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ENERGY & ENVIRONMENT DIVISION

RADON: A BIBLIOGRAPHY

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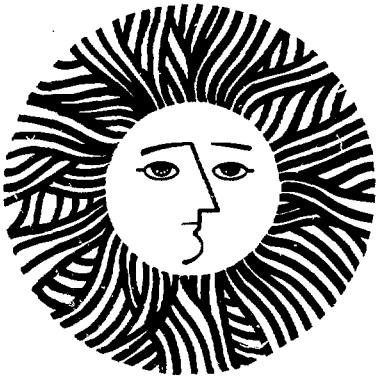

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RADON: A BIBLIOGRAPHY

The Lawrence Berkeley Laboratory, with the support of the Department of Energy, has developed a computerized database to manage research information in the area of building ventilation and indoor air quality. This literature survey contains references pertaining to the physical properties of radon and its daughters, instrumentation for their measurement, health effects, surveys and measurements, and regulatory information. The references in the bibliography are sequenced in alphabetical order and abstracts are included when supplied by the author. The objective of this report is to disseminate the bibliographic references compiled at the laboratory relating to radon research portion of the program. Interested database users are encouraged to contact the laboratory to receive instructions for direct database access. A flyer describing the database is supplied at the end of the bibliography and a brief overview of the Radon Research Program is given below.

RADON RESEARCH PROGRAM AT LBL

Radon-222 and its daughters, members of the uranium-238 decay chain present throughout the earth's crust, have long been recognized as significant contributors to natural background radiation. Exposure of the general population to radon and its daughters occurs primarily indoors, where concentrations are usually higher than outdoors. In buildings that have been built or retrofitted to have low air-exchange rates, a reduction in venitlation rate may result in an increase of indoor radon levels. The emphasis of the Radon Research Program is to study the significance of radon and its daughters as indoor air pollutants,

to measure and evaluate radon and daughter concentrations in buildings designed or retrofitted to reduce infiltration or ventilation, to develop radon monitoring instrumentation, and to study the physical behavior of radon and its daughters in the indoor environment.

1. American National Standards Institute, Inc. (New York, NY)

USA standard: Radiation protection in uranium mines and mills (concentrators). USAS N7.1-1960 31 p., 1961.

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2. American National Standards Institute, Inc (New York, NY)

American national standard: Supplement to radiation protection in uranium mines and mills (concentrators). ANSI N7.1a-1969 16 p., 1970.

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3. American National Standards Institute, Inc. (New York, NY)

American national standard: Radiation protection in uranium mines. ANSI N13.1-1971 54 p.

ABSTRACT: This standard covers the mining, transporting and refining of ores to produce uranium concentrates. Workers in uranium mines and mills are exposed to external gamma and beta radiation and to airborne dust and gas containing all of the elements in the uranium series. When inhaled, these elements may build up in deposits which may then deliver significant radiation doses to body tissues. This standard presents minimum requirements for the protection of workers from overexposure to radiation and radioactive dusts and gases from the uranium mining and milling industry. It also suggests procedures for proper control and examination of workers in order that the desired protection be maintained. It is intended that this standard will serve as a guide to management and regulatory agencies having responsibility in this field of activity.

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4. Argonne National Laboratory. (Argonne, IL)

Radiological and Environmental Research Division Annual Report: Center for Human Radiobiology, July 1978 - June 1979. ANL-79-65, Part II 229 p., 1979.

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5. Atomic Energy Commission.

Part 12: Grand Junction remedial action criteria.

FED. REGIST. (WASH., D.C.) 37: 61n-61o, 12/31/72.

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6. Bureau of Mines. (Washington, D.C.)

Alpha radiation exposure levels in underground uranium and other mines.

RADIOL. HEALTH DATA REP. 9(12): 719-723, 12/--/68.

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7. Bureau of Mines. (Washington, D.C.)

Continuous measurement of working level exposure of uranium miners.

TECHNOL. NEWS(60) 1-2, 02/--/79.

ABSTRACT: A continuous working level monitor has been developed. A constant flow pump draws mine air through a fiberglass filter on which radioactive particles collect and decay, releasing alpha, beta and gamma rays. A portion of the beta particles are detected by a Geiger-Mueller tube, and create electrical impulses which feed to a central monitor which has both analog and digital outputs. From these outputs the working level is calculated. Laboratory and field evaluations have demonstrated a working level accuracy of plus or minus 10%. The unit was shown to be durable in the several months of mine tests.

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8. Bureau of Mines. (Washington, D.C.)

Radon daughter dosimeter.

TECHNOL. NEWS 61: 1-2, 02/--/79.

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9. Department of Energy. Division of Environmental Control Technology. (Washington, D.C.), Department of Energy. Grand Junction Office. (Grand Junction, CO), Colorado Department of Health. (Denver, CO), C. E. McGuire, Inc. (Greeley, CO)

Progress report on the Grand Junction Uranium Mill Tailings Remedial Action Program. DOE/EV-0033 5 p., 02/--/79.

ABSTRACT: This report is on the uranium mill tailing remedial action program at Grand Junction, Colorado. It provides a history of the program, an analysis of the current status of the program, problems encountered and measures being taken to solve them, and a forecast of future effort required. From the start of remedial efforts in 1973 through September 30, 1978, remedial action has been done on 325 individual structures, including 289 private residences, 14 schools, and 22 commercial business/church locations. As recently as one year ago, the total number of structures requiring remedial action was estimated to be about 600. However, continuing measurements of radon daughter concentrations in structures which previously showed only slightly elevated gamma radiation have resulted in identification of additional structures exceeding the Surgeons General's guidelines for radon daughters. Because radon daughter concentrations in structures are highly variable depending on the season of the year and the level of activity, annual averages are used for determining eligibility under the guidelines. Based on this recent experience the estimate of the total number of structures which will eventually qualify for remedial action has been increased from $12,670,000 to $16,960,000.

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10. Department of Health, Education, and Welfare. Public Health Service. (Rockville, MD), Atomic Energy Commission.

Evaluation of radon 222 near uranium tailings piles. DER 69-1 67 p., 03/--/69.

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11. Department of National Health and Welfare. Radiation Protection Bureau. (Ottawa, Ontario, Canada)

Appendix F: Radiation survey of Long Harbour, Newfoundland.

FINAL REPORT: CANADIAN PUBLIC HEALTH ASSOCIATION TASK FORCE ON FLUORIDE. 117-137, 1978.

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12. Dilworth, Secord, Meagher & Associates, Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Development program for radon reduction, Report 5: Radon diffusion barrier tests on commercial paints. DSMA Report 1095/1033 6 p., 04/--/79.

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13. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Development Program for Radon Reduction, Report 2: Condensation nuclei concentration in occupied buildings. DSMA-1012/1009 3 p., 11/--/78.

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14. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Development Program for Radon Reduction, Report 4: Radon production rate of Elliot Lake soils. DSMA-1012/1024 9 p., 01/--/79.

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15. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Development Program for Radon Reduction, Report 7: Natural radioactivity in Ontario sands.

DSMA-1095/1046 11 p., 06/--/79.

16. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Development Program for Radon Reduction, Report 6: Variation of radon concentration in soil gas. DSMA-1095/1045 9 p., 06/--/79.

17. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Elliot Lake Technical Note No. 10: Estimating RaA concentration and WL by the modified Markov-Rolle method. DSMA-1095/1056 4 p., 08/--/79.

18. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Elliot Lake Technical Note No. 9: Use of the Rolle method for WL estimates in houses. DSMA-1095/1052 2 p., 08/--/79.

19. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Development Program for Radon Reduction, Report 8: Thoron interference with WL measurements. DSMA-1095/1053 3 p., 08/--/79.

20. Dilworth, Secord, Meagher and Associates Ltd. (Toronto, Ontario, Canada), Acres Consulting Services Ltd.

Elliot Lake Technical Note No. 6: 'Exact' Kusnetz factors for the Elliot Lake sampling technique. DSMA-1012/1022 3 p., 01/--/79.

21. DSMA Atcon Limited (Toronto, Ontario, Canada), Acres Consulting Services Limited

Development program for radon reduction, Report 11: Concrete block filters. DSMA Report 1095/1078 10 p., 12/--/79.

22. International Commission on Radiological Protection, Committee 4. (Sutton, UK)

Radiation protection in uranium and other mines: A report of Committee 4 of the International Commission on Radiological Protection. ICRP Publication 24 28 p., 03/--/76.

23. Keith Consulting. (Uranium City, Saskatchewan, Canada)

Reducing airborne radiation in dwellings using make-up air ventilation. 21 p., 1979.

24. Keith Consulting. (Uranium City, Saskatchewan, Canada)

Summary of investigation and remedial work. 4 p., 1979.

25. Keith Consulting. (Uranium City, Saskatchewan, Canada)

Radon infiltration in a house with concrete block walls. 14 p., 1979.

26. Keith Consultins. (Uranium City, Saskatchewan, Canada)

Concrete porosity and radon migration. 15 p., 03/--/79.

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27. Lawrence Berkeley Laboratory. Energy and Environment Division. (Berkeley, CA)

Energy Efficient Buildings Program. LBL-7842, 1977.

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28. National Council on Radiation Protection and Measurements. (Washington, D.C.)

Inhaled radioactivity. NCRP-45

NATURAL BACKGROUND RADIATION IN THE UNITED STATES. 75-89, 11/15/75.

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29. Nuclear Energy Agency. (Paris, France), Organisation for Economic Co-operation and Development. (Paris, France)

Personal dosimetry and area monitoring suitable for radon and daughter products: Proceedings of the NEA Specialist Meeting. 270 p.

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30. United Nations.

Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. 40 (A/32/40) 34 p., 07/05/77.

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31. Abu-Jarad, F., Fremlin, J. H.

Track etch detectors for radon measurements inside houses and for building material. 7 p.

ABSTRACT: Cellulose nitrate (LR-115 Kodak and CR-39) has been used as detectors to study the airborne alpha-activity inside houses by two different techniques (air sampler and can technique). It has been used also to study the emanation from different building materials and the efficiency of different paints in reducing the emanation. While the counting projector and screen were used for counting the tracks from each type of detector.

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32. Adams, J. A. S. (ed.), Lowder, W. A. (ed.)

Appendix 4: Properties of the uranium and thorium series.

THE NATURAL RADIATION ENVIRONMENT. 1033-1036, 1964.

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33. Alter, H. W.

Track Etch radon ratios to soil uranium and a new abundance estimate. 9 p.

ABSTRACT: Equilibrium values of the radon content of soil gas are most precisely determined by the time-integrating Track Etch technique. This method, extensively used as a uranium exploration tool, detects radon gas using dielectric detectors which record alpha particle emission from the gas. The detectors are placed in inverted cups which are buried in shallow holes on a grid over the area to be explored. The cups are left in the ground for three to four weeks. This period of time is essential to integrate the signal and eliminate the large fluctuations in radon signal strength which occur with time. Integrated radon values, corrected to a standard exposure time of 30 days, are conveniently expressed as the number of alpha tracks per square millimeter, T, of the solid state track detector.

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34. Altshuler, B., Nelson, N., Kuschner, M.

Estimation of lung tissue dose from the inhalation of radon and daughters.

HEALTH PHYS. 10(12): 1137-1161, 12/--/64.

ABSTRACT: The radon hazard is presumed to be lung cancer induced by alpha irradiation of basal cells in the bronchial epithelium. The effective dose is calculated by a relatively complete analysis which includes (1) the distribution of atmospheric activity by size and daughter, (2) the prediction of alpha decay in the bronchial regions from a model of mucus flow superimposed on calculated regional deposition, (3) measurements of epithelial thickness to determine accessibility of basal cells, and (4) classification of dose by inhaled daughter, size, alpha particle, region, and tissue depth. The cancer-related dose, taken as the largest dose to exceptionally shallow basal cells, associated with one working level of radon daughters is estimated to be 20 rads/yr for nose breathing at 15 l./min., and it may be higher. Comparison with animal experiments suggests that the working level may not be safe and that 30 pC/l. of daughters (0.1 WL) may not be too conservative for the MPC.

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35. Anderson, D. E.

Efficiencies of filter papers for collecting radon daughters.

AM. IND. HYG. ASSOC. J. 428-429, 1960.

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36. Aprilesi, G., Loria, A., Magnoni, G., Marseguerra, M., Morelli, S., Rivasi, M. R.

Absolute estimation of radon daughter concentrations in air by alpha-spectrometry.

NUCL. INSTRUM. METHODS 148(1): 187-194, 01/01/78.

ABSTRACT: A method for the estimation of the concentrations of radon daughters in air is given. The method is based on alpha spectrometric counting measurements performed either during or after the dust collection with an electrostatic precipitator. The relations between measured counts and concentrations in air of the collected nuclides (RaA, RaB and RaC) are obtained assuming a constant collection rate and a linear collection rate model. It turns out that the less sophisticated model gives more satisfactory estimations of the parameters.

---

37. Archer, V. E.

Epidemiologic studies of lung disease among miners exposed to increased levels of radon daughters. 7 p.

ABSTRACT: Mortality of uranium miners from both lung cancer and other respiratory disease is strongly dependent on exposure to radon daughters, cigarette smoking and height. Lung cancer among 15 different mining groups (uranium, iron, lead, [illegible]) was analyzed to determine what factors influence incidence and the induction-latent period. At low exposure and/or exposure rates, alpha radiation is more efficient in inducing lung cancer, producing an upward convex exposure-response curve. The induction-latent period is shortened by increased age at start of mining, by cigarette smoking and by high exposure rates. For followup periods of 20-25 years, the incidence increases with age at start of mining, with magnitude of exposure and with amount of cigarette smoking. Instead of extrapolating downward from high exposures to estimate risk at low levels, it is suggested that it might be more appropriate to use cancer rates associated with background radiation as the lowest point of the exposure-response curve.

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38. Archer, V. E., Lundin, F. E.

Radiogenic lung cancer in man: Exposure-effect relationship.

ENVIRON. RES. 1(4): 370-383, 12/--/67.

ABSTRACT: 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 the 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 E5 mm rad. An exposure of 120 WLM (estimated to equal 360 rad) appears to double the lung cancer incidence characteristic of the general population.

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39. Archer, V. E., Wagoner, J. K., Lundin, F. E.

Uranium mining and cigarette smoking effects on man.

J. OCCUP. MED. 15(3): 204-211, 03/--/73.

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40. Archer, V. E., Wagoner, J. K., Lundin, F. E.

Lung cancer among uranium miners in the United States.

HEALTH PHYS. 25(4): 351-371, 10/--/73.

ABSTRACT: Excess respiratory cancer has been demonstrated among all groups of uranium miners who have had more than 120 Working Level Months of radon daughter exposure. Lung cancer incidence rose with increasing exposure. Factors which might distort the exposure-response relationship were reviewed. Exposure to other agents such as cigarettes probably contributed to the excess, but these factors should not be considered in setting permissible levels. Respiratory cancers are continuing to appear at a high rate among the Study Group even though radon daughter levels have been markedly reduced and most of the Study Group have stopped mining.

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41. Austin, S. R., Droullard, R. F., Denver Mining Research Center. Special Studies Group. Bldg 20. Federal Center. Denver CO 80225.

Radon emanation from domestic uranium ores determined by modifications of the closed-can, gamma-only assay method. BuMines RI 8264 82 p., 1978.

ABSTRACT: Emanation coefficients of 950 samples of domestic uranium ore were successfully and rapidly determined with fair precision by modifications of the closed-can, gamma-only assay method, using commercially available or similar equipment. Coefficients range from <1% to 91%. Emanation varies considerably within each mine and area, but distinct differences among major mining areas were found, ranging from 7.5% for Moss Back Memb., Chinle Fm., SW Lisbon Valley, Utah to 56.5% for Ft. Union Fm. (?), Powder River Basin, Wyo. Coefficients also vary with: (1) uranium mineralogy; (2) radium mineralogy; (3) lithology of host rocks; (4) grain size of uranium and radium minerals; (5) comminution of ore; (6) estimated porosity and permeability; (7) moisture content; (8) ore grade; (9) supposed mobility of deposits; age of deposits is unknown but limited by (10) age of host rocks, which shows only doubtful correlation with emanation. Data obtained may be used to evaluate effects of investigated parameters on radon concentration in mines, and thus to select efficient control measures. Drill-core emanation data allow estimates of probable radon problems in undeveloped deposits.

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42. Auxier, J. A., Becker, K., Robinson, E. M., Johnson, D. R., Boyett, R. H., Abner, C. H.

A new radon progeny personnel dosimeter.

HEALTH PHYS. 21(1): 126-128, 07/--/71.

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43. Auxier, J. A., Shinpaugh, W. H., Kerr, G. D., Christian, D. J.

Preliminary studies of the effects of sealants on radon emanation from concrete.

HEALTH PHYS. 27(4): 390-391, 10/--/74.

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44. Auxier, J. A.

Respiratory exposure in buildings due to radon progeny.

HEALTH PHYS. 31(2): 119-125, 08/--/76.

ABSTRACT: 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 1-5 pCi/liter appears to be a reasonable limit for "lifetime" exposure indoors for "typical" home ventilation conditions.

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45. Axelson, O., Edling, C.

Health hazards from radon daughters in dwellings in Sweden. 6 p.

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46. Axelson, O.

Interaction between smoking and exposure to radon daughters. 4 p.

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47. Ayer, H. E.

Control of radon and its daughters in mines by ventilation. AECU-2858 20 p., 03/15/54.

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48. Barnaby, W.

Very high radiation levels found in Swedish houses.

NATURE (LONDON) 281: 6, 09/06/79.

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49. Bates, D. V., Fish, B. R., Hatch, T. F., Mercer, T. T., Morrow, P. E.

Deposition and retention models for internal dosimetry of the human respiratory tract.

HEALTH PHYS. 12(2): 173-207, 02/--/66.

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50. Bates, R. C., Franklin, J. C.

Uranium mine radon control research.

TRANS. AM. NUCL. SOC. 27: 150-151, 1977.

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51. Bates, R. C.

Rock sealant restricts falling barometer effect.

MIN. ENG. (N.Y.) 29(12): 38-39, 12/--/77.

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52. Bedrosian, P. H.

Photographic technique for monitoring radon-222 and daughter products.

HEALTH PHYS. 16(6): 800-802, 06/--/69.

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53. Bedrosian, P. H., Sensintaffar, E. L., Gels, G. L., Norwood, D. L., Culver, A. A.

Sealants for sources emanating Rn-222.

HEALTH PHYS. 27(4): 387-390, 10/--/74.

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54. Behounek, F.

History of the exposure of miners to radon.

HEALTH PHYS. 19(1): 56-57, 07/--/70.

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55. Black, S. C., Archer, V. E., Dixon, W. C., Saccomanno, G.

