

Improving indoor air quality by reducing radon and vapor intrusion through the use of ethylene vinyl alcohol (EVOH)

Armstrong, R.

Kuraray America, Inc. EVAL Business Unit, Pasadena Texas, USA

Keywords: indoor air quality, radon diffusion, ethylene vinyl alcohol, EVOH, coextrusion, diffusion resistance, volatile organic compound transport.

ABSTRACT

Ethylene Vinyl Alcohol copolymer (EVOH) is a random copolymer of ethylene and vinyl alcohol, commonly used as a barrier to hydrocarbons in automotive fuel systems and agricultural pesticide and herbicide solvents. EVOH provides extremely high resistance to the migration of gases and volatile organic compounds (VOC's). Recent tests of the radon diffusion coefficient of EVOH are compared to previously published results, which show EVOH has radon barrier properties several orders of magnitude better than polyethylene such as LLDPE or HDPE. For radon resistant new construction (RRNC) the use of EVOH in a composite with commonly used materials such as HDPE, LLDPE or TPO would dramatically reduce the diffusion of radon and VOC's through plastic sheeting or vapor retarders. Potential applications for a high barrier vapor retarder (HBVR) include radon and vapor barriers and in brown field remediation. The incorporation of EVOH in radon resistant new construction has the potential to dramatically reduce the diffusion of radon and other harmful vapors into building spaces and significantly improve indoor air quality.



RADON'S EMISSION IN ORNAMENTAL ROCKS

(Poster Session Presentation)

Gavioli, Y. S.¹, Correia, J. C. G.¹, Caranassios, A.¹, Ribeiro, R. C. C.¹

¹Centro de Tecnologia Mineral -CETEM-RJ Rio de Janeiro - RJ. CEP 21941-509.

ABSTRACT

The representative organizations of the companies from the sector of ornamental rocks had recently consulted the Commission of Nuclear Energy through CETEM-ES to request aid concerning the assessment of levels of radiation in Brazilian ornamental rocks, exported to the U.S.A. Such improper expositions would be supposedly being caused for the exhalation of Radon proceeding from "exotic" granites that they would be increasing the risk of lung cancer. Based on this, the objective of this work was to evaluate the risk associated with the exhalation of radon in *indoor* environments that may be causing improper expositions of the public, through nuclear techniques and calculation of dose consecrated internationally. For they had been in such a way carried through the radiometric and mineralogical characterization of different types of silicates rocks used for covering, determining the taxes of exhalation and concentration of activity of the radon in the chosen materials.

KEY-WORDS: Ornamental rocks, Radioactive Emissions, Radon.

The Minnesota State Radon Program
Program Effectiveness as Related to the Implementation of a Regulatory
Policy: A White Paper

Andrew Gilbert
Minnesota Department of Health Indoor Air Unit

ABSTRACT

In June of 2008, the Office of the Inspector General (OIG) released a report criticizing the actions of the Environmental Protection Agency (EPA) radon program as insufficient, citing the fact that the rate at which homes are being built is outpacing the number of radon mitigations done nationwide. This paper builds upon the OIG's report in two ways. First, it focuses the view of the OIG's report onto one state program- Minnesota. It looks at the capabilities of the Minnesota program, how effective it is at reducing radon risk, and the implications of enacting a regulatory policy; including associated costs and benefits. The second is that it begins to outline a system of program effectiveness measurement based upon proven risk reduction. Additionally, the research provides the foundation for evaluating whether or not Minnesota should establish a regulatory policy of its own to more effectively reduce risks associated with radon exposure.

Could a lung cancer death be the legal responsibility
of the radon tester or mitigator?

Grammer, David
R.A. Data

ABSTRACT

In operating a radon business, we are taught from the beginning about the health and safety risk issues for the technicians in the field. As the industry has reached an age of 20 plus years, it's time to understand that the risk is greater than we ever expected. It's easy to calculate and protect ourselves on a day to day basis against the health risk associated to the inhalation of radon. But the risk to the life of the radon business goes far beyond that. If you take a minute and Google radon litigation you very well may find your typical ambulance chasing attorneys are looking for clients with complaints against radon testers and mitigators. In an effort to help you learn how to defend a business against the ills of the legal industry, this presentation will bring to you firsthand results and an explanation of how to be better prepared if the sheriff shows up at the door serving papers for a lawsuit.

