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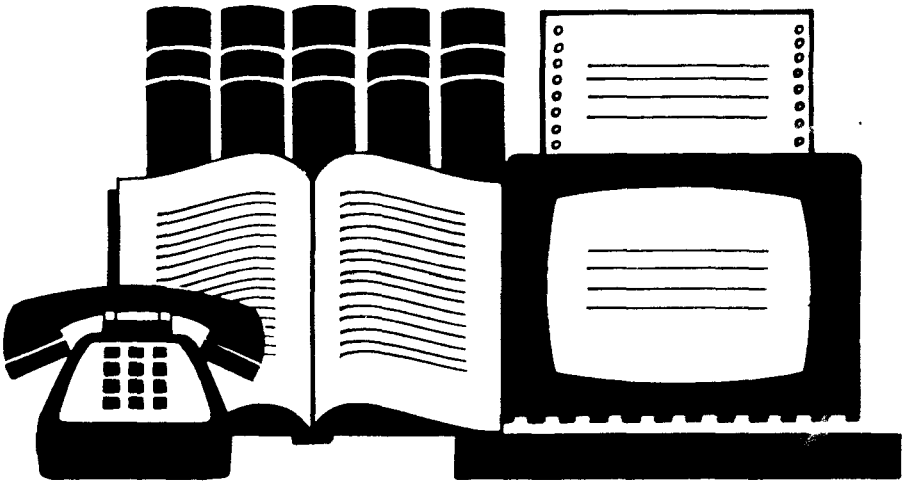
Indoor Radon Pollution



Bibliography on Radon

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U.S. Environmental Protection Agency

INTRODUCTION

Indoor radon pollution is a major topic of concern to many EPA employees, independent researchers, members of other federal, State and local government agencies, and the public.

EPA estimates that one million homes in the U.S. have levels of radon that are higher than recommended guidelines (Time, July 22, 1985, "The colorless, odorless killer"), and that indoor radon exposure may cause as many as 5,000 to 20,000 deaths from lung cancer every year(New York Times, May 24, 1985, "Drive to locate risk areas for radioactive gas urged").

Mary Hoffman, Reference Librarian, compiled this bibliography using pertinent online databases. Citations were selected for their relevance to EPA's radon program. The bibliography focuses on indoor radon pollution problems and is organized according to the following major topic areas: 1) general articles on radon, 2) contributing factors, 3) ventilation and energy efficiency, 4)radon in water, 5) measurement and modeling, 6)mitigation of the problem, and 7) health effects of radon. There is an appendix containing a list of contacts for further information on radon.

There is a great deal more literature available on other aspects of radon (e.g. radon from uranium tailings). An EPA librarian can assist in identifying other titles for further research.

Citations in this bibliography that are preceded by an asterisk (*) are held in the U.S. EPA Headquarters Library. Other citations can be borrowed for EPA employees through interlibrary loan.

A descriptive abstract is included with the citation, when available. The source of the abstract is noted by an alphabetic code enclosed in parentheses at the end of the entry. The databases and codes abbreviations are listed below:

(BIO) Biosis Previews
Biosciences Information Service
2100 Arch Street
Philadelphia, PA 19103

(EMB) Embase
User Education Officer
Elsevier Science Publishers/Excerpta Medica
52 Vanderbilt Avenue
New York, NY 10017

(ENV) Enviroline
Environment Information Center, Inc.
292 Madison Avenue
New York, NY 10017

(ENVB) Environmental Bibliography
Environmental Studies Institute
2074 Alameda Padre Serra
Santa Barbara, CA 93103

(GEO) Georef
American Geological Institute
One Skyline Place
5205 Leesburg Pike
Falls Church, VA 22041

(MED) Medline
Medlars Management Section
National Library of Medicine
8600 Rockville Pike
Bethesda, MD 20209

(NTIS) National Technical Information Service
U.S. Dept. of Commerce
5285 Port Royal Road
Springfield, VA 22041

(OSH) Occupational Safety & Health
Technical Information Branch
National Institute for Occupational
Safety & Health(NIOSH)
4676 Columbia Parkway
Cincinnati, OH 45226

(POL) Pollution Abstracts
Cambridge Scientific Abstracts
5161 River Road
Bethesda, MD 20816

(SCI) Scisearch
Online Customer Service Representative
Institute for Scientific Information

University City Science Center
3501 Market Street
Philadelphia, PA 19104

The Library staff wishes to thank Dr. David Mudarri, Special Initiatives Officer, Office of Program Management Operations, Office of Air & Radiation, for his advice and direction in the development of this bibliography.

For additional information, you may wish to contact the EPA Office of Radiation Programs at (202) 557-9710, or your state radon contact (see the list of State Radon Contacts in the Appendix).

Contact the EPA Headquarters Library for copies of the Radon Bibliography (Phone: (202) 382-5921).

I. GENERAL

I. General

Association of indoor radon concentrations and uranium in surficial material
Kothari, B. K.; Han, Y.
N.Y. State Dep. Health, Cent. Lab. and Res., Albany, NY, USA
Northeastern Environmental Science 3(1): 30-34, 1984
Country of Publ.: United States
ISSN: 0730-630X
20 REFS.
Subfile: B
Doc Type: SERIAL
Bibliographic Level: ANALYTIC
Languages: English
illus., 1 table
Indoor exposure to radioactive radon daughters is a potential health problem which can vary with geographic location. For available indoor radon data from nine locations, the geometric means of equivalent uranium data from the National Uranium Resource Evaluation (NURE) survey for the same locations associate with the percentage of homes with radon concentrations above a desired limit: this provides a basis for identifying areas in the U.S. where high values of indoor radon might be found for further radon studies.(GEO)

Assessment of Natural Radioactivity Levels in Building Materials and Evaluation of Indoor Radiation Exposure
Londhe, VS; Rao, SR; Pillai, KC
Bhaba Atomic Research Centre, Bombay
ENV TECHNOLOGY LETTERS, Feb 84, 5(2):81-8
Natural radioactivity levels were tested for building materials used in some cement houses in Bombay, India, and nearby areas. Exposure to natural radiation is comparatively higher in cement houses than in wooden or brick houses. One to two kg samples were collected from construction sites and from local dealers in Bombay. Granite samples were collected from surrounding quarries. The study presents estimations of natural radio-elements like Radon-222, Thorium-232, and Potassium-40 in a limited number of samples of building materials used in Bombay. Quantities of cement, sand, bricks and stones required for model room were calculated from the standard construction data. (1 graph, 11 references, 6 tables) (ENV)

Characterizing the Source of Radon Indoors
Nero, A. V. ; Nazaroff, W. W.
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC.
Report No.: LBL-16636; CONF-831049-1
Sep 83 47p
International seminar on indoor exposure to natural radiation and related risk assessment, Capri, Italy, 3 Oct 1983.
Languages: English
Document type: Conference proceeding
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8409; NSA0900
Country of Publication: United States
Contract No.: AC03-76SF00098

Average indoor radon concentrations range over more than two orders of magnitude, largely because of variability in the rate at which radon enters from building materials, soil, and water supplies. Determining the indoor source magnitude requires knowledge of the generation of radon in source materials, its movement within materials by diffusion and convection, and the means of its entry into buildings. This paper reviews the state of understanding of indoor radon sources and transport. Our understanding of generation rates in and movement through building materials is relatively complete and indicates that, except for materials with unusually high radionuclide contents, these sources can account for observed indoor radon concentrations only at the low end of the range observed. Our understanding of how radon enters buildings from surrounding soil is poorer, however recent experimental and theoretical studies suggest that soil may be the predominant source in many cases where the indoor radon concentration is high. 73 references, 3 figures, 1 table. (ERA citation 09:005373) (NTIS)

Continuous Measurements of Radon Entry in a Single-Family House
Grimsrud, DT; Nazaroff, WW; Revzan, KL; Nero, AV
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC
Report No.: LBL-15839; CONF-830617-14
Mar 83 21p
76. Annual Meeting of the Air Pollution Control Association, Atlanta, Georgia, USA, 19 Jun 1983
Languages: English
Document Type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8405; NSA 0900
Country of Publication: United States
Contract No.: AC03-76SF00098

The body of information in this paper is directed to researchers and other interested in the field of indoor air quality. It is a progress report that describes detailed measurements during a six-month period of radon concentration, ventilation rate, and other parameters that affect radon entry in a single-family house. Average radon concentrations in the house varied between 0.1 and 18.4 pCi/L during this period: the mean value observed was 3.1 pCi/L. Ventilation rates ranged from 0.03 to 1.00 ach; the mean value was 0.25 ach. The data show that the radon source strength varied substantially during the measurements; we continue to examine the environmental parameters measured to obtain a better understanding of the processes that influence radon entry into the house. The major radon entry site in this structure appears to be the basement sump. A portion of the time variation in the entry rate can be associated with changes in the water level in the sump that couples and decouples the sump with an exterior drain tile system. (ERA citation 09:001191) (NTIS)

COST EVALUATION OF CONTROL MEASURES FOR INDOOR RADON PROGENY (ENGLISH)
MOELLER DW; FUJIMOTO K
HARVARD UNIV,SCH PUBL HLTH,DEPT ENVIRONM HLTH SCI/ BOSTON//MA/02115
HEALTH PHYSICS, 46(6): 1181-1193, 1984

Based on assumed conditions within a typical US home, annualized costs for reducing indoor airborne radon progeny concentrations have been calculated for a variety of methods of control. These analyses were limited to methods for control in existing homes. Control through modified construction techniques was not evaluated. Methods assessed included increased air circulation, increased ventilation, particle removal using electrostatic precipitation and unipolar ion generation, and the application of sealants to room surfaces. Although surface sealants proved to be reasonably cost-effective per person-sievert dose reduction, such sealants are prone to cracking and the durability of their effectiveness questionable. Use of ceiling fans for increased air circulation and particle deposition appears to be least cost-effective, but this method may be attractive in some cases for reasons of comfort. The use of unipolar ion generators appears to be the best approach from the standpoint of cost effectiveness. These devices are also easy to install and are esthetically.(SCI)

DIFFUSION COEFFICIENT OF RADON DECAY PRODUCTS AND THEIR ATTACHMENT RATE TO THE ATMOSPHERIC AEROSOL

Porstendorfer, J; Mercer, TT
Univ of Rochester

Presented at DOE/Univ of Texas Natural Radiation 3rd Intl Sym, Houston, Apr 23-28, 78, v1, p281(13)

The attachment rates of the neutral atoms to the atmospheric aerosol indoors and outdoors were studied using Radon 220 decay products. These decay products were attached to aerosols in a laminar flow through a cylindrical tube. In a nuclei concentration range of 0.6-7 x 10.4 particles/cu cm, the attachment rate was 0.009-0.05 sec -1, corresponding to a half-life of attachment of 77-14 sec. When the humidity was changed from 20% to 100%, the average particle size increased by 2.1. (1 diagram, 6 graphs, 23 references, 3 tables((ENV)

THE DISTRIBUTION OF AMBIENT RADON AND RADON DAUGHTERS IN RESIDENTIAL BUILDINGS IN THE NEW JERSEY-NEW YORK AREA

George, AC; Breslin, AJ
DOE Env Measurements Lab, New York City,

Presented at DOE/Univ of Texas Natural Radiation Env 3rd Intl Sym, Houston, Apr 23-28, 78 v2, p1272(21)

The distribution of radon 222 and radon daughter concentrations in 21 New Jersey and New York residences was investigated for two years. One week time integrated measurements of radon concentration and working level were obtained simultaneously on several floors of a building. These measurements were repeated periodically to yield estimates of annual mean concentrations. Paticle size distributions were also studied to estimate lung doses. Concentrations on the first floors were 50% of those in cellars, and about equal to those of second floors. The average bronchial dose was 150 mrad/yr. (8 graphs, 1 map, 26 references, 1 table) (ENV)

THE DISTRIBUTION OF AVERAGE RADON DAUGHTER CONCENTRATIONS IN HOUSES ESTIMATED FROM SINGLE-SAMPLE SURVEYS (ENGLISH)

Scott, AG
DMSA ACRES, 4195 DUNDAS ST W, Toronto M8X 1Y4, Ontario, Canada

Health Physics, 45(2):435-538, 1983

Single-sample surveys have been used extensively since 1976

to provide rapid estimates of the variation in radon and daughter concentrations from community to community, to determine the variability of concentrations in a community, and as a guide to selection of premises for further investigation. The distribution of readings taken in each survey is approximately log-normal, which suggests that the WL in a house depends on the product of many controlling factors. The single-sample estimate was that 20% of the houses (400) were above 20mWL. The derived distribution of means suggests that viewpoint, as it represents approx. 1 year effort for the existing Remedial Program. The revised number is close to out present estimate that about 320 houses from the original survey group were in excess of 20 mWL annual mean. (SCI)

The Effects of Home Ventilation Systems on Indoor Radon-Radon Daughter Levels
(Final rept.)
Windham, S. T. ; Savage, E. D. ; Philips, C. R.
Eastern Environmental Radiation Facility, Montgomery, AL.
Report No.: EPA/520/5-77-011
Oct 78 26p
Languages: English
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI7911

The U.S. Environmental Protection Agency's Office of Radiation Programs is conducting a multifaceted study of the radiological implications of the phosphate mining and milling industry in the United States. The study began in June 1974 and has concentrated mainly on facilities located in Florida, North Carolina, and Idaho. The purpose of this study is to evaluate the radiological impact of this industry on the environment and develop appropriate radiation protection guidelines in areas where existing controls are determined to be inadequate. A study was conducted in a house in Polk County, Florida, to determine the effects of normal home ventilation methods on radon, radon progeny, and working levels. Three ventilation conditions were studied which approximate those found during normal occupancy. The effects of the central air conditioner, the central blower without air conditioning and outside air ventilation were studied, with radon, radon progeny, and working level measurements made sequentially until significant changes ceased to be observed. In all three experiments, radon, radon progeny, and working levels decreased, with the decreases corresponding to estimated increases in house ventilation rate. (NTIS)

EML (Environmental Measurements Laboratory) Indoor Radon Workshop, 1982
George, AC; Lowder, W; Fisenne, I; Knutson, EO; Hinchliffe, L
Department of Energy, New York.
Environmental Measurements Lab.
Corp. Source Codes: 062709001; 9512945
Sponsor: Department of Energy
Report No: DOE/EML-416; CONF-8211115-
Jul 83 120p
Environmental Measurements Laboratory (EML) Indoor Radon Workshop, New York, NY, USA , 30 Nov 1982

Comparisons are made of lung cancer data from five groups of miners exposed to a wide range of levels of air-borne radioactive particles. Partly because of variable quality of data for the different groups, alternative estimates of lung cancer risk are used: incidence or mortality rates, ratio of observed to expected rates and proportion of lung cancer to all deaths. These three criteria agree that lung cancer in mining groups tends to be directly proportional to mean radiation exposure. After assuming linearity of this relationship and absence of a dose-rate effect, it is estimated that one rad to the bronchial walls of one million persons produces about one lung cancer per year, and that the average integral dose required to produce one lung cancer is 1.3 x 10(5th)gm rad. An exposure of 120 WLM (estimated to equal 360 rad) appears to double the lung cancer incidence characteristic of the general population.(NTIS)

Evaluation of Waterborne Radon Impact on Indoor Air Quality and Assessment of Control Options
(Final rept. of Oct83-Mar 84)
Becker, AP III; Lachajczyk, TM
Envirodyne Engineers, Inc., St. Louis, MO
Corp. Source Codes: 071546000
Sponsor: Industrial Environmental Research Lab., Research Triangle Park, NC
Report No.: EPA/600/7-84/093
Sep 84 146p
Languages: English
NTIS Prices: PC A07/MF A01
Country of Publication: United States
Journal Announcement: GRAI8425
Contract No.: EPA-68-02-3178

This research program was conducted with two objectives; (1) evaluation of waterborne radon impacts on indoor air

quality, and (2) assessment of available control technologies to limit indoor exposure to radon and its decay products. This report contains a revie of radon's physical, chemical and radiological properties; a summary of its decay chain: and a synopsis of health risks, existing regulations, and recommendations concerning exposure to radon and progeny. This report also presents assessments of reported techniques for remocal of radon from water or indoor air. Techniques evaluated for removal of radon from water include decay, aeration, and granular activated carbon. Techniques evaluated for removal of radon and/or progeny from air include circulation, various types of ventilation, filtration, elecrostatic precipitation, charcoal adsorption, chemical reaction, and space charging. Where the reports examined inlude a sufficient amount of information to do so, an evaluation of the cost, efficiency and practicality of each technique is provided. (NTIS)

Factors Controlling Indoor Radon Levels. Annual Report, June 1983-May 1984
Harley, N. H.
New York Univ., NY. Dept. of Environmental Medicine.
Corp. Source Codes: 008702029; 4657000
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/EV/10374-4
31 May 84 31p
Portions are illegible in microfiche products.
Languages: English
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8422; NSA0900
Country of Publication: United States
Contract No.: AC02-80EV10374

The factors which contribute to indoor radon levels were investigated. Soil moisture content appears to be such a factor and influences indoor radon levels in a subtle way. The single family dwelling studied here is a typical suburban home, with a full basement, two living levels and a full attic. Seasonal data for 1981 to 1983 are shown by hour (about 90 hours in each average) for the basement, first floor and outdoors. A twenty-five story, 225 apartment, high rise building has been under study for about the same time interval. The apartment has five rooms, and is on the 24th floor. Continuous monitors are located in a work room and outdoors on a terrace. Data are available from the summer of 1981. 2 references, 12 figures, 9 tables. (ERA citation 09:034297) (NTIS)

IMPROVED PROCEDURES FOR ESTIMATING ANNUAL AVERAGE CONCENTRATIONS OF RADON AND ITS DECAY PRODUCTS IN HOUSES (ENGLISH)

BRUNO RC; ISRAELI M; MAGNO PJ
US EPA,OFF RADIAT PROGRAMS/WASHINGTON//DC/20460

HEALTH PHYSICS, 45(1): 255-255, 1983

The magnitude of the potential impact on public health from exposure of populations to indoor radon and its decay products creates a need for inexpensive and logistically simple procedures for estimating long-term average (e.g. yearly) concentrations in houses. The author's approach toward developing improved estimation procedures involves building a data base of field measurements over a full year in a large number of houses using a variety of instruments and sampling periods. They then use this data to determine confidence levels of estimates derived through a variety of measurement/sampling procedures. Their objectives are to develop a survey tool for characterizing the distribution of levels in a region, and a decision tool for determining whether yearly average levels exceed some chosen action level.(SCI)

INDOOR AIR POLLUTION: THE EXPERIENCE WITH RADON,

OSWALD, R. A. ; ALTER H. W.; GINGRICH J. E.
TERRADEX CORP, CA,

ISES/SOLAR ENERGY SOCIETY OF CANADA ENERGEX 8TH CONF, REGINA, CANADA, AUG 23-29, 82, V1, P46 (5)

CONCERN HAS BEEN EXPRESSED ABOUT THE INCREASING RISKS OF LUNG CANCER ASSOCIATED WITH ELEVATED INDOOR LEVELS OF RADON. THE PRINCIPAL SOURCE OF INDOOR RADON IS RADIUM IN UNDERLYING SOILS AND ROCKS AND IN BUILDING MATERIALS. INDOOR CONCENTRATIONS OF THIS RADIOISOTOPE CAN INCREASE AS A RESULT OF ENERGY CONSER VATION MEASURES WHICH REDUCE AIR INFILTRATION AND VENTILATION. TRACK ETCH DETECTORS HAVE BEEN USED TO MEASURE RADON LEVELS WHICH IN SOME AREAS HAVE BEEN FOUND TO EXCEED 20 PCI/L. (3 DIAGRAMS, 1 GRAPH, 2 PHOTOS, 14 REFERENCES, 2 TABLES)(ENV)

Indoor Radiation Exposures From Radon and Its Daughters:
A View of the Issue
Nero, Jr, AV
California Univ., Berkeley, Lawrence Berkeley Lab
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC
Report No: LBL-10525
Aug 81 27p
Languages: English
NTIS Prices: PC A03/MFA01
Journal Announcement: GRAI8219
Country of Publication: United States
Contract No.: W-7405-ENG-48

Exposure to radon daughters indoors can result in significant risk to the general public, particularly to those living in homes with much higher than average concentration. This paper reviews what is known about indoor concentrations, associated risks, and the effect of measures to save energy by reducing ventilation rates. It concludes that, by employing appropriate control measures in homes having unacceptably high concentrations, the average exposure (and therefore risk) of the general public can remain at its present level, or even decrease, despite programs to save energy by tightening homes. (NTIS)

Indoor Radiation Exposures from 222Rn and Its Daughters:
A View of the Issue
Nero, AV
Health Physics, 45(2):277-288, August 1983, 28 ref
CODEN: HLTPAO

Health implications of indoor radon (10043922) concentrations are reviewed. Sources, concentrations, and exposures in residences are examined. A wide range of concentrations has been observed. The main factors affecting concentration are the radon input rate and the ventilation rate. Building materials and the soil and rock underlying buildings and utilities affect radon-222 (14859677) within buildings. The absolute and relative importance of these sources depends on the structural type and location. Healthy risks to building occupants arise from exposure to the short lived radon-222 daughters. Estimates of the incidence of lung cancer based on statistics from the occupational exposures of miners suggest that 1000 to 2000 cases of lung cancer are due to such domestic radon exposures. The relationship between improving energy efficiency by reducing ventilation rates and health risks is considered. It is calculated that a 20 percent reduction in ventilation would produce a 25 percent increase in radon concentrations and a similar increase in daughter concentrations. Such ventilation improvements with no attempts to reduce these higher radation levels would cause an added 250 to 5000 lung cancer cases a year. Radon control

strategies are suggested, particularly for houses that reduce air changes below 0.5 per hour. Other pollution concentrations would rise in these buildings, along with radon daughter levels, causing concomitant health effects. However, reductions might be achieved at the same time because of lowered energy use, particularly reduced fossil exposures is suggested: one part setting an acceptable average value for population exposures. The author concludes that a vigorous program should be undertaken to understnad the size and variability of radon exposures in the United States, identifying the population at risk, and undertaking programs to reduce such exposures. (OSH)

The indoor radiological problem in perspective
Hurwitz, H jr
General Electric Company, Corporate Research and Development, Schenectady, NY 12345
RISK ANALYSIS, (USA) 1983, 3(1):63-77
CODEN: RIAND
Languages: English
Measures to tighten homes to conserve energy, as are being encouraged and subsidized by federal and state governments, may reduce air infiltration by 20% or more. Standard prudent risk-assessment methodologies predict that, due to increased levels of indoor radon caused by this reduction in ventilation, the added lifetime lung cancer risk to members of the public is of order 200/million people exposed. In situations where the radon source term is unusually high, or extreme reductions in ventilation are made, the added risk can be more than an order of magnitude greater. While these imputed risks are far outside the range that is normally acceptable, variations in radon source term and the health effects of indoor radon are being deemphasized. The technical background is presented in some detail, and implications with regard to management of risks to the public are discussed.(EMB)