Correlation of radiation exposure and lead-210 in uranium miners.

HEALTH PHYS. 14(2): 81-93, 02/--/68.

ABSTRACT: Bone samples from thirty-two uranium miners and eight non-miners were analyzed for Pb-210 content. An estimate of cumulative radiation exposure to radon decay products in uranium mines was made for each man and correlated with his bone Pb-210, both before and after adjustments for excretion were made. There is a definite correlation between exposure and bone Pb-210 as measured, but the correlation is somewhat better when adjustment for lead excretion is made. The concentration of Pb-210 in the bone of uranium miners is related to cumulative exposure (expressed as Working Level Months) by a power function: pCi/g = 4.27 E-5 (WLM)(1.439). By using a number of reasonable assumptions, it was possible to calculate back from the bone Pb-210 to determine the amount of radon daughters inhaled and retained, and from this to calculate radiation dosage delivered to bronchial tissue. These calculations indicate that one Working Level Month delivers approximately 2 rad to bronchial tissue.

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56. Bluszcz, A., Pazdur, A.

Some physical problems of very low Rn-222 concentration measurements with the proportional counter.

NUCL. INSTRUM. METHODS 167: 299-303, 1979.

ABSTRACT: Deposition of radon atoms on the detector walls has been shown to occur during measurements by means of a proportional counter filled with a Rn-222 - CO2 mixture. This paper describes studies of the phenomenon in a range of temperatures. A quantitative model based on the assumption of condensation of radon atoms on the CO2 film adsorbed on the detector walls is considered. Further experiments to verify this hypothesis are proposed.

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57. Bolch, W. E., Desai, N., Roessler, C. E., Kautz, R. S.

Determinants of radon flux from complex media: Virgin and reclaimed lands of Florida's phosphate region. 13 p.

ABSTRACT: Mathematical models for the transport of radon through two strata media is described. The bilayer model reduces to a transport equation for a single layer of finite depth when the upper layer does not exist. The finite model approaches a simpler expression, an infinite model, when depths exceed several meters. The models utilize a number of media parameters that can be measured independently or estimated from media characteristics. The paper summarizes the media parameters for several land types found in the West Central Florida phosphate region. Measured flux values by land type are compared to predicted flux values for the respective land type. The bilayer model is used to demonstrate reclamation management to reduce radon flux at the soil surface.

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58. Breslin, A. J.

Summary discussion of monitoring instrumentation in the uranium mining industry. 5 p., 02/--/72.

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59. Breslin, A. J.

Monitoring instrumentation in the uranium mining industry. 28 p., 02/--/72.

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60. Breslin, A. J., Gossenheim, S. F., George, A. C., Graveson, R. T.

A working level dosimeter for uranium miners. EML-333 16 p., 12/--/77.

ABSTRACT: A working level dosimeter for uranium miners has been developed and thoroughly tested. Detection is by an alpha-sensitive thermoluminescent phosphor positioned directly in front of a membrane filter through which sample air is drawn continuously at a rate of 90 cubic centimeters/minute. Response is linear over several decades of cumulative working level exposure and the limit of sensitivity is about 1.4 WL-h. Attainment of a critical design objective, reliable operation in the adverse environmental conditions of a uranium mine, has been verified by extensive field tests.

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61. Breslin, A. J., George, A. C., Weirstein, M. S., Health and Safety Laboratory. U.S. Atomic Energy Commission. New York NY.

Investigation of the radiological characteristics of uranium mine atmospheres. HASL-220 63 p., 12/--/69.

ABSTRACT: Radiological characteristics of the environments of nine representative uranium mines were studied by survey teams equipped to collect ad analyze samples underground. Spatial and temporal variations of radon concentration, workin level, and radon daughter ratio were investigated for three of four days in each mine by obtaining consecutive measurements at typical locations and operations. Additional measurements included gamma radiation, ore dust concentration, temperature, relative humidity, barometric pressure, and ventilation rate. Data are summarized and discussed in the text, and detailed in three appendices.

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62. Breslin, A. J. (ed)

Radon Workshop, February 1977. HASL-325 166 p., 07/--/77.

ABSTRACT: In February 1977, a third workshop on studies of the natural radiation environment was held at the Health and Safety Laboratory. Its theme was radon with specific emphasis on methods for measuring radon and radon daughters and on the application of those methods in investigations of normal and enhanced radon exposures. The 30 presentations and a summary of discussions in an open session are contained in this report.

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63. Brinck, W. L., Schliekelman, R. J., Bennett, D. L., Bell, C. R., Markwood, I. M.

Determination of radium removal efficiencies in water treatment processes. Technical Note ORP/TAD-76-5 18 p., 12/--/76.

ABSTRACT: Numerous well-water supplies for public water systems contain naturally occurring radium-226. Methods for removing radium from drinking water must be identified so that drinking water treatment plants may meet the limit set in the EPA drinking water regulations for radium in drinking water, 5 pCi/liter. Studies were performed by State agencies at 14 cities in Iowa and Illinois to determine the radium removal efficiency of four water treatment processes. Populations served by the water treatment plants ranged from 235 to 25,000. The radium-226 concentration in the raw water was greater than 5 pCi/liter at 13 of the supplies and ranged from 3 to 49 pCi/liter. Radium removal efficiencies at plants utilizing reverse osmosis and sodium ion-exchange processes were generally about 92%. A much wider range of removal efficiencies, 75% to 95%, was found at plants utilizing the lime-soda ash softening process. Plants utilizing iron removal processes only were found to have radium removals ranging from 11% to 53%. Pilot plant studies at the USEPA Cincinnati laboratory indicated that radium removal in the lime softening process is related to the pH used in the process. Higher radium removal efficiency accompanies higher pH values. It is concluded that water treatment processes are available for removing radium from drinking water to meet the 5 pCi/liter limit.

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64. Buchnitz, R. J.

Radon-222 and its daughters: A review of instrumentation for occupational and

environmental monitoring.

HEALTH PHYS. 26: 145-163, 1974.

ABSTRACT: The aim of this review is to provide an overview of the techniques which have been developed for measuring Rn-222 and its daughters in various media. The main emphasis is on measurements for surveillance and protection n occupational and environmental situations. Measurements in specialized research applications are not treated in detail. Overviews are first provided of the physical characteristics of Rn-222 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.

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65. Burgess, W. A., Shapiro, J.

Protection from the daughter products of radon through the use of a powered air-purifying respirator.

HEALTH PHYS. 15: 115-121, 1968.

ABSTRACT: The protection afforded by a powered air-purifying respirator against radon daughters has been evaluated under physiological working conditions in air concentrations of daughter products in excess of E-8 Ci/l. The tests demonstrated that this device could reduce the exposure to the radon daughters by factors of greater than 1000. Since the respirator filter did not remove the radon the actual degree of protection afforded by the device in a radon-radon daughter atmosphere was evaluated. Several different methods for calculating dose were used and the results compared. It is suggested that a conservative protection factor of 20 be utilized for such devices until the critical regions of the lung affected by exposure to radioactivity in mines are identified.

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66. Busigin, A., Nathwani, J. S., Phillips, C. R.

Attenuation of radon flux from uranium mill tailings by consolidation.

HEALTH PHYS. 36: 393-399, 03/--/79.

ABSTRACT: A method is developed for predicting the effectiveness of consolidation of uranium mill tailings in reducing the releases of radon derived from decay of radium. The method is based upon a model of the diffusion process in terms of emanation coefficients and diffusivities, and provides for easy experimental evaluation of these parameters. From the model, the minumum effective depth of consolidated tailings can be predicted.

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67. Busigin, A., van der Vooren, A., Phillips, C. R.

Interpretation of the response of continuous radon monitors to transient radon concentrations.

HEALTH PHYS. 37: 659-667, 11/--/79.

ABSTRACT: Continuous monitoring of radon concentrations can yield substantially more information than grab sampling in situations where concentrations vary significantly with time. Although several continuous monitors have been designed, calibration is usually difficult and not completely rigorous. In this work a simple and rigorous method is developed for the calibraion and operation of all types of continuous flow-through instruments. Theoretical and experimental verification of the method is provided.

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68. Busigin, A., van der Vooren, A. W., Phillips, C. R.

Collection of radon daughters on filter media.

ENVIRON. SCI. TECHNOL. 14(5): 533-536, 05/--/80.

ABSTRACT: Filters commonly used in the collection of radon daughters are compared in terms of surface collection and overall collection efficiency. Alpha spectroscopy is used to determine the magnitude of penetration of unattached and attached radon daughters to determine the surface collection efficiency of 20 different filters. Collection efficiency was found to be effectively 100% in all filters. However, surface collection varies

widely, with implications for recoil loss and for measurement of alpha spectra.

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69. Carr, G., Tappan, J. T.

Phase I demonstration and study of ventilation/filtration techniques as a uranium mill tailings remedial action. 74 p., 09/--/76.

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70. Carson, D. W.

Canalph-3: A portable three-channel alpha spectrometer for measuring the daughter products of radon and thoron. MRP/MSL 79-108 (TR) 64 p., 07/--/79.

ABSTRACT: A portable three-chanel alpha spectrometer for the measurement of radon and thoron daughters in uranium mines or homes is described. The computer programs for analysing the data to give the working levels of radon and thoron by both the alpha spectrometric and modified Kusnetz methods are included along with some typical results.

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71. Caruthers, L. T., Waltner, A. W.

Need for standards for natural airborne radioactivity (radon and daughters) concentrations in modern buildings.

HEALTH PHYS. 29(5): 814-817, 11/--/73.

ABSTRACT: A survey of radon 222 concentrations in the buildings of the North Carolina State University and surrounding homes is discussed. It was found that high air activities were not necessarily correlated with large concrete structures. Ventilation and degree of tightness of buildings were found to be dominant factors in indoor air radiation levels. Increased ventilation of one campus building significantly reduced radon levels. It is suggested maximum permissable concentrations or other radiation standards be mandated for buildins and homes.

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72. Cohn, J. I.

Comments on "Rapid measurements of Rn-222 concentrations in water with a commercial liquid scintillation counter."

HEALTH PHYS. 35(6): 863, 12/--/78.

ABSTRACT: In this letter to the editor, Cohn criticizes the paper by Prichard "Rapid measurement of Rn-222 concentration in water with a commercial liquid scintillation counter." (Health Physics, 33: p 577.) In question is the reported lower limit of detection obtainable with Prichard's method of radon measurement.

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73. Chamberlain, A. C., Dyson, E. D.

The dose to the trachea and bronchi from the decay products of radon and thoron.

BR. J. RADIOL. 29(342): 317-325, 06/--/56.

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74. Chapuis, A., Dajlevic, D., Duport, P., Soudain, G., Commissariat a l'Energie Atomique. Department de Protection. Service Technique d'Etudes de Protection et de Pollution Atmospherique. Section Dosimetrie Physique.

Radon dosimetry. 5 p.

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75. Clements, W. E., Wilkening, M. H.

Atmospheric pressure effects on 222 Rn transport across the earth-air interface.

J. GEOPHYS. RES. 79(33): 5025-5029, 11/20/74.

ABSTRACT: The effect of large-scale atmospheric pressure changes on the Rn-222 flux across the soil-air interface is investigated. Field data collected during 1972 and 1973 show that pressure changes of 1-2% associated with the passage of frontal systems produce changes in the Rn-222 flux from 20 to 60%, depending upon the rate of change of pressure and its duration. A simple model of molecular diffusion combined with pressure-induced transport in the soil has been confirmed by laboratory experiments using a vertical column of Ra-226 bearing sand. On the basis of this model, pressure changes of 10-20 mbar occurring over a period of 1-2 days produce Darcy velocities of the order of E-4 cubic meters 5-1 near the surface of a soil having a permeability of E-8 cubic meters. The corresponding variations in the Rn-222 flux predicted by the model are in agreement with those observed from valley alluvium in centra New Mexico.

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76. Cliff, K. D.

A radon daughter monitor for use in the general environment and in mines. 9 p.

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77. Cliff, K. D.

Radon daughter exposure of the U.K. population: Effects of energy conservation and possible action to reduce exposure. 13 p.

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78. Cliff, K. D.

Assessment of airborne radon daughter concentrations in dwellings in Great Britain.

PHYS. MED. BIOL. 23(4): 696-711, 1978.

ABSTRACT: Calculations of the activity concentration RaA (Po-218) in the air within living rooms and in the outside air were made at 87 dwellings in England and Scotland. From these measurements together with a determination of the ventilation rate existing in the room at the time of the measurements, the rate at which Rn-222 is emanating from room surfaces into room air in pCi/liter/hour can be calculated. For the dwellings studied the mean emanation rate is 0.34 pCi/liter/hour and on the basis of a mean ventilation rate of one room change per hour throughout the year and assuming an occupancy factor of 0.8 the population exposure rate for the population of Great Britain to the short-lived daughters of Rn-222 is estimated to be 0.15 Working Level Months per year.

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79. Cliff, K. D.

The measurement of low concentrations of radon-222 daughters in air, with emphasis on RaA assessment.

PHYS. MED. BIOL. 23(1): 55-65, 01/--/78.

ABSTRACT: A number of methods exist for the measurement of the activity concentrations of radon-222 daughters in air but in most cases interest is centred on determining the Working Levels. In those instances where individual daughter activity concentrations are assessed the precision of the assessment of RaA (Po-218) is poor unless spectrometry is used. In environmental monitoring the measurement of RaA activity concentrations is a reliable indicator of radon activity concentrations as low as 0.05 pCi/l (50 pCi/cubic meter) of RaA to be measured with simple readily transportable equipment. The method presented here also measures RaB (Pb-214) and RaC (Bi-214) activity concentrations and Working Levels with improved precision compared with established methods.

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80. Cliff, K. D.

Population exposure to the short-lived daughters of radon-222 in Great Britain.

RADIOL. PROT. BULL.(22) 18-23, 01/--/78.

ABSTRACT: A survey of the concentrations of radon 222 daughter products in and surrounding 87 English homes has been taken. Combined with a measurement of the corresponding ventilation rates, the emaration rate of radon 222 was calculated. An

adjusted mean of 0.54 pCi (sup) (-1) h (sup) (-1) was found for all homes except those using high radium content granite. Using a mean ventilation rate of one air change per hour throughout the year and based on an estimated occupancy factor of 0.8, the population exposure rate for the population of Great Britain is estimated to be 0.15 WLM Y (sup) (-1). Ventilation reduction imposed by rising fuel costs is expected to raise the present exposure levels.

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81. Cliff, K. D., Davies, B. L., Reissland, J. A.

Little danger from radon.

NATURE 279: 12, 05/03/79.

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82. Cohen, B. L.

Radon: Characteristics, natural occurrence, technological enhancement, and health effects. 63 p., 08/--/78.

ABSTRACT: Reviews the general properties of radon, its health effects and its various sources. Includes discussion of the following topics: 1) measuring techniques; 2) the working level unit; 3) radon behavior in the atmosphere; 4) radiation dose from inhalation; 5) health effects in miners and in the general public; 6) evaluation of the linearity hypothesis of dose-effects; 7) uranium mill tailings as a source of radon; 8) health effects from mill tailings; 9) reduction of emissions from mill tailings; 10) use of mill tailings in construction; 11) uranium mills and mines as sources of radon; 12) radon exposure reduction through uranium mining; 13) and other radon sources such as coal, natural gas, phosphates, and water supplies.

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83. Coleman, R. D., Kusnetz, H. L., Woolrich, P. F., Holaday, D. A.

Radon and radon daughter hazards in mine atmospheres: Investigations on supplemental control.

AM. IND. HYG. ASSOC. Q. 17: 405-410, 12/--/56.

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84. Colle, R. (ed.), McNall, P. E., Jr. (ed.)

Radon in buildings: Proceedings of a roundtable discussion of radon in buildings held at the National Bureau of Standards. NBS Special Publication 581 84 p., 06/--/80.

ABSTRACT: 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.

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85. Colle, R. (ed), McNall, P. E., Jr. (ed)

Radon in buildings: Proceedings of a Roundtable Discussion on Radon in Buildings held at the National Bureau of Standards, Gaithersburg, Maryland, June 15, 1979. NBS Special Publication 581 84 p., 06/--/80.

ABSTRACT: 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 interdisciplinay interests 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.

86. Costa-Ribeiro, C., Thomas, J., Drew, R. T., Wrenn, M. E., Eisenbud, M.

A radon detector suitable for personnel or area monitoring.

HEALTH PHYS. 17: 193-198, 1969.

ABSTRACT: A radon detector is described which can be used to measure integrated radon exposure. Radon but not its daughters in the atmosphere to be sampled diffuses through a porous medium into a chamber with a sensitive volume of 28 cubic centimeters. A 60 V potential is maintained between a hemispherical screen and an aluminized mylar film covering a zinc sulfide (ZnS(Ag)) coated lucite light pipe. When Rn-222 decays, Po-218, which is generally produced as a positively charged ion, is electrostatically collected on the aluminized mylar surface. Decay of Po-218 (T 1/2 = 3.05 min) produces scintillations in the zinc sulfide, which are recorded on a photographic film selected because of its sensitivity to the 4500 A radiation emitted by ZnS(Ag). The film is then developed and the exposure read by conventional densitometry. In this paper, the design of the device is described, and the results of field and laboratory tests are presented. The instrument has a capability of monitoring atmospheres which average between 40 pCi/l. and 550 pCi/l. of radon during a period of 170 hr.

87. Cote, P., Carson, D. W., Leclerc, A., Townsend, M. G., Tremblay, R. J.

Optimisation of radon and thoron daughter counting procedures. MRP/MSL 78-201 (OP&J) 17 p. , 10/--/78.

ABSTRACT: A general procedure for counting total alpha-particles in air containing mixtures of radon and thoron is introduced that allows estimation of radon and thoron daughter WL's to plus or minus 20%. A general procedure is also proposed for a 3-energy-channel alpha-spectrometer to evaluate RaA, RaB, RaC, ThB and ThC. Thoron daughter WL's were found to be about half those of radon daughter WL's in a uranium mine in Canada.

88. Countess, R. J.

Rn-222 flux measurement with a charcoal canister.

HEALTH PHYS. 31(5): 455-456, 11/--/76.

ABSTRACT: A simple method for measuring radon 222 emanation from surfaces has been developed. It consists of placing a U.S. Army gas canister containing activated carbon over a source to adsorb radon gas. Analysis of the daughter products formed from the adsorbed radon is performed by gamma spectroscopy. This process differs from earlier methods in that there is no need to transfer the carbon for gamma analysis, thus there is less possibility for radon loss. The canisters have the advantage of being reliable, reusable, convenient, and inexpensive. Counting errors as low as seven per cent are possible with 100 minute counts.

89. Countess, R. J., Thomas, J. W.

Radon flask monitor. HASL-330 17 p., 08/--/77.