DESIGNING EFFICIENT SUB SLAB VENTING AND VAPOR BARRIER SYSTEMS FOR SCHOOLS AND LARGE BUILDINGS

Thomas E, Hatton

Clean Vapor, LLC, 32 Lambert Road, P.O. Box 688 Blairstown, New Jersey 07825
thatton@cleanvapor.com www.cleanvapor.com

ABSTRACT

The author discusses the basic components of designing efficient sub slab radon venting and vapor barrier systems for schools and large buildings. There are two new construction case study schools. One school is located in Georgia and the other in New Jersey. Both have active radon venting plans as supplied by the architect. Both architect designs require considerable review and plan amendments. The school in New Jersey has a conventional under slab pipe collection system, multiple riser pipes and a standard polyethylene vapor barrier. The school in Georgia has an efficient under slab plenum box collection system, a single riser pipe and a Liquid Boot vapor barrier system. The paper compares sub slab vacuum field extension, the leakage associated with both vapor barrier systems, electrical consumption, as well as heat and cooling efficiencies. An energy consumption cost analysis demonstrates support for efficient designs and long term sustainability.

The Distribution of Indoor Radon Concentrations

Willard E. Hobbs, Jr.
Radon Reduction & Research
Santa Barbara, CA 93105

ABSTRACT

One of the least understood qualities of radon and its associated risk is the distribution of its concentration in the indoor environment. In this presentation I will clarify several of the important factors and provide a simple model for discussing and communicating the primary source of ionizing radiation radon. A few of these are as follows: (1) Radium, like most other minerals in the earth's crust¹, has an overall log-normal distribution in concentration; (2) The factors which affect the concentration of uranium in soils do so in a multiplicative fashion; (3) The measured levels of indoor radon concentrations follow a log-normal distribution which is characterized by a skewed distribution with a long tail to hazardous levels; (4) A fundamental comparison property for such a distribution is the geometric ratio of levels and not the arithmetic difference; and (5) The response of the soil gases to the building stock and ventilation parameters thereof provide an additional factor of approximately 2. These facts provide critical information for developing health strategies for states, communities and individual homeowners.

¹Wedepohl, K.H. (ed.) (1969) *Handbook of Geochemistry*, Berlin, New York, Springer-Verlag.

**SHOULD RADON MITIGATION SYSTEM INSTALLATIONS BE
PERMITTED?**

(Poster Session Presentation)

Jack Hughes

ABSTRACT

The intent of this poster session is to raise the issue of permitting radon mitigation system installations, and to explore the consequences of such permitting in terms of their impact on the public and the radon mitigation industry. Various potential consequences of permitting will be presented. Attendees will be asked to complete a questionnaire in which they will be asked to list other potential consequences of permitting, to provide their assessment of the impacts of permitting on affected parties, and to state their opinion as to the advisability of having mitigation system installation included in the realm of permitted activities. Information obtained on the questionnaires will be provided to AARST.



**Increasing radon testing and mitigation: A test
your home and win contest**

Kercsmar, Mason, Westneat, Rayens, Robertson, Hahn

ABSTRACT

The purpose was to evaluate a population-based contest to increase home radon testing and mitigation, promoting healthy homes and reducing lung cancer risk. Participants received a free test kit. Homeowners with the five highest radon levels won a free mitigation. Nearly 300 residents expressed interest; 193 were eligible with 68% returned readable kits. Of 131 readable test kits, 57% had radon levels at or above the 4.0 pCi/L EPA action level. Those with high radon were invited to participate in a follow-up. Of the half who participated, all were non-smokers; 36% had mitigated; 72% reported increased knowledge about radon and motivation to remediate; and 21% had a family member with lung cancer.

Those with a smoker in the home had significantly lower levels of radon in their homes than those without. A follow-up is underway to assess reliability and validity of the measurement device in homes with smokers.

**EXPERIMENTAL DETERMINATION OF THE EFFECTIVENESS OF RADON
BARRIERS**

Michael E. Kitto^{1,2} and Edward A. Perazzo³

¹Wadsworth Center, New York State Department of Health, P.O. Box 509, Albany, NY 12201

²School of Public Health, State University of New York, Rensselaer, NY 12144

³Siena College, Loudonville, NY 12211

ABSTRACT

Several types of membrane materials (radon retarders) are available for placement under concrete slabs as barriers to the upward movement of soil gas into buildings. Selection of barrier material is seldom based on its resistance to air permeation, as such information is not readily available. For the current study, the permeability of several membrane materials, which may be used as radon barriers, were tested in the laboratory using three methods. All membrane materials were found to significantly reduce radon permeation, but the efficacy of resistance varied considerably amongst the membranes.