Indoor radon concentrations
Moschandreas, DJ; Rector, HE
Environment International, 1982 8(1-6):77
The indoor air of 60 residences in and around a Maryland suburb of Washington, DC was monitored in a pilot study to determine residential radon concentrations. In each residence, a radon grab sample was acquired in the living room, and if possible in the basement. Infiltration rates were determined by tracer gas dilution. To help standardize sampling conditions, each home remained closed up for 8 hours prior to sampling and during analysis. Over 60% of the residences sampled showed air filtration rates below 0.6 air changes per hour. Approximatley 55% of all surveyed basements and 30% of all surveyed living areas displayed radon concentrations in excess of 4.0 nCi m -3. Assuming an equilibrium factor of 0.5, thse radon levels may lead to working levels above the annual guidelines suggested by EPA for Florida homes built on land reclaimed from phosphate mining. (ENVB)

Indoor radon measurements in the New York Capital District
Fleischer, RL; Turner, LG
General Electric Research Development Center,
Schenectady, NY 12301
Health Phys, 1984, 46(5):999-1011
CODEN: HLTPA
Languages: English
Radon-222 concentrations have been measured in 21 'energy-efficient' homes and 14 conventional homes in the New York Capital District. Usual concentrations are averaged over six-month or twelve-month periods using solid-state track detectors. Full-year averages are available for 23 of the homes, and the winter-to-summer variations have been observed. In a number of cases, sup 2sup 2 sup 2Rn. Two major patterns emerge. The living areas of the energy-efficient homes without heat-storage masses have median radon concentrations that are 1.6 times those for conventional homes, and the energy-efficient homes with heat storage masses have four to five times the sup 2 sup 2 sup 2Rn of conventional homes. (EMB)

INDOOR RADON PROGENY AEROSOLS-PROPERTIES, DYNAMICS, AND EFFECTS
(ENGLISH)
Martell, EA; Sweder, KS
Natl Ctr Atmospher Res/Boulder/ CO/ 80307
ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY
v187, APR, p52, 1984
(SCI)

INDOOR RADON SOURCES, CONCENTRATIONS, AND STANDARDS
(ENGLISH)
Nero, AV
Univ Calif Berkeley; Lawrence Berkeley Lab,
Berkeley/ CA / 94720
TRANSACTIONS OF THE AMERICAN NUCLEAR SOCIETY, 39:83-84, 1981
Indoor exposures to daughters of RN222 contribute significantly to the radiation dose that the general public receives. Controlling such exposures is complicated by the fact that indoor radon concentrations vary substantially from one geographical area to another and even one home to another; the major cause of this variation appears to be the source magnitude, defined as the rate at which radon enters the home. Even for concentrations considered to be typical in U.S. housing, the attendant risk of lung cancer that may be estimated, although relatively low, is sufficient to warrant attention. Moreover, for the small proportion of the population living in homes where radon concentrations are higher than average, the risk of developing cancer could be increased a few percent over their lifetime. Survey programs and air quality standards should be designed to give special attention to those at high risk.(SCI)

INTEGRATED ALPHA AND GAMMA RADIATION MEASUREMENTS IN DWELLING HOUSES (RADON, PASSIVE SMOKING, PARTICULATES, & HOUSING EPIDEMIOLOGY)
Paripas, B; Takacs, S; Somogyi,G; Nikl, I
PUBLIC HEALTH & EPIDEMIOLOGY INST, HUNGARY
WHO/ et al 3rd Intl Indoor Air Quality & Climate Conf, Stockholm, Sweden, Aug 20-24, 84, v2, p113(6)
A solid state nuclear track detector method was applied to determine radon and alpha exposures in houses in Hungary. A mathematical description of the method of measurement by a passive device equipped with two plastic sheets is presented. Mean exposures due to thoron and its progeny were estimated by statistical methods. A possible connection between the measured quantities and the lung cancer rates in two settlements is assessed. (1 diagram, 5 graphs, 8 references, 4 tables) (ENV)

INTEGRATED MEASUREMENT OF INDOOR RADON WITH A PASSIVE CHARCOAL DEVICE
(ENGLISH)
George,AC
US DOE, Environm Measurements Lab/New York/NY/10014
Health Physics, 43(1):122, 1982
Activated charcoal collectors were tested to determine their adsorption and retention characteristics for radon. Tests at typical indoor conditions of temperature and relative humidity indicate that simple inexpensive and maintenance free passive devices containing 150-200g of activated carbon can measure radon conveniently and adequately. Under radon concentration conditions encountered indoors and for an integration period shorter than the 3.8 day half-life of radon, the quantity adsorbed in the container is determined by counting the gamma rays from the decay products of radon. The lower limit of detection for radon is 0.2 pCi/L for an exposure period of 60 hours. Greater sensitivity can be obtained with larger devices containing charcoal with larger surface area. The calibration of the device is described. (SCI)

INTEGRATED RADON DATA FROM DWELLINGS IN MAINE AND TEXAS
(ENGLISH)
Prichard, HM; Gesell, TF; Hess, CT; Weiffenbach, C; Nyberg, P
Univ Texas, Sch Publ Hlth/Houston/TX/77025;
Univ Maine/Orono/ME/04469
US EPA, Off Radiation Programs/Las Vegas/NV/89114
Health Physics, 45(2):428-432, 1983
(SCI)

International Meeting on Radon-Radon Progeny Measurements-
Proceedings held on August 27-28, 1981
Dingle Associates, Inc., Washington, DC
Corp. Source Codes: 074434000
Sponsor: Environmental Protection Agency, Washington, DC
Report No.: EPA-520/5-83-021
Sep 83 284p
Languages: English
Document type: Conference proceeding
NTIS Prices: PC A13/MfA01
Journal Announcement: GRAI8403
Country of Publication: United States

EPA sponsored a two-day international meeting on radon and radon progeny measurements. The purpose of the meeting was to promote an interchange of information between international experts. The meeting format included formal presentations and direct discussions. Eighteen papers were presented on such topics as measurement programs using such instruments and methods. This publication contains the complete texts of 15 papers, abstracts of two papers, and edited transcripts of open discussions, 'Instrumentation and Measurement Methods' and 'Measurements and Related Topics'. (NTIS)

July 1984 and February 1985 Radon Intercomparison
Fisenne, IM; George, AC; Keller, H
Department of Energy, New York
Environmental Measurements Lab
Corp. Source Codes: 062709001; 9512945
Sponsor: Department of Energy, Washington, DC
Report No.: EML-445
Aug 85 31p
Portions of this document are illegible in microfiche products.
Original copy available until stock is exhausted.
Languages: English
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8526; NSA1000
Country of Publication: United States

This report summarizes the results of the July 1984 and February 1985, the seventh and eighth, radon intercomparison exercises held at the Environmental Measurements Laboratory. Twenty-eight organizations, including six US Federal facilities, one national laboratory, four state laboratories, eight universities, six private sector facilities, and three non-US laboratories participated in these exercises. The results indicate reasonable agreement among the participants at the sup 222 Rn concentration level of 35 pCi/L exp-1. (6 figures, 8 tables) (ERA citation 10: 045123) (NTIS)

LONG-TERM ENVIRONMENTAL RADON-222 MEASUREMENTS IN A SINGLE FAMILY DWELLING

Harley, NH; Altman, SM
New York Univ Sch Med., 550 First Ave., New York, NY 10016

27th Annual Meeting of the Health Physics Society, Las Vegas, NV, USA, June 17-July 1, 1982
Health Phys, 43(1):122, 1982
CODEN: HLTPA
Language: English

Hourly measurements of Rn-222 have been made simultaneously indoors and outdoors at a single family dwelling in northern New Jersey. These measurements are ongoing and about one year of data have been collected to determine diurnal and seasonal cycles. The measurements were performed using a monitor for continuous measurement of Rn-222 which does not depend upn measurement of short-lived Rn-222 daughters. The detector consists of a 12.7 cm diameter cylinder ipen at both ends and lined with alpha phosphor mounted on a 12.7 cm photomultiplier tube. Also the correlations of indoor Rn-222 with outdoor Rn-222 concentration, a few fundamental meteorological parameters, and emanation from the soil beneath the structure are also described. (BIO)

LONG-TERM MEASUREMENT OF RADON IN A SINGLE FAMILY DWELLING AND ITS CORRELATION WITH SELECTED METEOROLOGICAL VARIABLES (ENGLISH)

Harley, NH; Altman, SM
NYU, Sch Med/New York/NY/10016

Health Physics, 45(1):254-255, 1983

Hourly indoor and outdoor measurements of Rn-222 in a single family dwelling have been made in northern New Jersey since April 1981. Several meteorological parameters such as temperature, pressure, humidity, windspeed and direction, and soil heat flux have also been measured since July 1982. The radon monitors consist of a 12.5 cm diameter cylinder open at both ends and lined with zinc sulfide alpha phosphor and sit on a 12.5 cm phototube. The variability of indoor radon is adequately described by the measured parameters. (SCI)

MEASUREMENT OF INDOOR RADON CONCENTRATIONS IN PUBLIC BUILDINGS (ENGLISH)

Fenyes, EJ; Kinslow, RH
Univ Texas/Richardson/TX/75083

Health Physics, 47(1):204, 1984

Indoor radon concentrations have been measured in a 10 year

old two-story building of the University of Texas at Dallas. Variations of the radon concentration from the basement to the second floor in offices, classrooms, laboratories, storage rooms, corridors and other locations have been studied. Seasonal variations of the above concentrations and their dependence on ventilation rates and water usage have been measured. From these data the radiation exposure of students and university personnel from radon-222 and its daughters were estimated. The results are compared with preliminary results obtained from indoor radon measurements carried out in conventional and energy saving homes, hospitals and industrial buildings in the Dallas area. The health aspects of indoor radon pollution in homes and at work are discussed. (SCI)

MEASUREMENT OF INDOOR RADON-222 CONCENTRATIONS USING THE SCINTILLATION FLASK TECHNIQUE
Vasquez,GM; Schlapper,GA
Nuclear Eng Dep, Texas A & M Univ.
College Station, TX 77802
30th Annual Meeting of the Health Physics Society, Chicago, IL, May 26-31, 1985
Health Physics, 49(1):133, 1985
CODEN: HLTPA
Language: English
Rn-222 concentrations were measured in several buildings on the Texas A & M University campus using (air grab) scintillation flasks. Sampling was scheduled so that daily and weekly variations in radon levels could be evaluated. Using these results, doses to lungs was estimated for students and other university staff at various times of the day and week. For completeness, the Rn-226 content of the soil was determined near the buildings of interest, and radon emanation rates through concrete surfaces were also measured. Soil analysis was performed on a high resolution GeLi detector and radon emanation rates were obtained using the accumulator method. During the presentation, data acquired will be compared to literature values from similar studies. (BIO)

MEASUREMENT OF TIME-INTEGRATED RADON CONCENTRATIONS IN RESIDENCES
Nyberg, PC; Bernhardt, DE
US Environmental Protection Agency, Office Radiation Programs-LVF, P.O. Box 18416, Las Vegas, NV, 89114
Health Physics, 45(2): 539-543, 1983
(BIO)

Measurements of radon-daughter particle size.
Knutson, EO; George, AC; Knuth, RH; Koh, BR
Environmental Measurements Laboratory, U.S. Department of Energy, New York, NY 10014
RADIATION PROTECTION DOSIMETRY, (ENGLAND) 1984, 7(1-4):121-125
CODEN: RPDOD
Languages: English
(EMB)

Measurements of radon in residential buildings in Maryland and Pennsylvania, USA
George, AC; Duncan, M; Franklin, H
Environmental Mesurements Laboratory, U.S. Department of Energy, New York, NY 10014
RADIATION PROTECTION DOSIMETRY,(ENGLAND) 1984, 7(1-4): 291-294
CODEN: RPDOD
Languages: English
(EMB)

Observation of high concentrations of radon in certain houses
Rundo, J; Markun, F; Plondke, NJ
Argonne National Lab, Argonne, IL 60439
Health Phys, (England) 1979, 36(6):729-30
CODEN: HLTPA
Languages: English
There is a paucity of data on the normal levels of radon in houses in this country. It should be noted that these radon concentrations were determined directly, whereas the values noted were inferred from determinations on the short-lived daughters of radon. The authors report that they observed much higher concentrations of radon in some houses in the Chicago area; the high levels were unrelated to excessive radioactivity in building materials, or to the presence of uranium mine tailings in the foundations, and they should be regarded as 'normal'. This work was supported by the Department of Energy; more details will be published elsewhere.(EMB)

Physical Processes Affecting Levels of Radon, Thoron, and Their Decay Products in an Indoor Environment. Technical Progress Report, June 1, 1984-December 31, 1985
Wilkening, M; Schery, SD
New Mexico Inst of Mining and Technology, Socorro
Corp. Source Codes: 01264000; 461500
Sponsor: Department of Energy, Washington, DC
Report No.: DOE/ER/60216-TI
31 Mar 85 5p
Portions of this document are illegible in microfiche products.
Languages: English
NTIS Prices: PCA02/MF A01
Journal Announcement: GRAI8515; NSA1000
Country of Publication: United States
Contract No.: AS04-84ER60216

Highlights of work performed under this contract include completion of indoor air studies at an experimental house on the university campus, publication and submission for publication of nation-wide measurements of thoron and thoron daughters, commissioning of an aerosol spectrometer (matching funds provided by NMIMT), and completion of a three-year radon study of housing in Socorro, NM, using passive monitors. Current work centers on a comarison of indoor and outdoor radioactivity and ion measurements, mathematical moedling of radon transport through heterogeneous media, and modeling of physical factors affecting indoor thoron and its daughters. (ERA citation 10:021660) (NTIS)

Radiation in Buildings. The Inconvenience About Radon and How to Counteract it.
Statens Planverk, Stockholm (Sweden)
Corp Source Codes: 072360000; 9860009
Report No.: SPV-54
1981 118p
In Swedish. U.S. Sales only.
Languages: English
NTIS Prices: PC A06/MF A01
Journal Announcement: GRAI8312
Country of Publication: Sweden

The report presents facts about radiation, its origin and risks. It is stated that the natural radiation is dependent on the bedrock. Various control methods and ways to reduce high radiation levels are described. The information is based upon present-day knowledge of the inconvenience about radon. (Atomindex citation 13:658859) (NTIS)

Radiation Protection Information. Naturally Occurring Radiation in the Nordic Countries-Levels
Statens Inst for Straalehygiejne, Copenhagen, Denmark
Corp. Source Codes: 084512000; 5962100
Sponsor: Institute of Radiation Protection, Helsinki Finland; Geislavarnir Rikisins, Reykjavik, Iceland; Statens Inst. for Strallehygiene, Oslo, Norway; Statens Straalskyddsinstitut, Stockholm, Sweden
Report No.: INIs-MF-9683
1985 27p
Languages: English
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8524
Country of Publication: Denmark
From the measurements and discussions presented in this report, the following conclusions may be drawn: The population dose from naturally occurring radiation is on the average lower in Denmark and much lower in Iceland than in the other Nordic countries. In Sweden, Finland and Norway, the largest contributors to the population doses from naturally occurring radiation are radon daughters in indoor air. Fro Denmark and Iceland, radon daughters contribute aboutr the same to the total effective dose equivalent as the external gamma radiation. Some groups of people in the Nordic countries are highly exposed to radon daughters. In some cases, the received doses are very high (higher than the dose limit for radiation workers). From the conclusions above, the radon daughter problem should be given priority, at least in Sweden, Finland and Norway, especially regarding the search for population groups receiving the highest doses. (Atomindex citation 16:034499) (NTIS)

Radioactive aerosols produced by radon in room air.
Mercer, TT; Stowe, WA
Inhaled Part Vap, (England), 1970, 2(3):839-851
ISSN: DGOM-0000
Journal Code: GOM
Languages: English(EMB)

Radioactive emissions and radon
Harley, JH
Environ Meas Lab, United States, Dept Energy, New York, NY
Bull NY Acad Med, 1981, 57(10):883-896
CODEN: BNYMA
Languages: English
The dose to the bronchial epithelium delivered by the alpha-emitting daughters of radon-222 is the highest radiation dose received by man from natural sources. Indoor concentrations are several times larger than those found outdoor, and because

urban man spends over 90% of his time indoors, those exposures are worth study. This paper summarizes available concentration data and describes the associated doses and possible health implications. Environmental radon daughter exposures can possibly cause some fraction of the lung cancer incidence in nonsmokers. On the other hand, the existing radon daughter concentrations and 'spontaneous' lung cancer rates place an upper limit on the possible radiation effects for this specific case. There has been some concern that energy conservation measures involving reduced ventilation in homes will increase exposures to radioactivity as well as to other toxic agents in indoor air. At present, sufficient ventilation data are not available for a sound assessment. Several areas in the United States have enhanced levels of radon daughters in indoor air. Any effects of this exposure cannot be detected epidemiologically, but there is still pressure to set regulatory standards for new construction and for possible remedial action in older homes. The complex social, economic, and political fctors involved are not touched on here, but will probably control the practical outcome of any standard-setting actions. (EMB)

Radioactivity (Radon and Daughter Products) as a Potential Factor for Building Ventilation
(Final Rept.)
Kusuda, T; Hunt, CM; McNall, PE
National Bureau of Standards, Washington, DC
Corp Source Codes: 240800
1979 5p
Pub. in American Society of Heating, Refrigeration, and Air-Conditioning Engineers Jnl, 21, n7, p30-34, Jul 79
Languages: English
NTIS Prices: Not available NTIS
Journal Announcement: GRAI7921

Awareness has developed in the United States, particularly within the last five years, that traces of radioactive radon gas and its daughter products are present in varying amounts in the indoor air. Some of the existing literature on the subject is briefly reviewed and discussed. It is recommended that further attention be given to quantify radon concentration data pertinent to the environmental health aspects of ventilation requirements from the standpoint of indoor air quality consistent with building energy conservation. (NTIS)

Radon and its Daughters in Energy-Efficient Buildings
Nero, AV; Boegel, ML; Hollowell, CD; Ingersoll, JG; Nazaroff, WW
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp Source Codes: 005029222; 9513034
Report No.: LBL-10775; CONF-810153-2
Nov 80 9p
Special symposium on natural radiation environment, Bombay, India, 19 Jan 1981
Portions of document are illegible
Languages: English
Document type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8307; NSA0700
Country of Publication: United States
Contract No.: AC03-76SF00098

Our group has been carrying out work on several aspects of radon and its daughters indoors. We have measured radon emanation rates and radionuclide concentrations in building materials, performed surveys of radon and daughter concentrations in residences, begun to examine control technologies and strategies and devoted significant efforts to instrumentation developments. To more completely characterize radon and its daughters indoors, more substantial efforts are needed on the questions of geologic distribution of radon, transport into structures, daughter behavior indoors and instrument response under various conditions. (ERA citation 07:060167)(NTIS)

RADON AND ITS PROGENY IN THE INDOOR ENVIRONMENT
Tartaglia, Mark; Dinardi, Salvatore R.; Ludwig, Jerry
Univ of Massachusetts
J Env Health, Sept-Oct 84, 47(2):62

Radon 222 gas and its daughter products have been recognized as indoor air contaminants. Measured concentrations of radon and its progeny in many structures exceed recommended levels. Sources of indoor radon are identified, and the influence of various building and meteorological factors and parameters on indoor radon levels are discussed. Attendant health effects and appropriate control measures are surveyed. (1 graph, 27 references, 1 table)(ENV)

RADON AND RADON DAUGHTERS DUE TO NATURAL URANIUM OCCURRENCES IN A RURAL ONTARIO COMMUNITY
Taniguchi, H; Vasudev, P
Canada Radiation Protection Bureau, Ottawa
Presented at DOE/Univ of Texas, Natural Radiation Env 3rd Intl Sym, Houston, Apr 23-28, 78 v2, p1623(10)

The results of a survey of radon 222 and its short-lived daughters in 343 homes in the rural community of March Township, Ontario Province, Canada, are reported. Aerial gamma ray spectrometry carried out over the 90 sq km area

showed the presence of up to 5 ppm uranium. The arithmetic average value of the raon daughters in the basement of these homes was 0.014 .0.026 working level. Thirteen percent of these residences had radon daughter concentrations exceeding an arbitrary reference value of 0.02 working level. (4 graphs, 1 map, 9 references, 1 table) (ENV)

Radon and thoron daughters in housing
Gunning, C.; Scott, A.G.
DSMA/ACRES, 4195 Dundas St. W., Toronto, Ontario, Canada M8X 1Y4
HEALTH PHYS VOL. 42, NO. 2, pp. 527-528, Publ.Yr: 1982
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH
Although the thorium activity is at least equal to the uranium activity in the surface environment at Elliot Lake, the WL(Th) in houses is insignificant compared with the WL(Rn), and the remedial action limit of 20 mWL(Rn). Exceptions to this may occur in commerical buildings where there are large areas of unpainted concrete and poor ventilation, and in those few cases where the transit time of soil gas into the building is so short that the thoron does not decay significantly in transit.(POL)

Radon-Daughter Exposures in Energy-Efficient Buildings
Nero, AV: Berk, JV; Boegel, ML; Hollowell, CD; Ingersoll, JG
California Univ., Berkeley. Lawrence Berkeley Lab
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC
Report No.: LBL-11052; CONF-800389-4
Oct 81 10p
Specialist meeting on assessment of radon and daughter exposure and related biological effects, Rome, Italy, 3 Mar 1980
Languages: English
Document Type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8219
Country of Publication: United States
Contract No.: W-7405-ENG-48

A radon concentration of 1 pCI/L (37 Bq/m exp 3) appears to lie in the range that is typical for air inside US residential buildings. Moreover, some US residences have concentrations higher than 1 pCi/L, sometimes by an order of magnitude, implying significant individual risk to occupants. For typical radon daughter equilibrium ratios, this concentration corresponds to a radon daughter exposure rate of 0.2 working level months (WLM) per year. This exposure rate may account for a significant lung cancer incidence if data on lung cancers per unit exposure in miners are applicable to such low exposures. Reductions in air exchange rates may rise the typical exposure rate and even increase it to unacceptable levels in some cases. Measures that reduce energy use by reducing natural infiltration or mechanical ventilation in new or retrofit buildings are therefore undergoing severe scrutiny. Lawrence Berkeley Laboratory has performed measurements in buildings specifically designed to use energy efficiently or utilize solar heating. In many of these buildings radon concentrations appear to arise primarily from soil underlying the buildings. Measures to control higher levels, e.g., by mechanical ventilation with heat recuperation, appear to be economical. However, to evaluate energy-saving programs adequately requires a much more comprehensive characterization of radon sources (for example,, by geographical area) and a much fuller understanding of the dynamics of radon and its daughters indoors than now exist.(NTIS)