ABSTRACT: A continuous monitor for radon in air based on scintillation alpha counting has been developed for measurement of concentrations over 1 pCi/l. The monitor draws air through a scintillation flask and the operation is automated such that the total alpha counts are printed out every 2000s. Radon concentration is calculated with use of a correction for daughter activity deposited in the flask during previous sampling.

90. Countess, R. J.

Measurement of 222-Rn in water.

HEALTH PHYS. 34: 390-391, 04/--/78.

91. Cox, F. M.

New solid lithium fluoride thermoluminescent dosimeters. 11 p.

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92. Cross, F. T., Stuart, B. O., Palmer, R. F., Gaven, J. C., Upton, K. C.

Inhaled radon daughters and uranium ore dust in rodents. PNL 2850 (Pt. I)

PACIFIC NORTHWEST LABORATORY ANNUAL REPORT FOR 1978 TO THE DOE ASSISTANT SECRETARY FOR ENVIRONMENT. PART I: BIOMEDICAL SCIENCES. 3.55-3.57, 1978.

ABSTRACT: Groups of male SPF Wistar rats were exposed to several levels of radon daughters and uranium ore dust. These studies were designed to elucidate the dependence of pulmonary disease states on radon daughter exposure rate with concurrent exposure to ore dust. Clinical and histopathological data to date indicate no significant differences among exposed animals when compared with controls.

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93. Crozier, W. D., Biles, N.

Measurements of radon 220 (thoron) in the atmosphere below 50 centimeters.

J. GEOPHYS. RES. 71(20): 4735-4741, 10/15/66.

ABSTRACT: Direct measurements of radon 220 (Thoron) have been made from the ground surface to a height of 50 cm, using apparatus adapted from that of G.W. Israel. Activity profiles are similar to those calculated by Jacobi and Andre and by Wormell; this supports their assumption that in the 50-cm height range a linear increase of diffusivity with height properly describes the turbulent diffusion of radioactive emissions from the soil surface, at least for turbulence of moderate intensity. The maximum activity at ground level, as expected, occurs at night during intervals of very low wind speed; it reaches values 75 to 150 times as high as the typical activities at 50 cm and 1 m. The radon 220 flux through the soil surface at our site is approximately 2.1 E-15 curie/square centimeter/second, or 0.006 atom/square centimeter/second. The activities of radon 220 plus polonium 216 observed under conditions of very low turbulent diffusion are capable of yielding an ion production rate of about 250 ion pairs/cubic centimeter/second in the lowest 10 cm of the atmosphere over appreciable time intervals; this seems adequate to explain the presence of the shallow stratum of relatively high space charge density previously reported to exist under the conditions.

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94. Crozier, W. D.

Direct measurement of radon-220 (thoron) exhalation from the ground.

J. GEOPHYS. RES. 74(17): 4199-4205, 08/15/69.

ABSTRALT: A method has been devised for direct measurement of Rn-220 flux through the ground surface ('exhalation'), and measurements are reported for six sites. At one site comparisons are made between the measured exhalation and those exhalations deduced from Rn-220 profiles in the air above the site; agreement is good with low intensity of turbulence. The discrepancies with higher turbulence are discussed.

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95. Culot, M. V. J., Olson, H. G., Schiager, K. J.

Effective diffusion coefficient of radon in concrete, theory and method for field measurements.

HEALTH PHYS. 30(3): 263-270, 03/--/76.

ABSTRACT: A linear diffusion model serves as the basis for determination of an effective radon diffusion coefficient in concrete. The coefficient was needed to later allow quantitative prediction of radon accumulation within and behind concrete walls after application of an impervious radon barrier. A resolution of certain discrepancies noted in the literature in the use of an effective diffusion coefficient to model diffusion of a radioactive gas through a porous medium is suggested. An outline of factors expected to affect the concrete physical structure and the effective diffusion coefficient of radon through it is also presented. Finally, a field method for evaluating effective radon

diffusion coefficients in concrete is proposed and results of measurements performed on a concrete foundation wall are compared with similar published values of gas diffusion coefficients in concrete.

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96. Culot, M. V. J., Schiager, K. J., Olson, H. G.

Prediction of increased gamma fields after application of a radon barrier on concrete surfaces.

HEALTH PHYS. 30: 471-478, 06/--/76.

ABSTRACT: A sizable reduction of the indoor radon progeny exposure level is anticipated in structures from the application of a radon barrier to the indoor surfaces of concrete foundations, behind or in which uranium mill tailings exist. The predicted accumulation of radon and gamma emitting radon progeny behind the barrier was studied. Radon accumulations were modeled by application of linear diffusion theory to a multilayered system of porous media. A comparison of the gamma exposures associated with concentration profiles prior to and after application of a radon barrier resulted in the prediction of sufficiently low fractional increases to justify field testing of the barrier.

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97. Culot, M. V. J., Schiager, K. J., Olson, H. G.

Development of a radon barrier.

HEALTH PHYS. 35(2): 375-380, 08/--/78.

ABSTRACT: High radon progeny exposure exist in structures where uranium mill tailings have been improperly used as a concrete aggregate constituent and a leveling or backfill material. The application of a radon barrier on the indoor face of these structures' foundations is considered a potential means to reduce the radon progeny exposure to the occupants. Presented here are the methods used and the results obtained in the search for a material capable of inhibiting or entirely blocking diffusion of a noble radioactive gas such as radon; a material which would simultaneously offer good durability and be practical. Demonstration of the method's applicability is shown by successful reduction of radon concentrations to sub-background levels in an experimental building built atop uranium mill tailings.

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98. Damon, P. E., Hyde, H. I.

Scintillation tube for the measurement of radioactive gases.

REV. SCI. INSTRUM. 23(12): 766, 12/--/52.

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99. Decker, H. M., Buchanan, L. M., Hall, L. B., Goddard, K. R.

Air filtration of microbial particles.

AM. J. PUBLIC HEALTH 53(12): 1982-1988, 12/--/63.

ABSTRACT: A review of the problem of cleaning air to remove microbial particles is presented with particular attention to the kinds of equipment available for this purpose. The potentialities and limitations of various filters and other devices are discussed. Recommendations are made for different situations.

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100. Douglas, R. L., Hans, J. M., Wolff, T. A., U.S. Environmental Protection Agency. Office of Radiation Programs - Las Vegas Facility. P.O. Box 15027. Las Vegas NV 89114.

Working level screening survey of structures constructed of materials containing pumice. ORP/LV-78-6 25 p., 05/--/78.

ABSTRACT: This report describes the results of a screening survey conducted in several northern New Mexico communities to estimate the levels of radon progeny (working levels) in buildings constructed of materials containing pumice. This localy-produced material is used as a lightweight aggregate in concrete blocks, and contains slightly

elevated levels of natural radionuclides. The screening survey results indicate that the use of pumice block may increase the working level in the structure, although the effect is so small that it is difficult to separate it from background variations and from the variability caused by other parameters.

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101. Drew, R. T., Eisenbud, M.

The natural radiation dose to indigenous rodents on the Morro Do Ferro, Brazil.

HEALTH PHYS. 12(9): 1267-1274, 09/--/66.

ABSTRACT: The feasibility of studying the dose from natural radioactivity received by indigenous rodents in remote areas has been demonstrated on the Morro do Ferro, a large hill in Minas Gerais, Brazil. The abnormally high ambient gamma radiation, 1 m above the ground, ranges from 0.05 to 3.2 mR/hr, and is due to the presence of thorium in the soils and rocks. Estimates were made of the dose from external gamma radiation, internally deposited Ra-226 and Ra-228, and inhalation of Rn-220, Rn-222 and their daughter products. The techniques used to obtain these data in the field and laboratory are described. External gamma exposure was measured by releasing trapped rodents into which fluoroglass rod dosimeters had been implanted subcutaneously. The dosimeters were removed after retrapping about 5 weeks later and indicated that the average dose over a several week period ranged from 0.15 to 0.76 mrad/hr, equivalent to 1.3-6.7 rad/yr. The bone dose from Ra-228 has been estimated by radiochemical analysis, the preliminary results of which indicate concentrations of 0.7 to 2.8 pc/g bone ash leading to a dose in the order of 3 rem/yr. Estimates of the dose from inhalation of the radioactive noble gases were made using field measurements of the Rn-222 and Rn-220 content of air aspirated from rodent burrows. It was found that the Rn-220 concentrations vary from near normal levels to E-4 microcuries/ml. The problems involved in calculating the dose to the lung and other organs from Rn-220 and Rn-222 inhalation are discussed and preliminary data are given. Using alternative methods of calculation the dose to the lung tissues is estimated to be in the range of 3 x E-3 to 3 x E-4 rem/yr.

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102. Duggan, M. J., Howell, D. M.

The measurement of the unattached fraction of airborne RaA.

HEALTH PHYS. 17(3): 423-427, 09/--/69.

ABSTRACT: The significance of the unattached fraction, f, of airborne RaA in assessing the hazard from the inhalation of radon and its daughter products is discussed, and reference made to some of the measurements of f which various workers have carried out in mine atmospheres. A method developed by the authors for measuring f is described. The method entails sampling the atmosphere through a pair of filters positioned side by side. One of the filters is preceded by a diffusion battery designed to remove most of the unattached daughters but hardly any of the attached ones, and the difference in activities collected on the filters is therefore a measure of the unattached daughter product concentration. Since f if concerned only with RaA atoms it is necessary to distinguish the gamma-activity on the filters due to RaA from that due to RaC'; this distinction was made by a alpha-spectrometry. Furthermore, because of the short half-life of RaA on the one hand, and the desire for high sensitivity on the other, it was found necessary to measure the activity while sampling was in progress. The method has been used to measure f in the open air and it has been found that only when both f and RaA concentration are unusually low does the sensitivity become inadequate for a meaningful determination of f.

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103. Duncan, D. L., Boysen, G. A., Grossman, L., Franz, G. A., III, U.S. Environmental Protection Agency. Office of Radiation Programs. Las Vegas Facility. Las Vegas NV 89114.

Outdoor radon study (1974-1975): An evaluation of ambient radon-222 concentrations in Grand Junction, Colorado. Technical Note ORP/LV-77-1 24 p., 04/--/77.

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104. Durkin, J.

An electronic instrument for radon daughter dosimetry. Report of Investigations 8255 22 p. , 1977.

ABSTRACT: Owing to the daily exposures of uranium mining personnel to Rn-222

daughters, a device is needed that will continually monitor individual exposure. Such a device has been built and tested by the Bureau of Mines and is known as a radon daughter dosimeter. This is an electronic instrument using a solid-state detector and circuitry. The concept of the instrument, which is a personal device worn throughout the working shift, is to evaluate an individual's cumulative exposure to airborne radon progeny, expressed in units of working level hours. Since the instrument is in close proximity to the miner and measures continual exposure, it avoids the errors caused by the present technique of spot checking of the environment and provides a more accurate account of total cumulative exposure.

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105. Durkin, J.

Electronic radon daughter dosimetry.

HEALTH PHYS. 37: 757-764, 12/--/79.

ABSTRACT: Daily exposure of uranium mining personnel to Rn-222 daughters has established the need for a device that will continually monitor an individual's exposure. Such a device has been built and tested with promising results. The device is an electronic dosimeter using both a solid-state detector and circuitry, and is a personal instrument worn throughout the working shift. Since the instrument is in close proximity to the miner and measures continually, it provides a more accurate account of total cumulative exposure; and avoids the errors caused by the present technique of spot checking the environment. The system permits the measurement of cumulative exposures to airborne radon progeny, expressed in units of Working Level Hours (WLH).

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106. Ellett, W. H.

Exposure to radon daughters and the incidence of lung cancer.

TRANS. AM. NUCL. SOC. 27: 148-149, 1977.

ABSTRACT: Inhalation of radon 222 daughters by miners is known to increase the risk of lung cancer. Recent data suggest there may be a linear relationship between exposure to radon 222 daughters and risk. Further study of the effects of age, sex and smoking habits is needed to further quantify the risks. It is suggested that the risks of lung cancer for the working force as a whole extends to levels below current occupational guidelines.

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107. Ellett, W. H.

Recent advances in understanding the risk due to the inhalation of radon daughters.
HASL-325

RADON WORKSHOP: FEBRUARY 1977. 102-104, 07/--/77.

ABSTRACT: Reviews recent advancements in assessing the risks due to absolute and relative risks to U.S. uranium miners are revised upwards by a factor of two, to 2 excess lung cancers per E6 orsan rem per year at risk, and to a doubling dose of about 40 CWLM respectively.

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108. Evans, R. D.

Engineers' guide to the elementary behavior of radon daughters.

HEALTH PHYS. 17(2): 229-252, 08/--/69.

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109. Fitzgerald, J. E., Jr., Guimond, R. J., Shaw, R. A., U.S. Environmental Protection Agency. Office of Radiation Programs. Washington, D.C. 20460.

A preliminary evaluation of the control of indoor radon daughter levels in new structures.
EPA-520/4-76-018 62 p., 11/--/76.

ABSTRACT: As part of its assessment of the radiological impact of the phosphate industry in Florida, the U.S. Environmental Protection Agency has surveyed residences built atop uraniferous reclaimed phosphate mining land. These surveys have shown elevated radon

daughter levels to exist in structures built on this land. In order to allow safer use of this land for residential construction, various state-of-the-art radon daughter control technologies were evaluated by the Agency. These included forced ventilation, polymeric sealants, excavation, crawl space construction, and improved slab quality. From a cost-effectiveness evaluation, crawl space construction was determined to best satisfy the criteria for "optimal" radon daughter control. These criteria were established as: (1) operative passivity (i.e., requiring no occupant responsibilities); (2) uniform effectiveness over the lifetime of a structure; (3) a one-time reasonable cost upon implementation; and (4) not having a significant impact on the lives of future occupants.

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110. Fleischer, R. L., Mogro-Campero, A.

Techniques and principles for mapping of integrated radon emanation within the earth. 78CRD093 6 p., 05/--/78.

ABSTRACT: Radon signals from within the ground are employed in locating subsurface uranium deposits and are of potential use in sensing impending earthquakes. Several factors are documented that affect the reproducibility and reliability of radon measurements, and new methods are described that make current state-of-the-art radon measurements much improved over those obtainable in the past.

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111. Fleischer, R. L., Mogro-Campero, A.

Mapping of integrated radon emanation for detection of long-distance migration of gases within the earth: Techniques and principles.

J. GEOPHYS. RES. 83(B7): 3539-3549, 07/10/78.

ABSTRACT: Integrated measurements of radon concentrations within the ground but close to the surface are being used extensively in searches for premonitory signals from earthquakes and in exploration for uranium. We present a description of the different components of the radon signals that may be present and describe methods for separating them. We also show quantitatively what signals the different radon-integrating devices are sensitive to, how readings in a given geometry can be related to actual concentrations in the soil gas under conditions of diffusional equilibrium, and what some of the effects of water in soil are. This knowledge allows the magnitude of the local contributions to be measured, so that distant signals can be recognized as departures from these values. The importancee of recognizing where upward transport of soil gas occurs is emphasized.

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112. Fleischer, R. L., Mogro-Campero, A.

Radon enhancements in the earth: Evidence for intermittent upflows?

GEOPHYS. RES. LETT. 6(5): 361-364, 05/--/79.

ABSTRACT: Rn-222 measurements at 60cm in the earth show background patterns that can be remarkably reproducible over time. At a site in New Mexico the readings taken at monthly intervals over a 13-month period for a set of 55 positions give different, but nearly constant monthly readings at each position, the typical standard deviation being 22%. Superimposed on that stable pattern have been three periods during which spatially grouped radon readings increased by a factor of 2 or more over their normal values. The simplest description of the source of the increases is sporadic puffs of upflowing gas, originating at as yet unknown depths. Alternative, less likely interpretations are considered. Separate periods of mostly low radon values may be due to downflow of gas.

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113. Franklin, J. C., Meyer, T. O., Bates, R. C.

Barriers for radon in uranium mines. 23 p.

ABSTRACT: Water-based epoxy sealants were examined during a 2-year period to determine their effectiveness as barriers to radon release in uranium mines. Radon emanation rates from uranium ore samples were monitored for extended periods in the laboratory before and after sealant application. Reduction of radon flux due to the coating of laboratory samples was approximately 80 percent. Test chambers in a dormant uranium mine were monitored to determine both short and long-term barrier effectiveness. These field studies of the sealants indicated radon flux reductions exceeding 50 percent relatively soon after application and nearly 75 percent about 1 year later. An unexpected

complication to early monitoring in the form of a large radon emanation increase, believed due to added moisture, is discussed.

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114. Franklin, J. C., Nuzum, L. T., Hill, A. L.

Polymeric materials for sealing radon gas into the walls of uranium mines. Report of Investigations 8036 26 p.

ABSTRACT: The Bureau of Mines conducted extensive laboratory and limited field tests to determine whether a polymeric material could effectively reduce the emanation rate of radon gas from uranium ore. In the laboratory 46 different single-coat materials and 14 two-coat applications were tested. The laboratory tests showed that up to 100 percent of the radon gas could be sealed into the rock. Materials tested in the laboratory were polyesters, furan resins, epoxies, latices, and totally inorganic coatings. From the laboratory work six different materials were selected for field testing. The first test was single-coat materials in five static chambers; the second test used two-coat applications in an open chamber. Both tests were conducted in the Dakota mine at Grants, N. Mex. During the second test, the emanation rate of radon gas was reduced up to 62 percent.

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115. Fremlin, J. H., Abu-Jarad, F.

Alpha-emitters in the environment I: Natural sources.

NUCL. INSTRUM. METHODS 173: 197-200, 1980.

ABSTRACT: The main natural alpha-activities arise from uranium and thorium. There are 4 x E9 t of uranium in the ocean with perhaps E12 t in the top kilometer of the earth's solid crust, with rather more thorium. These activities are not dangerous unless inhaled or ingested and the main risk to humans arises from the inhalation of Rn-222, a decay product of U-238. Radon concentrations have been measured in a number of ordinary rooms and the emission of radium from the walls has been measured by means of Kodak LR115 plastic detectors. Rate of change of air in each room has also been measured by releasing a small quantity of freon and observing the rate of loss. Figures suggest that in Britain radon may be responsible for around 100 deaths per year from lung cancer.

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116. Fu-Chia, Y., Chia-Yong, T.

The general formula for the measurement of concentrations of radon and thoron daughters in air.

HEALTH PHYS. 34(5): 501-503, 05/--/78.

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117. Gammage, R. B., Kerr, G. D., Huskey, L.

Exploratory study of the use of TSEE dosimeters in radon monitoring.

HEALTH PHYS. 30(1): 145-148, 01/--/76.

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118. Geiger, E. L.

Operating experience with equipment for continuous monitoring of radon gas and radon daughters.