The 5 Ws of a Radon Website

(Poster Session Presentation)

Michael E. Kitto^{1,2} and Edward A. Perazzo³

¹Wadsworth Center, New York State Department of Health, P.O. Box 509, Albany, NY 12201

²School of Public Health, State University of New York, Rensselaer, NY 12144

³Siena College, Loudonville, NY 12211

ABSTRACT

Many private, commercial, and government entities maintain web sites regarding environmental radon, but few monitor the traffic or visitors to the site. Several commercial softwares exist that allow monitoring of visitors to an Internet site. These software programs provide information regarding 1) Who (countries) visited the site, 2) What (pages) was viewed, 3) When (hourly, daily, and monthly) the website was visited, 4) Where (external link) the viewer found the website, and 5) Why (keywords) the visitors' interest in the site. As an example of the information that is available, a summary regarding visitors to the *www.nyradon.org* website for the past year is discussed.

Examination of Ohio Indoor Radon Data

Ashok Kumar, Akhil Kadiyala, Vijay Devabhaktuni, Arjun Akkala
The University of Toledo, 2801 W. Bancroft Street, Toledo, OH 43606

ABSTRACT

It is estimated that 700 to 1300 people die annually in Ohio from radon-induced lung cancer. The Ohio Radon Information System (ORIS) available online at <http://www.radon.utoledo.edu> has been developed to create the much-needed awareness among Ohio's citizens on radon concentrations in their localities and the problems associated with radon exposure. Over the years, the database has been expanded to 145,996 radon observations for home; 1,341 radon observations for school; 1,281 radon observations for drinking water; 28,062 radon observations for mitigation database, and 68,495 radon observations for tester database - made available by testing laboratories, ODH, Ohio EPA, and universities. This paper presents various statistics of the analyses performed on the radon databases developed in the last 22 years.

Radon concentration data is not available for each and every zip code, owing to several reasons including inaccessibility. In places where data is unavailable, radon data may be estimated based on existing data by applying effective interpolation techniques, for being able to render radon mitigation planning comprehensive. This paper presents application of several techniques including Kriging, Radial Basis Functions (RBFs), and Artificial Neural Networks (ANNs) for estimating radon concentration values in missing zip codes. Initial results concerning the relative performance of such techniques are shown and the impact of the interpolated data on radon awareness in Ohio is discussed.

**SHOULD ONLY ACTIVE RADON RESISTANT NEW CONSTRUCTION
BE REQUIRED IN ALL ZONE ONE COUNTIES?**

James L. McNees, CHP
Office of Radiation Control
Alabama Department of Public Health
Montgomery, Alabama

ABSTRACT

Some individuals within standards development groups involved with radon are discussing a possible revision of the existing Radon Resistant New Construction (RRNC) standards into a consensus national standard that would advocate the requirement that all new RRNC installations in Zone One counties be active radon systems which include a radon fan. This paper investigates the potential for needless installations of radon fans and associated energy waste that such a requirement might cause

Many publications have documented that at radiation levels near natural background, the *Linear No Threshold Theory* of radiation risk is at best a weak theory. Some publications, including some directly related to radon exposure, have demonstrated no detectable risk to occupants of residences with radon concentrations in the range of the WHO reference level of 2.7 pCi/l. Certainly occupants of homes with radon concentrations at or below half of the WHO reference are not subject to sufficient risk to justify an active radon removal system.

The author uses existing publications on the operational cost of an active system to investigate the wasted energy that would result in over half of the new homes constructed in Alabama's Zone One counties should the installation of active RRNC ever become required. This, plus the unnecessary expense of unneeded radon fans, leads to the conclusion that for the State of Alabama any RRNC standard should require both a passive system capable of being made active and an initial occupancy radon test to determine if a radon fan is needed. Requiring active-only RRNC would be an excessive waste of money and energy.

Air Pipescape’ program, an aid to optimize radon mitigations

Leo Moorman, Ph.D.

ABSTRACT

An Air Pipescape numerical program calculating pressure-flow combinations simultaneously for entire, multi-branch radon mitigation systems will be demonstrated and compared with measurements on installed systems. Low and high flow, multi-branch systems and a difficult to mitigate house will be discussed. All implemented designs successfully reduced radon concentrations. Sub-slab, air exchange rates are linked to final radon concentrations and air velocities and Reynolds number values to sound. Significant improvements in energy losses were accomplished. The effect on relative flow due to the friction of adding a significant number of elbows in passive and active mitigation systems is calculated. In a real-time, interactive demonstration the audience is asked to modify an example mitigation system. The Air Pipescape program has become an aid in optimization of the design of radon mitigation systems by delivering a minimum criterion, yet lowering the need to oversize pipe diameter and ventilator power.