Radon in Buildings: Proceedings of a Roundtable Discussion of Radon in Buildings Held at Gaithersburg, Maryland on June 15, 1979
(Final rept.)
Colle, R. ; McNall, Jr, Preston E.
National Bureau of Standards, Washington, DC.
Corp. Source Codes: 004692000
Report No.: NBS-SP-581
Jun 80 88p
Library of Congress catalog card no. 80-600069.
Languages: English
Document Type: Conference proceeding
NTIS Prices: PC A05/MF A01
Journal Announcement: GRAI8019
Country of Publication: United States
This is the proceedings of a Roundtable Discussion of Radon in Buildings held June 15, 1979 at the National Bureau of Standards in Gaithersburg, Maryland. The meeting brought together a number of participants with diverse interdisciplinary interest in radiation protection, radiation measurement and building technology, provided a forum to exchange information, and drew attention to some of the problems and research needs associated with radiation exposure due to radon in buildings. Emphasis was placed on (1) the characterization of the sources and pathways of radon in buildings; (2) the biological and health effects; (3) measurement considerations; and (4) strategies and control technologies to minimize indoor radiation exposure.(NTIS)

Radon in Dwellings. Field Study, Part 1
Erikson, BE; Boman, CA; Nyblom, L; Swedjemark, GA
National Swedish Inst. for Building Research, GA
Corp. Source Codes: 075131000; 9860033
Jun 80 87p
In Swedish.
U.S. Sales only. Available in microfiche only.
Languages: Swedish
NTIS Prices: MF A01
Country of Publication: Sweden
This report presents the function of the ventilation by natural draught in three-storey houses. In some cases also the measurement of gamma radiation, radon and radon daughters was made. The investigation took place in Uppsala.
(Atomindex citation 12:596009) (NTIS)

Radon in dwellings and influencing factors.
Stranden E; Berteig L
Health Phys ,Aug 1980, 39 (2) p275-84,
* ISSN 0017-9078
Journal Code:G2H
Languages: ENGLISH(ENV)

Journal Announcement: 8103
Subfile: INDEX MEDICUS
Tags: Human
Some factors that have influence upon the radon concentration in dwellings are discussed in this paper. Measurements of the exhalation rates from different building materials are presented together with calculations of indoor radon concentrations. The influence of wind and temperature upon the ventilation rate and radon concentration in a test-house have been measured, and the effect of airing and artificial ventilation upon the radon concentration is discussed.(MED)

Radon in earth-sheltered structures
Landa, Edward R.
Underground Space, 1984 VOL. 8, NO. 4, p. 264
Radon concentration in the indoor air of six residential and three non-residential earth-sheltered buildings in eastern Colorado was monitored quarterly over a nine-month period using passive, intergrated detectors. Average radon concentrations during the three-month sampling periods ranged from about 1 to 9 pCi/L, although one building, a poorly ventilated storage bunker, had concentrations as high as 39 pCi/L. These radon concentrations are somewhat greater than those typically reported for conventional buildings (around 1 pCi/L); but they are of the same order of magnitude as radon concentrations reported for energy-efficient buildings which are not earth-sheltered.(ENVB)

RADON MEASUREMENTS AND EMANATION STUDIES
Berk, JV; Boegel, ML; Ingersoll, JG; Nazaroff, WW; Stitt, BD; Zapalac, GH
LBNL, LBNL Energy & Energy Div, 1979 Report LBL-11650 Oct 80, p2-18(6)
The extent to which radon is a contaminant of indoor air in residential buildings is being investigated. Energy efficient and conventional residential structures were monitored for radon and associated daughters. Emanation rates from building materials were also measured. Preliminary reserch results are discussed. (4 diagrams, 4 graphs, 6 references) (ENV)

RADON MEASUREMENTS IN BUILDINGS IN SOUTHERN AND WESTERN WISCONSIN
McDonnell, LJ; Benetti, JC
State Wisconsin Division Health, Section Radiation Protection, P.O. Box 309, Madison, Wisconsin 53701
30th Annual Meeting of the Health Physics Society, Chicago, IL, May 26-31, 1985
Health Physics, 49(1):157, 1985
CODEN: HLTPA
Language: English
(BIO)

Radon Measurements Indoors. An Evaluation of Performed Measurements
Joensson, G
Lund Inst of Tech (Sweden); Fysiska Institutionen
Corp. Source Codes: 016500015; 9860097
Report No: LUTFD2/TFKF-3038/1-29 (1983)
Feb 83 29p
In Swedish.
U.S. Sales only.
Languages: Swedish
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8502
Country of Publication: Sweden
Measurements of radon concentrations have been made using photographic film detectors in the communities of Uppsala, Soedertaelje and Tyresoe. The result from 6700 film exposures in boht one-family and apartment houses are reported. The fraction of dwellings with radon daughter concentrations exceeding 200 Bq/m exp 3 is between 3 and 14 percent for one-family houses and 0 ot 5 percent for apartment buildings. 8 to 68 percent of the one-family houses and 57 to 83 percent of the apartment buildings had concentrations lower than 70 Bq/m exp 3. The seasonal variations were reported in one-family houses in Uppsala. In houses with low concentrations, the winter values were higher than the summer values. For houses with high concentrations the reversed variation was recorded. (Atomindex citation 14:783109)
(NTIS)

Radon-222 and progeny measurements in 'typical' East Tennesee residences
Goldsmith, WA; Poston, JW; Perude, PT; Gibson, MO
Health Saf Res Div, Oak Ridge Natl Lab, Oak Ridge, TN
Health Physics, 1983 45(1):81-88
CODEN: HLTPA

Languages: English
Modified Wrenn chambers for continous monitoring of sup 2 sup 2 sup 2Rn, featuring several improvements including a computer-assisted electronics package, have been developed at the Oak Ridge National Laboratory. A field test of these instruments was conducted by placing them in the homes of the staff members. Field testing was conducted in seven homes for periods ranging from 4 to 18 days. During this testing period, the sup 2sup 2sup 2Rn concentration in these houses was monitored continuously. Radon-222 concentrations in the basements of three of the seven houses were in excess of 100 Bq/msup 3 almost continuously. One residence had instantaneous concentrations approaching 1000 Bq/msup 3. Samples of soil and building materials from these residences indicated that sup 2sup 2sup 2Rn concentrations were in the normal range (40 Bq/kg). Radon progeny measurements were made in five of these houses on a 'typical' day. Results obtained were as follows: for basements, a geometric mean of 0.016 WL (geometric S.D. of 2.9); for upper floors a geometric mean of 0.014 WL (geometric S.D. of 2.9). This paper summarizes the results obtained in the field test.(EMB)

RADON TRANSPORT IN SOIL AND ITS RELATION TO INDOOR RADIOACTIVITY (ENGLISH)
WILKENING M
NEW MEXICO INST MIN & TECHNOL/SOCORRO//NM/87801
SCIENCE OF THE TOTAL ENVIRONMENT , V45, OCT, P219-226, 1985
The transport of radon from soil to the indoor living space involves diffusion and viscous flow in the soil coupled with transfer to the building interior of radon-rich air which accumulates in cavities and channels below and around the foundations of buildings. Radon concentrations in soil pores at depth are dependent upon the radium content of the soil, emanating power for radium, and soil moisture content. Atmospheric pressure fluctuation, thermal gradients in fractured rocks, and air instabilities due to temperature differences allow air of high radon content to reach living space in dwellings in addition to that which comes directly from building materials and other sources.(SCI)

Radon Transport Through and Exhalation From Building Materials: A Review and Assessment
Colle, R.; Rubin, R.J.; Knab, L.I.: Hutchinson, J.M.R.
NBS, Washington, D.C., USA
NTIS, SPRINGFIELD, VA
SUMMARY LANGUAGE - ENGLISH;
PB82-112384.
Languages: ENGLISH(POL)

Regional geology and radon variability in buildings
Sachs H.M.; Hernandez T.L.; Ring J.W.
Cent. Energy Environ. Stud., Princenton Univ. Princeton, NJ 08544 U.S.A.
ENVIRON. INT. (U.S.A.), 1982, 8/1-6 (97-103), Coden: ENVID
Languages: ENGLISH
Radon concentrations in dwellings vary by more than two orders magnitude likely to be high requires studying the variability of the contributors to radon in buildings. Among common sources, geological factors (water supply and substrate) are the most variable, whereas building materials are much less variable. Ventilation variation among houses is generally responsible for radon variations comparable to those introduced by building materials, but it is more significant at lower ventilation rates. In some regions with relatively high proportions of houses with elevated radon concentrations, mappable geological factors are associated with most cases of higher radon concentrations. However, a priori identification of rock types likely to be implicated is likely to be successful in only a few cases. (EMB)

Report of the Task Force on Radon in Structures
(Position paper)
Radiation Policy Council, Washington, DC.
Corp. Source Codes: 071604000
Report No.: RPC-80-002
15 Aug 80 146p
Languages: English
NTIS Prices: PC A07/MF A01
Journal Announcement: GRAI8114
Country of Publication: United States
The Task Force reviewed the physical and biological bases for concern about radon exposures to the general public and examined the status of Federal activities in four areas: epidemiological studies; regulatory authorities; programs to measure radon levels in homes; and the coordination of Federal radon research. The Task Force concluded that Council attention to this problem is warranted because of the possible prevalence of relatively large exposures, a trend toward even higher exposures due to improved energy efficiency in inhabited structures, the risk from such exposures, and the potential large population at risk. The Task Force concluded that wide ranging programs should not be undertaken until more is known about the prevalence of high exposures and ways of controlling them. The thrust should be towards developing an information base that will allow good policy decisions. Also concluded was that although

current Federal authority cannot address some radon exposure situations, it would be premature to request additional authority until the technical basis for determining radon levels and reducing them is more fully established.(NTIS)

Results of a survey on radioactivity of building materials in Italy
Sciocchetti G; Clemente GF; Ingrao G; Scacco F
Environ. Sci. Div., Enea-Cre-Casaccia, C.P. 2400-00100 ROMA ITALY
Health Phys, 45(2): 385-8, 1983.
CODEN: HLTPA
Language: ENGLISH
A program is underway in Italy to identify construction materials with high radioactivity contents and to evaluate the resulting indoor exposure on a nationwide scale. Building materials included those of natural origin and those employing particular byproducts such as fly ash and phosphogypsum. The survey emphasized natural building materials, which were widely used in man areas having particular geological features. First results show that Itay included areas of high natural background, i.e., in Lazio and Campania, in which high levels of indoor exposure occurred that was directly related to specific activities of the building materials. 220Rn daughters were sometimes present at such levels that their contribution to the lung exposure was comparable to that from 222Rn daughters.(BIO)

Room for a Role for Radon in Lung Cancer Causation?
Axelson, O
Department of Occupational Medicine, University Hospital, Linkoping, Sweden
Medical Hyotheses,(Canada) Jan 1984, 13(1):51-61
ISSN: 0306-9877
Journal Code: MOM
Languages: English
Reduced ventilation due to energy saving has focused interest on a potential lung cancer risk from increased indoor concentations of alpha-emitting radon and radon daughters, escaping from building materials and from the ground. Some preliminary studies now also indicate a hazard to be present as related to radon daughter exposure in homes. However, the indoor radon daughter levels have probably been continuously increasing for half a century, especially in colder climates, due to the introduction of central heating instead of stoves and open fire places, reducing thermal ventilation. Furthermore, in our time, many people have got additional exposure thorugh extended indoor work time instead of earlier outdoor activities in farming, etc. The steeply increasing lung cancer rates over

the past decades as well as the various oddities affecting the relationship between smoking and lung cancer, e.g. the urban-rural difference in lung cancer risk, also after standardization for smoking, the influence of immigration on lung cancer morbidity as well as varying rates around the world and other observations, would obtain simple explanations by taking radon daughter exposure into account in addition to smoking. Then, also some curious and hitherto unexplained 'inverse' relationships between lung cancer and inhalation of cigarette smoke or bronchitis in air-polluted areas, respectively would become understandable.(MED)

SHRINKAGE CRACKS IN CONCRETE ARE A MAJOR ROUTE OF RADON ENTRY INTO HOUSES
* (ENGLISH)
KATCHMAR R; SCOTT A
DSMA ACRES/ELLIOT LAKE P5A 1Y6/ONTARIO/CANADA/
HEALTH PHYSICS , V37, N6, P801-801, 1979
Work at Elliot Lake suggested that the cause of high radon levels (greater than 200 Bq/m-3) in homes was the entry of gas carrying radon through shrinkage cracks between adjacent pieces of concrete in the basement walls or floors. However, the literature suggests that radon diffusion through concrete can also be a cause of high radon levels. The authors suggest that it would be possible to reeduce radon concentrations in homes by closing only the subgrade cracks rather than applying a barrier to radon diffusion over the whole subgrade surface. Subsequent remedial work based on this principle has proved successful in lowering radon concentrations in houses.(SCI)

Some Aspects of Radon and Its Daughter-Products in Man and His Environment
Rundo, J; Markun, F; Plondke, NJ; Sha, JY
Argonne National Lab, IL
Corp. Source Codes: 001960000; 0448000
Sponsor: Department of Energy, Washington, DC
Report No.: CONF-810153-4
1981 9p
Special symposium on natural radiation environment.
Bombay, India, 19 Jan 1981
Portions are illegible on microfiche products
Languages: English
Document Type: Conference proceedings
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8317; NSA0800

Country of Publications: United States
Contract No.: W-31-109-ENG-38
A major but short-lived postprandial increase in the exhalation rate of radon by persons containing no radium was observed. The concentrations of radon and its short-lived daughter-products in houses was unusally high (5 to 10 pCi 1 exp -1, 185 to 370 Bq m exp -3) in some houses with unpaved crawl spaces, and with concrete basements. External counting of radon daughter-products in the residents of one of the radon-contaminated houses indicated that there may be interference with the assay of plutonium in the lungs of persons who live in those houses. (ERA citation 08:024362) (NTIS)

Sources of indoor radon in houses: A review
Bruno, R.C.
* Off. Radiat. Programs, U.S. EPA
J. AIR POLLUT. CONTROL ASSOC VOL. 33, NO. 2, pp. 105-109,
Publ.Yr: 1983:
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH
The purpose of this paper is to examine the significant sources of indoor radon as well as its primary pathways into the indoor environment. While an exact modeling of indoor radon levels is not possible, the simple analysis presented may be used to determine the potential contribution of each source to the total average radon concentration in a typical house. This information is particularly valuable in assigning logical priorities for the development of radon control measures and devices which will be both practical and effective. For the purpose of our analysis, a model of a typical house is defined as a single story house with a floor area of 150 m super(2) and a ceiling height of 2.5 m, enclosing an indoor volume of 375,000 L. It is assumed that the floor of the house is a 10 cm thick concrete on-grade slab and that an additional 150 m super(2) of masonry are used for the house walls. Although it is clear that this simplification is not an accurate physical description of the average house, the conclusions which flow out of our analysis would not be significantly different if a more complex and realistic definition of a typical house were used. (BIO)

The variation of basement radon concentration with barometric pressure
Hernandez, Thomas L.; Sachs, Harvey M.; Ring, James W.
Health Physics, 1984 VOL. 46, NO. 2 (February), p. 440

By comparing 12 radon concentrations with microbarometric data during the period May-June 1981, it can be shown that higher concentrations correspond to falling barometric pressure, while the lower concentrations correspond to steady or rising pressure. This concentration/pressure relationship is evidence that naturally occurring pressure gradients induce large variations in the total time-dependent radon-source flux exhaling from all basement surfaces (building materials and exposed soil).(ENVB)

II. CONTRIBUTING FACTORS

II. CONTRIBUTING FACTORS

AEROSOL PROPERTIES OF INDOOR RADON DECAY PRODUCTS (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY)
MARTELL EDWARD A.
NATL CENTER ATMOSPHERIC RESEARCH, CO,
WHO/ET AL 3RD INTL INDOOR AIR QUALITY & CLIMATE CONF, STOCKHOLM, AUG 20-24, 84, V2, P161(5)
LUNG CANCER RISKS ATTRIBUTABLE TO INDOOR RADON ARE DEPENDENT ON PROPERTIES OF RADON PROGENY AEROSOLS, WHICH IN TURN ARE DEPENDENT ON THE NATURE AND CONCENTRATION OF SMALL PARTICLES IN INDOOR AIR. IN CLEAN FILTERED AIR, RADON PROGENY ARE ATTACHED TO SMALL HYGROSCOPIC PARTICLES OF HIGH MOBILITY WHICH ARE RAPIDLY DEPOSITED ON SURFACES. HOWEVER, PROGENY ATTACHED TO CIGARETTE SMOKE ARE ON LARGE PARTICLES OF LOW MOBILITY WHICH PERSIST IN AIR.
(18 REFERENCES)(ENV)

Attachment of RaA (super(218)Po) to Monodisperse Aerosol
Ho, W.-L.; Hopke, P.K.; Stukel, J.J.
1163 Valdosta Rd., San Jose, CA
* ATMOS. ENVIRON 16(4):825-836, 1982
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH
An attachment kinetics system for contacting a known quantity of radon (super(222)Rn) with monodisperse aerosol under carefully controlled environmental conditions was developed to study the attachment of RaA (super(218)Po) to monodisperse aerosols as a function of particle size, particle concentration, particle composition, temperature, relative humidity, radon concentration and retention time. Monodisperse aerosols with diameters ranging from 2 to 10 mu m were studied. A complete mathematical model was derived to describe the whole experiment and relate the measured quantities to the attachment constant. The plateout of RaA onto the wall surface of the chamber was examined in terms of a plateout constant in order to correct for the wall loss of RaA in the attachment measurements. It was found that the plateout constant decreases with increasing temperature and/or relative humidity. From the attachment measurements, the attachment constant was found to be proportional to particle concentration and particle cross-section area and insensitive to the surface composition of the particles. The probability of an RaA particle collision leading to an attachment to the surface is expressed as the sticking coefficient.(POL)

CONTRIBUTION OF SOIL GAS, POTABLE WATER, AND BUILDING MATERIAL TO RADON IN U.S. HOMES (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY)
KOTHARI B. K.
NEW YORK STATE DEPT HEALTH, WHO/ET AL 3RD INTL INDOOR AIR STOCKHOLM, AUG 20-24, 84, V2, P85(8)

EXTENSIVE REGIONAL SURVEYS OF RADON DAUGHTERS IN DWELLINGS HAVE REVEALED THAT RADON IN SOIL AIR IS THE PRIMARY SOURCE OF INDOOR RADON POLLUTION IN SWEDEN. DOCUMENTATION OF THE NATURAL RADIATION ENVIRONMENT IN A GEOLOGICAL CONTEXT IS INVALUABLE FOR TRACING AREAS OF HIGH RADON RISK. CLASSIFICATION OF LAND INTO HIGH, NORMAL, AND LOW RADON RISK AREAS IS NOW BEING APPLIED IN THE COMPILATION OF RADON RISK MAPS. (1 DIAGRAM, 2 MAPS, 2 REFERENCES, 2 TABLES)(ENV)

The effect of humidity on the detection of radon.
Money M; Heaton B
* Health Phys ,Nov 76, 31 (5) p456-7,
ISSN 0017-9078
Journal Code: G2Hde

The effect of humidity on radon emanation has been found to be of secondary importance relative to other effects, especially pressure, and is generally ignored when considering the external factors affecting levels of radon detected by a sampling system. (MED)

Effect of internal wall covers on radon emanation inside houses
Abu Jarad F.; Fremlin J.H.
Dep. Phys., Univ. Birmingham, Birmingham B15 2TT UNITED KINGDOM
HEALTH PHYS. (U.S.A.) 1983, 44(3):243-248
Coden: HLTPA
Languages: ENGLISH

Most types of paint for the internal walls of houses will reduce radon emanation from building materials. At the same time, the effect of paint will increase the concentration of radon inside the material itself and will increase the radon emanation from unpainted areas. One type of wallpaper contains 6 and 0.3 ppm of uranium in its decorated and undecorated surfaces, respectively, the coloring being the main source of uranium. Other wallpapers appear to be free from uranium. Wallpaper, gypsum and plaster may increase the radon activity inside houses depending on their radium contents.(EMB)

Effect of Local Geology on Indoor Radon Levels: A Case Study
Hawthorne, AR; Gammage, RB; Dudney, CS
Oak Ridge National Lab, TN
Corp. Source Codes: 021310000; 4832000
Sponsor: Department of Energy
Report No.: CONF-840803-15
1984 8p
International conference on indoor air quality and climate, Stockholm, Sweden, 20 Aug 1984
Paper copy only: copy does not permit microfiche production.
Languages: English
Document Type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8504; NSA0900
Country of Publication: United States
Contract No.: AC05-84OR21400

This paper presents the results of radon monitoring in 40 East Tennessee homes that were a component of a larger study to evaluate indoor air quality. Measurements were conducted during two 3-month time periods with passive integrating track etch monitors in each of the forty homes. In a subset of homes, measurements were also conducted with a real-time monitor that provided readings on an hourly basis. The results of the monitoring indicate that about 30% of the homes had radon levels were associated with local variations in geology: most of the homes having higher levels were located on the porous dolomite ridge partially surrounding Oak Ridge, Tennessee.(7 reference, 3 figures, 2 tables) (NTIS)

INDOOR RADON DAUGHTER CONCENTRATIONS AND PASSIVE SMOKING (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY)
BERGMAN HANS ; EDLING CHRISTER; AXELSON OLAV
UNIV HOSPITAL, SWEDEN,
WHO/ET AL 3RD INTL INDOOR AIR QUALITY & CLIMATE CONF, STOCKHOLM, AUG 20-24, 84, V2, P79(6)

RADON DAUGHTERS ARE KNOWN TO ATTACH TO AEROSOL PARTICLES. THE EXTEND TO WHICH RADON DAUGHTERS IN INDOOR AIR MIGHT ATTACH TO CIGARETTE SMOKE WAS RESEARCHED. EXPERIMENTS SHOWED THAT MODERATE CONCENTRATIONS OF RADON DAUGHTERS INDOORS COULD MORE THAN DOUBLE IN THE PRESENCE OF CIGARETTE SMOKE. THE RADON DAUGHTER LEVELS OBTAINED WITH SMOKE MAY IMPLY A SUBSTANTIAL RISK OF LUNG CANCER FOR BOTH ACTIVE AND PASSIVE SMOKERS. (4 GRAPHS, 14 REFERENCES) (ENV)

LONG-TERM MEASUREMENT OF RADON IN A SINGLE FAMILY DWELLING AND ITS CORRELATION WITH SELECTED METEOROLOGICAL VARIABLES (ENGLISH)

HARLEY NH; ALTMAN SM
NYU,SCH MED/NEW YORK//NY/10016
HEALTH PHYSICS , 45(1): 254-255, 1983
Hourly indoor and outdoor measurements of Rn-222 in a single family dwelling have been made in northern New Jersey since April 1981. Several meteorological parameters such as temperature, pressure, humidity, windspeed and direction and soil heat flux have also been measured since July 1982. The radon monitors consist of a 12.5 cm diameter cylinder open at both ends and lined with zinc sulfide alpha phosphor and sit on a 12.5 cm phototube. The variability of indoor radon is adequately described by the measured parameters.(SCI)

MAPPING THE RADON RISK OF OUR ENVIRONMENT (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY)
WILSON CAROLE
SWEDISH GEOLOGICAL, SWEDEN,
WHO/ET AL 3RD INTL INDOOR AIR QUALITY & CLIMATE CONF, Stockholm, Aug 20-24, 84, v2, p85(8)
Extensive regional surveys of radon daughters in dwellings have revealed that radon in soil air is the primary source of indoor radon pollution in Sweden. Documentation of the natural radiation environment in a geological context is invaluable for tracing areas of high radon risk. Classification of land into high, normal and low radon risk areas is now being applied in the compilation of radon risk maps. (1 diagram, 2 maps, 2 references, 2 tables) (ENV)