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119. Geiger, E. L.

Radon film badge.

HEALTH PHYS. 13(4): 407-411, 04/--/67.

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120. George, A., Breslin, A. J.

Deposition of radon daughters in humans exposed to uranium mine atmospheres.

HEALTH PHYS. 17(1): 115-124, 07/--/69.

ABSTRACT: Uranium mine and laboratory experiments are described for the determination of total respiratory deposition of radon daughters together with the effect of particle size, tidal volume, respiratory frequency, nasal deposition and growth of radon daughter particle size. Total respiratory deposition of radon daughters measured in humans exposed in uranium mines was found to range from 23% to 45%. From the mine and laboratory experiments, both particle size and tidal volume were found to influence deposition, fractional deposition increasing with decreasing particle size and iincreasing tidal volume. Particle size differed with location within a mine. No dependence of deposition on respiratory frequency or minute volume was discerned. In laboratory experiments, nasal deposition of attached and unattached radon daughters was found to be 2% and 62%, respectively and evidence was developed indicating the rapid growth of radon daughter particles in the respiratory tract.

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121. George, A. C.

Radon and radon daughter field measurements. 9 p.

ABSTRACT: Practical methods for measuring the concentration of radon and radon daughters in air are reviewed, and procedures and instruments are recommended for reliable field measurements.

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122. George, A. C., Breslin, A. J.

The distribution of ambient radon and radon daughters in residential buildings in the New Jersey-New York area. 36 p.

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123. George, A. C.

Scintillation flasks for the determination of low level concentrations of radon.

PROCEEDINGS OF NINTH MIDYEAR HEALTH PHYSICS SYMPOSIUM.

ABSTRACT: Simple, inexpensive scintillation flasks that are easier to maintain and are more sensitive than flasks of conventional design have been fabricated for measuring environmental radon. The flasks which are of two sizes (3 inches and 4 and a half inches diameter), are constructed of plastic tubing and sheet, fitted with brass valves for flow-through sample collection, and are coated internally with silver-activated zinc sulfide phosphor. When counting background becomes excessive through use, the flasks can be easily cleaned and resphosphored. The sensitivities of the small and large radon flasks for 1 pCi/liter of Rn-222 are about 0.7 cpm and 2 cpm, respectively, when counted after the daughters have grown into equilibrium with the radon, compared to about 0.5 cpm for standard Lucas flasks.

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124. George, A. C., Hinchliffe, L.

Measurements of uncombined radon daughters in uranium mines.

HEALTH PHYS. 23(6): 791-803, 12/--/72.

ABSTRACT: Uncombined fractions of radon daughters were measured in several locations in each of 6 uranium mines with a diffusion- type sampler adapted from an instrument developed by Mercer. Simultaneous measurements were obtained of radon gas concentration, working level and particle concentration. Expressed in accordance with the ICRP definition of uncombined fraction, f, values obtained ranged from 0.002 to 0.12 with more than half being less than 0.03. The higher fractions were found in fresh ventilating air uncontaminated by diesel engines or dusty operations. An inverse relationship was noted between uncombined fraction and particle concentration, which ranged from 3 E3/cubic centimeter near ventilation inlets to more than E7/cubic centimeter in main haulageways and working stores.

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125. George, A. C., Breslin, A. J. (ed.)

A passive environmental radon monitor. HASL-325

RADON WORKSHOP. FEBRUARY 1977. 25-30, 07/--/77.

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126. Gesell, T. F.

Occupational radiation exposure due to Rn 222 in natural gas and natural gas products.

HEALTH PHYS. 29(5): 681-687, 11/--/75.

ABSTRACT: The potential hazard of occupational exposure to the radiations of Rn-222 and its daughters in the natural gas industry is examined. The results of a study of Rn-222 concentrations and external radiation fields in nine geographically diverse natural gas processing plants are given, and the results are interpreted in terms of occupational exposure. It is concluded that while both internal and external exposures to the radiation from Rn-222 and its short-lived daughters do occur, the magnitudes of the exposures are not serious. The potential problem of exposure during maintenance operations to long-lived Rn-222 daughters which may build up on the interior surfaces of gas processing equipment is recognized but not resolved.

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127. Gogolak, C. V., Beck, H. L.

Diurnal variations of radon daughter concentrations in the lower atmosphere. 33 p.

ABSTRACT: A series of experiments has been performed in which the Rn-222 decay products Po-218, Pb-214, and Bi-214 have been measured simultaneously at 1, 10 and 25 meters above the ground to study the diurnal changes in the vertical concentration profiles, and the extent to which these changes depend on diurnal changes in radon exhalation rate and vertical turbulent diffusivity. The Bi-214/Pb-214 activity ratio was used to indicate the state of equilibrium between radon and its daughters. These data were compared to numerical solutions of the one-dimensional diffusion equation, which were obtained for various time-dependent diffusivity profiles and exhalation rates.

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128. Goldsmith, W. A., Haywood, F. F., Leggett, R. W., Union Carbide Corporation.

Transport of radon which diffuses from uranium mill tailings. 20 p.

ABSTRACT: Considerable attention has been given recently to potential hazards of radon exposure in the vicinity of large piles of uranium mine tailings. A procedure has been developed, using the results of numerous independent investigations, to describe the average annual behavior of radon which escapes from a tailings pile. The radon source term is developed from known profiles of Ra-226 in soil and is treated as an area source. Dispersion is calculated by using local meteorological data in a Gaussian diffusion model. A comparison has been made between calculated annual average radon concentrations attributable to the tailings pile in Salt Lake City, Utah, and a series of radon measurements which were made in the vicinity of the tailings pile over a period of one year. Population exposures were estimated and compared to those associated with exposure to background concentrations Rn-222. It was found that annual exposures to Rn-222 of tailings pile origin are about 10% of those associated with background Rn-222 in the Salt Lake City metropolitan area.

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129. Goodwin, A.

Problems and techniques for removal of radon and radon-daughter products from mine atmospheres.

NUCL. SAF. 14(6): 643-650, 11/--/73.

ABSTRACT: Ventilation with fresh air has been, and will continue to be, the primary solution for controlling radon and radon-daughter activity in mines. However, procedures to make the ventilation process more effective and to reduce contamination have been proposed, such as sealing off of old workings, the use of coatings to reduce radon inflow, and mine pressurization. Air-cleaning techniques have proved successful in certain applications. For example, radon daughters can be removed by mechanical filtering and by electrostatic precipitation methods, both of which remove condensation nuclei to which

radon daughters become attached. The radon gas that passes through continues to decay, but, in the absence of condensation nuclei, the daughters have large diffusion lengths and are trapped on the walls of air courses, thus inhibiting their growth. Radon gas has been successfully removed from air, although there are no known reports of this having been done in operating mines. It has been captured on activated charcoal and silica gel and chemically removed by reacting with a halogen fluoride and a metal fluoride.

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130. Gotchy, R. L., Schiager, K. J.

Bioassay methods for estimating current exposures to short-lived radon progeny.

HEALTH PHYS. 17(2): 199-218, 08/--/69.

ABSTRACT: Concentrations of Pb-210 (RaD) and Po-210 (RaF) were measured in the urine, feces, blood, hair and whiskers from 25 people associated with the operation of a uranium mine near Golden, Colorado. The concentrations of Pb-210 and Po-210 in blood, hair and whiskers were found to be correlated with occupational exposure by power function relationships. Blood levels of Pb-210 provide reasonable estimates of mean exposure levels in the range of 1-5 working levels (plus or minus 50% or better) for samples pooled for one or more calendar quarters. Pb-210 or Po-210 activity in either hair or whiskers can be used to estimate mean exposure levels in the range of 0.4-7 working levels (plus or minus 50% or better) when samples are pooled for one or more calendar quarters. A decreasing exponential relationship was found between the Pb-210 to Po-210 activity ratios in the blood of working uranium miners and years of underground experience. Possible applications of these relationships to exposure monitoring and some of the inherent problems associated with bioassays for uranium miners are discussed.

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131. Groer, P. G., Keefe, D. J., McDowell, W. P., Selman, R. F.

An instant working level meter with automatic individual daughter readout for uranium mines.

PROCEEDINGS OF THE THIRD INTERNATIONAL CONGRESS OF THE INTERNATIONAL RADIATION PROTECTION ASSOCIATION. 950-956

ABSTRACT: The Instant Working Level Meter (IWLM) evaluates the Working Level and the individual Rn-daughter concentrations in an uranium mine atmosphere within five minutes. The instrument is portable and fully automatic. The WL and the RaA, RaB and RaC concentrations (pCi/liter) are displayed in digital form. Calculation of these quantities is performed by a pre-programmed CMOS calculator chip using the counts observed in the instruments' three channels (RaA, RaB + C, RaC'). The Rn-daughters are collected on a membrane filter at a flowrate of 12 liter/min. Alpha-spectroscopy is performed with a silicon surface barrier detector, the beta + gamma-counts are detected with a plastic scintillator plus PM tube. No assumptions about Rn-daughter equilibrium are made. Only constancy of the Rn-daughter concentrations during the time of sampling (2 minutes) is assumed. The unit is entirely solid state with exception of the photomultiplier. The range of the instrument is 0.01 - 100 WL.

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132. Groer, P. G.

The accuracy and precision of the Kusnetz method for the determination of the working level in uranium mines.

HEALTH PHYS. 23(1): 106-109, 07/--/72.

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133. Groer, P. G., Evans, R., Gordon, D. A.

An instant working level meter for uranium mines.

HEALTH PHYS. 24: 387-395, 04/--/73.

ABSTRACT: The Instant Working Level Meter (IWLM) evaluates the Working Level (WL) in a uranium mine atmosphere within 4 min. Two minutes are needed to measure the background mostly due to ambient gamma radiation and two minutes are spent to measure background plus WL. It has two alpha channels (RaA and RaC') and one beta + gamma channel (RaB and RaC). The counts in the different channels are multiplied electronically by calculated weighting coefficients and combined to give the WL. No assumptions about Rn daughter equilibrium are

made. Only constancy of the radon daughter concentrations in the atmosphere during the time of sampling is assumed. So far a total of 5 instruments of the type described in this report have been built and used in uranium mines.

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134. Grot, R. A., Clark, R. E.

Air leakage characteristics and weatherization techniques for low income housing. 28 p.

ABSTRACT: Data are presented on the air infiltration characteristics of approximately 250 dwellings occupied by low-income households in 14 cities in the United States. The dwellings are located in all major climatic zones of the country. The air leakage characteristics of these buildings were assessed using two types of measurements: 1) tracer-gas decay technique using air sample bags, which was developed by the National Bureau of Standards; and 2) fan depressurization test. The actual air infiltration rates of this group of dwellings are presented. The induced air exchange rates obtained from fan depressurization tests are also given, and it is shown that little correlation exists between the latter results and the actual air infiltration rates in these dwellings so long as no effort is made to divide the buildings into classes of similar buildings. The use of fan depressurization as a diagnostic tool to assist weatherization crews in tightening buildings is discussed. Preliminary estimates are presented of the reduction in induced air leakage that may be achieved by applying building weatherization techniques.

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135. Guggenheim, S. F., George, A. C., Graveson, R. T., Breslin, A. J.

A time-integrating environmental radon daughter monitor.

HEALTH PHYS. 36: 452-455, 03/--/79.

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136. Guimond, R. J., Jr., Ellett, W. H., Fitzgerald, J. E., Windham, S. T., Cuny, P. A.

Indoor radiation exposure due to radium-226 in Florida phosphate lands. EPA 520/4-78-013 108 p., 02/--/79.

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137. Hagi, M., Savani, N. K., Rao, P. V., Wethington, J. A., Jr.

Statistical analysis of radon flux measurements. 20 p.

ABSTRACT: The radon emerging from the Earth's surface can be used in classifying lands for development purposes. Radon flux is subject to diurnal variation, weather variables, seasonal fluctuations etc. We have attempted to apply statistical sampling procedures to this problem in order to ascertain the proper spacing of sampling points, the number of samples taken at each point per day, and the number of days in the sampling program in order to establish the exhalation rate at a known precision. Results from small and large pieces of land showed that reliable radon flux measurements require extensive sampling programs. For best results, preliminary measurements should be made, and the results should be used to determine the number of determinations needed in the final protocol.

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138. Hamilton, E. I.

The relative radioactivity of building materials.

AM. IND. HYG. ASSOC. J. 32(6): 398-403, 06/--/71.

ABSTRACT: The concentrations of potassium, thorium, uranium, and radium, and the relative radioactivity of building materials used in the United Kingdom are described. Particular attention is paid to a potential building building material, namely, calcined gypsum prepared as a byproduct in the manufacture of superphosphate fertilizers. The radioactivity of this gypsum material varies according to its origin but is likely to exceed that of any other building material. The wide scale use of this material has to be considered in relation to both somatic and genetic radiation dose of individuals and large populations.

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139. Hammon, H. G., Ernst, K, Gaskill, J. R., Newton, J. C., Morris, C. J.

Development and evaluation of radon sealants for uranium mines. UCRL-51818 67 p., 05/21/75.

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140. Hammon, H. G., Ernst, K., Newton, J. C.

Noble gas permeability of polymer films and coatings.

J. APPL. POLYM. SCI. 21: 1989-1997, 1977.

ABSTRACT: Permeabilities of noble gases, particularly argon, krypton, and xenon, were measured through a number of polymer films and coatings. Extrapolation of the log of the permeation coefficient versus the square of the gas molecular diameter was used to estimate radon permeability. An equation has been developed that can predict permeability to these noble gases as a function of the base polymer structure of the coating.

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141. Hague, A. K. M. M., Collinson, A. J. L.

Radiation dose to the respiratory system due to radon and its daughter products.

HEALTH PHYS. 13(5): 431-443, 05/--/67.

ABSTRACT: Annual radiation doses to the respiratory system due to radon and its daughter products have been calculated in various working environments of London (U.K.) area. The method is based on an accurate calculation of the energy dissipation of gamma-particles in the vulnerable tissue, 1 micro-diameter and located at various depths, from the daughter activity calculated from the deposition rates and the mucous movement. The proportions of the daughter activity present as free ions in air have been calculated from extensive published theoretical and experimental results. As a more realistic lung model, an extensive set of experimental data on aerosols and a more precise calculation of energy dissipation, among other, have been employed in the present study; it is claimed that the method is an advance on those Altshuler, Nelson and Kuscher and Jacobi. The radiation dose is found to be highest in segmental bronchi; in comparison with Altsjuler et al.'s results, the present calculation almost always i

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142. Harley, N. H., Pasternack, B. S.

The rapid estimation of radon daughter working levels when daughter equilibrium is unknown.

HEALTH PHYS. 17(1): 109-114, 07/--/69.

ABSTRACT: A technique is described based on a method of Kusnetz which allows radon daughter working levels to be determined after a single alpha count on a filtered air sample. The value of dis/min/l. determined from this count is divided by a universal factor which covers any daughter equilibrium situation, to obtain the value for working levels. The error associated with the working level value for this universal factor is less than plus or minus 25%. Factors also derived for specific ranges of daughter equilibrium to be used when the ranges are known. Whenever information is available concerning the range of equilibrium, the error associated with this calculation is reduced. For example, when the range of RaA/RaB/RaC' is known to be between 1/1/1 and 1/0.1/0.01, the error associated with the working level is no more than plus or minus 13%. The technique requires one alpha count at 30 or 40 min after the end of sampling and for this reason is a highly practical technique for use in uranium mine monitoring. A table of values is included which allows the calculation of these factors for any desired concentration or range of concentrations.

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143. Harley, N. H., Pasternack, B. S.

Alpha absorption measurements applied to lung dose from radon daughters.

HEALTH PHYS. 23(6): 771-782, 12/--/72.

ABSTRACT: In this study, experimental alpha attentuation data were obtained in polycarbonate which is essentially identical to tissue in ionization potential. Alpha transmission and stopping power data were developed for the radon daughters RaA (Po-218) and RaC' (Po-214). The experimental stopping power measurements were found to be in

agreement with values calculated using the Bethe-Bloch equation and the Bragg addivity rule. Experimental alpha attenuation data were also obtained in a gas with the same composition as ICRP tisse and were found to be identical with that in the solid tissue equivalent. The experimental data were then applied to determine the spatial distribution of alpha dose in bronchial epithelium when the alpha activity is present in mucus on the tracheobronchial surfaces. Dose curves as a function of depth into the bronchial epithelium were developed for two different air way diameters. The alpha dose from exposure to radon daughters was computed using the bronchial activities derived by Altshuler for a radon concentration of 100 pCi/l. The new dosimetry yields results which are lower by about 20%. An independent dose calculation for radon daughters was also performed incorporating more recent data on mine atmospheres. The alpha dose to bronchial epithelium using these factors was found to be considerably lower than any calculated previously for the same radon concentration. A few alpha doses were also computed in terms of working level units. It was shown that the alpha dose for one working level may be widely different depending upon the ratios of the radon daughters.

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144. Harstad, J. B., Decker, H. M., Buchanan, L. M., Filler, M. E.

Air filtration of submicron virus aerosols.

AM. J. PUBLIC HEALTH 57(12): 2186-2193, 12/--/67.

ABSTRACT: A new method is described for evaluating air filters with submicron aerosols. The method is unique in that the aerosols were viable, highly concentrated, and composed entirely of submicron particles (0.1 micron NMD). Tests were conducted to compare air filters in removing submicron T1 phase aerosols and bacterial aerosols of Bacillus subtilis var niger spores (1 micron NMD). Architects, engineers, and research investigators concerned with control of submicron paticles might consider filtration rather than other methods of air cleaning.

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145. Hausknecht, D. F., Rogozen, M. B.

Residential radon levels from solar rockbed storage: Technical note 382-00-11. SAI-1-068-80-545 15 p., 01/11/80.

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146. Haywood, F. F., Hawthorne, A. R., Stone, D. R., Union Carbide Corporation.

Measurements of airborne pollutant concentrations inside a well insulated structure with low ventilation rate. 3 p.

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147. Haywood, L. R.

Selection of radon level corresponding to 0.02 WL. 11 p., 02/--/80.

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148. Healy, J. W., Rodgers, J. C.

A preliminary study of radium-contaminateed soils. Informal Report LA-7391-MS 45 p., 10/--/78.

ABSTRACT: A preliminary study was made of the potential radiation exposures to people from radium contamination in the soil in order in provide guidance on limits to be applied in decontaminating land. Pathways included were inhalation of radium from resuspension; ingestion of radium with foods; external gamma radiation from radium daughters; inhalation of radon and daughter, both in the open air and in houses; and the intake of Pb-210 and Po-210 from both inhalation and ingestion. The depth of the contaminated layer is of importance for external exposure and especially for radon emanation. The most limiting pathway was found to be emanation of the radon into buildings with limiting values comparable to those found naturally in many areas.