**Design and Performance of an Aerated Floor System
for Radon Mitigation Projects**

Bill Morris and David Folkes, EnviroGroup Limited



ABSTRACT

Several aerated floor systems were incorporated into the design of newly constructed buildings, including a home in the Southwest and a community center in the Rocky Mountain region, to provide an under-slab void network that could be vented for Radon / vapor intrusion control. Compared to a conventional slab on grade and granular venting layer design, the aerated floor system was selected to allow more efficient movement of ventilation air, increasing the potential for passive air flows to adequately dilute sub-slab gas concentrations and protect indoor air. Passive mitigation avoids the electrical and operation and maintenance costs associated with electric fans, resulting in a more sustainable and “green” remediation system. Air flow and pressure measurements were taken to determine how well the aerated flooring system performed under normal and wind pressure gradients, induced gradients using whirlybird fans, solar powered fans and using traditional radon blowers. Based on the data collected, wind-driven gradients provide sufficient ventilation to dilute moderate sub-slab concentrations to predictable and acceptable levels with a reasonable number of riser pipes. The addition of a radon fan allowed depressurization of the under-slab void network and conversion to a mitigation system that could address higher concentration conditions.

Nation-wide ^{222}Rn and ^{220}Rn atlas for India

T.V.Ramachandan¹, L.A.Sathish^{2*} and S.Sundareshan³

¹Ex-Environmental Assessment Division, Bhabha Atomic Research Center, Mumbai- 450 085, India

²Department of Physics, Government Science College, Bangalore – 560 001, India

³Department of Physics, Vijaya College, Bangalore – 560 004, India

ABSTRACT

Considering the epidemiological effect of radon on human beings, an attempt is made to make a nation-wide atlas of ^{222}Rn and ^{220}Rn for India. About 5000 measurements have been carried out in 1500 dwellings across the country. The solid state nuclear track detectors were deployed for the measurement of indoor ^{222}Rn , ^{220}Rn and their progeny levels. The mean annual inhalation dose rate due to ^{222}Rn , ^{220}Rn and their progeny in the dwellings is found to be 0.97 mSv y^{-1} (GSD 2.49). It is observed that the major contribution to the indoor inhalation dose is due to ^{222}Rn and its progeny. However, the contribution due to ^{220}Rn and its progeny is not trivial as it is about 20% of the total indoor inhalation dose rates. The dependence of indoor radon levels in dwellings has shown a significant difference between the nature of walls and floorings. The results are discussed in detail.

Key words: ^{222}Rn , ^{220}Rn , inhalation, radiation doses.



The spatial and volumetric variations of radon in Bangalore city, India

(Poster Session Presentation)

LA Sathish^{1*}, K Nagaraja², HC Ramanna¹, V Nagesh¹, S Sundareshan³ and TV Ramachandran⁴

¹Department of Physics, Government Science College, Bangalore – 560 001, India

²Department of Physics, Bangalore University, Bangalore – 560 056, India

³Department of Physics, Vijaya College, Bangalore – 560 004, India

⁴Ex-Environmental Assessment Division, Bhabha Atomic Research Center, Mumbai- 450 085, India

ABSTRACT

Radon levels have been measured in houses at ten different locations and rooms of various sizes ranging from 30 to 310 m^3 for Bangalore city, India. The study was focused on the basis of quality of construction, age of building, similar nature of walls and types of floorings etc. Solid state nuclear track detectors were used for measuring the concentrations. The average spatial values of ^{222}Rn and ^{220}Rn concentrations were found to be 33.4 ± 6.1 and $21.6 \pm 2.5 \text{ Bq m}^{-3}$ respectively. However, the volumetric concentrations were ranged between 4.0 - 93.0 Bq m^{-3} . The annual dose rate due to ^{222}Rn , ^{220}Rn and their progenies for the population in the studied location ranged from 0.1 to 0.5 mSv . It is alarming that the dwellers of lower volume receive relatively a higher dose rate and the result shows significant radiological risk. The magnitude and its effects of doses are discussed in detail.