Measurement of exp 222 Rn Indoors and Outdoors. Progress Report, June 1, 1982-May 31, 1983
Harley, N. H. ; Altman, S. M.
New York Univ. Medical Center, NY.
Corp. Source Codes: 013007000; 4665000
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/EV/10374-3
1983 69p
Portions are illegible in microfiche products.
Languages: English
NTIS Prices: PC A04/MF A01
Journal Announcment:GRAI8408; NSA0800
Country of Publication: United States
Contract No.: AC02-80EV10374
Research progress is reported on a study of the levels and variability of Radon 222 both indoors and outdoors. Sensors were deployed in a single family dwelling and in a high-rise apartment building. Temperature, pressure, relative humidity, rainfall, and wind data were also collected at these sites. Modeling of indoor radon concentrations has been initiated. (ERA citation 08:039358)(NTIS)

Measurement of indoor radon concentrations in public buildings
(English)
Fenyves, EJ; Kinslow, RH
Univ Texas/Richardson/TX/75083
Health Physics, 47(1):204, 1984
Indoor radon concentrations have been measured in a 10 year old two-story building of the University of Texas at Dallas. Variations of the radon concentration from the basement to the second floor in offices, classrooms, laboratories, storage rooms, corridors and other locations have been studied. Seasonal variations of the above concentrations and their dependence on ventilation rates and water usage have been measured. From these data the radiation exposures of students and university personnel from radon-222 and its daughters were estimated. The results are compared with preliminary results obtained from indoor radon measurements carried out in conventional and energy saving homes, hospitals and industrial buildings in the Dallas area. The health aspects of indoor radon pollution in homes and at work are discussed. (SCI)

Measurement of Radon in Dwellings 1955-81
Mjoenes, L.
Statens Straalskyddsinstitut, Stockholm (Sweden).
Corp. Source Codes: 100859000; 5966500
Report No.: SSI-A-82-07
4 May 82 32p In Swedish.
U.S. Sales Only.
Languages: Swedish
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8326
Country of Publication: Sweden
The results are presented in two sets, namely measurements made 1955-56 and measurements after 1972. The results include measurements from 549 dwellings. The classification of the buildings has the following four categories: type of house, ventilation system, building materials and the year of erection. The compilation may form a support to a prestudy of the association with lung cancer and existing radon daugthers. An estimation of individual exposure to radon is made starting from the resident time and the type of buildings. (Atomindex citation 14:717195)(NTIS)

Measurement of sup 222 Rn and Its Relationship to Environmental Variables. Progress Report, June 1984-June 1985
Harley, N. H.
New York Univ. Medical Center, NY. Inst. of Environmental

Medicine.
Corp. Source Codes: 013007004; 4664000
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/EV/10374-5
1985 38p
Portions are illegible in microfiche products.
Languages: English
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8513; NSA1000
Country of Publication: United States
Contract No.: AC02-80EV10374
Research progress on factors controlling indoor radon levels is reported. A seasonal baseline is being determined which can be related to radon diffusion from soil. 18 figures. (ERA citation 10:016983) (NTIS)

Measurements of radon-daughter concentrations in and around dwellings in the northern part of the Netherlands; a search for the influences of building materials, construction and ventilation

Wolfs F.; Hofstede H.; De Meijer R.J.; Put L.W.
Kernfysisch Versneller Instituut, Rijksuniversiteit Groningen, 9747 AA Groningen, Netherlands
HEALTH PHYS. (U.S.A.), 1984, 47(2):271-279
CODEN: HTLPA
Languages: ENGLISH
The concentration of radon daughters has been determined in and around 80 dwellings located in the northern part of the Netherlands by using a one-filter method. Median values of 2.0 and 0.4 mWL were measured for the indoor and outdoor concentrations, respectively. The average outdoor concentration was about an order of magnitude higher for wind directions between SE and SW than for SW-NW. On the average, dwellings with double-pane windows and/or concrete floors were found to have significantly higher radon concentrations than those with single-pane windows and/or wooden floors. For the living room of a particular dwelling 18 measurements were carried out. The data for this dwelling indicate a linear relation between the concentration indoors and outdoors with a slope of 3.8+ or 2.0. This unexpected behavior is thought to be related to ventilation via the crawl space. Measurements of ventilation patterns and measurements of radon concentrations in the living room and in the crawl space are consistent with this picture. (EMB)

Measurements of the Deposition Rates of Radon Daughters on Indoor Surfaces

Toohey, R. E. ; Essling, M. A. ; Rundo, J. ; Hengde, W.
Argonne National Lab., IL.

Corp. Source Codes: 001960000; 0448000
Sponsor: North China Inst. of Radiation Protection, Taiyuan, Shanxi.; Department of Energy, Washington, DC.
Report No.: CONF-831049-3
1983 11p
International seminar on indoor exposure to natural radiation and related risk assessment, Capri, Italy, 3 Oct 1983.
Portions are illegible in microfiche products.
Languages: English
Document Type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8413; NSA0900
Country of Publication: United States
Contract No.: W-31-109-ENG-38

The deposition rates of radon daughters on indoor surfaces have been measured by exposing the window of a proportional counter to the air of a house with high concentrations of radon and its daughters. Deposition velocities for unattached RaA and RaB of approximately 4 mm sec exp -1 were obtained by dividing the deposition rates by the concentrations of unattached daughters in the air. These results agree with those obtained by other workers but are dependent on the assumptions made about the fractions of the daughters which are attached to the atmospheric aerosol.(ERA citation 09:014965)(NTIS)

Measuring Radon Source Magnitude in Residential Buildings
Nazaroff, W. W. ; Boegel, M. L. ; Nero, A. V.
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC.
Report No.: LBL-12484; CONF-810881-1; EEB-Vent---81-8
Aug 81 34p
US Environmental Protection Agency meeting on radon and radon progeny measurement, Montgomery, AL, USA, 27 Aug 1981.
Languages: English
Document type: Conference proceeding
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8216; NSA0700
Country of Publication: United States
Contract No.: W-7405-ENG-48

A description is given of procedures used in residences for rapid grab-sample and time-dependent measurements of the air-exchange rate and radon concentration. The radon source magnitude is calculated from the results of simultaneous measurements of these parameters. Grab-sample measurements in three survey groups comprising 101 US houses showed the radon source magnitude to vary approximately log-normally with a geometric mean of 0.37 and a range of 0.01 to 6.0 pCi L exp -1 h exp -1. Successive measurements in six houses in the northeastern

United States showed considerable variability in source magnitude within a given house. In two of these houses the source magnitude showed a strong correlation with the air-exchange rate, suggesting that soil gas influx can be an important transport process for indoor radon. (ERA citation 07:015678) (NTIS)

The particle size dependent attachment of radon daughters to a carrier aerosol
Haider B.; Ishida J.
Gesellschaft fur Strahlen- und Umweltforschung, Munchen, Institute fur Strahlenschutz, D-8042 Neuherberg GERMANY, WEST
J. AEROSOL SCI. (ELMIRA) (U.S.A.) 1984, 15(3):434-437
Coden: JARSB
Languages: ENGLISH
Most of the airborne radon-222 daughters are attached to aerosol particles. An experimental set-up for measuring the radon daughter activity as a function of the aerosol particle size is described. An electrostatic classifier selects particles of a certain size range from the indoor or natural aerosol. An arrangement of a filter and an alpha detector registers the radioactivity of the particles. Simultaneously the aerosol concentration is measured by an aerosol electrometer which is upgraded for two particle concentrations.(EMB)

PASSIVE SMOKING AND INDOOR RADON DAUGHTER CONCENTRATIONS
BERGMAN H; AXELSON O
LINKOPING UNIV HOSP,DEPT OCCUPAT MED/S-58185 LINKOPING//SWEDEN/
LANCET , 2(N8362): 1308-1309, 1983
Observations about passive smoking should be considered against a background of naturally occurring radioactivity in dwellings, i.e. radon emanating into houses from the ground and from building materials. The decay of radon results in alpha-emitting radon daughters, which attach to aerosol particles in indoor air, such as cigarette smoke, and radon daughter exposure is a well-established risk factor for lung cancer in miners. In support of this view the authors present some preliminary studies of indoor radon daughter concentrations as influenced by cigarette smoke.(SCI)

RADIOLOGICAL EVALUATION OF STRUCTURES CONSTRUCTED ON PHOSPHATE-RELATED LAND,
GUIMOND, RICHARD J. ; WINDHAM SAMUEL T.
EPA OFFICE OF RADIATION PROGRAMS,

PRESENTED AT DOE/UNIV OF TEXAS NATURAL RADIATION ENV 3RD INTL SYM, HOUSTON, APR 23-28, 78, V2, P1457 (19)
A STUDY OF THE RADIOLOGICAL IMPACT OF LIVING IN STRUCTURES BUILT ON RECLAIMED PHOSPHATE-MINE LAND WAS CONDUCTED IN CENTRAL FLORIDA. TRACK ETCH FILM AND OTHER TECHNIQUES WERE USED TO MEASURE BACKGROUND AND ENHANCED LEVELS OF RADIATION. RESULTS SUGGEST THAT AREAS WHICH CONTAIN RADIUM-BEARING SOIL ASSOCIATED WITH PHOSPHATE MATERIALS GENERALLY HAVE A GREATER GAMMA EXPOSURE AND INDOOR RADON DECAY PRODUCT CONCENTRATIONS THAN NORMAL BACKGROUND AREAS. AVERAGE INDOOR RADON DECAY PRODUCT LEVELS OF UP TO 0.20 WORKING LEVEL WERE MEASURED. (1 DIAGRAM, 1 GRAPH, 1 MAP, 8 REFERENCES, 8 TABLES)(ENV)

Radon concentrations and infiltration rates measured in conventional and energy-efficient houses
Hollowell, C. D.; Ingersoll, J. G.: Nazaroff, W. W.: Nero, A. V.; Boegel, M. L.
Health Physics, 1983 45(2): 401 (August)(ENVB)

Radon in dwellings and influencing factors
Stranden E.; Berteig L.
State Inst. Radiat. Hyg., 1345 Osteras
NORWAY
* HEALTH PHYS. (ENGLAND) 1980, 39(2):275-284
Coden: HLTPA
Languages: ENGLISH
Some factors that have influence upon the radon concentration in dwellings are discussed in this paper. Measurements of the exhalation rates from different building materials are presented together with calculations of indoor radon concentrations. The influence of wind and temperature upon the ventilation rate and radon concentration in a test-house have been measured, and the effect of airing and artificial ventilation upon the radon concentration is discussed.(EMB)

Source Characterization and Transport Process Affecting Levels of Radon and Its Decay Products in an Indoor Environment.
Final Technical Report
Wilkening, M. ; Schery, S. D.
New Mexico Inst. of Mining and Technology, Socorro.
Corp. Source Codes: 012640000; 4615500
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/ER/60095-T3
Jul 84 10p

Portions are illegible in microfiche products.
Languages: English
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8511; NSA1000
Country of Publication: United States
Contract No.: AC04-82ER60095

The objectives of this study are to determine the effects of pressure variation on diffusion and flow of radon from porous and fractured media;the effects of natural air exchange processes in indoor environments on radon, thoron and their daughter products; radon daughter ion-aerosol interactions, and new instrumentation and methods. The results obtained during this study are discussed. 12 references, 2 tables. (ERA citation 10:011609)(NTIS)

Source Characterization and Transport Processes Affecting Levels of Radon and Its Decay Products in an Indoor Environment.
*Annual Report
Wilkening, M. ; Schery, S. D.
New Mexico Inst. of Mining and Technology, Socorro. Dept.of Physics.
Corp. Source Codes: 012640011; 9513999
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/ER/60095-T1
5 Jan 84 5p
Languages: English
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8409; NSA0900
Country of Publication: United States
Contract No.: AC04-82ER60095

Research progress in the following areas is reported: (1) exhalation of radon and thoron from soil at a field station; (2) measurements of indoor radioactivity; (3) instrumentation development for measurement of radon, thoron, and their daughters; (4) radon levels in indoor and outdoor locations measured with passive track-etch detectors; (5) ion-aerosol interactions; and (6) a study of radon levels and their use for measuring air exchange in caves. (ERA citation 09:008527)(NTIS)

Source Characterization and Transport Processes Affecting Levels of Radon and Its Decay Products in an Indoor Environment.
*Final Technical Report
Wilkening, M. ; Schery, S. D.
New Mexico Inst. of Mining and Technology, Socorro. Dept. of Physics.

Corp. Source Codes: 012640011; 9513999
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/ER/60095-T2
Jul 84 10p
Portions are illegible in microfiche products.
Languages: English
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8425;NSA0900
Country of Publication: United States
Contract No.: AC04-82ER60095

Research performed under contract to DOE is summarized. Specific topics discussed include: exhalation of radon and thoron from soil at a field station; indoor radioactivity-measurements and models; instrumentation development; radon in indoor and outdoor locations using passive track-etch detectors; ions and aerosols: and radon levels and air exchange in caves. 2 tables. (ERA citation 09:038409)(NTIS)

THE SENSITIVITY TO HUMIDITY OF RADON MONITORING INSTRUMENTS (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY),

SCHMIED HANNES
AIB CONSULTING ENGINEERS, SWEDEN,
WHO/ET AL 3RD INTL INDOOR AIR QUALITY & CLIMATE CONF, STOCKHOLM, AUG 20-24, 84, V2, P119(6)

FIELD COLLECTION WAS CALIBRATED. FROM FOUR CALIBRATIONS IN A RADON CHAMBER IT WAS CLEAR THAT THE INSTRUMENT WAS SENSITIVE TO ABSOLUTE HUMIDITY. TECHNIQUES FOR COMPENSATING FOR THIS SENSITIVITY IN MEASURED RESULTS ARE EXPLAINED. (4 GRAPHS, 7 REFERENCES, 1 TABLE)(ENV)

A STUDY OF INDOOR AEROSOL SIZE DISTRIBUTION AND ATTACHMENT OF RADON DAUGHTERS (ENGLISH)

JOHANSSON GI; AKSELSSON R; BOHGARD M; NYMAN S; PETERSSON H; SAMUELSSON C
DEPT NUCL PHYS/S-22362 LUND//SWEDEN/;
DEPT ENVIRONM HLTH/S-22362
LUND//SWEDEN/; HOSP LUND,DEPT RADIAT PHYS/S-22185 LUND//SWEDEN/

JOURNAL OF AEROSOL SCIENCE , 14(3): 455-458, 1983

The particle size distribution in 11 different dweellings was studied during 5-7 days, samples being taken every 15 min. Large variation in the aerosol concentration has been found. Also the size distribution of the aerosol varies depending on the level of activity in the home, e.g. smoking and cooking. The average area median diameter found in the dwellings was 0.2um. A technique for the measurement of radon daughter distribution on different

airborne matter was developed and tested. The method is based on the use of an electrical mobility analyzer and alpha-spectrometry of the radon daughtes collected on a fluoropore filter. Some results are presented and discussed.(SCI)

Time-averaged indoor Rn concentrations and infiltration rates sampled in four U.S. cities

Doyle, SM; Nazaroff, WW; Nweo, AV
Building Ventilation and Indoor AIr Quality Program
Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720

Health Physics, 1984, 47(4):579-586
CODEN: HLTPA
Languages: English

Indoor RN concentrations, measured in 58 houses during a 4- to 5-month period during the winter and spring of 1981-82, varied from 0.16 pCi lsup -sup 1 (4-590 Bq msup -sup 3). Average infiltration rates were determined for each house during the period, based on a measurement of the effective leakage area, and an infiltration model, and found to range from 0.2-2.2 air changes per hour (hsup -sup 1). Indoor Rnm concentrations correlated poorly with infiltration rates for houses within each city as well as for the entire sample. Differences in Rn entry rates among houses thus appear to be more important than differences in infiltration rates in determining whether a house has high indoor Rn levels, consistent with previous indications from grab-sample measurements. Radon entry rates and indoor concentrations were generally higher in houses in Fargo, ND and Colorado Springs, CO, than in houses in Portland, ME, and Charleston, NC. (EMB)

Transport of Radon from Soil into Residences

Nazaroff, WW; Nero, AV
California Univ., Berkeley. Lawrence Berkeley Lab.

Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC
Report No.: LBL-16823; CONF-840803-4
Feb 84 15p
International conference on indoor air quality and climate, Stockholm, Sweden, 20 Aug 1984
Portions are illegible in microfiche products.
Languages; English
Document Type: Conference proceedings

NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8501; NSA0900
Country of Publication: United States
Contract No.: AC03-76SF00098

To develop effective monitoring and control programs for indoor radon it is important to understand that causes of the broad range of concentrations that has been observed. Measurements of indoor radon concentration and air-exchange rate in dwellings of several countries indicate that this variability arises largely from differences among structures in the rate of radon entry. Recent evidence further suggests that the major source of indoor radon in many circumstances is the soil adjacent to the building foundation and that pressure-driven flow, rather than molecular diffusion, is the dominant transport process by which radon enters the buildings. Key factors affecting radon transport from soil are radon production in soil, flow-inducing mechanisms, soil permeability, and building substructure type. (24 references, 1 figure)
(ERA citation 09:044520) (NTIS)

III. VENTILATION & ENERGY EFFICIENCY

III. VENTILATION & ENERGY EFFICIENCY

Effect of Weatherization on Radon Levels in Maine Dwellings
Hess, C. T. ; Hill, R. C.
Maine Univ. at Orono.
Corp. Source Codes: 050804000; 3877000
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/CS/20458-T1
1984 17p
Languages: English
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8509; NSA1000
Country of Publication: United States
Contract No.: AC01-77CS20458

A study of radon concentration in the air of 30 Maine dwellings was performed before and after weatherization during November 1982-May 1983. The average radon (.75 pCi/l) was lower than a group of houses in a previous study in October 1980-May 1981 (3.1 pCi/l). The after-weatherization levels show an increase over the before-weatherization levels. Trailers were found to have lower radon concentrations than houses. The maximum value measured was 3.2 pCi/l before and 6.2 pCi/l after correction for season of exposure. 13 references, 5 figures, 3 tables. (ERA citation 10:009056)(NTIS)

Health effects of radon from insulation of buildings.
Cohen, BL
University of Pittsburgh, Pittsburgh, PA 15260
Health Phys, (ENGLAND), 1980 39(6):937-41
CODEN: HLTPA
Languages: English

Available information is reviewed on radon levels in buildings, health effects of radon, and increased exposure from insulation of buildings. If current estimates of health effects of radon are accepted, it is concluded that energy conservation by insulation of buildings would cause at least 10,000 extra fatal cancers per year in the U.S. due to reduced ventilation.(EMB)

Health Risk Associated With Energy-Conservation-Radon Increases In Well-Insulated Houses.
Inhaber, H;Caton, G;Gove, R
Oak Ridge Natl Lab/Oak Ridge/TN/37830
Transactions of the American Nuclear Society, 41:50-51, 1982 (SCI)

Human Disease from Radon Exposures: The Impact of Energy Conservation in Residential Buildings
Budnitz, RJ;Berk, JV; Hollowell, CD; Nero, AV; Nazaroff, WW; Rosenfeld, AH
U.S. Lawrence Berkeley Lab, Calif.
Energy & Buildings, Aug 79 2(3): 209
Reduced ventilation in buildings, a major energy conservation measure, can lead to elevated levels of indoor generated air contaminants, such as radon-222. The sources, concentrations, and health effects of indoor radon-222 are examined. Continuous exposure to 1 NCI/Cu m increases the annual added risk of lung cancer by about 100 cases/million. Measures now available to limit increases of indoor radon-222 concentrations while stil achieving energy conservation are described. (2 diagrams, 2 graphs, 20 references) (ENV)

Human Disease from Radon Exposure: The Impact of Energy Conservation in Buildings
Budnitz, RJ; Berk, JV; Hollowell,CD; Nazaroff, WW; Nero, AV
California Univ., Berkeley. Lawrence Berkeley Lab.
Sponsor: Department of Energy
8 Aug 78 16p
Language: English
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI7904; NSA0300
Contract No.: W-7405-ENG-48
The level of radon and its daughters inside conventional buildings is often higher than the ambient background level. Interest in conserving energy is motivating home-owners and builders to reduce the rate of infiltration of fresh air into homes, and hence to increase the concentration of indoor air contaminants, including radon. It is unlikely, but possible, that the present radiation levels from radon daughters account for much of the lung cancer rate in non-smokers. In any event, it is likely that some increased lung cancer risk would result from increased radon exposures: hence it is desirable not to allow radon concentrations to rise signifi-cantly.There are several ways to circumvent the increased risk without compromising energy conservation considerations.
(ERA citation 03:057614) (NTIS)

INDOOR RADON LEVELS IN THE NORTHEASTERN USA: EFFECTS OF ENERGY EFFICIENCY IN HOMES
FLEISCHER R L; MOGRO-CAMPERO A; TURNER L G
GEN. ELECTRIC RES. DEV. CENT., SCHENECTADY, NY 12301.
HEALTH PHYS, 45 (2):407-12 1983
CODEN: HLTPA
Language: ENGLISH
Elevated 222Rn levels in modern homes that had low air interchange rates with the out-of-doors prompted a survey of

solar and conventional homes in northeastern New York State [USA]. The solar homes as a group had 3-fold the 222Rn levels of the conventional homes, and specific problems existed that were introduced or exaggerated by modern construction. The highest 2 levels of Rn in the solar homes gave radiation doses over 30 yr that were known to produce lung cancer in 1% of homes gave radiation doses over 30 yr that were known to produce lung cancer in 1% of Ur miners. Summer readings in more than half of the cases were different from winter ones by a factor of .gtoreq. 2, so that year-round measurements were necessary for precise dosimetry. The track etching technique was suited for such measurements.(ENVB)

Radioactivity (Radon and Daughter Products) as a Potential Factor in Building Ventilation
Kusuda, T; Hunt, CM; McNall, PE
NBS
Ashrae J, Jul 79 21(7):30
State of the art information on radon and its daughter products in air within buildings is reviewed. There are no national standards for maximum allowable levels in the residential environment. A major reason for variations in reported radon levels may be measurement errors. However radon and its daughter products may be limiting factors in establishing ventilation rates in residences. (1 graph, 21 references, 3 tables) (ENV)

Radon and Radon Daughter Measurements in Solar Energy-Conservation Buildings
George, A. C. ; Knutson, E. O. ; Franklin, H.
Department of Energy, New York. Environmental Measurements Lab.
Corp. Source Codes: 062709001; 9505987
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/EML-407
Jul 82 16p
Languages: English
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8308; NSA0700
Country of Publication: United States
Measurements of radon and radon daughters in 11 buildings in five states, using active or passive solar heating showed no significant increase in concentration over the levels measured in buildings with conventional heating systems. Radon levels in two buildings using rock storage in their active solar systems exceeded the US Nuclear Regulatory Commission's 10 CFR 20 limit of 3 pCi/l for continuous exposure. In the remainder of the buildings, radon concentrations were found to be at levels considered to be normal. It appears that the slightly elevated indoor radon concentrations result from the local geological

formations and from the tightening of the buildings rather than as a result of the solar heating technology. (ERA citation 07:062009)(NTIS)

Radon concentrations and infiltration rates measured in conventional and energy-efficient houses.
Hollowell, CD; Ingersoll, JG; Nazaroff, WW; Nero, AV; Boegel, ML
Health Physics, 45(2):401, August 1983(ENVB)

IV. RADON IN WATER

IV. Radon in Water

Acceptable concentration of radon in drinking water.
Hems, G
Air Water Pollut (ENGLAND), Oct 1966, 10 (10) p769-75
ISSN D32B-0000 Journal Code: 32B
Languages: ENGLISH(MED)

The contribution of radon in tap water to indoor radon concentrations.
Gesell, Thomas F; Prichard, Howard M.
Univ. of Texas
Presented at DOE/Univ. of Texas Natural Radiation Env 3rd Intl Sym, Houston, Apr 23-28, 78, v2, p1347(17)
The contribution of radon 222 in domestic water supplies to the concentration of radon in indoor atmospheres was investigated and found to be significant for concentrations over a few thousand PCI/L. A model predicting average indoor increments due to this source is described and supported by a series of measurements made in the laboratory and in private homes in Houston. The importace of the dwelling volume and the air change rate is discussed. (11 graphs, 12 reference, 5 tables) (ENV)

Cytogenetic investigation of people in Finland using household water with high natural radioactivity
Stenstrand K.; Annanmaki M.; Rytomaa T. Inst. Radiat. Protect.,
HEALTH PHYS. (ENGLAND) ,1979, 36/3 (441-444),
* Coden: HLTPA
Languages: ENGLISH
In some areas of Finland ground water with high concentrations of natural radioactivity has been found in Artesian wells. The highest concentrations found so far are 1.2 mu Ci/l (45 kBq/l) of radon-222, 256 pCi/l (9.5 Bq/l) of radium-226 and 14.9 mg/l of uranium (Ca77). The main problem connected with radioactivity is the high radon concentration in the air of dwellings where radon-rich household water is used. We show here that residents in such dwellings have a significantly elevated frequency of chromosome aberrations in peripheral blood lymphocytes.(EMB)

Determination of Environmental or Occupational Rn-222 in Air and Water and Ra-226 in Water with Feasible and Rapid Methods of Sampling and Measurement
* Pohl, E., and J. Pohl-ruling

Health Physics, vol. 31, no. 4, pages 343-348, 14 references,
October 1976
Coden: HLTPAO
For air-sampling 30-liter containers of flexible foil are taken to the sites. To measure the RN-222 and Ra-226 content of water, special bottle are used with volumes of 0.5 and 2.5 liters respectively. All samples are measured in the laboratory. In this way it is possible to take a great number of samples at the sites considered, which is necessary to obtain significant annual mean values. The measuring equipment consists of 10-20 liter ionizaion chamber in connection with an electronic electrometer and a chart-recorder. The air sample is transferred very rapidly into the evacuated chamber, so that one can define the zero-point for the increase in ionization current due to the short-lived decay products. The radon content of a water sample is also transferred as fast as possible into the chamber with inactive air streaming through a de-emanating bottle. Changeable central electrodes keep the background low and permit a rapid succession of measurements. For the determination of small Ra-226 contents double-chamber equipment with background compensation is used.(OSH)

An estimate of population exposures due to radon in public water supplies in the area of Houston, Texas.