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149. Hess, C. T., Casparius, R. E., Norton, S. A., Brutsaert, W. F.

The investigation of natural levels of Rn-222 in ground-water in Maine for assessment of related health effects. 29 p.

150. Hill, A.

Rapid measurement of radon, decay products, unattached fractions, and working level values of mine atmospheres.

HEALTH PHYS. 28: 472-478, 04/--/75.

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151. Hofmann, W., Steinhausler, F., Pohl, E.

Age-, sex- and weight-dependent dose distribution patterns for human organs and tissues due to inhalation of natural radioactive nuclides. 27 p.

ABSTRACT: Dose calculations due to inhaled radionuclides are in general based on the lung model of the ICRP Task Group on Lung Dynamics. All its parameters, including the pathways to other organs, refer to an adult "Reference Man", also averaging for the differences in sex and weight. At first we developed age-dependent lung models using feasible theoretical considerations as well as the experimental data given on the postnatal growth of the respiratory tract. On the base of these age-dependent models we then calculated the regional particle deposition for the short-lived decay products of Rn-222 and Rn-220, as these radionuclides occur everywhere in our environment outdoors as well as indoors. Dose calculations were carried out for defined reference atmospheres and living activities the latter being responsible for the respiratory minute volume. The mean doses for the various parts of the respiratory tract as well as for other organs show a maximum at the age of about six years. These are more than twice as high as with an adult for most of the organs and tissues. We found the half-line of the clearance time for the absorption of decay products from the alveolar region into the blood to be about one hour in contradiction to the ICRP retention model. Furthermore it was shown that for precise dose calculations the differences in sex and weight have to be considered as well.

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152. Holaday, D. A., Rushing, D. E., Coleman, R. D., F., Woolrich P., Kusnetz, H. L., Bale, W. F., U.S. Department of Health, Education, and Welfare. Public Health Service. Bureau of State Services. Division of Special Health Services. Occupational Health Program.

Control of radon and daughters in uranium mines and calculations on biologic effects. PHS Publ. 494 77 p., 1957.

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153. Holleman, D. F., Martz, D. E., Schiager, K. J.

Total respiratory deposition of radon daughters from inhalation of uranium mine atmospheres.

HEALTH PHYS. 17: 187-192, 1969.

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154. Hollowell, C. D., Budnitz, R. J., Case, G. D., Traynor, G. W.

Combustion-generated indoor air pollution: I. Field measurements 8/75 - 10/75. LBL-4416 23 p., 01/--/76.

ABSTRACT: The indoor air quality of six homes with gas and electric cooking and gas heating appliances was characterized to determine the level of gaseous and aerosol air pollutants from typical indoor combustion sources. Field measurements of SO2, NO/NO2, O3, and CO were determined on a continuous basis. Total aerosol samples were collected on filter media for laboratory analysis by X-ray fluorescence and ESCA techniques for the determination of aerosol elemental composition and ionic species such as SO4, NO3, and NH4. Results of the study indicate that levels of gaseous and respirable aerosol air pollutants in the indoor environment do frequently exceed those levels commonly found in the outdoor urban air. Such findings may have a large impact on the future design of epidemiological studies, on energy conservation strategies for buildings, and on the need for more stringent control of air pollution from indoor combustion sources.

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155. Hollowell, C. D., Berk, J. V., Boegel, M. L., Ingersoll, J. G., Krinkel, D. L., Nazaroff, W. W.

Radon in energy-efficient residences. LBL-9560 11 p., 03/--/80.

ABSTRACT: Radon concentrations were measured in seventeen houses incorporating energy-saving features, most of which included specific measures to achieve low infiltration rates. Ventilation rates in these houses ranged from 0.04 to 1.05 air changes per hour; corresponding radon concentrations were found to range from 0.6 to 22 nCi/cubic meter. In general, radon concentration tended to increase with decreasing ventilation rate. In one house, a mechanical ventilation system with an air-to-air heat exchanger was installed, and radon concentrations were measured at selected ventilation rates. The correlation between increasing ventilation and decreasing radon concentration was confirmed, and it appears that mechanical ventilation with air-to-air heat exchangers can maintain air quality as well as energy efficiency in many houses where air quality problems exist.

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156. Holmgren, R. N.

Working levels of radon daughters in air determined from measurements of RaB + RaC.

HEALTH PHYS. 27: 141-145, 07/--/74.

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157. Holoway, C. F., Turner, J. E., Johnson, M. L., Loebl, A. S.

Bibliography on the dosimetry of radon and radon daughters. ORNL-5284 76 p., 02/--/78.

ABSTRACT: This selection of 479 papers through 1976, dealing with various aspects of the dosimetry of radon and its daughters, should be of interest to those concerned with assessing literature on problems associated with uranium mines and mill tailings and with development of criteria for the disposition of sites contaminated with uranium and its decay products. Major topics include background levels, epidemiology, food chains, ingestion, inhalation, metabolic models, pathology, synergistic effects of smoking plus inhalation of radon daughters, soil, standards, uranium mine and mill tailings and contamination of water. The principal elements covered are uranium, radium, radon, polonium, lead and bismuth. The papers are classified into 35 categories, ranging alphabetically from AIR to WORKING LEVEL, each containing up to seven subcategories.

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158. Holub, R. F., Droullard, R. F., Ho, W. L., Hopke, P. K., Parsley, R., Stukel, J. J.

The reduction of airborne radon daughter concentration by plateout on an air mixing fan.

HEALTH PHYS. 36(4): 497-504, 04/--/79.

ABSTRACT: A series of experiments have been made in the U.S. Bureau of Mines Radon Test Chamber to study the effects of condensation nuclei, humidity and turbulence on the rapid deposition or plateout of radon daughter activity on the chamber walls. Under low humidity conditions the presence of a small fan reduced the working level by 41%. The activity was not deposited on the walls by the turbulent flow from the fan but actually became attached to the fan blades. High relative humidity (greater than 80%) totally inhibited this observed effect. A detailed mechanism for transport of the daughter species seems to be the critical factor in interpreting the experimental results.

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159. Hursh, J. B., Morken, D. A., Davis, T. P., Lovaas, A.

The fate of radon ingested by man.

HEALTH PHYS. 11(6): 465-476, 06/--/65.

ABSTRACT: Four experiments were performed in which two subjects on two occasions drank approximately 1 microcubic radon plus daughters in 100 millimeter of water. Measurements on radon loss in expired air, whole body Radium C content, and radon in the blood permit the calculation of an (MPC)w of 2.0 x E-4 microcubic/millimeter for occupational exposure. This is based on the stomach as the critical organ but doses to the lung, kidney and liver are estimated.

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160. Irfan, M., Fagan, A. J.

Measurement of radon daughters in air using gamma spectrometry.

NUCL. INSTRUM. METHODS 166: 567-570, 1979.

ABSTRACT: A method is given to determine relative values of concentrations of radon daughters, RaA, RaB and RaC, in the atmosphere by measuring the gamma activity of RaC collected on a filter through which air is sampled for a short time. The method is based on regression analysis of integrated counts observed in several time intervals of a few minutes duration. A method of calibration enables a determination of absolute values of concentrations of radon daughters is also proposed.

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161. Jacobi, W.

The dose to the human respiratory tract by inhalation of short-lived Rn222- and Rn220-decay products.

HEALTH PHYS. 10(12): 1163-1174, 12/--/61.

ABSTRACT: The deposition of Rn daughters in the different regions of the human respiratory tract is derived from the particle size of their carrier aerosol in ordinary, unfiltered air. The resulting mean distribution of the radioactivity in the respiratory tract is estimated, taking into account the clearance from the alveolar tissue and the ciliary transport in the bronchial tree. The radiation dose distribution in the epithelium of trachea and bronchi is calculated, taking into account the alpha-absorption in the mucus layer and the variation of stopping power with alpha-energy. The resulting mean absolute alpha-dose in different regions of the respiratory tract is given for each inhaled nuclide, especially at their natural level in atmospheric air and their maximum permissible level. The results indicate, that owing to the ciliary transport, a considerable fraction of the dose in the upper respiratory tract is due to the transfer of activity from the bronchioli and lower bronchi in the mucus stream. The highest dose should be expected in the lower bronchi.

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162. Jacobi, W.

Relations between the inhaled potential alpha-energy of Rn222- and Rn220-daughters and the absorbed alpha-energy in the bronchial and pulmonary region.

HEALTH PHYS. 23(1): 3-11, 07/--/72.

ABSTRACT: On the basis of the new ICRP-lung model the ration of the absorbed alpha-energy or integral alpha-dose in the bronchial and pulmonary region to the inhaled potential alpha-energy is estimated as function of the aerosol concentration, the vventilation rate and the wall-deposition rate in the working area. With increasing aerosol concentration and decreasing ventilation rate this ratio decreases in the bronchial region but increases in the pulmonary region. Finally the possible variation of bronchial and pulmonary dose per WLM inhaled is discussed with respect to the maximum permissible annual intake of Rn- and Tn- daughters.

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163. James, A. C., Strong, J. C.

A radon daughter monitor for use in mines.

PROCEEDINGS OF THE THIRD INTERNATIONAL CONGRESS OF THE INTERNATIONAL RADIATION PROTECTION ASSOCIATION. 932-938

ABSTRACT: A self-contained monitor for the measurement of airborne RaA, RaC and the working level, WL, in the shortest practicable time and with a minimum of calculation is described. The ratio of two gross alpha-counts gives, directly, the ratio of airborne alpha-emitter concentrations, RaC':RaA, after collection on a filter. This is achieved because the contribution from airborne RaB to the measured alpha-activity is minimised by choosing short sampling and counting times. The RaA concentration is derived from the first alpha-count, during air sampling. WL is derived from the second alpha-count. No background correction is required. Systematic errors in estimated quantities are small. With a total measuring time of eleven minutes, the limits of detection are approximately 1 pCi/litre for RaA and 1.0 x E-4 for WL.

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164. Johnson, J. E., Olson, H. G., U.S. Department of Energy. Solar Energy.

Measurement of 222 Rn build-up in solar heated buildings and calculation of radiation doses: Final report of Innovative Research Program Subtask for period December 1977-September 1978. COO-4546-2 5 p., 10/--/78.

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165. Johnson, R. H., Jr., Bernhardt, D. E., Nelson, N. S., Calley, H. W., Jr.

Assessment of potential radiological health effects from radon in natural gas. EPA-520/1-73-004 60 p., 11/--/73.

ABSTRACT: Natural gas contains varying amounts of radon-222 which becomes dispersed in homes when natural gas is used in unvented appliances. Radon decays to alpha-emitting daughter products which can contribute to lung cancer when inhaled and deposited in the respiratory system. For the average use of unvented kitchen ranges and space heaters, the tracheobronchial dose equivalent to individuals was estimated as 15 and 54 mrem/yr, respectively, or 2.73 million person-rems/yr to the United States population. A review of exposure conditions, lung model parameters, dose conversion factors, and health effect factors indicated this population dose equivalent could potentialy lead to 15 deaths a year from lung cancer. This represents only 0.03 to 0.08 percent of normal lung cancer mortality. Since control of radon levels in gas would cost over $100 million for each reduction of one health effect, it was concluded that a requirement for such controls would not be cost effective on a national basis.

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166. Jonassen, N.

Indoor radon concentrations and building materials: Control of airborne radioactivity. 7 p.

ABSTRACT: The contribution to the airborne radioactivity from the building materials can be predicted by measurements of exhalation rates of samples placed in closed containers. The effect of sample dimensions, porosity and dead space on the back diffusion is discussed, and it is shown that the back diffusion will usually not change the measured exhalation rates with more than 10-15%. Efforts on reducing ventilation rates in order to save energy can lead to unacceptable high levels of radon and radon daughters in the indoor environment. The major radon source for indoor air is often the soil, from which radon can diffuse through the base of the house. The posibility of reducing the diffusion rate by proper composition of the floor and base material is mentioned. Finally the results of an investigation on reducing the radon daughter concentrations by circulation and filtration are reported. It is shown that a passage of the air through an ordinary filter with a rate of 1-2/hour may reduce the radon daughter level with a factor of 5-10.

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167. Jonassen, N., McLaughlin, J. P.

Exhalation of radon-222 from building materials and walls. 16 p.

ABSTRACT: On the basis of a linear diffusion model the porosity, diffusion length and radon production rate can be found for a given material by placing a sample of the material in a closed vessel and following the build up of activity at various (constant) pressures. The model was tested on an alum shale light weight concrete (with a radium content of approximately 5 pg/g). The exhalation rate of radon from a series of building materials was determined by placing the materials in a closed vessel and measuring the equilibrium activity. The model predicts that the exhalation rate derived from the equilibrium activities will be lower than the values corresponding to exhalation into an infinite space. The difference depends upon the geometry of samples and vessels used and may vary from few up to maybe 20%. The model was finally used to determine the effective diffusion coefficient of radon in a concrete wall by measuring the rado concentration in the pore air at various depths.

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168. Jonassen, N.

Exhalation of radon-222 from building materials.

ABSTRACT: Many building materials contan small amounts of the radioactive element radium. By decay of radium is formed the radioactive gas radon, which might diffuse out of the material and thus be found in the ambient air. When radon and especially its short lived daughter products are inhaled radiational damage of the lung tissue might result.

Some results of field measurements of radon levels in apartments and houses are reported and it is shown that summer measurements with high natural ventilation rates are generally higher than winter measurements. The exhalation of radon from building materials can be studied by placing samples in closed vessels and following the growth of activity in the vessels. It is shown that a ventilation rate of one air exchange per hour will lower the theoretical maximum level to 0.8% of the unventilated maximum value.

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169. Jonassen, N.

On the effect of electric fields on airborne radon-222 daughter products. 4 p.

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170. Jonassen, N., Hayes, E. I.

Determination of concentrations of radon-222 daughters in air. Research report 6 35 p., 06/14/73.

ABSTRACT: Amongst the natural radioactive constituents of the earth's atmosphere are the inert gas radon-222 and its short-lived daughter products Po-218, Pb-214, Bi-214 and Po-214. In the field of atmospheric electricity it is of interest to measure the daughter concentrations as they contribute to the general level of ionization in the air and also attach to aerosol particles. Since the activity encountered is usually low (approximately 0.1 pCi/liter) the experimental uncertainties on the determined concentrations may be large. In recent years the application of alpha spectrometry using surface barrier detectors with alpha energy resolution better than 80 keV FWHM has led to a reduction in the uncertainties. In this report a method of reducing still further the uncertainties in the determination of the radon 222 daughter concentrations measured by means of a conventional alpha particle spectroscopic technique is described.

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171. Jonassen, N., Hayes, E. I.

The measurement of low concentrations of the short-lived radon-222 daughters in the air by alpha spectroscopy.

HEALTH PHYS. 26(1): 104-110, 01/--/74.

ABSTRACT: Amongst the natural radioactive constituents of the earths atmosphere are the gas Rn-222 and its short-lived daughter products Po-218, Pb-214, Bi-214 and Po-214. In the field of atmospheric electricity it is of interest to measure the daughter concentrations as they contribute to the general level of ionization in the air and also attach to aerosol particles. Moreover since the exposure of the respiratory system to Rn-222 and its daughters may constitute a health hazard, recommendations for maximum permissible concentrations of Rn-222 and its short-lived daughters in air have been proposed (ICRP, 1959; NCRP, 1959). The hazard due to Rn-222 itself is much less than that due to its short-lived daughter products. In this paper a method for measuring the concentrations of these short-lived Rn-222 daughters using alpha particle spectroscopy of filter samples is described and compared with previous methods. Preliminary measurements in an unventilated basement room are reported.

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172. Jonassen, N., Hayes, E. I.

Absorption of 5.47 MeV alpha particles by membrane filter material.

HEALTH PHYS. 27(3): 313-316, 09/--/74.

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173. Jonassen, N., Hayes, E. I.

A correction when measuring Rn222 daughter concentrations by alpha spectroscopy of filter samples.

HEALTH PHYS. 27(3): 310-313, 09/--/74.

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174. Jonassen, N.

On the effect of atmospheric pressure variations on the radon-222 concentration in unventilated rooms.

HEALTH PHYS. 29(1): 216-220, 07/--/75.

ABSTRACT: A series of approximately 100 determinations of the daughter concentrations was performed in an unventilated basement room with walls constructed in part of concrete. An average working level (WL) was found to be 0.07 WL for radon-222 and daughter concentrations. However, it varied from 0.04-0.14 WL during the 4-month monitoring period. It was assumed that the variations in the working level were caused primarily by changes in the atmospheric pressure. An ionization chamber was installed to study this effect more closely.

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175. Jonassen, N., McLaughlin, J. P.

The effect of RaB recoil losses on radon daughter measurements.

HEALTH PHYS. 30(2): 234-238, 02/--/76.

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176. Jonassen, N., McLaughlin, J. P.

On the recoil of RaB from membrane filters.

J. AEROSOL SCI. 7(2): 141-149, 03/--/76.

ABSTRACT: The loss in vacuo or RaB atoms by alpha recoil from daughter deposits collected with membrane filters was investigated. Experimentally determined values of the recoil loss influencing the loss efficiency and also the significance of such losses in radon daughter measurements are discussed.

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177. Jonassen, N.

Removal of radon daughters from indoor air by mechanical methods. 5 p., 1980.

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178. Jonassen, N., McLaughlin, J. P., Laboratory of Applied Physics I. Technical University of Denmark.

Radon in indoor air I. Research Report 6 24 p., 1976.

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179. Jonassen, N., McLaughlin, J. P., Laboratory of Applied Physics I. Technical University of Denmark.

Radon in indoor air II. Research Report 7 42 p., 1977.

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180. Jones, G. E., Kleppe, L. M.

A simple and inexpensive system for measuring concentrations of atmospheric radon-222. UCRL-16952 18 p., 06/27/66.

ABSTRACT: A radon-222 sampling system has been designed and built which uses a charcoal adsorption technique for collecting and analyzing that gas in a simple, inexpensive, reliable way. Results of measurements made with the system, although only preliminary, are in agreement with data obtained by other investigators.

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181. Kahn, B., Eichholz, G. G., Clarke, F. J.

Assessment of the critical populations at risk due to radiation exposure in structures. 106 p., 06/--/79.

17:37 SYSTEM TIME CANCELLED...SYSTEM WILL REMAIN UP TONIGHT....

182. Kapustin, V. K., Leonov, V. V., Sokolikov, A. V.

Determination of low levels of alpha radioactivity in aqueous sewage.

SOV. RADIOCHEM. (ENGL. TRANSL.) 20(1): 121-126, 09/--/78.

