. Envirocare disposes of LLRW in above ground cells. A seven-foot excavation lined with two feet of clay comprises the cell floor. Approximately 22 feet of waste is then placed in the cell in one-foot thick compacted lifts. The cover system consists of a nine-foot clay radon barrier and three-foot rock erosion barrier. This is required to prevent radon emissions at the surface of the radon barrier from exceeding 20 pCi/m2s, the radon release standard in Criterion 6 of 10 CFR 40. The required thickness of the current clay radon barrier cover was based on the original radon flux model used to evaluate the safety of Envirocare's proposed LLRW and 11e.(2) license operations. Because of the lack of actual measurements, universally conservative values were used for the long-term moisture content and the radon diffusion coefficients of the waste and radon barrier material. Since receiving its license, Envirocare has collected a number of samples from the radon barrier and waste material to determine their actual radon attenuation characteristics, including the long-term moisture content and the associated radon diffusion coefficient. In addition, radon flux measurements have been performed to compare the model calculations with the calculated results. The results from these analyses indicate that the initial modeling input parameters, specifically the long-term moisture content and the radon diffusion coefficient, are more conservative than that needed to ensure compliance with the applicable regulatory requirements.