Prichard HM; Gesell TF
University of Texas, School of Public Health, Houston.
Health Phys (UNITED STATES) ,Oct 1981, 41 (4) p599-606,
ISSN 0017-9078
Journal Code: G2H
Languages: ENGLISH
An estimate of the incremental population lung exposures(WLM) attributable to the domestic use of ground waters containing RN-222 is made for the vicinity of Houston, Texas. Because of the complexity of the water distribution system, extensive water sampling was required to characterize the concentration of radon in the water in various areas. Models describing the transfer of radon from water to indoor air and the resulting indoor concentrations were developed and experimentally tested. Census data on population and housing characteristics were folded into the final model used to compute annual population exposure of 4000 WLM (approx. 40,000 rem) to the 1.6 million inhabitants of the study area. The resulting estimates are discussed in the context of similar exposures brought about by other technological activities.(MED)

GEOLOGIC AND HYDROLOGIC FACTORS CONTROLLING RADON-222 IN GROUND WATER IN MAINE USA

BRUTSAERT W F; NORTON S A; HESS C T; WILLIAMS J S
DEP. CIV. ENG., UNIV. MAINE, ORONO, MAINE 04469.

* GROUND WATER 19 (4). 1981. 407-417.
CODEN: GRWWA
Language: ENGLISH

High 222Rn concentrations exist in ground water from most granitic rocks in Maine. Some values exceed the suggested limit of 500 pCi/l (USA-EPA[Environmental Protection Agency], 1976) by > 100-fold. Although high values (.hivin.x = 22,100 pCi/l) were conclusively linked with the granites, high values were also present in ground water in metasedimentary rocks from sillimanite- (.hivin.x = 13,630 pCi/l) and sillimanite-orthoclase zone metamorphic terrains. Metamorphic (anatectic) pegmatites with hydrothermally introduced U were thought to be the source of Rn in high grade terrain. At lower grade (chlorite to staurolite), no relationship exists between 222Rn content and metamorphic grade, although each rock formation had a somewhat characteristic 222Rn range from ground water ranges which overlapped. Local 222Rn variations existed within the same rock body, reflecting local geologic and hydrologic conditions. Data on well depth, type of well, well yield, overburden type and thickness and water chemistry showed that 222Rn may increase slightly with well depth up to 50-75 m and was essentially constant thereafter. Low yield wells, generally associated with areas of thin overburden, had higher 222Rn values than high yield wells, normally associated with thick sand and gravel overburdens. 222Rn concentrations decreased with increasing Na concentrations, suggesting that low 222Rn wells were closely linked with surface waters. No other chemical parameter (Na, K, Ca, Mg, Fe, Mn, Zn or Cu) correlated with 222Rn content within a single rock unit.(BIO)

Monitoring for 228Ra in water supplies(letter)

Mills WA; Ellett WH; Sullivan RE

* Health Phys ,Dec 1980, 39 (6) p1003
ISSN: 0017-9078
Journal Code: G2Hde:
Languages: ENGLISH

It is not known whether measured ratios of indoor are typical regionally or nationally. The rationale for not requiring separate 226Ra analysis under the drinking water regulations was economic. The authors contend that additional monitoring, based on knowledge of local conditions, would serve to minimize the number of undetected contaminated supplies at a much lower national cost than a rigid requirement for 226Ra analysis. (MED)

NATIONWIDE USA OCCURRENCE OF RADON IN PUBLIC WATER SUPPLIES

HORTON T R
U.S. ENVIRONMENTAL PROTECTION AGENCY, EASTERN ENVIRONMENTAL RADIATION FACILITY, P.O. BOX 3009, MONTGOMERY, AL 36193.

27TH ANNUAL MEETING OF THE HEALTH PHYSICS SOCIETY, LAS VEGAS, NEV., USA, JUNE 27-JULY 1, 1982.
HEALTH PHYS 43 (1): 92, 1982.
Coden: HLTPA
Language: ENGLISH

The U.S. Environmental Protection Agency (USEPA) began a systematic, nationwide radon in water sampling program in November 1980. The criteria for sampling were the following: 1) a public water supply serving a minimum of 1,000 people, 2) the source of the public water supply is groundwater, and 3) the water sample must be finished water. Prior to November 1980, the USEPA had gathered radon results for approximately 1,000 water supplies in 25 states. These water supplies included both private and public groundwater supplies and surface supplies independent of population served. The present collection effort has sampled more than 2,000 water supplied in 29 states (as of December 1981). Along with the radon determinations for each sampled water supply, gross alpha and beta were also determined. In many cases radium-226 and isotopic uranium concentrations are measured. Results through May of 1982 are presented.(BIO)

Radon-222 in municipal water supplies in the central United States.

Prichard HM; Gesell TF
University of Texas, School of Public Health, Houston.

Health Phys (UNITED STATES), Nov 1983, 45 (5) p991-3,
ISSN 0017-9078
Journal Code: G2H
Contract/Grant No.: ES01742-02
Languages: ENGLISH

Radon-222 in domestic water supplies can be an important source of radon in the indoor atmosphere, producing an increment of 1 pCi/L in the indoor air for every 10,000 pCi/L in the water. The actual conversion factor if highly dependent on water use, dwelling volume and the degree of air infiltration. As houses are tightened for the sake of energy conservation, the importance of all indoor sources of radon, including the water supply are correspondingly enhanced. While several accounts of radon in ground waters have been published, much of that information has been influenced by prior knowledge of high levels in the area surveyed. Furthermore, much of the currently available data deal with small private systems, as opposed to the larger public

supplies that would be important factors in population dose calculations. The survey reported in this article represents an effort to conduct a "blind" sampling of these muncipal ground water supplies.(MED)

RADON-222 IN MUNICIPAL WATER SUPPLIES IN THE CENTRAL USA
PRICHARD H M; GESELL T F
UNIV. TEXAS SCH. PUBLIC HEALTH, HOSUTON, TEX. 77025.
HEALTH PHYS 45 (5): 991-993, 1983.
Coden: HLTPA
Language: ENGLISH(BIO)

Radium and radon in Danish drinking water
Ulbak, K.: Klinder, O.
National Institute of Radiation Hygiene, DK-2700 Bronshoj, Copenhagen, DENMARK
RADIAT. PROT. DOSIM. (ENGLAND), 1984, 7/1-4 (87-89)
Coden: RPDOD
Languages: English(EMB)

Rapid measurements of 222Rn concentrations in water with a commercial liquid scintillation counter.
Prichard HW; Gesell TF
* Health Phys ,Dec 1977, 33 (6) p577-81
ISSN: 0017-9078
Journal Code:G2H
Languages: ENGLISH
A technique is described by which concentrations of Rn-222 in water as low as 10 pCi/l can be determined by a 40-min. count of a 10-ml sample. Preparation time is about 1 min/sample, and no special equipment is required other than access to a commercial liquid scintillation system.(MED)

RAPID MEASUREMENTS OF RADON-222 IN WATER BY IN-SITU GERMANIUM LITHIUM SPECTROMETRY
KOMURA K; SAKANOUE M
KANAZAWA UNIV., KANAZAWA.
23RD ANNUAL MEETING OF THE JAPAN RADIATION RESEARCH SOCIETY, NAGASAKI, JAPAN, OCT. 10-12, 1980.
J RADIAT RES 22(1): 80, 1981.
CODEN: JRARA
Language: ENGLISH(BIO)

Study of the 222Ra-short-lived daughter disequilibrium in a mixed maritime and continental atmosphere near granitic soils.
Renoux A; Tymen G; Le Gac J
* Health Phys ,Aug 1980, 39 (2) p291-8
ISSN: 0017-9078
Journal Code:G2H(MED)

V. MEASUREMENT & MODELING

V. MEASUREMENT & MODELING

An alpha-scintillation method for measuring low radon concentrations in air.
Kobal, I.; Skofljanec, M.; Kristan, J.
Univ. of Ljubljana, Jamova 39, YU-61000 Ljubljana, Yug.
International symposium on the monitoring of radioactive airborne and liquid releases from nuclear facilities Portoroz, Yug. Sept. 5-9, 1977
Monitoring of radioactive effluents from nuclear facilities. IAEA Proceedings Series. Subject Group II: Nuclear Safety and Environmental Protection/ Radiological Safety pp. 173-180
Publ.Yr: 1978
Publ: Vienna International Atomic Energy Agency
illus. refs.
Languages: ENGLISH
Doc Type: CONFERENCE PAPER
A vacuum pump sucks 20-100 L of air through concentrated sulfuric acid to remove moisture, then through a specially designed double spiral tube filled with glass beads. The trap is cooled with liquid N2 and Rn removed from the gas phase to an alpha scintillation cell. The method is sensitive K0.01 pCi/L. (AM)(POL)

Alpha-Spectroscopic Techniques for Field Measurement of Radon Daughters
Nazaroff, W. W.; Nero, A. V.; Revzan, K. L.
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC.
Report No.: LBL-10769; CONF-810153-1
Jun 81 15p
Special symposium on natural radiation environment, Bombay, India, 19 Jan 1981.
Languages: English
Document Type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8204; NSA0600
Country of Publication: United States
Contract No.: W-7405-ENG-48
Alpha spectroscopic techniques have not often been used to measure radon daughter concentrations in field studies because the equipment required is bulky and expensive. With advances in integrated circuit technology, less expensive, portable instruments have been developed that now make it possible to use these techniques to measure the low concentrations of radon daughters typically found indoors. One of two procedures may be used, two-count or single-count, depending on whether precision of measurement or rapidity of measurement is the more important objective.(NTIS)

Associations between grab sample and integrated radon measurements in dwellings in Maine and Texas Prichard H.M.; Gesell T.F.; Hess C.T.; et al. Univ. Texas Sch. Public Health, Houston, TX 77025 U.S.A.
ENVIRON. INT. (U.S.A.) 1982, 8(1-6):83-87
Coden: ENVID
Languages: ENGLISH
Radon concentrations were measured in several locations in each of approximately 100 dwellings in central Maine and in Houston, TX. Integrated samples were taken during the heating (or cooling) seasons with commercially available passive alpha track devices, while grab samples were taken at the time of integrated sampler deployment. It was found that both indoor and outdoor measurements in both areas were distributed log normally, and that the geometric mean of indoor measurements in Maine was three times higher than that of corresponding measurements in the Houston area. It was also noted that the mean of the indoor grab sample measurements was not significantly different from the mean of the indoor integrated measurements, and that the degree of correlation between the grab samples and a given indoor integrated sample was nearly as good as between integrated samples taken at different living area locations.(EMB)

An automated atmospheric radon sampling system.
Newstein H; Cohen LD; Krablin R
Atmos Environ,(England) Oct 1971, 5 (10) p823-31
ISSN 0004-6981
Journal Code: 97B
Languages: ENGLISH (MED)

AUTOMATED SYSTEM FOR MEASURING AIR EXCHANGE RATE AND RADON CONCENTRATION IN HOUSES
NAZAROFF W W; OFFERMANN F J; ROBB A W
BUILD. VENTILATION INDOOR AIR QUALITY PROGRAM, ENERGY ENVIRON. DIV.,
LAWRENCE BERKELEY LAB., UNIV. CALIF., BERKELEY, CA 94720, USA.
HEALTH PHYS, 45 (2): 525-38, 1983
CODEN: HLTPA
Language: ENGLISH
An automated system for continuously measuring the air exchange rate and 222Rn concentration in an occupied residence was developed. The air exchange rate was measured over 90 min intervals by tracer gas decay using SF6 as the tracer gas. The Rn-concentration was measured over 3 h intervals using a flow-through scintillation cell. Temperatures at up to 7 points were measured every half hour. A microcomputer system controlled the measurements, performed

preliminary data analysis and logged the data and results. Continuous measurement of ventilation rate and Rn concentration permitted the effective Rn source magnitude to be calculated as a function of time. The 1st field application of this system was a study in Rochester, NY [USA], of residential air exchange rates and indoor air quality. For the 8 houses monitored, the mean values over 4-14 day periods ranged from < 0.2-2.2 pCi/l for Rn, 0.22-1.16/h for air exchange rate and < 0.05-0.75 pCi/l per h for Rn source magnitude.(BIO)

CALIBRATION OF A DIFFUSION SAMPLER USED FOR THE MEASUREMENT OF UNATTACHED RADON DAUGHTER PRODUCTS

SUBBA RAMU M C
AIR MONIT. SECT., DIV. RADIOL. PROT., BHABHA AT. RES. CENT., BOMBAY 400 085, MAHARASHTRA, INDIA.

ATMOS ENVIRON, 14 (1): 145-8, 1980
CODEN: ATENB
Language: ENGLISH

A diffusion sampler for the collection of unattached Rn daughter products was calibrated and had an efficiency of about 90% at a flow rate of 11 min-1. Previous lower efficiencies apparently were caused by insufficient precautions in excluding aerosols from the calibration systems. Studies showed that diffusion samplers can conveniently be used for investigation of the formation of radiolytic aerosols in filtered gases and air, and of the attachment of Rn daughter atoms or ions to aerosols. [This study is relevant to occupational health and air pollution.] (BIO)

Characterization of Radon Levels in Indoor Air

George, A. C.
Department of Energy, New York. Environmental Measurements Lab.

Corp. Source Codes: 062709001; 9505987
Sponsor: Department of Energy, Washington, DC.
Report No.: CONF-820627-16
1982 22p
75. annual meeting on the Air Pollution Control Association, New Orleans, LA, USA, 20 Jun 1982.
Languages: English
Document Type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8318; NSA0800
Country of Publication: United States

The purpose is to describe the different types of monitoring and sampling techniques that can determine the radiation burden of the general public from radon and its decay products. This is accomplished by measuring the range and distribution of radon and radon decay products through

broad surveys using simple and convenient integrating monitoring instruments. For in-depth studies of the behavior of radon decay products and calculation of the radiation dose to the lung, fewer and more intensive and complex measurements of the particle size distribution and respiratory deposition of the radon decay products are required. For diagnostic purposes, the paper describes measurement techniques of the sources and exhalation rate of radon and the air exchange inside buildings. Measurement results form several studies conducted in ordinary buildings in different geographical areas of the United States, using the described monitoring techniques, indicate that the occupants of these buildings are exposed to radon and radon decay product concentrations, varying by as much as a factor of 20. (ERA citation 08:027425)(NTIS)

A continuous monitor for the measurement of environmental radon.
Chittaporn P; Eisenbud M; Harley NH
* Health Phys ,Aug 1981, 41 (2) p405-10
ISSN 0017-9078
Journal Code:G2H
Contract/Grant No.: ES-00260; CA-13343
Languages: ENGLISH
This work describes a new continuous environmental monitor which measures radon alone without interference from radon daughters. The detector is a cylinder (13cm diameter by 14cm high) and is lined with alpha scintillation phosphor on a Mylar substrate. Scintillation counting provides an efficient and reliable low background system to detect alpha radioactivity.(MED)

Dose Estimation by Simultaneous Measurement of the Radon/Thoron Concentration and the Equilibrium Factors in Air Using a Passive Dosemeter(DISS)
Urban, M.
Kernforschungszentrum Karlsruhe G.m.b.H. (Germany, F.R.). Hauptabteilung Sicherheit.
Corp. Source Codes: 056218034; 9201717 Sponsor: Karlsruhe Univ. (T.H.) (Germany, F.R.). Fakultaet fuer Elektrotechnik.
Report No.: KFK-3726
Mar 84 113p
In German.
U.S. Sales Only.
Languages: German

NTIS Prices: PC A06/MF A01
Journal Announcement: GRAI8508; NSA0900
Country of Publication: Germany, Federal Republic of
Responsible for an increased radiation exposure is the inhalation of radon and its short lived daughters. A time integrating passive dosemeter was developed to determine the concentrations of the radon isotopes as well as their equilibrium factors. The alpha energy spectrum inside a dosemeter is measured by means of a nuclear track detector. The concentrations in air and the equilibrium factors are calculated by using a new mathematical dosemeter model. A small pilot study in houses was done to test the dosemeter. (ERA citation 09:050480)(NTIS)

FIELD EVALUATION OF EBERLINE'S RADON DAUGHTER WORKING LEVEL MONITOR (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY),
DOWNARD T. R. ; GEIGER E. L.; MILLARD J. B.
THERMO ELECTRIC CORP, NM,
WHO/ET AL 3RD INTL INDOOR AIR QUALITY & CLIMATE CONF, STOCKHOLM, AUG 20-24, 84, V2, P99(6)
THE EBERLINE INSTRUMENT DIV. OF THERMO ELECTRIC CORP. DEVELOPED A MICROCOMPUTER-BASED PORTABLE INSTRUMENT FOR MEASURING POTENTIAL ALPHA ENERGY OR WORKING LEVELS OF RADON DECAY PRODUCTS. TEST DATA WERE OBTAINED IN TWO RADON CHAMBERS, IN HOMES IN NEW MEXICO, AND IN BUILDINGS UNDERGOING REMEDIAL ACTION. CALIBRATION WITH AN ELECTROPLATED ALPHA SOURCE GAVE THE SAME RESULTS AS CALIBRATION IN A RADON CHAMBER. THE COEFFICIENT OF VARIATION BETWEEN UNITS WAS WITHIN 10% WITHOUT ANY NORMALIZATION OF DATA. (2 GRAPHS, 3 REFERENCES, 2 TABLES) (ENV)

Improved radon daughter monitoring procedure.
Rolle R
Am Ind Hyg Assoc J (United States) ,Mar-Apr 1969,
30 (2) p153-60,
ISSN 0002-8894
Journal Code: 3CI
Languages: ENGLISH
(MED)

An improved technique for measuring working levels of radon daughters in residences.
Nazaroff, WW
Health Phys, Oct 1980, 39(4):683-6
ISSN: 0017-9078
Journal Code: G2H
Languages: English (MED)

Indoor Radon Concentrations with track-etch detectors (English)
Oswald, RA; Alter, HW; Gingrich, JE
Terradex Corp/Walnut Creek/CA/94598
Health Physics, 43(1):122, 1982 (SCI)

Indoor radon source fluxes: Experimental tests of a two-chamber model
Hernandez T.L.; Ring J.W.
Cent. Energy Environ. Stud., Princeton Univ., Princeton, NJ 08544 U.S.A.
ENVIRON. INT. (U.S.A.) ,1982, 8(1-6):45-57
CODEN: ENVID
Languages: ENGLISH
Modeling houses as two coupled chambers, namely, the living area and basement, predicts more accurately the total indoor radon source flux from building materials and geology than a one-chamber model in houses with disparate radon concentrations. Three regional surveys found mean radon concentration ratios between basement and living area to range from 1.4 to 4.2, implying weak interchamber coupling in most cases. The invariability of second-order system parameters under steady infiltration but different initial conditions confirms the adequacy of the two-chamber model. The presence of a characteristic radon source flux was detected within the basements of two houses, in one case across different infiltration, coupling, and initial conditions. One-chamber models fit to two-chamber tracer gas data in one house show a source flux variation of a factor of 6 across changing coupling, while the two-chamber source flux variation was only a factor of 1.5. A substantial fraction of the apparent one-chamber living area source flux in these cases is the variable convective radon flux from the basement. The technique is not sensitive enough to detect living area source fluxes if either the interchamber coupling is strong or if the basement source flux is substantially larger.(EMB)

Instrumentation for a Radon Research House
Nazaroff, W. W. ; Revzan, K. L. ; Robb, A. W.
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC.
Report No.: LBL-12564; CONF-811048-3
Jul 81 7p
International symposium on indoor air pollution, health and energy conservation, Amherst, MA, USA, 13 Oct 1981.
Languages: English Document Type: Conference proceeding
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8212; NSA0700
Country of Publication: United States
Contract No.: W-7405-ENG-48