ABSTRACT: A method is proposed for the determination of the summary alpha-radioactivity of aqueous samples, based on the use of a solid scintillator, with preliminary concentration of alpha emitters on lanthanum hydroxide. The dependence of the sensitivity of the method on the concentration of the co-precipitant and salt-containing solution was investigated. Optimum conditions of analysis were selected: C La = 10-70 milligram/liter, layer thickness of scintillator K-9 20 milligram/2 cubic-centimeters, thickness of supplementary layer of K-9 20 milligram/2 centimeters. The minimum measurable specific alpha-activity, using an FEU-49B photomultiplier, with volume of sample 1 liter,

17:37 SYSTEM TIME CANCELLED...SYSTEM WILL REMAIN UP TONIGHT....

total layer thickness of phosphor K-9 40 milligram/2 centimeters, total time of analysis 1.5 hours, efficiency of recording 0.80, and relative error of the measurement for monitoring the summary specific activity of alpha-emitters of unknown composition in the sewage of radiochemical enterprises in the range E-6 - E-12 Ci/liter was demonstrated. This method can be used for the determination of radon in natural water according to its short-lived decay products.

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183. Kataoka, T., Ikebe, Y., Minato, S.

Influence of the distribution of Rn-222 concentration under the ground on natural gamma-ray flux density and exposure rate.

HEALTH PHYS. 37: 669-675, 11/--/79.

ABSTRACT: Analytical formulas are derived for uncollided gamma-ray flux density and exposure rate above the ground due to Rn-222 distributed in the soil exponentialy with depth. A Monte-Carlo method is applied to collided gamma-rays. It is concluded from the results of the calculations that the flux density and exposure rate are strongly affected by the escape-to-production ratio and diffusion coefficient of Rn-222 in the soil. These calculations are applied to natural radionuclides in the soil of the campus of Nagoya University. It is shown that the difference between the total exposure rate on the campus calculated by assuming exponential distribution of Rn-222 in the soil and that by assuming uniform distribution ranges from 3 to 8%.

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184. Keefe, D. J., McDowell, W. P., Groer, P. G.

Use of a microprocessor in a remote working level monitor.

IEEE TRANS. NUCL. SCI. NS-23(1): 704-709, 02/--/76.

ABSTRACT: The instrument described measures the short-lived Rn-222 daughter concentrations and the Working Level (WL) in sealed "hot chambers" located in uranium mines. Radiation-induced pulses from two separate sensors are transmitted through 500 foot cables to a microprocessor, which processes the pulses and controls the operation of the system. A read-only memory stores a fixed program which is used to calculate the desired concentrations. The results are printed as pCi/l (Rn-daughter concentrations) and WL.

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185. Keefe, D. J., McDowell, W. P., Groer, P. G., Witek, R. T.

Optimizing measurement sensitivity to facilitate monitoring environmental levels of Rn-daughter concentrations.

IEEE TRANS. NUCL. SCI. NS-25(1): 787-789, 02/--/78.

ABSTRACT: In the measurement of environmental levels of radioactivity, the primary problem is the accumulation of a statistically meaningful number of counts within a reasonable period of time. In the case of measurements of airborne Rn-222 daughter concentrations, the problem is further complicated by the particularly short half-life, 3.05 minutes, of RaA (Po-218). Since three Rn-daughters - RaA, RaB (Pb-214) and RaC

(Bi-214) - are of interest, the equations interrelating these Rn-daughter concentrations were derived from the laws of radioactive-series decay. These equations, although straightforward, are cumbersome to solve. To facilitate the efficient use of these equations, a computer program has been written which permits the calculation of Rn-daughter concentrations or expected counts for a given set of measurement parameters (flow rate and detector efficiencies). A subroutine then calculates the optimum pumping and counting times required to provide the number of counts necessary for acceptable statistics at environmental levels of Rn-222 daughter concentrations. This subroutine contains a set of parameters, flow rate and efficiencies, that are fixed using realistic restrictions. The use of these optimized pumping and counting times results in maximum measurement sensitivity under realistic constraints.

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186. Keefe, D. J., McDowell, W. P., Groer, P. G.

The environmental working level monitor, final report: Development and fabrication of radon daughter detection equipment. P7628C 44 p., 09/29/78.

ABSTRACT: The Environmental Working Level Monitor (EWLM) is an instrument used to automatically monitor airborne Rn-daghter concentrations and the Working Level (WL). It is an ac powered, microprocessor based instrument with an external inverter provided for dc operation if desired. The microprocessor's control processor unit (CPU) controls the actuation of the detector assembly and processes its output signals to yield the measurements in the proper units. The detectors are fully automated and require no manual operations once the instrument is programmed. They detect and separate the alpha emitters of RaA and RaC' as well as detecting the beta emitters of RaB and RaC. The resultant pulses from these detected radioisotopes are transmitted to the CPU. The programmed microprocessor performs the mathematical manipulations necessary to output accurate Rn-daughter concentrations and the WL. A special subroutine within the system program enables the EWLM to run a calibration procedure on command which yields calibration data. This data can then be processed in a separate program on most computers capable of BASIC programming. This calibration program results in the derivation of coefficients and beta efficiencies which provides the calibrated coefficients and beta efficiencies required by the main system program to assure proper calibration of the individual EWLMs.

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187. Keefe, D. J., McDowell, W. P., Groer, P. G., Argonne National Laboratory., U.S. Department of Energy.

The environmental working level monitor: Final report. P7628C, 09/29/78.

ABSTRACT: The Environmental Working Level Monitor (EWLM) is an instrument used to automatically monitor airborne Rn-daughter concentrations and the Working Level (WL). It is an ac powered, microprocessor based instrument with an external inverter provided for dc operation if desired. The microprocessor's control processor unit (CPU) controls the actuation of the detector assembly and processes its output signals to yield the measurements in the proper units. The detectors are fully automated and require no manual operations once the instrument is programmed. They detect and separate the alpha emitters of RaA and RaC' as well as detecting the beta emitters of RaB and RaC. The resultant pulses from these detected radioisotopes are transmitted to the CPU. The programmed microprocessor performs the mathematical manipulations necessary to output accurate Rn-daughter concentrations and the WL. A special subroutine within the system program enables the EWLM to run a calibration procedure on command which yields calibration data. This data can then be processed in a separate program on most computers capable of BASIC programming. This calibration program results in the derivation of coefficients and beta efficiencies which provides the calibrated coefficients and beta efficiencies required by the main system program to assure proper calibration of the individual EWLM's.

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188. Kelkar, D. N., Joshi, P. V.

A rapid method for estimating radium and radon in water.

HEALTH PHYS. 17: 253-257, 1969.

ABSTRACT: A rapid method for the estimation of radium and radon in water samples with activity levels more than 1-2 pCi/l, is described. Radium and daughter products of radon are precipitated with more than 95% efficiency in the presence of ZnS (Ag) scintillation powder giving a composite scintillator-sample combination. Apart from being rapid and inexpensive, the method is suitable for field use as it requires very little apparatus and does not involve laborious chemical analysis. Effects of temperature, pH and amount of ZnS (Ag) were studied and conditions for optimum yield were determined experimentally. Results

of radium and radon levels in some thermal springs measured in the field using this method, are also presented in the paper.

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189. Kerr, G. D.

Measurement of radon progeny concentrations in air.

TRANS. AM. NUCL. SOC. 17 (Suppl.): 542-543, 1973.

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190. Kobal, I., Skofljanec, M., Kristan, J.

Outdoor and indoor radon concentrations in air on the territory of SR Slovenia, Yugoslavia. 3 p.

ABSTRACT: In connection with the investment in uranium mining and milling facilities at Zirovski vrh (North-Western part of Slovenia), some tiny and field measurement of radon concentrations in air in Slovenia were started. Emphasis was given to the uranium deposit area, but some other reference sites were also selected. Radon determinations were accompanied by measurement of the meteorological parameters wind speed and direction, humidity, temperature and atmospheric pressure. At representative sites, diurnal concentration variations were followed. Radon concentrations were usually found to lie below 1 pCi/l (= 37 Bq/cubic meter), but in the vicinity of mine tailings and in houses built of stone from Zirovski vrh, this level was exceeded and concentrations up to 20 pCi/l were found.

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191. Kolb, W., Schmier, H.

Building material induced radiation exposure of the population.

ENVIRON. INT. 1(1/2): 69-71, 1978.

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192. Kotrappa, P., Bhanti, D. P., Raghunath, B.

Diffusion coefficients for unattached decay products of thoron: Dependence on ventilation and relatively humidity.

HEALTH PHYS. 31: 378-380, 10/--/76.

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193. Kraner, H. W., Schroeder, G. L., Lewis, A. R., Evans, R. D.

Large volume scintillation chamber for radon counting.

REV. SCI. INSTRUM. 35(10): 1259-1265, 10/--/64.

ABSTRACT: A 450-cc cylindrical Lucite chamber covered internally with ZnS(Ag) and viewed at each end by 5-in. photomultiplier tubes with summed outputs has been used routinely as a low background (approximately 0.8 counts per min for a new chamber) Rn scintillation counter. The counter is simple to construct and has operated reliably for about two years. The counting efficiency for Rn in transient equilibrium with its two alph-emitting daughters is 2.1 counts per Rn decay. Thin lines of silver conducting paint applied externally on the ends of the chamber, together with surrounding Al foil, form a complete electrostatic shield which has assured reproducible counting efficiencies by suppressing randomly occurring internal fields. Results of experiments, in which external potentials were applied to the end plate electrodes of an experimental chamber, are presented in detail. It was found that as little as 22 V applied across the chamber can change the counting efficiency by 8%. A back voltage effect caused by the deposition of ionization-induced charge on the internal surfaces during voltage application was observed.

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194. Krisiuk, E. M., Lisachenko, E. P., Tarasov, C. I., Shamov, V. P., Shalak, N. I.

Exposures from radiation sources of natural origin. CONF-730907-P2

PROCEEDINGS OF THE THIRD INTERNATIONAL CONGRESS OF THE INTERNATIONAL RADIATION PROTECTION

ASSOCIATION. 870-881

ABSTRACT: Ionizing radiation in dwellings is one of the main sources of radiation effect on the population. Limitation or decrease of this factor may be done by standardization of radioisotope concentration in building materials. Gamma-spectrometric analyses for Ra-226, Th-232 and K-40 in 300 samples of building materials from various regions of the USSR have been performed and predicted values of gamma radiation doses in buildings made of these materials have been calculated. To evaluate the parameters determining air concentration of Rn in dwellings Rn accumulation and mechanism of its release have been studied. For limitation of external gamma radiation levels in dwellings the following values of specific radioisotope permissible concentration have been suggested: 10, 7, 126 pCi/gram for Ra-226, Th-232 ad K-40 respectively. For limitation of Rn concentration in dwellings permissible level of effective Ra-226 concentration (the product of Ra-226 concentration by emanation factor) has been recommended 0.6 pCi/gram.

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195. Krisiuk, E. M.

Airborne radioactivity in buildings.

HEALTH PHYS. 38: 199-202, 02/--/80.

ABSTRACT: Expressions for the concentration of radon and thoron daughters in indoor air have been derived. Taking into account the exhalation rate and diffusion processes of building materials, room dimensions, and ventilation rates, we estimate that the mean radon and thoron daughter concentrations in indoor air are 0.10 pCi/liter and 0.0064 pCi/liter, respectively. These values correspond to a lung dose equal to 126 mrem/yr.

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196. Kristan, J., Kobal, I.

A modified scintillation cell for the determination of radon in uranium mine atmosphere.

HEALTH PHYS. 24(1): 103-104, 01/--/73.

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197. Kruger, J., Nothling, J. F.

A comparison of the attachment of the decay products of radon-220 and radon-222 to monodispersed aerosols.

AEROSOL SCI. 10: 571-579, 1979.

ABSTRACT: The adsorption of radioactive aerosols is of prime importance when assessing the hazard of inhalation of radioactive materials, especially in the uranium mining industry. In previous studies of the attachment rate, contradicting results on the dependence on particle size have been found. The attachment rate for the attachment of the decay products of Rn-222 to monodispersed polystyrene aerosols (of a diameter from 1.2 to 5.3 micrometers) in the concentration range 1-67 particles/cubic centimeter was measured directly. This is compared with the attachment rate of radon-220 decay products which was measured in a previous experiment. As before, the attachment between the radioactive atoms and the aerosols was found to be directly proportional to the particle concentration N, as well as to the square of the particle radius R. The attachment coefficient of 4.1 x E5 x radius squared x cubic centimeters/minute and the sticking probability of 0.13 for Rn-222 decay products were found to be larger than that for the decay products of Rn-220 (2.4 x E5 x radius squared x cubic centimeters/minute and 0.08, respiectivelr). The mechanism for the attachment, however, is the same.

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198. Kukacka, L. E., Isler, R. J.

Cost estimate for remedial action program for residences in the Grand Junction, Colorado Area. BNL-17433 15 p., 02/--/73.

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199. Kusnetz, H. L.

Radon daughters in mine atmospheres: A field method for determining concentrations.

AM. IND. HYG. ASSOC. Q. 17(1): 85-88, 03/--/56.

ABSTRACT: A new concept of describing the tolerance level of radon daughters has been presented. This concept is in terms of the alpha-energy dose resulting from the complete decay of the daughters. A rapid field method for determining atmospheric concentrations of radon daughters in terms of Mev of alpha energy/liter has been shown. No attempt has been made to set a maximum allowable concentration for radon and/or its daughters. Should an MAC different from the tolerance level given in this paper be adopted, the factors in Fig. 1 would change by an appropriate constant. The method itself would remain the same.

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200. Kusuda, T., Silberstein, S., McNall, P. E., Jr.

Modeling of radon and its daughter concentrations in ventilated spaces. 18 p., 07/--/79.

ABSTRACT: In order to predict indoor radiation levels due to radon daughters at low building ventilation and air leakage rates, differential equations governing the decay and venting of radon (Rn-222) and its daughters were solved. A computer program based on the solutions was written to predict radon and daughter concentrations, total potential alpha energy and equilibrium factor. The program can account for time dependence of ventilation and emanation rates and is readily usable by building designers. Sample calculations using the program showed that potential alpha energy levels in tightened buildings can commonly reach about 0.01 working level (WL), a level more than twice as high as concentrations currently found in most houses.

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201. Kusuda, T., Silberstein, S., McNall, P. E., Jr.

The effects of lowered ventilation on indoor radiation due to radon and its daughters. 20 p., 07/--/79.

ABSTRACT: In order to develop guidelines for saving energy by restricting ventilation without exposing the population to hazardous indoor radiation levels, differential equations governing the decay and venting of radon (Rn-222) and its daughters were solved. A computer program based on the solutions was written to predict radon and daughter concentrations, total potential alpha energy and equilibrium factor, and to be used in future simulations of the behavior of these quantities in buildings. The program is readily usable by building designers. Sample calculations using the program showed that tightened buildings can commonly have potential alpha energy levels near 0.01 working level (WL), a level possibly requiring remedial action.

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202. Larson, R. E.

Measurements of radioactive aerosols using thin plastic scincillators.

NUCL. INSTRUM. METHODS 108(3): 467-470, 05/01/73.

ABSTRACT: A thin plastic scintillator mounted on a photomultiplier (PM) tube is used as a detector for the beta-radioactive daughter products of radon (Rn-222) collected on filter papers.

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203. Leonard, R. B., Janzer, V. J.

Natural radioactivity in geothermal waters, Alhambra Hot Springs and nearby areas, Jefferson County, Montana.

J. RES. U.S. GEOL. SURV. 6(4): 529-540, 07/--/78.

ABSTRACT: Radioactive hot springs issue from a fault zone in crystalline rock of the Boulder batholith at Alhambra, Jefferson County, in southwestern Montana. The discharge contains high concentrations of radon, and the gross alpha activity and the concentrations of adium-226 exceed maximum levels recommended by the EPA for drinking water. Part of the discharge is diverted for space heating, bathing and domestic use. The radioactive thermal waters at measured temperatures of about 60 degrees C are of the sodium bicarbonate type and saturated with respect to calcium carbonate. Radium-226 in the rock and on fractured surfaces or coprecipitated with calcium carbonate probably is the principal source of radon that is dissolved in the thermal water and discharged with other gases from some wells and springs. Local surface water and shallow ground water are of the calcium bicarbonate type and exhibit low background activity. The temperature, percent sodium, and radioactivity of mixed waters adjacent to the fault zone increase with depth. Samples from most of the

major hot springs in southwestern Montana have been analyzed for gross alpha ad beta activity. The high level of radioactivity at Alhambra appears to be related to leaching of radioactive material from fractured siliceous veins by ascending thermal waters and is not a normal characteristic of hot springs issuing from fractured crystalline rock in Montana.

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204. Letourneau, E. G., McGregor, R. G., Taniguchi, H.

Background levels of radon and radon daughters in Canadian homes.

PROCEEDINGS OF SPECIALISTS' MEETING ON PERSONAL DOSIMETRY AND AREA MONITORING SUITABLE FOR RADON AND DAUGHTER PRODUCTS. 167-187

ABSTRACT: Various measurements of radon and radon daughters in Canadian homes in communities not associated with uranium mining were carried out in the past two years. A summary of these results is presented for basic information.

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205. Likes, R. S., Mogro-Campero, A., Fleischer, R. L.

Moisture-insensitive monitoring of radon.

NUCL. INSTRUM. METHODS 159(2/3): 395-400, 02/15/79.

ABSTRACT: Long-term measurements of radon for dosimetry or uranium exploration can be affected by water in or on solid detectors. The problems are documented and a simple cure presented. The air space containing the detector is protected by a permeable membrane and an appropriate desiccant.

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206. Lin, F. M., Cameron, J. R.

A bibliography of thermoluminescent dosimetry.

HEALTH PHYS. 14(5): 495-514, 05/--/68.

ABSTRACT: Comprehensive bibliography on the subject of thermoluminescent dosimetry (TLD) is presented. Included are basic papers on thermoluminescence (TL), and applications of TL that have a direct bearing on TLD.

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207. Lindeken, C. L., Jones, D. E., McMillen, R. E.

Environmental radiation background variations between residences.

HEALTH PHYS. 24: 81-86, 01/--/73.

ABSTRACT: Environmental background radiation exposure measurements made in approximately 100 residences in the vicinity of Livermore, California, show variations in annual exposure from 52 to 130 mR. Measurements were made with CaF2:Dy (TLD-200) dosimeters at quarterly intervals for a period of 1 yr. Dwellings were typically wood-frame structures with stucco exteriors. Interior exposure rates were, on the average, about 25% lower than those out of doors. Dosimeters were used without energy filters, since it appears photons with energies less than 100 keV contribute little to the total dose from natural radiation sources. Elimination of energy filters materially simplifies packaging and handling requirements for these measurements.

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208. Lloyd, R. D.