Key words: Radon, dwellings, volume, dose rates

Pre-assembled Do-It-Yourself Mitigation Kits
(Poster Session Presentation)

Thomas E. Shaeffer, Radon Solutions

ABSTRACT

This paper describes a radon mitigation system that homeowners can install themselves. The author believes homeowners are reluctant to have mitigation systems installed due to cost, aesthetics, or fear of contractors. Many would want to do-it-themselves, but lack of knowledge and resources are prohibitive. The author believes that by providing pre-assembled systems that are affordable and easy to install, more homes will be mitigated. The author believes that current installation requirements by the EPA make it complex and costly for the consumer. This system addresses 3 variances. By diluting the radon gas with large volumes of exterior air, the mixture can be discharged at ground level, two or more feet from potential backdraft openings. Suction side connects to a special quick-disconnect mounting flange on top of sump cover, allowing for ease of sump maintenance, yet stops air leaks that could cause draft problems of combustion appliances. As in most of Europe, the fan is mounted indoors. While defective gaskets or leaks at electrical junction are rare, this potential risk is addressed by supplying an electronic continuous radon monitor for home use only, alpha-track 3 month and 12 month test kits to run concurrently to cross-check the home detector.

Radon-related lung cancer deaths and mitigation cost effectiveness in a radon prone region

Daniel J. Steck
Physics Department, St. John's University
Collegeville, MN 56321

ABSTRACT

Can a significant number of radon-related lung cancers be averted by mitigating existing high radon houses? Would public health resources be used effectively in a comprehensive radon measurement and mitigation program? Simple questions, complex answers. For example, the risk of lung cancer, which depends on the radon exposure in living spaces, varies spatially, so a countrywide cost effective analysis may reach different conclusions than a regional analysis. A detailed cost-effectiveness analysis has not been done for the US in almost 20 years. During that time, new information has been discovered about indoor radon distributions, residential radon risk, and the cost and effectiveness of installed mitigation systems. An analysis protocol recently developed for WHO concluded that remediating existing homes was not cost-effective in the UK and likely to not be cost effective in most developed countries. An analysis following the WHO protocol is underway for a radon prone region in the US, the upper Midwest. This analysis uses actual radon distribution measurements, radon mitigation effectiveness and costs, plus medical and other costs associated with lung cancer.

**COMPARISON OF TWO DAY CONSECUTIVE RADON
MEASUREMENT RESULTS TO 90 DAY AVERAGE MEASUREMENT
RESULTS, USING THE DATA FROM CONTINUOUS RADON MONITOR
IN A TYPICAL SINGLE FAMILY HOME IN MD, USA**

(Poster Session Presentation)

**Fredrick Stieff and Payasada (Paul) Kotrappa
Rad Elec Inc. 5714-A Industry Lane
Frederick MD 21703**

ABSTRACT

Two calibrated Radon Scout continuous radon monitors are installed in the basement of a typical single family home in MD, USA, as per the EPA protocol. These units are set to provide three hour average concentrations, in addition to the basement temperature, humidity and barometric pressures. The units are run for three months in closed house conditions. The data is analyzed with an aim to find, if any, correlation of three hourly peaks to outdoor environmental conditions such as rain, snow and wind. Further aim is to determine the how the two day consecutive average radon concentrations compare with the three month average radon concentrations. This work describes the results for the first two quarters of 2010 and will continue for the entire year. This may answer some frequently faced queries by the radon measurement professionals, in the course of their work.

Interaction of radon exposure and smoking among Czech uranium miners

**Ladislav Tomasek
National Radiation Protection Institute
Bartoskova 28, Prague, Czech Republic**

ABSTRACT

Objectives: The aim is to compare lung cancer risks from radon in smoking categories in a Czech study of uranium miners and to evaluate interactions between smoking and radon exposure.

Methods: The study is based on a case-control study nested within a large cohort study (11 000 miners, 1074 lung cancers). The controls in the nested study are individually matched by year of birth and attained age. Smoking data were collected in person or from relatives of deceased subjects. Some smoking data were obtained from medical files. Exposures in uranium mines were based on extensive measurements and personal dosimetry. The analyses are based on conditional logistic regression with linear dependence of the risk on radon exposure adjusted for smoking.

Results: The study resulted in 876 cases of lung cancer with smoking data. The linear dependence of lung cancer relative risk on radon exposure adjusted for smoking was not substantially different from analyses when smoking was ignored and reflected mainly the risk among smokers. However, the excess relative risk per unit exposure among never-smokers (74 cases) was 7 fold higher in comparison to that in smokers.

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Conclusions: The excess relative risk per unit radon exposure among non-smokers was higher in comparison to current smokers, reflecting probably differences in lung morphometry and clearance. The relative risks from combined effects are substantially lower than the risk derived from the multiplicative model, but somewhat higher than those from the additive model.

The work was supported by the Czech Ministry of Health (IGA NS 10596).