A highly automated monitoring and control system for studying radon and radon-daughter behavior in residences has been designed and built. The system has been installed in a research house, a test space contained in a two-story wood-framed building, which allows us to conduct controlled studies of (1) pollutant transport within and between rooms, (2) the dynamics of radon daughter behavior, and (3) techniques for controlling radon and radon daughters. The system's instrumentation is capable of measuring air-exchange rate, four-point radon concentration, individual radon daughter concentrations, indoor temerature and humidity, and outdoor weather parameters (temperature, humidity, modules, wind speed, and wind direction). It is also equipped with modules that control the injection of radon and tracer gas into the test space, the operation of the forced-air furnace, the mechanical ventilation system, and the mixing fans located in each room. A microcomputer controls the experiments and records the data on magnetic tape and on a printing terminal. The data on tape is transferred to a larger computer system for reduction and analysis. In this paper we describe the essential design and function of the instrumentation system, as a whole, singling out those components that measure ventilation rate, radon concentration, and radon daughter concentrations. (ERA citation 07:005416)(NTIS)

Intercomparison and Intercalibration of Passive Radon Detectors in North America
George, A. C. ; Hinchliffe, L. ; Fisenne, I. M. ; Knutson, E. O.
Department of Energy, New York. Environmental Measurements Lab.
Corp. Source Codes: 062709001; 9512945
Sponsor: Department of Energy, Washington, DC.
Report No.: EML-442
May 85 22p
Languages: English
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8526; NSA1000
Country of Publication: United States

To evaluate the state-of-the-art of radon measurements,

three types of passive devices commonly used in North America by several groups involved in radon programs were exposed to two known levels of radon at the Environmental Measurements Laboratory. Although scintillation cells are not passive devices, they were also included in the high radon environment because of their widespread usage. The higher concentration (2500 Bq.m exp -3) was achieved in an environmental chamber with controlled temperature and humidity, while the lower concentration (75 to 250 Bq.m exp -3) was at ambient conditions. Quality control was strictly maintained by continuous measurement of radon concentrations with scintillation cell counters, verified by pulse ionization chamber measurements. After exposure, the devices were returned to the participating laboratories, who then provided the radon concentration as measured by their detectors. The results indicate that most devices appear to be satisfactory with room for improvement. This report discusses possible causes of discrepancies and strongly recommends the need for further intercomparison and intercalibration exercises to assure that the quality of radon measurements continues to improve. This work is part of the program entitled 'International Intercalibration and Intercomparison Programme for Radon, Thoron and Daughters Monitoring Equipment' sponsored by the Organization for Economic Cooperation and Development/Nuclear Energy Agency (OECD/NEA) and the Commission of the European Communities. (ERA citation 10:045122)(NTIS)

LOCALIZATION OF INDOOR RADON SOURCES USING INTEGRATING TRACK ETCH DETECTORS (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY),
OSWALD RICHARD A. ; ALTER H. W.
TERRADEX CORP, CA,
WHO/ET AL 3RD INTL INDOOR AIR QUALITY & CLIMATE CONF, STOCKHOLM, AUG 20-24, 84, V2, P105(8)
PASSIVE, INTEGRATING TRACK ETCH DETECTORS ARE NOW AVAILABLE FOR MAKING SIMULTANEOUS, LONG-TERM MEASUREMENTS OF INDOOR RADON, SOIL GAS RADON, AND RADON IN WATER. THE SMALL SIZE OF THE DETECTORS MAKES THEM SUITABLE FOR MAKING MEASUREMENTS IN AND NEAR SUSPECTED RADON ENTRY POINTS. TYPICAL RADON CONCENTRATIONS DOCUMENTED WITH THESE DEVICES ARE REPORTED. (3 PHOTOS, 13 REFERENCES, 1 TABLE)(ENV)

Measuring Radon Levels Indoors: Techniques are suggested and study results are reported
(NTIS Tech Note)
Department of Energy, Washington, DC.
Corp. Source Codes: 052661000
Dec 83 1p
Write NTIS for information about Tech Notes subscriptions and back issue packages available.

Languages: English
NTIS Prices: Not available individually
Journal Announcement: GRAI8403
Country of Publication: United States
This citation summarizes a one-page announcement of technology available for utilization. A report describes various types of monitoring and sampling techniques that can determine the radiation imposed on the general public from radon and its decay products. Such techniques are important because they allow an assessment of possibly-increased radon levels resulting from energy conservation and increasingly airtight buildings. The radon may come from building materials and underlying soil, rocks, and water. Among the techniques covered are those for measuring the range and distibution of radon and radon decay products through broad surveys using simple and convenient integrating/monitoring instruments. ...FOR ADDITIONAL INFORMATION: Detailed information about the technology described may be obtained by ordering the NTIS report, order number: DE 82-021874, price code: A02. For information not in the report, contact Andreas C. George, U.S. Department of Energy, Environmental Measurements Laboratory, 376 Hudson Street, New York, N.Y. 10014; (212) 620-3653.(NTIS)

A method for measuring the concentrations of the short-lived daughter products of radon-222 in the atmosphere.
Duggan MJ; Howell DM
Int J Appl Radiat Isot, 1968 (Dec), 19 (12):865-870
ISSN 0020-708X
Journal Code: GQN
Languages: ENGLISH(MED)

METHODS FOR A CONTINUOUS REGISTRATION OF RADON, THORON, AND THEIR DECAY PRODUCTS INDOORS AND OUTDOORS,
PORSTENDORFER, J. ; WICKE A.: SCHRAUB A.
STRAHLENZENTRUM DER JUSTUS-LIEBIG UNIVERSITAT, W GERMANY,
PRESENTED AT DOE/UNIV OF TEXAS NATURAL RADIATION ENV 3RD INTL SYM, HOUSTON, APR 23-28, 78, V2, P1293 (15)
THE DEVICES AND METHODS USED TO DETERMINE CONCENTRATIONS OF RADON 222, THORON (RADON 220) THEIR DAUGHTER PRODUCTS, AND THE VENTILATION RATE INSIDE BUILDINGS ARE DISCUSSED. THESE CONCENTRATIONS ARE DETECTED CONTINUOUSLY BY COLLECTING THE POSITIVELY CHARGED POLONIUM 216 AND POLONIUM 218 ATOMS ON A SURFACE-BARRIER DETECTOR WITH THE USE OF ELECTRIC FIELD PRECIPITATION. RADON AND THORON DECAY PRODUCT CONCENTRATIONS ARE MEASURED BY COLLECTING THE AEROSOLS ON A MEMBRANE FILTER AND SIMULATANEOUSLY COUNTING THE ACTIVITIES BY ALPHA SPECTROSCOPY. (2 DIAGRAMS, 6 GRAPHS, 51 REFERENCES)(ENV)

OBSERVATION OF HIGH-CONCENTRATIONS OF RADON IN CERTAIN HOUSES
(ENGLISH)
RUNDO J; MARKUN F; PLONDKE NJ
ARGONNE NATL LAB/ARGONNE//IL/60439
* HEALTH PHYSICS , 36(6): 729-730, 1979
Occasional determinations by the authors of the concentrations of radon in the air of houses in the Chicago area, have given results in general agreement with the ranges of values quoted for Tennessee and Florida. They now report the observation of much higher concentations of radon in some houses in this area: the high levels are unrelated to excessive radioactivity in building materials, or to the presence of uranium mill tailings in the foundations, and they must be regarded as "normal." It seems clear to the authors that the average exposure of man to radon daughters in houses in this country may be substantially higher than hitherto has been thought, depending on the fraction of all houses with unpaved crawl spaces which also show high levels of radon. There is clearly scope for a comprehensive survey of the levels of radon in houses in the U.S., and especially of its daughters which are responsible for most of the absorbed dose to the lung.(SCI)

Optimizing the total-alpha three-count technique for measuring concentrations of radon progeny in residences
Nazaroff, W. W.
Health Physics, 1984 46(2): 395 (February)
(ENVB)

A PASSIVE RADON DOSIMETER FOR SURVEY PROGRAMS IN DWELLINGS
(ENGLISH)
URBAN M; PIESCH E
KARLSRUHE NUCL RES CTR,DIV HLTH PHYS/KARLSRUHE//FED REP GER/
NUCLEAR TRACKS , 5(4): 383-383, 1981((SCI)

Passive, integrated measurement of indoor radon using activated carbon
George A.C.
Environmental Measurements Laboratory, U.S. Department of Energy, New York, NY 10014
HEALTH PHYS. (U.S.A.) ,1984, 46(4):867-872
CODEN: HLTPA
Languages: ENGLISH
Activated carbon canisters were tested to determine their adsorption and retention characteristics for radon. Our tests conducted indoors under typical conditions of temperature and relative humidity indicate that simple, inexpensive and

maintenance-free passive devices containing 150-200 g of activated carbon can measure radon conveniently and adequately. The amount of radon absorbed in the collector is determined by counting the gamma rays from the decay products of radon. The lower limit of detection for radon is 0.2 pCi/l. for an exposure of 72 hr. Greater sensitivity can be obtained with larger counting systems and devices containing carbon with more surface area. Tests in a residential building and in a test chamber indicate that the measured radon in the canister is proportional to the mean concentration of radon during the period of exposure when correction for relative humidity is made. For practical situations encountered indoors,the device yields results accurate to within + or - 20%. Results from field measurements indicate that the use of the device is feasible. (EMB)

RADOK: an integrating, passive radon monitor.
Annanmaki M; Koskela H; Koponen M; Parviainen O
Institute of Radiation Protection, Helsinki, Finland.
Health Phys (UNITED STATES) Apr 1983, 44 (4) p413-6,
ISSN 0017-9078
Journal Code: G2H
Languages: ENGLISH (MED)

Radon in Dwellings. A Method for the Calculation of Radon Daughters in Dwellings
Bergstroem, B. ; Clavensjoe, B.
Swedish Council for Building Research, Stockholm.
Corp. Source Codes: 060307000; 5964200
Report No.: BFR-R-88-1982
1982 38p
In Swedish.
U.S. Sales Only.
Languages: Swedish
NTIS Prices: PC A03/MF A01
Journal Announcement: GRAI8402
Country of Publication: Sweden
The aim of the project was to present a mathematical model for the calculation of the expected values of radon and radon daughters of indoor air. It is assumed that certain parameters can be made available, such as the emission of radon from building materials, leakage from soil to buildings, the contents of radon in water etc. The control of dose limits can thus be made by the constructor of buildings. (Atomindex citation 14:748981) (NTIS)

RADON DAUGHTER CAROUSEL - AN AUTOMATED INSTRUMENT FOR MEASURING INDOOR CONCENTRATIONS OF PO-218, PB-214, AND BI-214 (ENGLISH)
NAZAROFF WW
UNIV CALIF BERKELEY LAWRENCE BERKELEY LAB,PROGRAM BLDG VENTILAT & INDOOR AIR QUAL/BERKELEY//CA/94720
REVIEW OF SCIENTIFIC INSTRUMENTS , 54,(9): 1227-1233, 1983
(SCI)

Radon-222 and its daughters--a review of instrumentation for occupational and environmental monitoring.
Budnitz RJ
* Health Phys ,1974 Feb, 26 (2) p145-63,
ISSN 0017-9078
Journal Code:G2H
Languages: ENGLISH
The aim of this review is to provide an overview of the techniques which have been developed for measuring RN222 and its daughters in various media. The main emphasis is on measurements for surveillance and protection in occupational and environmental situations. Measurements in specialized research applications are not treated in detail. Overviews are first provided of the physical characteristics of RN222 and its daughters; of the sources of and typical levels of concentrations in the natural environment and in occupational exposures and of the radiation guides. The various measurement techniques are then discussed.(MED)

Radon-222 concentrations and decay-product equilibrium in dwellings and in the open air
Keller G.; Folkerts K.H.
Institut fur Biophysik der Universitat des Saarlandes, Boris Rajewsky Institut, D 6650 Homburg/Saar
GERMANY, WEST
HEALTH PHYS. (U.S.A.) ,1984, 47(3):385-398
Coden: HLTPA
Languages: ENGLISH
Results are presented of measurements of the activity concentrations of sup 2sup 2sup 2Rn and its short-lived decay products and the sup 2sup 1sup 7Pb/sup 2sup 1sup 2Bi concentrations in more than 200 dwellings in West Germany and in the open air. For more than 130 measurements of the equilibrium factor F in dwellings the median value was found to be 0.3. Measurements of F in the open air under various conditions resulted in a mean value of about 0.4. The results of the investigations showed that indoors F depends only slightly on ventilation, indoor sup 2sup 2sup 2Rn concentration and other parameters. The equilibrium factor F in the open air, however, was found to depend on meteorological conditions. Empirical correlations from the data obtained

for the daughter/sup 2sup 2sup 2Rn concentration ratios were derived to provide relations for the prediction of the individual daughter product concentrations at a measured sup 2sup 2sup 2Rn level. It was established that the daughter/sup 2sup 2sup 2Rn concentration ratios for indoor air do not change within the range of sup 2sup 2sup 2Rn concentrations investigated (1-370 Bq . msup -sup 3). These relations, however,are not valid for the daughter/sup 2sup 2sup 2Rn concentration ratios in outdoor air. The correlations derived further suggest that the individual daughter product concentrations may be assessed with sufficient accuracy by only measuring the sup 2sup 2sup 2Rn concentrations. Thus the daughter ratios obtained in this way should enable good estimates of the lung dose for members of the public due to inhalation of the short-lived sup 2sup 2sup 2Rn daughters and the dose contribution of the individual sup 2sup 2sup 2Rn-daughter products.(EMB)

Residential Radon Daughter Monitor Based on alpha Spectroscopy
Nazaroff, W. W.
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 1112800
Sponsor: Department of Energy, Washington, DC.
May 80 100p
Languages: English
NTIS Prices: PC A05/MF A01
Journal Announcement: GRAI8107; NSA0600
Country of Publication: United States
Contract No.: W-7405-ENG-48

The radioactive daughters of radon-222 pose a serious indoor air quality problem in some circumstances. A technique for measuring the concentrations of these radioisotopes in air is presented. The method involves drawing air through a filter; then, for two time intervals after sampling, counting the alpha decays from polonium-218 and polonium-214 on the filter. The time intervals are optimized to yield the maximum resolution between the individual daughter concentrations. For a total measurement time of 50 minutes, individual daughter concentrations of 1.0 nanocuries per cubic meter are measured with an uncertainty of 20%. A prototype of a field monitor based on this technique is described, as is a field test in which the prototype was used to measure radon daughter concentrations as a function of ventilation conditions in an energy-efficient house. (ERA citation 06:001327)(NTIS)

THE RESPONSE OF PLASTIC DETECTORS TO RADON ACTIVITY INSIDE HOUSES (ENGLISH)
ABUJARAD F; FREMLIN JH
PETR & MINERALS UNIV,DEPT PHYS/DHAHRAN/

/SAUDI ARABIA/; UNIV BIRMINGHAM,DEPT PHYS/BIRMINGHAM B15 2TT/W MIDLANDS/ENGLAND/
NUCLEAR TRACKS , 5(4): 382-382, 1981(SCI)

RESULTS OF INDOOR RADON MEASUREMENTS USING THE TRACK ETCH METHOD (ENGLISH)
ALTER HW; OSWALD RA
TERRADEX CORP,460 N WIGET LN/WALNUT CREEK//CA/94598
HEALTH PHYSICS , 45(2):425-428, 1983
Recently the Track Etch technique has been developed and calibrated for performing integrated measurements in large indoor surveys. The totally passive Track Etch monitors are inexpensive and convenient. Because they are so rugged and insensitive to environmental factors, they are also reliable. This paper summarizes the results of numerous indoor radon measurements made in the U.S., Canada and Sweden over the past year by means of Track Etch monitors. Detailed data may be published in the future by the sponsoring organizations.(SCI)

A TECHNIQUE FOR EVALUATING AIRBORNE CONCENTRATIONS OF DAUGHTERS OF RADON ISOTOPES,
PERDUE, P. T. ; LEGGETT R. W.: HAYWOOD F. F.
PRESENTED AT DOE/UNIV OF TEXAS NATURAL RADIATION ENV 3RD INTL SYM, HOUSTON, APR 23-28, 78, V1, P347 (10)
ELEVATED QUANTITIES OF ACTINON DAUGHTERS IN AIR HAVE BEEN OBSERVED IN SOME BUILDINGS CONTAMINATED WITH RAFFINATES FROM URANIUM ORE PROCESSING. PREVIOUS METHODS FOR MEASURING THE CONCENTRATION OF RADON 222 DAUGHTERS ASSUME THAT RADON 219 DAUGHTER CONCENTRATIONS ARE NEGLIGIBLE. A METHOD FOR THE SIMULTANEOUS MEASUREMENT OF DAUGHTERS OF RADON 222, 220, AND 219 IN AIR IS DESCRIBED. THE METHOD CONSISTS OF A MODIFIED ALPHA SPECTROSCOPY TECHNIQUE AND COMPUTER PROGRAM FOR DETERMINING ISOTOPE CONCENTRATIONS. (3 GRAPHS, 8 REFERENCES)(ENV)

Tentative method of analysis for radon-222 content of the atmosphere.
Health Lab Sci (United States) ,Apr 1969, 6 (2) p114-29,
ISSN 0017-9035
Journal Code: G2C
Languages: ENGLISH(MED)

Theory and practice of radon monitoring with charcoal adsorption
Cohen, Ernest S.; Cohen, Bernard L.
Health Physics, 1983 ,45(2):501 (August)(ENVB)

Theory of passive measurement of radon daughters and working levels by the nuclear track technique
Fleischer R.L.
General Electric, Research and Development Center, P.O. Box 8, Schenectady, NY 12301 U.S.A.
HEALTH PHYS. (U.S.A.) 1984, 47(2):263-270
Coden: HLTPA
Languages: ENGLISH
A theoretical basis is described for long-term measurement of the activities of the alpha emitters in air by the track-etching technique. Inference of the other activities allows working levels to be derived. A set of absorber foils allows the differing response to alpha particles of different energies to be used to identify the relative abundance of the alpha emitters and the importance of diffusion to surfaces. The method is appropriate to measuring long-term exposures to radon atmospheres in homes or mines.(EMB)

USE OF NURE DATA FOR NATURAL RADIATION EXPOSURE - INDOOR RADON AND GAMMA-RAY RADIATION (ENGLISH)
KOTHARI BK
NEW YORK STATE DEPT HLTH,CTR LABS & RES/ALBANY//NY/12201
HEALTH PHYSICS , 45(1): 254-254, 1983(SCI)
Radionuclide data obtained in the National Uranium Resource Evaluation (NURE) survey fo the U.S. Department of Energy were used to correlate equivalent uranium with indoor radon concentrations and to calculate natural outdoor exposure rates. In the NURE survey, distributions of equivalent uranium and thorium and K concentrations of 'surface soil' were obtained by flying NaI crystals generally at flight spacings of three or six miles. Indoor exposure to radioactive radon daughters is a potential health problem which varies with geographical location. The present difficulty in identifying problem areas might improve by the use of eU data from the NURE program. Results from exposure rate maps and limitation of the NURE data are discussed.(SCI)

VI. MITIGATION

VI. MITIGATION

Chemical methods for removing radon and radon daughters from air.
Stein L
* Science (United States),31 Mar 1972, 175 (29): 1463-5
ISSN 0036-8075.
Journal code: UJ7
Languages: ENGLISH
Liquid bromine trifluoride and the solid complexes CIF4SbF2, BrF4SbF6,BrF4Sb2F11, IF4(SbF6), and BrF2BIF6 react spontaneously with radon and radon daughters at 25°C. converting the radio-elements to nonvolatile ions and compounds. The reagents can be used in gas-scrubbing units to remove radon and radon daughters from air. The halogen fluoride-antimony pentafluoride complexes may be suitable for purifying air in uranium mines and analyzing radon in air, since they have low dissociation pressures at 25°C and are less hazardous to handle than liquid halogen fluorides.(MED)

Concentrations of particulates and radon progeny.
Offerman, F.V.; Fisk, W.J.; Nazaroff, W.W.; Sextro, R.G.
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC.
Report No.: DOE/BP-216
Feb 83 25p
Paper copy only, copy does not permit microfiche production.
Languages: English
NTIS Prices: PC A02
Journal Announcement: GRAI8419; NSA0900
Country of Publication: United States
Contract No.: AC03-76SF00098
The specific purpose of this study was to review the literature on portable residential air cleaners, including fan-filter units, ionizers, and electrostatic precipitators, and to generally assess their applicability for controlling indoor concentrations of particulates and radon progeny which may result from weatherization. Little meaningful performance testing information was found. Implications of particulate control regarding exposure to radon progeny are uncertain. (ERA citation 09:023225)(NTIS)

Control of Indoor Radon Decay Products by Air Treatment Devices,
Hinds, William C.; Rudnick Stephen N.; Maher Edward F.; First Melvin W.
Harvard Univ,
* APCA J, Feb 83, 33(2): 134
Room size air cleaners can achieve substantial reductions in

working levels in residences. Reductions observed at air infiltration rates of 0.52 air changes per hour ranged from 58 to 89%. Although the two air cleaners tested produced the greatest reductions, the low cost, simplicity, and other benefits of air circulating fans, particularly the celing fan, appear to make them most suitable for residences.(ENV)

Control of Respirable Particles and Radon Progeny with portable Air Cleaners

Offermann, F. J.; Sextro, R. G.; Fisk, W. J.; Nazaroff, W. W.; Nero, A. V.
California Univ., Berkeley. Lawrence Berkeley Lab.
Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC.
Report No.: LBL-16659
Feb 84 98p
Languages: English
NTIS Prices: PC A05/MF A01
Journal Announcement: GRAI8424; NSA0900
Country of Publication: United States
Contract No.: AC03-76SF00098

Eleven portable air cleaning devices have been evaluated for control of indoor concentrations of respirable particles and radon progeny. Following injection of cigarette smoke and radon in a room-size chamber, decay rates for particles and radon progeny concentrations were measured with and without air cleaner operation. Particle concentrations were obtained for total number concentration and for number concentration by particle size. In tests with no air cleaner the natural decay rate for cigarette smoke was observed to be 0.2 he exp -1. Air cleaning rates for particles were found to be negligible for several small panel-filters, a residential ion-generator, and a pair of mixing fans. The electrostatic precipitators and extended surface filters tested had significant particle removal rates, and a HEPA-type filter was the most efficient air cleaner. The evaluation of radon progeny control produced simlar results: the air cleaners which were effective in removing particles were also effective in removing radon progeny. At low particle concentrations plateout of the unattached radon progeny is an important removal mechanism. Based on data from these tests, the plateout rate for unattached progeny was found to be 15 hr exp -1. The attached and unattached nuclides have been estimated for each radon decay product as a function of particle concentration. While air cleaning can be effective in reducing total radon progeny, concentations of unattached radon progeny can increase with increasing air cleaning. 39 reference, 26 figures, 9 tables.
(ERA citation: 09:034230)(NTIS)

Cost evaluation of control measures for indoor radon progeny.
Moeller DW; Fujimoto K
Harvard School of Public Health, Boston, MA.
Health Phys (UNITED STATES) ,Jun 1984, 46 (6) pl181-93
ISSN 0017-9078
Journal Code: G2H
Languages: ENGLISH
Based on assumed conditions within a typical U.S. home, annualized costs for reducing indoor airborne radon progeny concentrations have been calculated for a variety of methods of control. These analyses were limited to methods for control in existing homes. Control through modified construction techniques was not evaluated. Methods assessed included increased air circulation, increased ventilation, particle removal using electrostatic precipitation and unipolar ion generation, and the application of sealants to room surfaces. Although surface sealants proved to be reasonably cost-effective per person-sievert dose reduction, such sealants are prone to cracking and the durability of their effectiveness is questionable. Use of ceiling fans for increased air circulation and particle deposition appears to be least cost-effective, but this method may be attractive in some cases for reasons of comfort. The use of unipolar ion generators appears to be the best approach from the standpoint of cost effectiveness. These devices are also easy to install and are esthetically readily acceptable.(MED)

Demonstration of Remedial Techniques against Radon in Florida Phosphate Lands
(Final Report)
Scott, A. G. ; Findlay, W. O.
American Atcon, Inc., Columbia, MD.
Corp. Source Codes: 080346000
Sponsor: Eastern Environmental Radiation Facility, Montgomery, AL.
Report No.: EPA-520/5-83-009
Jul 83 195p
Languages: English
NTIS Prices: PC A09/MF A01
Journal Announcement: GRAI8410
Country of Publication: United States
Contract No.: EPA-68-02-3559
This report is to document the results of an activity which forms part of a program intended to demonstrate means of controlling indoor radon levels in structures built on Florida phosphate lands. The natural radon concentration of the soil is elevated in some parts of the Florida phosphate lands, resulting in elevated radon concentrations in the soil gas. If building construction is such as to provide pathways, or routes of entry, between the interior of the building and the soil below, then this radon-bearing soil gas may enter the building and result in elevated indoor levels. This report therefore documents a review

of current building practices, with the intention of identifying routes of entry. Based upon this knowledge certain modifications to building practices may be seen as a means to reducing indoor radon levels.(NTIS)

Effect of a Fan in Reducing the Concentration of the Radon Daughters Inside a Room by Plate-Out to the Surface of the Wall Using Plastic alpha -Detectors

Abu-Jarad, F.; Fremlin, J.H.
Dept. Phys., Univ. Petro. Min., Dhahran, Saudi Arabia

HEALTH PHYS, 42(1):82-85, 1982
Languages: ENGLISH

The number of radon daughters which are deposited per unit area on the two sides of the blades of the fan are more than tnose plated out per unit area on the surface of the walls. However, the total surface area of the fan blades is only 0.2% of the surface area of the walls. The activity on the blades will therefore reduce the level inside the room by similar to 1% while the main decrease in air-borne activity is due to the plate-out on the surfaces of the walls of the room. We did not measure the concentration of conden sation nuclei in the roomn or on the wall so that we cannot discriminate between free ions or atoms and those adsorbed on condensation nuclei in the air on the wall with and without the fan on. Although the increase in a-tracks cm super(-2) h super(-1) on the wall with and without the fan is due to the increase of plate-out of radon daughters, still more information can be gained if tracks resulting from airborne Rn are separated from tracks resulting from plated out radon daughters. Also, it is not clear if the plate out of radon daughters on the walls and fan blades would be the same as plate out on the detectors. (POL)

Evaluation of Indoor Aerosol Control Devices and Their Effects on Radon Progeny Concentrations

Sextro, RG; Offermann, FJ; Nazaroff, WW; Nero, AV; Revzan, KL
California Univ., Berkeley. Lawrence Berkeley Lab.