Gamma-ray emitters in concrete.

HEALTH PHYS. 31: 71-73, 07/--/76.

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209. Lockhart, L. B., Jr., Patterson, R. L., Jr., Hosler, C. R.

Determination of radon concentration in the air through measurement of its solid decay products. NRL-6229 32 p., 03/29/65.

ABSTRACT: An analytical method has been devised for the determination of the radon concentration in the air by measurement of the radioactive decay of the solid radon daughters collected on air filters during a fixed sampling period. The ratio of the radioactivity present at two periods, determined by an initial count immediately after termination of sampling and a second count an hour later, is used to estimate the extent of radioactive equilibrium established between radon and its daughters and to obtain a correction factor for relating radon daughter activity to radon activity. The disintegration rates of the various decay products of radon as a function of the age of the radon conglomerate have been calculated during the growth and collection periods and for successive 5-minute decay periods extending through the first 71 minutes following termination of filtration. A procedure for the calibration of beta counters for the evaluation of RaB and RaC activities was established. Use was made of this analytical method to determine radon concentrations in the air near ground level.

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210. Lockhart, L. B., Jr., Patterson, R. L., Jr., U.S. Naval Research Laboratory. Washington, D.C.

The extent of radioactive equilibrium between radon and its short-lived daughter products in the atmosphere. NRL-6374, 04/05/66.

ABSTRACT: A set of experimental conditions have been derived which optimizes the accuracy with which the radon content of the atmosphere and its apparent residence time there can be determined from measurement of the filterable gross beta activity during two separate 10-minute periods following the end of a 20-minute collection period. The 20 minute collection is made on a filter of essentially 100% retentivity (glass fiber filter) and counted for beta activity through a 10-mil (70 milligram/cubic centimeter) aluminum absorber on equipment of known efficiency for the beta particles emitted by RaB and RaC. The ratio of measured counts during the 61-through-71 minute decay period to that during the 1-through 11 minute period is employed to obtain the atom ration of RaC to RaB in the air sampled, the apparent age of the conglomerate of radon and its daughters, and the total counts to be expected from any given radon concentration in the air. Extensive examples of atmospheric measurements are given which suggest that under most conditions in the free atmosphere radon is essentially at secular equilibrium with its daughter products. Other collections made following addition of radon to a restricted volume show the expected increase in with time, which confirms the basic validity of the procedure.

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211. Lovett, D. B.

Track etch detectors for alpha exposure estimation.

HEALTH PHYS. 16(5): 623-628, 05/--/69.

ABSTRACT: Solid state dielectric detectors have been applied as integrating alpha particle monitoring devices to permit the estimation of alpha particle lung doses received by workers in radon-radon daughter contaminated atmospheres. The characteristics of these detectors are discussed and the results of laboratory and field testing are summarized.

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212. Loysen, P.

Errors in measurement of working level.

HEALTH PHYS. 16(5): 629-635, 05/--/69.

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213. Lucas, H. F.

Improved low-level alpha-scintillation counter for radon.

REV. SCI. INSTRUM. 28(9): 680-683, 09/--/57.

ABSTRACT: A low counter background is obtained by use of steel for the shell and quartz for the counter window, while marked improvement in the stability is obtained by coating the window with an electrically conducting layer of tin oxide. The distribution of radon and its daughters within the counter under various conditions was determined by comparison of observed and calculated counting efficiencies. A stable counting efficiency of 5.58 plus or minus 0.05 cpm/pCi radon and a background counting rate of 0.08 cpm is obtained. The usefulness of this counter is augmented by adsorbing the radon on charcoal.

The radon is then easily transferred to the counter with a small volume of helium and a Sismamotor pump. This system is suitable for the analysis of samples of radon as small as E-11 c or concentrations in air smaller than E-16 C radon/liter.

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214. Lucas, H. F., Jr.

Alpha scintillation radon counting.

WORKSHOP ON METHODS FOR MEASURING RADIATION IN AND AROUND URANIUM MILLS. 3(9): 69-96

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215. Lucas, H. F., Jr., Adams, J. A. S. (ed.), Lowder, W. A. (ed.)

A fast and accurate survey technique for both radon-222 and radium-226.

THE NATURAL RADIATION ENVIRONMENT. 315-328, 1964.

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216. Lundin, F. E., Jr., Wagoner, J. K., Archer, V. E.

Radon daughter exposure and respiratory cancer quantitative and temporal aspects: Report from the epidemiological study of United States uranium miners. NIOSH-NIEHS Joint Monograph No. 1 176 p., 06/--/71.

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217. Marsard, W. L., Logsdon, R. F.

An evaluation of the bacterial filtering efficacy of air filters in the removal and destruction of airborne bacteria.

ASHRAE J. 49-52, 05/--/65.

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218. Martz, D. E., Holleman, D. F., McCurdy, D. E., Schiager, K. J.

Analysis of atmospheric concentrations of RaA, RaB and RaC by alpha spectroscopy.

HEALTH PHYS. 17: 131-138, 1969.

ABSTRACT: A new method is presented for determining the airborne concentrations of RaA, RaB and RaC in atmospheres contaminated with Rn-222. The method employs alpha spectroscopy to measure the count rates RaA and RaC′ present on a membrane filter sample at two post-sampling times. The individual air concentrations and the statistical variances associated with each then may be calculated from the equations given. Theoretical and experimental comparisons are presented which indicate the improved accuracy of the spectroscopic method over methods previously available.

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219. Martz, D. E., Schiager, K. J.

Protection against radon progeny inhalation using filter type respirators.

HEALTH PHYS. 17: 219-228, 1969.

ABSTRACT: The efficiencies of several respiratory protective devices in removing the airborne radon daughter activity found in underground uranium mines were determined under standardized test conditions. The protection afforded to working uranium miners by simple filter respirators was estimated by comparison in vivo counting of the internally deposited RaC activity present in the respiratory systems of miners at the end of the working shift. The mean protection efficiency obtained was 85.2 plus or minus 13.8%, based on in vivo counts of 21 miners. The problem of providing adequate respiratory protection for underground uranium miners is discussed and a suggested list of criteria for respirator design is given.

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220. Matsinu, G. G.

Scintillation detectors for Rn-222 in air and water. 13 p.

ABSTRACT: A scintillation detector and an emanation circuit that enable sensitive measurements of Rn-222 in water in field practice and in laboratory routine, have been developed. Activities as low as 0.1 pCi per sample may be measured with a very simple procedure. The detector is also well suited to measure Rn-222 in air at concentrations down to 0.001 pCi/l, if a large size detector is used.

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221. McCurdy, D. E., Schiager, K. J., Flack, E. D.

Thermoluminescent dosimetry for personal monitoring of uranium miners.

HEALTH PHYS. 17(3): 415-422, 09/--/69.

ABSTRACT: An accurate dosimetry system using thermoluminescent detectors has been developed for monitoring radiation exposures to individual uranium miners. The system permits the evaluation of cumulative exposures to airborne radon progeny, expressed in units of Working Level Months, as well as the external gamma-ray exposure originating from the ore bodies. Thermoluminescent materials such as LiF, CaF2Dy and CaSO4:Mn have been evaluated as possible alpha-sensitive detectors of radon progeny collected on a filter paper. The most promising TLD utilizes CaF2:Dy, and is sufficiently sensitive to detect the accumulation of E5 MeV of latent alpha energy collected on a filter paper. Proper annealing of the CaF2:Dy crystal provides two response peaks, at 185 C and 265 C, for which fading is neglisible for any proposed monitoring period.

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222. McDowell, W. P., Keefe, D. J., Groer, P. G.

Interfacing calculator chips to nuclear-counting systems.

IEEE TRANS. NUCL. SCI. NS-22(1): 467-470, 02/--/75.

ABSTRACT: In the design of nuclear-counting system it is sometimes desirable to perform simple arithmetic operations on the collected data in order to present it in a more useful form. In many cases these calculations do not require a high-speed processor, and thus can be performed simply and inexpensively through the use of calculator chips. This paper describes the use of a calculator chip in a portable, battery-operated device designed to measure the radon-daughter concentration in air samples from uranium mines.

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223. McDowell, W. P., Keefe, D. J., Groer, P. G., Witek, R. T.

A microprocessor-assisted calibration for a remote working level monitor.

IEEE TRANS. NUCL. SCI. NS-24(1): 639-644, 02/--/77.

ABSTRACT: A method is described for calibrating a Remote Working Level Monitor, an instrument which measures Working Level and Rn- daughter concentrations in the atmosphere. The method makes use of a microprocessor to calculate beta efficiencies for RaB and RaC from the counts accumulated in the RaA, Ra(B+C) and RaC′ channels of the instrument. Both the alpha spectroscopic and total-alpha methods are used to determine the Rn-daughter concentrations. These methods require the processor to solve systems of linear equations with several unknowns. No assumptions about Rn-daughter equilibrium are made.

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224. McLaughlin, J. P., Jonassen, N.

The effect of pressure drops on radon exhalation from walls. 14 p.

ABSTRACT: The exhalation of radon-222 from walls was measured in a concrete walled basement room by studying the growth of activity in exhalation cans sealed to various portions of the walls. In a series of measurements constant underpressures from 5 - 25 mmHg were maintained in the exhalation cans during the build up of activity. It appears that the exhalation rate increases linearly with the underpressure. In the theoretical considerations of pressure drops it is assumed that the basement concrete walls in toto are capable of sustaining for many hours underpressure - enhanced exhalation values comparable to those experimentally measured at various places on the wall. It is shown that the fractional increase in room air activity is proportional to the total pressure drop and increases with the time it takes the pressure drop to establish. As an example a pressure drop of 20 mmHg will double the equilibrium activity in the room if its establishment takes

place at a constant rate over a period of approximately 27 hours. This is in keeping with observations on the room air radon levels over a number of months.

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225. Megumi, K., Mamuro, T.

A method for measuring radon and thoron exhalation from the ground.

J. GEOPHYS. RES. 77(17): 3052-3056, 06/10/72.

ABSTRACT: A method for determining directly the rate of radon and thoron exhalation from the ground was studied. Radon and thoron gases are directly adsorbed on a layer of granular activated charcoal distributed over the ground surface, and the charcoal is subjected to gamma-ray spectrometry. The radon quantity is determined from the area of the photopeak due to 0.61-Mev gamma-rays of Bi-214 and the thoron quantity from the area of the photopeak due to 2.61 Mev gamma-rays of TL-208. Some results of measurements obtained by this method are presented.

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226. Melvin, J. D., Copping, N. A., Shapiro, M. H.

An automated radon-thoron monitor for earthquake prediction research.

NUCL. INSTRUM. METHODS 153(1): 239-251, 07/01/78.

ABSTRACT: We describe an automated instrument for earthquake prediction research which monitors the emission of radon and the ion from rock. The instrument explors (1) aerosol filtration techniques and beta-counting to determine radon and thoron levels: (2) a programmable microcomputer which controls mechanical operations, collects data, and monitors the condition of key components: (3) a call-up telemetry system for the transmission of data to a central location over standard telephone lines. Data from the field operation of the instrument is presented.

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227. Mercer, T. T., Stowe, W. A.

Deposition of unattached radon decay products in an impactor stage.

HEALTH PHYS. 17(2): 259-264, 08/--/69.

ABSTRACT: Depending on impactor design and flow rate, as much as 80% of available unattached RaA and ThB atoms can be collected in a round-jet impaction stage in a convenient form for analysis. The collection efficiency decreases linearly, but slowly, with increasing flow rate. It is shown to be due to a diffusional process not significantly affected by either relaive or absolute humidity.

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228. Michel, J., Moore, W. S.

Ra-228 and Ra-226 content of groundwater in fall line aquifers.

HEALTH PHYS. 38: 663-671, 04/--/80.

ABSTRACT: Studies of the radium isotopic content of groundwater from a Coastal Plain aquifer adjacent to the Fall Line in South Carolina show that elevated Ra-228 and Ra-226 concentrations are associated with the aquifer. There is little seasonal variation in the concentration of either radium isotope for a single well, but up to an order of magnitude variation among wells within a 4 square kilometer area (Ra-228 activities range from 4.71 to 11.9 pCi/l, whereas Ra-226 activities range from 2.71 to 26.53 pCi/l.). The Ra-228/Ra-226 activity ratio among wells ranges from 0.23 to 3.0, and is inversely proportional to Ra-226 content. These results are contrary to the assumption in the U.S. Environmental Protection Agency drinking water regulations which state that Ra-228 rarely exceeds Ra-226 and thus require Ra-228 measurements only when Ra-226 exceeds 3.0 pCi/l. It is unknown whether these results are typical for all Fall Line aquifers of the southeastern U.S., which extend from Alabama to Maryland and supply water to many small towns. However, these results, which show that the Ra-226 concentration does not parallel Ra-228 concentration in this geologic region, call for a re-examination of the EPA regulation.

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229. Miles, J. C. H., Davies, B. L., Algar, R. A., Cliff, K. D.

The effects of domestic air treatment equipment on the concentration of radon-222 daughters in a sealed room.

R. SOC. HEALTH J. 82-85, 06/--/80.

ABSTRACT: Reduction of the ventilation rate in houses in the interests of energy conservation can lead to a build-up of radon-222 in room air. This results in irradiation of the lungs by the radioactive daughters of radon. An electrostatic precipitator has been used to remove radon daughters from the atmosphere of a sealed room. It is shown that this can reduce the dose to the bronchial epithelium by an order of magnitude, and effectively counter the effects even of extremely low ventilation rates.

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230. Mochizuki, S.

Rn-222 exhalation and its variation in soil air (I): Method and instrument. 13 p.

ABSTRACT: A new method has been developed and newly designed four apparatus were constructed for measuring the concentration of radon in soil air without disturbing natural condition of the soil. By this method, radon concentration in the soil air at adequate points inner the depth of one meter below the ground is obtained from the concentration of radium A which was measured in the same air. Radium A concentration is measured by spectrometry of alpha-ray detected from radioactive ions which are floated in the soil air. By the fundamental experiments and preliminary observation carried out in the soil air below the ground, it was confirmed that the newly constructed apparatus is useful to measure the radon concentration in the soil air.

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231. Mochizuki, S.

Comparison of natural atmospheric radioactivity appeared over Hachijo Island and Miyake Island in the early spring.

J. METEOROL. SOC. JPN. 56(1): 52-56, 02/28/78.

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232. Moeller, D. W., Underhill, D. W., Gulezian, G. V.

Population dose equivalent from naturally occurring radionuclides in building materials. 29 p.

ABSTRACT: Naturally occurring radionuclides in building materials are a source of external and internal radiation exposure to the U.S. population. Under certain conditions exposure rates are sufficiently high that control measures, either on a voluntary or mandatory (legislative) basis, should be considered. Such measures include (1) material substitution, (2) improved manufacturing standards, (3) changes in basic building designs, (4) application of surface sealants, and (5) increased ventilation accompanied by processes for the adsorption and/or filtration of airborne radionuclides. Analyses show that several of these measures appear to be well justified in terms of the $1,000 per person-rem cost-effectiveness guidelines utilized for commercial nuclear power plants by the U.S. Nuclear Regulatory Commission.

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233. Mogro-Campero, A., Fleischer, R. L.

Search for long distance migration of subsurface radon. 13 p.

ABSTRACT: Long distance radon migration is defined as that requiring nondiffusive transport modes. The limitations of diffusive motion are shown by using likely field parameters. Two non-diffusive transport processes are discussed quantitatively: convection driven by the geothermal gradient and flow induced by atmospheric pressure changes. Finally, we treat the problem of experimentally determining whether long range radon migration occurs in a given situation. This includes criteria for selecting anomalous readings in radon surveys and possible reasons for the appearance of such anomalous values.

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234. Mogro-Campero, A., Fleischer, R. L.

Subterrestrial fluid convection: A hypothesis for long-distance migration of radon within

the earth.

EARTH PLANET. SCI. LETT. 34(2): 321-325, 03/--/77.

ABSTRACT: Scattered observations suggest that radon can migrate through the earth for distances greater than or equal to 100 meters, a process of great potential aid in both earthquake prediction and uranium exploration. It is noted that existing theories predict that fluid convection in the earth, driven by the local geothermal gradient, can occur in areas of relatively high permeability. The velocity of fluid flow may be sufficient to transport radon over large distances before it decays. The convection by hypothesis also provides a possible explanation of seasonal effects that have been observed in local and general radon emanation into the atmosphere.

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235. Money, M., Heaton, B.

The effect of humidity on the detection of radon.

HEALTH PHYS. 31(5): 456-457, 11/--/76.

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236. Moore, H. E., Poet, S. E., Martell, E. A.

The size distribution and origin of Pb-210, Bi-210, and Po-210 on airborne particles in the troposphere. 10 p.

ABSTRACT: Data is presented on the concentration (dpm/100 cubic meter), specific activity (dpm/g aerosol) and percent of Pb-210, Bi-210, and Po-210 versus particle size interval for ground level air samples. Similar data for Sr-90 in air and Ra-226 and Pb-210 in one soil sample is given. Calculated mean aerosol residence times increase with increasing particle size interval; however, specific activities and percent of each isotope decreases with particle size interval. These variations along with comparison to soil data suggest that the distribution of these isotopes reflects the initial attachment distribution plus a smaller component due to entrainment of particles from soil and other surfaces. Coagulation into size intervals greater than 0.3 micrometers radius appears slow compared to removal processes. Thus, the mean troposphere aerosol residence time for tropospheric aerosol particles is one week or less.

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237. Morse, R. H.

Radon counters in uranium exploration. Publ. No. IAEA-SM-208/55

EXPLORATION FOR URANIUM ORE DEPOSITS.

ABSTRACT: Rapid analytical techniques for uranium, radium and radon, each of which is characterized by a different geochemical behaviour and each of which is absolutely specific for uranium. An efficient geochemical exploration programme will be based on a judicious combination of these elements. The battery-operated digital alpha scintillometer combines portability with high sensitivity. Radon and radium can be determined in the field. Thoron is recognized by a rapid drop in count-rate owing to its 54.5-s half-life. At the detailed level of exploration radon in soil gas provides a useful supplement to ground gamma scintillometry. Readings as low as 20 counts/minute or lower are significant. High readings due to especially permeable soils are characterized by rapidly falling count-rates because of dilution by thoron. Uranium anomalies are characterized by steady or rising count-rates. Counting beyond the first minute and monitoring any changes is essential. Diurnal radon variations are not critical in Canada. An example is provided from the Bancroft area which compares radon in soil to ground gamma scintillometry. The radon survey shows more detail, in agreement with the geology, than the scintillometer.

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238. Nazaroff, W. W., Boesel, M. L., Hollowell, C. D., Roseme, G. D.

The use of mechanical ventilation with heat recovery for controlling radon and radon-daughter concentrations. LBL-10222 21 p., 03/--/80.