Corp. Source Codes: 005029222; 9513034
Sponsor: Department of Energy, Washington, DC
Report No.: LBL-17598; CONF-840803-8
Feb 84 16p
International conference on indoor air quality and climate, Stockholm, Sweden, 20 Aug 1984
Portions are illegible in microfiche products.
Languages: English
Document type: Conference proceedings
NTIS Prices: PC A02/MF A01
Journal Announcement: GRAI8502; NSA0900
Country of Publication: United States

The radon emanation rate from by-product materials is sometimes one or two orders of magnitude higher than the emanation rate from natural building materials. Materials in which the concentration of radioactive isotopes exceeds an allowed limit should be rejected as unsuitable for house construction. The exposure of the population to radon particles in buildings which already exist may be decreased by coating the walls of the rooms with a sealant. This article examines the influence of seven coating materials on the radon emanation rate.(BIO)

Influence of sealants on 222radon emanation rate from building materials.
Morawska, L
Institute of Physics, Jagellonian University, Cracow, Poland.
Health Phys(UNITED STATES), Apr 1983, 44(4): 416-8,
ISSN 0017-9078
Languages: ENGLISH (MED)

MEASUREMENT OF SEALANT EFFICACY AGAINST RADON EMANATION
EICHOLZ G G; KAHN B; MATHENY M D
SCH. NUCL. ENG., GEORGIA INST. TECHNOL., ATLANTA, GA. 30332.
24TH ANNUAL MEETING OF THE HEALTH PHYSICS SOCIETY.
* HEALTH PHY, 37 (6): 801, 1979 (RECD. 1980)
CODEN: HLTPA
Language: ENGLISH
Radon emanation from walls constructed of uranium-containing materials such as phosphate slag or granitic aggregate may contribute significantly to the total population exposure. Measurements have been conducted to test the efficacy of some common coating materials, applied to a concrete block wall, to reduce the radon inhalation risk. The results depend on the roughness and porosity of the wall, and vary from ineffective for some common paints to moderately good for epoxy paints. Two methods of measurement were employed, one measuring the attached fraction, which depends on the existence of a constant concentration of attachment nuclei; and the other on radon adsorption on a charcoal bed.(BIO)

A Preliminary Evaluation of the Control of Indoor Radon Daughter Levels in New Structures
Fitzgerald, Jr., Joseph E. ; Guimond, Richard J. ; Shaw, Roger A.
Office of Radiation Programs, Washington, DC. Div. of Criteria and Standards.
Corp. Source Codes: 038529001
Report No.: EPA-520/4-76-018

Nov 76 88p
Indoor radon concentrations seem to depend on both building material and leakage of radon from the ground. This new study, in a rural area, is a further attempt to elucidate the etiology of lung cancer, taking into consideration type of house and ground conditions, as well as smoking habits. Although the choice of a rural study population helped to eliminate the various confounding exposures in the urban environment, it limited the size of the study because of the rareness of lung cancer in rural populations. Long-term residents, 30 years or more in the same houses, were studies, and again an association was found between lung cancer and estimated exposure to radon and radon daughters in homes. The data also seem to indicate the possibility of a multiplicative effect between smoking and exposure to radon and radon daughters in homes, but there was alsosome confounding between these factors in the data. (EMB)

Radon in Dwellings. Constructional Steps to Reduce the Concentration of Radon in Indoor Air
Clavensjoe, B. ; Ericson, S. -O. ; Erikson, B. E. : Haakansson, B. ; Swedjemark, G. A.
Swedish Council for Building Research, Stockholm.
Corp. Source Codes: 060307000; 5964200
Report No.: BFR-R-28-1982
1982 150p
In Swedish.
U.S. Sales Only.
Languages: Swedish
NTIS Prices: PC A07/MF A01
Journal Announcement: GRAI8402
Country of Publication: Sweden
Various procedures to limit the concentration of radon in 10 small houses have been tested. In five cases the filling around the basement was replaced to a distance of 4 meters. The inflow of radon was then reduced by 30-90%. A combination of ventilating by 0,5 air renewals per hour and replacement of the filling reduced the inflow by 90-99%. The cost, however, was high. Houses made of lightweight concrete containing shale were put right by increased ventilation. Two houses were re-papered with aluminum foils and the emission of radon from the building material was reduced by 0%.(Atomindex citation 14:719127) (NTIS)

Radon in Dwellings. Field Study, Part 1
Erikson, B. E. ; Boman, C. A. ; Nyblom, L. : Swedjemark, G. A.
National Swedish Inst. for Building Research, Gaevle.
Corp. Source Codes: 075131000; 9860033
Jun 80 87p
In Swedish.

U.S. Sales Only. Available in microfiche only.
Languages: Swedish
NTIS Prices: MF A01
Journal Announcement: GRAI8421
Country of Publication: Sweden
The report presents the function of the ventilation by natural draught in three-storey houses. In some cases also the measurement of gamma radiation, radon and radon daughters was made. The investigation took place in Uppsala. The houses were built of light weight concrete made of alum-shale. The measurements showed that the contents of radon daughters were far below the provisional limits. (Atomindex citation 12:596009)(NTIS)

Radon's threat can be subdued
Brennan, Terry; Turner, William
Solar Age, May 1985, 9(5):19
Researchers have known for decades about the pollution of indoor air, but only recently have builders, homeowners and health officials become concerned with the problem. Radon may end up in the indoor environment via several paths.This article contains a table of standards for airborne radon in buildings and describes different methods of detection of radon and mitigation of the problem.(ENVB)

Tracing of Radon Leakages (Radon, Passive Smoking, Particulates & Housing Epidemiology)
Gustafsson, Jorgen; Nilsson, Ingemar
Natl Testing Inst, Sweden
WHO/ET AL 3rd Intl Indoor Air Quality & Climate Conf, Stockholm, Aug 20-24, 84, v2, p125(12)
It is widely accepted that indoor radon daughter levels in Sweden are frequently caused by radon from the soil. To minimize transport from soil to houses, the cracks or leaks where the radon convectively trasnports into dwellings must be found. An instrument was created at the Natl Testing Inst to aid in finding such leaks. The principles of the scintillation flask are explained, and some results from field measurements are reported. (1 diagram, 8 graphs, 1 photo, 7 references, 1 table) (ENV)

THE USE OF MECHANICAL VENTILATION WITH HEAT RECOVERY FOR CONTROLLING RADON AND RADON DAUGHTER CONCENTRATIONS IN HOUSES
NAZAROFF W W; BOEGEL M L; HOLLOWELL C D; ROSEME G D
ENERGY EFFICIENT BUILDINGS PROGRAM, ENERGY AND ENVIRONMENT DIVISION, LAWRENCE BERKELEY LABORATORY, UNIVERSITY OF CALIFORNIA, BERKELEY, CA. 94720, U.S.A.
* ATMOS ENVIRON, 15 (3):263-70, 1981.
CODEN: ATENB (BIO)

VII. HEALTH EFFECTS

VII. HEALTH EFFECTS

Assessing the Risks from Exposure to Radon in Dwellings
Walsh, P. J. ; Lowder, W. M.
Oak Ridge National Lab., TN.
Corp. Source Codes: 021310000; 4832000
Sponsor: Department of Energy, Washington, DC.
Report No.: ORNL/TM-8824
Jul 83 40p
Languages: English
NTIS Prices: PC A03/MF A01
Country of Publication: United States
Contract No.: W-7405-ENG-26

The factors used to assess the radiation dose and health risks from human exposure to radon in dwellings are critically reviewed in this summary. Sources of indoor radon and determinants of air concentrations and exposure levels are given as well as the uncertainties that exist in their formulation. Methods of assessing health effects from inhalation of radon and its progeny are discussed with emphasis on dosimetry of radon daughters and formulation of risk per dose values. Finally, methods of assessing risks for general population exposures to indoor radon concentrations are treated. (ERA citation 08:050034)(NTIS)

Bronchial dose due to decay products of sup 2sup 2sup 2Rn in the living environment
Parthasarathy K.S.; Unnikrishnan K.
Div. Radiol. Protect., Bhabha Atomic Res. Cent., Bombay INDIA

* CHEMOSPHERE (ENGLAND) ,1977, 6(5):279-284
CODEN: CMSHA
Languages: ENGLISH

Dosimetry of the lung with reference to the inhalation of these decay products is a special area of concern in the mining and milling of uranium. Since July 1971 a maximum permissible exposure of 4 working level months in a year is recommended for radiation workers in uranium mines in the USA. Since the dose to working level year conversion factor for uranium mines is 24 rads the recommended level of radon exposure leads to a dose of 8 rads. If a dose corresponding to one tenth of that due to occupational workers is accepted for public at large it is necessary to restrict the annual dose to 0.8 rad. Corresponding concentration is nearly 0.002 working levels. A maximum permissible concentration of 0.002 WL for general public may appear to be very restrictive. This concentration indoors can be

walls. An electrostatic precipitator used as domestic dust cleaner removed decay products with an efficiency of 80% when air is recirculated through it. A new method based on the electrostatic and diffusion collection of decay products has also been reported. (23 references).(EMB)

DOSE CALCULATIONS FOR THE RESPIRATORY TRACT FROM INHALED NATURAL RADIOACTIVE NUCLIDES AS A FUNCTION OF AGE 1. COMPARTMENTAL DEPOSITION RETENTION AND RESULTING DOSE

HOFMANN W; STEINHAEUSLER F; POHL E
INST. PHYS., UNIV. SALZBURG, AKADEMIESTR. 26, A-5020 SALZBURG, AUSTRIA.

* HEALTH PHYS, 37 (4):517-22, 1979.
CODEN: HLTPA
Language: ENGLISH

The deposition and retention models and the anatomical and physiological data as proposed by the ICRP [International Commission of Radiological Protection] Task Groups on Lung Dynamics and Reference Man are valid only for adult dosimetry. The change of the growing organism causes an age-dependent variation of the radiation burden to the respiratory tract. Age-dependent functions of anatomical and physiological parameters were defined. Data were either interpolated from literature or calculated from theoretical modeling. With these functions and defined aerosol composition, age-dependent deposition probabilities in the single regions of the respiratory tract were determined. For the demonstration of lung dosimetry as a function of age the naturally occurring Rn daughters were used. By applying typical mean nuclide concentrations found in the atmosphere of an urban environment and defined age-dependent daily life patterns, the annual inhaled amount of radioactivity was computed. Dose calculations for the single ICRP lung model compartments were performed. The inhaled dose in both the tracheobronchial and pulmonary regions showed a strong dependence on age; a pronounced maximum value was reached at the age of approx. 6 yr for Rn and Th decay products.(BIO)

Environmental radiation and the lung.

Hamrick PE; Walsh PJ

Environ Health Perspect ,1974 Dec, 9: 33-52
ISSN:0091-6765
Journal Code EIO
Languages: ENGLISH
(96 Refs.)(MED)

ENVIRONMENTAL RADON AND CANCER CORRELATIONS IN MAINE, USA

HESS C T; WEIFFENBACH C V; NORTON S A
UNIV. MAINE, ORONO, ME 04469, USA.

HEALTH PHYS, 45 (2):339-48, 1983.
CODEN: HLTPA
Language: ENGLISH

The distribution of 222Rn was measured in the 16 countries of Maine, USA by liquid scintillation counting of water samples from > 2000 public and private wells and 350 wells were characterized for geology and hydrology. Airborne Rn was measured in 7 houses with grab samples and in 18 houses for 5-7 days each with continuously recording diffusion-electrostatic Rn detectors. Concentrations of Rn water ranged from 20-180,000 pCi/l. Granite areas (36) yielded the highest average levels (.hivin.x = 22,100 pCi/l) with considerable intragranite variation. Metasedimentary rocks yielded levels characteristic of the lithology for metamorphic grades ranging from chlorite to andalusite. Sillimanite and higher grade rocks yielded higher 222Rn levels, probably due to the intrusion of U-bearing pegmatites in these terranes. Airborne calculated by areally averaging rock types and their associated 222Rn levels, were significantly correlated with rates for all cancers combined and rates for lung and reproductive cancers in the counties. Although numerous factors other than cancer induction by indoor daughter exposures may have been responsible for the observed correlations, these had not been investigated in detail. (BIO)

EXPOSURE TO RADON IN DWELLINGS AND LUNG CANCER: A PILOT STUDY (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY)

Pershagen,Goran; Damber, Lena; Falk, Rolf
Natl Inst of Env Medicine, Sweden

WHO/et al 3rd Intl Indoor Air Quality & Climate Conf, Stockholm, Aug 20-24, 84 v2, p73(6)

A case control technique was used to examine the relation between estimated lifetime exposure to radon in Swedish dwellings and lung cancer. FIfty-three cases of lung cancer and 53 controls were studied. Exposure estimates were based on data regarding house characteristics of relevance for indoor radon levels. A higher exposure to radon was indicated for the lung cancer cases than for controls among smokers but not among non-smokers. A positive interaction between radon and smoking may explain these results. (9 references, 3 tables) (ENV)

Field applications of a radon barrier to reduce indoor airborne radon progeny
Culot M.V.J.; Olson H.G.; Schiager K.J.
Monroeville Nucl. Cent., Westinghouse Electric Corp., Monroeville, Pa. 15146 U.S.A.
* HEALTH PHYS. (ENGLAND) 1978, 34(5):498-501
CODEN: HLTPA
Languages: ENGLISH
Epoxy barriers were shown to be practical and effective for preventing radon influx into structures. Gamma exposure rates must be analyzed carefully to ensure that buildup behind the radon barrier will not introduce an unacceptable gamma exposure level. To assure success in sealing out radon, it is essential that all pathways (channels) between the source and the interior of the structure be identified and sealed. The use of a sealant was especially economical in situations where structural integrity might have been jeopardized by physical removal of uranium mill tailings.(EMB)

Influence of radon daughter exposure rate, unattachment fraction, and disequilibrium on occurrence of lung tumors
Cross F.T.; Palmer R.F.; Dagle G.E.; et al.
Biology and Chemistry Department, Pacific Northwest Laboratory, Richland, WA 99352 U.S.A.
RADIAT. PROT. DOSIM. (ENGLAND) 1984, 7(1-4):381-384
Coden: RPDOD
Languages: ENGLISH
Groups of male, specific-pathogen-free (SPF), Wistar rats were exposed to several concentrations of radon daughters and uranium ore dust to clarify the roles of exposure rate, unattached raA daughters, and the degree of radon daughter disequilibrium, in the development of respiratory system disease. Modelled, human dosimetric data indicate that the dose to sensitive tissues of the respiratory tract increases with increasing radon daughter unattachment fraction and degree of disequilibrium. Data bearing on these developments as well as updated results of experiments designed to test the role of radon daughter exposure rate on lung tumour incidence as reported.(EMB)

INFLUENCE OF SEALANTS ON RADON-222 EMANATION RATE FROM BUILDING MATERIALS
MORAWSKA L
INST. PHYSICS, JAGELLONIAN UNIV. PL. 30-059, CRACOW, REYMONTA 4, POL.
CODEN: HTLPA
HEALTH PHYS 44 (4):416-8, 1983.
(MED)

Lung cancer and housing characteristics
Simpson S.G.; Comstock G.W.
Dep. Epidemiol., Sch. Hyg. Publ. Health, Johns Hopkins Univ., Baltimore, MD 21205 U.S.A.
ARCH. ENVIRON. HEALTH,(U.S.A.) 1983, 38(4):248-251
Coden: AEHLA
Languages: ENGLISH
Lung cancer incidence in Washington County, Maryland was determined for a 12-yr period and was correlated with personal and housing data from a nonofficial 1963 census. Because indoor radon measurements were not available, two housing characteristics reported to be related to indoor radon concentration - type of basement construction and type of building materials - were used as surrogate measures. An adjusted rate of lung cancer incidence was obtained for each characteristic. Only age, male sex, amount smoked, and standard of living were significantly associated with lung cancer. Rates were highest in houses which had concrete walls and no basements, although the differences were slight and could have occurred by chance. (EMB)

LUNG-CANCER AND RADON IN DWELLINGS (ENGLISH)
AXELSON O; EDLING C; KLING H; ANDERSSON L; RINGNER A
LINKOPING UNIV HOSP,DEPT OCCUPAT MED/S-58185 LINKOPING//SWEDEN/; CTY
COUNCIL KALMAR,ENVIRONM MED UNIT/KALMAR//SWEDEN/
LANCET, 2(8253): 995-996, 1981 (SCI)

LUNG-CANCER AND RESIDENCY - CASE-REFERENT STUDY ON THE POSSIBLE IMPACT OF EXPOSURE TO RADON AND ITS DAUGHTERS IN DWELLINGS (ENGLISH)
AXELSON O; EDLING C; KLING H
LINKOPING UNIV HOSP,DEPT OCCUPAT MED/S-58185 LINKOPING//SWEDEN/
SCANDINAVIAN JOURNAL OF WORK ENVIRONMENT & HEALTH ,
5(1):10-15, 1979(SCI)

A model for predicting lung cancer risks induced by environmental levels of radon daughters.
Harley NH; Pasternack BS
* Health Phys, Mar 1981, 40 (3) p307-16
ISSN 0017-9078
Journal Code:G2H
Contract/Grant No.: ES 00260; CA 13343
Languages: ENGLISH
An estimate of the possible annual lung cancer incidence and the

lifetime risk from exposure to environmental levels of radon daughters is presented. The model developed to do this accounts for the apparent increase in the lifetime tumour risk with increasing age of first exposure that has been noted in epidemiological studies of underground uranium miners. The model predicts that if the higher level mining exposures can be used to extrapolate to environmental exposures, then from about one-fifth to all of the spontaneous (nonsmoking related) bronchogenic lung cancer may be attributed to this source. It appears reasonable to use this model for predicting effects due to elevated environmental exposures.(MED)

Radiogenic lung cancer in man: exposure-effect relationship.
Archer VE; Lundin FE Jr
Environ Res,(United States) Dec 1967, 1 (4) p370-83
ISSN 0013-9351
Journal Code: EI2
Languages: ENGLISH
Contract No.: AC03-76SF00098
Eleven portable air cleaning devices have been evaluated for control of indoor concentrations of respirable particles, and their concomitant effects on radon progeny concentrations have been investigated. Of the devices we examined the electrostatic precipitators and extended surface filters had significant particle removal rates, while the particle removal rates for several small panel-filters, an ion-generator, and a pair of mixing fans were found to be negligible. The evaluation of radon progeny control produced similar results: the air cleaners which were effective in removing particles were also effective in reducing radon progeny concentrations. Furthermore, at the low particle concentrations, plateout of the unattached radon progeny was found to be a significant removal mechanism. The overall removal rates due to deposition of attached and unattached progeny have been estimated from these data, and the equilibrium factors for total and unattached progeny concentrations have been calculated as a function of particle concentration. (7 references, 2 figures) (ERA citation 09:046582) (NTIS)

RADON DAUGHTER EXPOSURE IN DWELLINGS AND LUNG CANCER (RADON, PASSIVE SMOKING, PARTICULATES & HOUSING EPIDEMIOLOGY)
Edling, Christer: Wingren, Gun; Axelson, Olav
Univ Hospital, Sweden
WHO/et al 3rd Intl Indoor Air Quality & Climate Conf Stockholm, Aug 20-24, 84, v2, p. 29(6)
Some epidemiological studies have suggested a relationship betweenradon daughter exposure in dwellings and lung cancer. A survey is currently underway in Sweden in 15 municipalities with alum shale deposits to

determine the importance of soil radioactivity in interior radon concentrations and to identify a link between the latter and lung cancer incidence. Preliminary data support the contention that about 50% of the recorded lung cancers might be attributable to elevated exposure to radon and its daughters. (17 references, 3 tables) (ENV)

Radon in dwellings and lung cancer. A discussion
Stranden E
State Inst. Radiat. Hyg., Osteras
NORWAY
* HEALTH PHYS, (ENGLAND) 1980, 38(3):301-306
Coden: HLTPA
Languages: ENGLISH
A discussion of the lung cancer risk associated with radon exposure inside dwellings is presented. The risk factors found for miners are discussed and modified according to the lower mean breathing rates inside dwellings and the differences in atmosphere. Statistical information on the lung cancer incidence in the Norwegian population indicates that a 'doubling exposure rate' of radon daughters inside dwellings may be about 2-3 WLM/yr. This corresponds to a radon concentration of about 10-15 pCi/l. These values are used in a discussion of the consequences of a future reduction of the mean ventilation rates in modern houses.(EMB)

Radon in homes - A possible cause of lung cancer
Edling C.; Kling H.; Axelson O.
Department of Occupational Medicine, University Hospital, S-581 85 Linkoping SWEDEN
SCAND. J. WORK ENVIRON. HEALTH,(FINLAND) 1984, 10(1):25-34
Coden:SWEHD
Languages: ENGLISH
An earlier case-referent study (Scand j work environ & health 5 (1979) 10-15) has indicated a possible relationship between lung cancer and exposure to radon and radon daughters in dwellings. measurements in buildings specifically designed to use energy efficiently or utilize solar heating. In many of these buildings radon concentrations appear to arise primarily from soil underlying the buildings. Measures to control higher levels, e.g., by mechanical ventilation with heat recuperation, appear to be economical. However, to evaluate energy-saving programs adequately requires a much more comprehensive characterization of radon sources (for example, by geographical area) and a much fuller understanding of the dynamics of radon and its daughters indoors than now exist.(NTIS)

Radon 222 in the gastrointestinal tract: a proposed modification of the ICRP 30 model.
Dundulis W.P. Jr.; Bell W.J.; Keene B.E.; Dostie P.J.
Rhode Island Department of Health, Division of Occupational Health and Radiation Control, Providence, RI 02908 U.S.A.
HEALTH PHYS, (U.S.A.) 1984, 47(2):243-252
Coden: HLTPA
Languages: ENGLISH
The New England states have a long involved history of radon in individual well water supplies. As a result of these previous findings on the abundance of radon, coupled with its potential health impact, the new England Radiological Health Committee (NERHC) formulated a technical developing uniform concentration guidelines for radon in individual domestic water supplies. This working group determined that the current ICRP Publication 30 metabolic model for the gastrointestinal (GI) tract was inadequate to address the empirically observed rates of sup 2sup 2sup 2Rn removal from the body. A modification to the ICRP Publication 30 GI tract model is proposed which attempts to resolve these differences. Calculations are presented, using both the original and modified ICRP Publication 30 models, which indicate that individual potable water supplies containing sup 2sup 2sup 2Rn concentrations as high as 400,000 pCi/l do not significantly increase the probability of stomach or intestinal cancer, as defined by the BEIR III risk estimates. Since this paper deals exclusively with the GI tract, no attempt is made to address the lung burden imposed by the contribution of radon released into the household air by aeration at the tap or other fixtures. Only when the contribution of the radon water source term to both the respiratory and ingestion pathways is evaluated as a whole can any meaningful standard for sup 2sup 2sup 2Rn in individual domestic water supplies be established.(EMB)

Review of Portable Residential Air Cleaners for Controlling alpha-Radiation dose at bronchial bifurcations of smokers from indoor exposure ro radon progeny.
Martell, E.A.
Natl. Cent. Atmos. Res., Boulder, CO 80307
PROC. NATL ACAD. SCI. U. S. A. (U.S.A.), 1983, 80(5I):1285-1289
Coden: NASA
Languages: ENGLISH
Synergistic interactions of indoor radon progeny with the cigarette smoking process have been evaluated experimentally. Smoking enhances the air concentration of submicron particles and attached radon decay products. Fractionation in burning cigarettes gives rise to the association of radon progeny with large particles in mainstream cigarette smoke, which are selectively deposited in 'hot spots' at bronchial bifurcations. Because smoke tars are resistant to dissolution in lung fluid, attached radon progeny undergo substantial radioactive decay at

bifurcations before clearance. Radon progeny inhaled during normal breathing between cigarettes make an even larger contribution to the alpha-radiation dose at bifurcations. Progressive chemical and radiation damage to the epithelium at bifurcations givers rise to prolonged retention of insoluble sup 2sup 1sup 0Pb-enriched smoke particles produced by tobacco trichome combustion. The high incidence of lung cancer in cigarette smokers is attributed to the cumulative alpha-radiation dose at bifurcations from indoor radon and thoron progeny - sup 2sup 1sup 8Po, sup 2sup 1sup 4Po, and sup 2sup 1sup 2Po, and sup 2sup 1sup 2Bi - plus that from sup 2sup 1sup 0Pb-enriched smoke particles. It is estimated that a carcinogenic alpha-radiation dose of 80-100 rads (1 rad=0.01 J/kg = 0.01 Gy) is delivered to congruent with10sup 7 cells (congruent with10sup 6 cells at individual bifurcations) of most smokers who die of lung cancer.(MED)

Relationship between Indoor Radon and Lung Cancer: A Study of Feasibility of an Epidemiological Study

Rasmussen, S. ; Neuberg, D. ; DuMouchel, W. : Kleitman, D. : Chernoff, H.
Massachusetts Inst. of Tech., Cambridge.
Corp. Source Codes: 001450000
Sponsor: Environmental Protection Agency, Washington, DC.
Report No.: MIT/TR/EPA-1
1981 62p
Languages: English
NTIS Prices: PC A04/MF A01
Journal Announcement: GRAI8417
Country of Publication: United States
Contract No.: EPA-68-01-6216

This report describes a study to assess the feasibility of an epidemiologic investigation of the relationship between residential radon exposure and lung cancer. Field measurements of residential radon levels in the State of Maine are described. Using these radon measurements and BEIR, 1980 risk assessments, it is estimated that at most 10% of lung cancers in Maine can be considered attributable to residential radon exposure. Calculations are made of sample sizes necessary for a case-control study of radon and lung cancer, for several levels of radon and smoking health effects. The effects of misclassification of exposure variables on the probability of detecting a radon health effect are discussed. A comparison is made of three different mathematical models which could be used for sample size estimation. Dollar cost estimates are given for conducting an epidemiologic case-control study of the relationship between residential radon exposure and lung cancer.(NTIS)

Relationship between the sup 2sup 1sup 0Pb content of teeth and exposure to Rn and Rn daughters

Clemente G.F.; Renzetti A.; Santori G.; et al.
Comitato Nazionale per la Ricerca e per lo Sviluppo dell'Energia Nucleare e delle Energie Alternative, C.R.E. Casaccia, Division of Environmental Sciences, Rome ITALY

HEALTH PHYS, (U.S.A.) 1984, 47(2):253-262
Coden: HLTPA
Languages: ENGLISH

Existing data on sup 2sup 1sup 0Pb in human teeth are reviewed for various countries. The mean value of sup 2sup 1sup 0Pb in the teeth of population groups exposed to 'normal' levels of radon-daughter exposure is about 2 mBq/g. A detailed analysis of 48 samples from a 'normal' Italian population group revealed that smoking habits and age may have some influence on sup 2sup 1sup 0Pb content of teeth, while this is not the case for differences in sex. A group of 45 Austrians exposed to elevated levels of radon and radon daughters is compared with the Italian group. After subtraction of background levels of sup 2sup 1sup 0Pb as found for the normal Italian population, the incremental sup 2sup 1sup 0Pb tooth content due to excessive radon-daughter exposure has been correlated with the individual cumulative exposure corrected for background radon-daughter exposure. A statistical analysis shows the significance of the linear correlation at the alpha = 0.01 level. For the incremental increase of sup 2sup 1sup 0Pb in teeth, a value of 1.2 mBq/g has been used for a lifetime exposure to 1 WLM. This result is compared to corresponding data published in the literature, which are predominantly related to the sup 2sup 1sup 0Pb content of bone after short-time exposure at high levels, e.g. in uranium mines. The comparison seems to indicate the influence of the exposure rate and the need for a comprehensive model, which takes into account radon-daughter inhalation, radon dissolved in body fluids and sup 2sup 1sup 0Pb metabolism.(EMB)

Respiratory exposure in buildings due to radon progeny

Auxier J.A.
Hlth Phys. Div., Oak Ridge Nat. Lab., Oak Ridge, Tenn. 37830 U.S.A.

* HEALTH PHYS. (ENGLAND) 1976, 31(2):119-125
Coden: HLTPA
Languages: ENGLISH

The alpha radiation dose to the lungs of people who live in buildings constructed of some granites, low density concretes, and gypsum boards is higher than for residents of most other types of dwellings due to the airborne progeny of radon. There is evidence that sealing the interior surfaces with epoxy paint, for example, can reduce the alpha dose to the lung significantly without a compensating increase in whole body exposure to the gamma rays from radon progeny. Based on the incidence rates for

lung cancer in uranium miners, a concentration of radon of the order of 1-5pCi/l. appears to be a reasonable limit for 'lifetime' exposure indoors for 'typical' home ventilation conditions.(EMB)

APPENDIX:

STATE RADON CONTACTS

STATE RADON CONTACTS

ALABAMA (AL)
Office Hours - 8:00-5:00 CST
24 Hour Phone #205/261-4378

Division of Radiological Health
State Department of Public Health
State Office Building
Montgomery, Alabama 36130

ALASKA (AK)
Office Hours - 8:00-4:30 PST
24 Hour Phone #907/789-9858

Radiological Health Program
Department of Health & Social Services
Pouch H-06F
Juneau, Alaska 99811-9976

ARIZONA (AZ)
Office Hours - 8:00-5:00 MST
24 Hour Phone #602/262-8011

Arizona Radiation Regulatory Agency
925 South 52nd Street, Suite 2
Tempe, Arizona 85281

ARKANSAS (AK)
Office Hours - 8:00-4:30 CST
24 Hour Phone #501/661-2136

Division of Radiation Control and
Emergency Management
Department of Health
4815 West Markham Street
Little Rock, Arkansas 72205-3867

CALIFORNIA (CA)
Office Hours - 8:00-5:00 PST
Business: 916/322-2073

Radiological Health Branch
State Department of Health Services
714 P Street, Office Bldg. #8
Sacramento, California 95814

Los Angeles County
Business: 213/744-3244

Occupational Health and Radiation
Management
County of Los Angeles
Department of Health Services
2615 South Grand Aveneue Services
Los Angeles,California 90007

Orange County
24 Hour Phone #714/834-2127

Orange County Health Care Agency
Public Health and Medical Services
Environmental Health
Radiological Health Section
1725 West 17th Street
Santa Ana, California 92702

Mailing Address: Post Office Box 355
Santa Ana, California 92702

COLORADO (CO)
Office Hours - 8:30 -5:00 MST
24 Hour Phone #303/377-6326

Radiation Control Division
Department of Health
4210 East 11th Avenue
Denver, Colorado 80220

CONNECTICUT (CT)
Office Hours- 8:30-4:30 EST
Business: 203/566-5668

Radiation Control Unit
Department of Environmental Protection
State Office Building
165 Capital Avenue
Hartford, Connecticut 06106

DELAWARE (DE)
Office Hours- 8:00-4:30 EST
24 Hour Phone #302/678-9111

Office of Radiation Control
Division of Public Health

Department of Health and Social Services
Robbins Bldg.
802 Silver Lake Blvd
Silver Lake Plaza
Post Office Box 637
Dover, Delaware 19901

DISTRICT OF COLUMBIA (DC)
Office Hours - 8:15-4:45 EST
Business:202/727-7190

Department of Consumer and Regulatory Affairs
Service Facility Regulation Administration
614 H Street, N.W. Room 1014
Washington, D.C. 20004

FLORIDA (FL)
Office Hours - 8:00-5:00 EST
24 Hour Phone #305/299-0580

Office of Radiation Control
Department of Health and Rehabilitative Services
1317 Winewood Boulevard
Tallahassee, Florida 32301

Orlando Office
Business: 305/299-0580

Environmental Radiation Control Program
Office of Radiation Control
Department of Health and Rehabilitative Services
Post Office Box 15490
Orlando, Florida 32858

GEORGIA (GA)
Office Hours - 8:00-5:00 EST
24 Hour Phone #404/656-4300

Environmental Radiation Coordinator
Department of Natural Resources
Trinity-Washington Building
270 Washington Street, S.W., Rm. 824
Atlanta, Georgia 30334

GUAM (GU)
Business:671/734-2671

Department of Public Health and
Social Services
Government of Guam
Post Office Box 2816
Agana, Guam 96910

HAWAII (HI)
Office Hours - 7:45-4:30 HST
Business:808/548-4383

Noise and Radiation Branch
Environmental Protection and Health
Services Division
Department of Health
591 Ala Moana Boulevard
Honolulu, Hawaii 96813

IDAHO (ID)
Office Hours - 8:00-5:00 MST
Business:208/334-4107

Radiation Control Section
Department of Health and Welfare
Statehouse Mail
Boise, Idaho 83720

ILLINOIS (IL)
Office Hours -8:30-5:00 CST
24 Hour Phone# 217/782-7860

Department of Nuclear Safety
1035 Outer Park Drive
Springfield, Illinois 62704

INDIANA (IN)
Office Hours - 8:15-4:45 EST
Business:317/633-0152

Radiological Health Section
State Board of Health
1330 West Michigan Street
Post Office Box 1964
Indianapolis, Indiana 46206

IOWA (IA)
Office Hours - 8:00-4:30 CST
Business:515/281-4928

Environmental Health Section
Iowa Department of Health
Lucas State Office,Building
Des Moines, Iowa 50319

KANSAS (KS)
Office Hours - 8:00-4:30 CST
Business:913/862-9360

Bureau Of Air Quality and Radiation
Control
Department of Health and Environment
Forbes Field, Bldg. 740
Topeka, Kansas 66620

KENTUCKY (KY)
Office Hours- 8:00-4:30 EST
24 Hour Phone # 502/564-7815

Radiation Control Section
Cabinet for Human Resources
275 East Main Street
Frankfort, Kentucky 40621

LOUISIANA (LA)
Office Hours - 8:00-4:30 CST
24 Hour Phone #:504/925-4518

Nuclear Energy Division
Office of Air Quality and Nuclear Energy
Department of Environmental Quality
Post Office Box 14690
Baton Rouge, Louisiana 70898-4690

MAINE (ME)
Office Hours - 8:00-5:00 EST
24 Hour Phone # 207/289-2155

Division of Health Engineering
157 Capitol Street
Augusta, Maine 04333

Mailing Address: State House, Station 10
Augusta, Maine 04333

MARYLAND (MD)
Office Hours - 8:30-4:30 EST
Business: 301/225-6031

Community Health Management Program
Department of Health and Mental Hygiene
O'Conor Office Building
201 West Preston Street
Baltimore, Maryland 21201

MASSACHUSETTS (MA)
Office - 8:45-5:00 EST
Business:617/727-6214

Radiation Control Program
Department of Public Health
150 Tremont Street, Seventh Floor
Boston, Masschusetts 02111

MICHIGAN (MI)
Office Hours - 8:30-5:00 EST
24 Hour Phone #:517/337-6100

Division of Radiological Health
Bureau of Environmental and Occupational
Health
Department of Public Health
3500 North Logan Street
Post Office Box 30035
Lansing, Michigan 48909

MINNESOTA (MN)
Office Hours -8:00-4:30 CST
24 Hour Phone # 612/778-0800

Section of Radiation Control
Environmental Division
Minnesota Department of Health
717 Delaware Street, SE.
Post Office Box 9441
Minneapolis, Minnesota 55440

MISSISSIPPI (MS)
Office Hours - 8:00-5:00 CST
Business:601/354-6657

Division of Radiological Health
State Department of Health
3150 Lawson Street
Post Office Box 1700
Jackson, Mississppi 39215-1700

MISSOURI (MO)
Office Hours -8:00-5:00 CST
Business:314/751-8208

Bureau of Radiological Health
173 East Elm Plaza
Post Office Box 570
Jefferson City, Missouri 65102

MONTANA (MT)
Office Hours - 8:00-5:00 MST
Business:406/444-3671

Occupational Health Bureau
Department of health and Environmental
Sciences
Cogswell Building
Helena, Montana 59620

NEBRASKA (NE)
Office Hours- 8:00-5:00 CST
Business:402/471-2168

Division of Radiological Health
Department of Health
301 Centennial Mall, South
Post Office Box 95007
Lincoln, Nebraska 68509

NEVADA (NV)
Office Hours - 8:00-5:00 PST
Business:702/885-5394

Radiological Health Section
Health Division
Department of Human Resources

505 East King Street
Carson City, Nevada 89710

NEW HAMPSHIRE (NH)
Office Hours -7:45-3:45 EST
24 Hour Phone # 603/271-3636
(State Police-ask to page)

Radiological Health Program
Post Office Box 148
Concord, New Hampshire 03301

NEW JERSEY (NJ)
Office Hours- 8:00-5:00 EST
24 Hour Phone # 609/292-7172

Radiation, Pesticides, and
Environmental Laboratories
Department of Environmental Protection
380 Scotch Road
Trenton, New Jersey 08628

NEW MEXICO (NM)
Office Hours- 8:00-5:00 MST
24 Hour Phone # 505/827-9126

Radiation Protection Bureau
Environmental Improvement Division
Department of Health and
Environment
Post Office Box 968
Santa Fe, New Mexico 87504-0968

NEW YORK (NY)
Office Hours -8:00-4:45 EST

State Health Agency
24 Hour Phone # 518/457-2200

Bureau of Environmental Radiation
Protection
State Health Department
Empire State Plaza, Corning Tower
Albany, New York 12237

State Environmental Agency
24 Hour Phone # 518/458-1875

Bureau of Energy and Radiation
Division of Regulatory Affairs
State Department of Environmental
Conservation
50 Wolf Road
Albany, New York 12233

State Labor Agency
Business # 212/488-7790

Radiological Health Unit
State Department of Labor
2 World Trade Center
New York, New York 10047

NORTH CAROLINA (NC)
Office Hours-7:30-5:30 EST
24 Hour Phone # 919/733-3861

Radiation Protection Section
Division of Facility Services
Department of Human Resources
Post Office Box 12200
Raleigh, North Carolina 27605-2200

NORTH DAKOTA (ND)
Office Hours 8:00-5:00 CST
24 Hour Phone # 701/224-2121

Division of Environmental Engineering
Department of Health
Missouri Office Building
1200 Missouri Avenue
Bismarck, North Dakota 58501

OHIO (OH)
Office Hours - 7:45-4:30 EST
Business: 614/466-1380

Radiological Health Program
Department of Health
246 North High Street
Post Office Box 118
Columbus, Ohio 43216

OKLAHOMA (OK)
Office Hours - 8:00-4:30 CST
24 Hour Phone # 405/271-5221

Radiation and Special Hazards Service
State Department of Health
Post Office Box 53551
Oklahoma City, Oklahoma 73152

OREGON (OR)
Office Hours 8:00-5:00 PST
24 Hour Phone # 503/229-5797

Radiation Control Section
State Health Division
Department of Human Resources
1400 Southwest Fifth Avenue
Portland, Oregon 97201

Mailing Address: State Health Division
Post Office Box 231
Portland, Oregon 97207

PENNSYLVANIA (PA)
Office Hours 8:00-4:00 EST
24 Hour Phone #:717/783-8150

Bureau of Radiation Protection
Department of Environmental Resources
Fulton Building, 16th Floor
Third and Locust Street
Harrisburg, Pennsylvania 17120

Mailing Address: Post Office Box 2063
Harrisburg, Pennsylvania 17120

City of Philadelphia
Business:215/MU6-5155

Environmental Health Services
Philadelphia Department of Public Health
500 South Broad Street
Philadelphia, Pennsylvania 19146

PUERTO RICO (PR)
Office Hours-8:00-12:00;
1:00-4:30 AST
24 Hour Phone #:809/767-6060

Radiological Health Division
G.P.O. Call Box 70184
Rio Piedras, Puerto Rico 00936

RHODE ISLAND (RI)
Office Hours -8:30-4:30 EST
Business:401/277-2438

Division of Occupational Health
and Radiation Control
Department of Health
Cannon Building, Davis Street
Providence, Rhode Island 02908

SOUTH CAROLINA (SC)
Office Hours - 8:30-5:00 ESt
After Hours Phone # 803/758-5531
Business:803/758-8354

Bureau of Radiological Health
South Carolina Department of Health
and Environmental Control
2600 Bull Street
Columbia, South Carolina 29201

SOUTH DAKOTA (SD)
Office Hours- 8:00-5:00 CST
Business:605/773-3364

Licensure and Certification Program
State Department of Health
Joe Foss Office Building
523 East Capital
Pierre, South Dakota 57501

Environmental Agency
Business:605/773-3329

Office of Air Quality and Solid Waste
Department of Water and Natural
Resources
Joe Foss Office Building
523 East Capital
Pierre, South Dakota 57501

TENNESSEE (TN)
Office Hours - 8:00-4:30 CSt
24 Hour Phone # 615/252-3300

Division of Radiological Health
TERRA Building, 150 9th Avenue,N.
Nashville, Tennessee 37203

TEXAS (TX)
Office Hours 8:00-5:00 CST
24 Hour Phone # 512/458-7460

Bureau of Radiation Control
Department of Health
1100 West 49th Street
Austin, Texas 78756-3189

UTAH (UT)
Office Hours 8:00-5:00 MST
Business:801/533-6734

Bureau of Radiation Control
State Department of Health
State Office Building, Box 45500
Salt Lake City, Utah 84145

VERMONT (VT)
Office Hours 8:00-4:30 EST
24 Hour Phone #802/244-8757 Pager #9

Division of Occupational and
Radiological Health
Department of Health
Administration Building
10 Baldwin Streeet
Montpelier, Vermont 05602

VIRGINIA (VA)
Office Hours- 8:30-4:30 EST
Business:804/786-5932

Bureau of Radiological Health
Division of Health
109 Governor Street
Richmond, Virginia 23219

VIRGIN ISLANDS (VI)
Office Hours-8:00-5:00 AST
Business:809/774-1301

Department of Public Works
Post Office Box 3594
St. Thomas, Virgin Islands 00801
(St. Thomas and St. John)

WASHINGTON (WA)
Office Hours- 8:00-5:00 PST
24 Hour Phone # 206/NUCLEAR

Radiation Control Section
Department of Social and Health
Services
Mail Stop LF-13
Olympia, Washington 98504

WEST VIRGINIA (WV)
Office Hours- 8:30-4:30 EST
24 Hour Phone # 304/348-5380

Industrial Hygiene Division
151 11th Avenue
South Charleston, West Virginia 25303

WISCONSIN (WI)
Office Hours- 7:45-:30 CST
Business:608/273-5181

Radiation Protection Section
Division of Health
Department of Health and Social Services
Post Office Box 309
Madison, Wisconsin 53701

WYOMING (WY)
Office Hours- 8:00-5:00 MST
24 Hour Phone # 307/777-7244

Radiological Health Services
Division of Health and Medical Services
Hathaway Building
Cheyenne, Wyoming 82002-0710