ABSTRACT: An energy research house in Maryland was found to have radon concentrations far in excess of recommended guidelines. A mechanical ventilation system with heat recovery was installed in this house to test its effectiveness as an energy-efficient control technique for indoor radon. Radon concentration was monitored continuously for two weeks under varying ventilation conditions [0.07 to 0.8 air changes

per hour (ach)] and radon daughter concentrations were measured by grab-sample techniques about nine times daily during this period. At ventilation rates of 0.6 ach and higher radon and radon daughter levels dropped below guidelines for indoor concentrations. Comparison with other studies indicates that indoor radon buildup may be a problem in a considerable portion of houses characterized by their low infiltration rates. The use of mechanical ventilation systems with air-to-air heat exchangers may offer a practical, cost-effective, and energy-efficient means of alleviating not only the radon problem specifically but also the general deterioration of indoor air quality in houses designed or retrofitted to achieve low infiltration.

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239. Negro, V. C., Watnick, S.

"FUNGI": A radon measuring instrument with fast response.

IEEE TRANS. NUCL. SCI. NS-25(1): 757-761, 02/--/78.

ABSTRACT: The FUNGI uses an electrostatic field to collect daughter products of radon decay, and a solid state detetor to resolve the energies of radium A (Po-218) and radium C' (Po-214) alpha particles. This permits a great degree of flexibility in the measurement of radon and radon daughters. In addition, by limiting the instrument response to the radium A channel only, the response to changes in radon concentration of this instrument is ten times faster than other instruments, making it suitable for radon survey applications.

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240. Neustein, H., Cohen, L. D., Krablin, R.

An automated atmospheric radon sampling system.

ATMOS. ENVIRON. 5(10): 823-831, 1971.

ABSTRACT: An automated radon gas sampling system using the double filter method is described. Four such systems have been installed on a 1000 foot tower in northwest Philadelphia, Pennsylvania, at elevations of 20, 200, 570, and 890 feet above ground. Simultaneous sulfur dioxide concentration measurements are made at the radon sampling elevations together with measurements of wind speed, wind direction, and temperature at elevations of 40, 100, 200, 350, 570, and 890 feet. Average radon concentrations are measured every hour, while the meteorological variables are recorded continuously, with 10 minute averages calculated four times an hour. These systems have had a downtime of less than 15 per cent since March, 1970. The radon systems are capable of monitoring radon concentrations with a sensitivity of E-14 Ci liter, and an uncertainty at E-13 Ci liter of 7 per cent. The observed average radon concentration at twenty feet above the ground was 1.5 x E-13 Ci liter, in substantial agreement with other published values. Data are presented which display the diurnal variation of radon concentration as a function of elevation. Also presented are data which show a radon concentration dependence on wind direction.

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241. Parker, H. M.

The dilemma of lung dosimetry.

HEALTH PHYS. 16(5): 553-561, 05/--/69.

ABSTRACT: A legitimate criticism of health physics arises from the derivation of quite complex relationships for the permissible deposition of radionuclides in the body, in the absence of valid experience in man. It has to be accepted that inhalation of substantial amounts of radon and daughter products has a finite probability of causing cancer in the bronchial epithelium. Establishment of a quantitative dose effect relationship has a formidable array of impediments. The radioactive nuclides in mine air comprise a short-lived chain existing in physical forms from free ions through small nuclei to large dust particles. Intake and primary retention of these media has to be calculated from models. Subsequent translocation up the bronchial tree is a significant factor in exposure. If the nucleus of a basal cell of bronchial epithelium is assumed to be the biological target, the penetration of alpha particles to it can be modeled in various degrees of sophistication. This leads to a numerical relationship between nature and concentration of the ambient radioactivity and the relevant tissue dose or dose-rate. The quoted number may be high or low by a factor of about three. This is essentially a permissible dose type of calculation. It is not a demonstrated dose effect relationship. The feasibility of programs to progressively eliminate these uncertainties will be discussed in terms of refined study of mine exposees, relevance of data from radium or other human cases, and animal experimentation.

242. Parks, N. J.

A more sensitive method for the assay of Rn-222 concentations in water samples with liquid scintillation counters.

HEALTH PHYS. 36(2): 207, 02/--/79.

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243. Parthasarathy, K. S.

Decay products of Rn222 in the living environment.

HEALTH PHYS. 31(2): 187-188, 08/--/76.

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244. Partridge, J. E., Horton, T. R., Sensintaffar, E. L.

A study of radon-222 released from water during typical household activities. Technical Note ORP/EERF-79-1 13 p., 03/--/79.

ABSTRACT: Small quantities of radon-222 can be found in all ground water from natural sources as a result of decay of radium-226 both in water and the soils and soil matrix surrounding the water. Radon in drinking water has previously been considered a source of radiation exposure primarily from an ingestion standpoint. However, the EPA, Office of Radiation Programs, is investigating the potential for exposure to individuals from inhalation of gaseous radon released from water. This report describes the results of a study to determine the fraction of radon released from water during typical household activities such as clothes washing, dishwashing, showering, etc., and estimates the potential radon concentration in air and resulting working levels in structures.

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245. Pearson, J. E., Jones, G. E.

Emanation of radon 222 from soils and its use as a tracer.

J. GEOPHYS. RES. 70(20): 5279-5289, 10/15/65.

ABSTRACT: The temporal, geophysical, and geographical parameters related to the emanation of Rn-222 at the earth-atmosphere interface have been studied. Such information is necessary in the evaluation of boundary conditions for an investigation of the vertical diffusivity of the atmosphere if natural Rn-222 is to be used as a tracer. A system for collecting Rn-222 emanating at the surface of the earth with a minimum of disturbance to the site has been developed. It includes a stainless-steel collector, open on the bottom where it is in contact with the soil; a pump; water and carbon dioxide traps; and chilled traps in which the radon is adsorbed on activated coconut charcoal. Sampling patterns in east-central Illinois were selected using a randomized complete block design to permit statistical analysis of emanation data with respect to location, soil type, meteorological conditions, and other parameters. Although no statistically significant variation of Rn-222 emanation with location or soil type was found, a variation with wind speed, gustiness, and soil moisture was observed. Criteria for the selection of locations suitable for vertical diffusivity studies using Rn-222 as a naturally occurring tracer should include, ideally, uniform emanation for tens of kilometers in all directions, substantially level topography, and uniform vegetative cover. The location chosen for these studies meets these criteria.

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246. Perdue, P. T., Leggett, R. W., Haywood, F. F.

A technique for evaluating airborne concentrations of daughters of radon isotopes. 12 p.

ABSTRACT: Elevated quantities of actinon (Rn-219) daughters in air have been observed in some buildings contaminated with raffinates from uranium ore processing. Previous methods for measuring the concentration of Rn-222 daughters assume that Rn-219 daughter concentrations are negligible, and there was no available method for measuring concentrations of Rn-219 daughters. The authors have developed a method for the simultaneous measurement of daughters of Rn-222, Rn-220, and Rn-219 in air by modifying a well-known alpha spectroscopy technique and computer program used for determining Rn-222 daughter concentrations.

247. Perdue, P. T., Shinpaugh, W. H., Thornsate, J. H., Auxier, J. A.

A convenient counter for measuring alpha activity of smear and air samples.

HEALTH PHYS. 26(1): 114-116, 01/--/74.

248. Pohl, E., Pohl-Ruling, J.

Determination of environmental or occupational Rn222 in air and water and Ra226 in water with feasible and rapid methods of sampling measurement.

HEALTH PHYS. 31(4): 343-348, 10/--/76.

ABSTRACT: 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 bottles are used with volumes of 0.5 and 2.5l 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 a 10-20 liter ionization chamber in connection with an electronic electrometer and a chart-recorder. The air sample is transferred very fast 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 a double-chamber equipment with background compensation is used.

249. Pohl, E., Pohl-Ruling, J.

Dose calculations due to the inhalation of Rn222, Rn220 and their daughters.

HEALTH PHYS. 32(6): 552-555, 06/--/77.

250. Porstendorfer, J., Mercer, T. T.

Adsorption probability of atoms and ions on particle surfaces in submicrometer size range.

J. AEROSOL SCI. 9: 469-474, 1978.

ABSTRACT: The absolute attachment coefficient of neutral and electrically charged Tn decay products on particles in the size range between 0.009-0.03 micrometers was measured. For these experiments, condensation aerosols of a narrow size range were used. The experimental values agree with those of the diffusion theory of attachment under the assumption that the sticking probability of the decay product is unity.

251. Porstendorfer, J., Mercer, T. T.

Diffusion coefficient of radon decay products and their attachment rate to the atmospheric aerosol. 11 p., 04/--/78.

ABSTRACT: The attachment rate of the neutral atoms to the atmospheric aerosol indoors and outdoors were studied by means of Tn (Rn-220) decay products, which were attached in a laminar flow through a cylindrical tube. In a nuclei concentration range between (0.6 - 7) E4 particles/cubic centimeter the attachment rates were 0.009 - 0.05/second (relative humidity: 30 - 50%) corresponding to a half-life of attachment 77 to 14 seconds. The change of the average nuclei size with humidity could be determined by measuring the attachment rate for different water vapour concentrations. By changing the humidity from 20% to about 100% the average particle size increase up to a factor 2.1.

252. Porstendorfer, J., Wicke, A., Schraub, A.

The influence of exhalation, ventilation and deposition processes upon the concentration of

radon (Rn222), thoron (Rn220) and their decay products in room air.

HEALTH PHYS. 34(5): 465-473, 05/--/78.

ABSTRACT: The influence of radon and thoron exhalation from the walls and the air-exchange upon the Rn(Rn-222)-and Tn(Rn-220) concentration indoors has been studied. On the basis of a simple room model the degree of equilibrium between radon, thoron and their decay products, free attached fraction, has been calculated. These calculations were performed under the consideration of: (1) the measured natural radioactive indoor and outdoor aerosol size distribution, (2) the known attachment of the uncombined decay products, (3) the experimentally evaluated recoil factor, and (4) of an estimated deposition rate on the wall surface.

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253. Porstendorfer, J., Mercer, T. T.

Concentration distributions of free and attached Rn and Tn decay products in laminar aerosol flow in a cylindrical tube.

J. AEROSOL SCI. 9(4): 283-290, 08/--/78.

ABSTRACT: The problem of the steady state diffusion of radon decay products in laminar aerosol flow through a cylindrical tube is presented. Neglecting axial diffusion and assuming constant aerosol concentration in the tube, the concentration distribution, the flux and the transmission of the free and attached radioactive atoms were calculated, taking into consideration the formation and attachment of the decay products. The first five eigenvalues En and the corresponding coefficients for different attachment rates X were computed. These results can be used to determine experimentally the diffusion coefficients of Rn and Tn decay products or small ions and their rates of attachment of aerosols.

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254. Porstendorfer, J., Mercer, T. T.

Influence of electric charge and humidity upon the diffusion coefficient of radon decay products.

HEALTH PHYS. 37: 191-199, 08/--/79.

ABSTRACT: The diffusivity of freshly formed thoron decay products was studied under a variety of conditions with respect to relative humidity and electric charge and over a range of thoron concentrations from approximately 340 nCi/l to 3.4 X E5 nCi/l. 85-88% of ThB (Pb-212) atoms carried a positive charge when formed. In moist air (relative humidity between 30% and 90%) the diffusivity of the positively charged ThB atoms was 0.088 plus or minus 0.004 square centimers/second; it was the same for neutral ThB atoms, regardless of humidity. In very dry air, the diffusivity of the charged atoms could not be established unequivocally, but it was about 0.024 square centimers/second.

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255. Porstendorfer, J.., Wicke, A., Schraub, A.

Methods for a continuous registration of radon, thoron and their decay products in- and outdoors.

ABSTRACT: A report about our devices and methods is given used for the determination of the concentrations of Rn, Tn and their daughters, the ventilation rate and the average exhalation rate in rooms of buildings. Rn and Tn concentrations are detected continuously collecting the positively charged RaA and ThA atoms on a surface-barrier detector using electric field precipitation. The determination of Rn and Tn decay product concentrations is carried out by collecting the aerosols on a membran filter and simultanously counting the activities by alpha-spectroscopy. The decrease of a tracer gas concentration (CO2) is used to determine the ventilation rate of a room.

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256. Pradel, P. J., Koch, L.

La radioprotection dans les mines d'uranium.

ANN. MINES 37-44, 03/--/75.

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257. Price, P. B., Fleischer, R. L.

Identification of energetic heavy nuclei with solid dielectric track detectors: Applications to astrophysical and planetary studies. 71-C-207 22 p., 07/--/71.

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258. Prichard, H. M., Gesell, T. F.

Rapid measurements of Rn222 concentrations in water with a commercial liquid scintillation counter.

HEALTH PHYS. 33(6): 577-581, 12/--/77.

ABSTRACT: A technique is described by which concentrations of Rn-222 in water as low as 10 pCi/liter can be determinuteed by a 40-minute count of a 10-milliliter sample. Preparation time is about 1 minute/sample, and no special equipment is required other than access to a commercial liquid scintillation system.

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259. Prichard, H. M.

Reply to "Comments on 'Rapid measurements of Rn222 concentrations in water with a commercial liquid scintillation counter.'"

HEALTH PHYS. 35(6): 863, 12/--/78.

ABSTRACT: In this letter to the editor, Prichard replies to criticism by Cehn on Prichard's paper, "Rapid Measurement of Rn-222 Concentrations in Water with a Commercial Liquid Scintillation Counter." Prichard suggests errors in Cehn's analysis and discusses improvement in the measurement technique in question.

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260. Puri, R. C.

Uranium mine ventilation planning for control of radon and its daughter products.

J. MINES, MET. FUELS 35-40, 02/--/73.

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261. Raabe, O. G.

Concerning the interactions that occur between radon decay products and aerosols.

HEALTH PHYS. 17(2): 177-185, 08/--/69.

ABSTRACT: The state of experimental and theoretical knowledge concerning the attachment of radon decay products to aerosols is reviewed. Particular emphasis is upon a new attachment principle which predicts that attachment is proportional to the surface area of the aerosol particles for all particle sizes and for all but extremely high concentrations of radon. Aspects of the character and fate of radon decay products which have yet to be fully understood and which require further experimental studies are discussed. Employing the theory of a self-preserving particle size distribution of natural aerosols, a hypothetical form for aerosols in uranium mines is developed and employed to calculate the expected fractions of unattached radium A, B and C for various aerosol concentrations and equilibrium times. The results compare favorably with available experimental values.

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262. Raabe, O. G., Wrenn, M. E.

Analysis of the activity of radon daughter samples by weighted least squares.

HEALTH PHYS. 17(4): 593-605, 10/--/69.

ABSTRACT: A new mathematical method employing weighted least-squares has been developed for the analysis of air samples for radon daughters. This method allows calculation of the concentrations in air of the daughter products of both Rn-220 and Rn-222 based upon the radioactive decay of a sample. It employs observations of the total counts of alpha particles from the sample during various periods of time, rather than estimates of

the counting rate at any particular time. There is no upper limit to the number of observations that may be used in the computations. Errors are estimated based upon the statistical limitations of the data. The method has been tested on radon daughter samples taken in uranium mines under conditions both of equilibrium and extreme disequilibrium and compared to the commonly employed Tsivoglou method. Filters were counted in the mines using a combination of ZnS phosphor, photomultiplier tube, and scalar. The concentrations of radium A, B, and C were calculated with both methods. The results of this comparison indicate major advantages of the new technique in research applications, including greater accuracy and clearly defined estimats of errors.

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263. Raghavacya, M., Jones, J. H.

A wire screen-filter paper combination for the measurement of fractions of unattached radon daughters in uranium mines.

HEALTH PHYS. 26: 417-429, 05/--/74.

ABSTRACT: Lack of current actual field data on such factors as radon daughter equilibrium ratios and fractions of unattached radon daughter atoms and the relationship of the measured working levels to actual lung dose has caused questioning of the working level concept as the basis for mine radiation control work. We describe a simple technique for measuring equilibrium ratios and the fractions of unattached radon daughter atoms in air using a wire screen prefilter to collect unattached atoms. Values obtained by this method in several United States uranium mines ae presented.

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264. Raghunath, B., Kotrappa, P.

Diffusion coefficients of decay products of radon and thoron.

J. AEROSOL SCI. 10(2): 133-138, 03/--/79.

ABSTRACT: The diffusion of the decay products of radon and thoron have relevance in the evaluation of inhalation hazards in uranium and thorium processing industries. A recently developed diffusion sampler, based on Mercer's theory of diffusional deposition between the concentric circular plates, has been used for determining the diffusion coefficients of the unattached decay products of radon and thoron (RaA, RaC and ThB). Experiments were conducted at different ventilation rates (6 and 60 changes/hour) at different relative humidities (10 and 90%) and both in air and argon atmospheres. Diffusion coefficients were found to increase with increasing ventilation rates and were found to decrease at higher relative humidities, the effect being more marked at lower ventilation rates. Both of these effects were less pronounced in argon than in air. Results are discussed in light of the known properties of these decay products.

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265. Ramsay, W.

Radon from uranium mill tailings: A source of significant radiation hazard?

ENVIRON. MANAGE. 1(2): 139-145, 1976.

ABSTRACT: Calculations regarding the long-term hazards to health from the radioactive gas radon which emanates from the tailings of milled uranium ores are presented here. The absolute and relative risks to the population from mill tailings, as well as technical solutions to the problem of disposal methods which would eliminate or minimize lung cancer risk, are discussed. Since the emission of radon from tailings will occur thousands of years after the projected benefits from nuclear-fission power have been obtained, the problem of present and future hazard from mill tailings calls for increased regulatory consideration.

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266. Rangarajan, C., Datta, S.

A computer program for theoretical and experimental studies on radon and thoron daughter product activities. B.A.R.C./I-438 33 p., 1976.

ABSTRACT: The report describes a computer program RADIUM written in FORTRAN language for CDC-3600 and BESM-6 computers. The program is for theoretical and experimental work with radon and thoron daughter products but parts of it can be used for other decay chains also. It has five options, the first three for theoretical calculations and the last two

for experimental work. Option one calculates the build-up of activity in a decay chain starting with an initial activity of the first member only. The build-up is calculated for two cases, the first, for simple exponential decay starting with the initial activity of the first member and the second, for the accumulation of the first member at a constant rate, into a system. The option includes provision of non-radioactive depletion constants for both cases. The second and third options are for calculation of activity during collection and after collection respectively into a system, of the members of the decay chain existing in a proportion corresponding to a given build-up time. Option four is for calculating radon and thoron activities in the atmosphere from the measured counts on the collected filter assuming equilibrium between radon-thoron and their daughters. Option five is for the weighted least-squares resolution of the individual activities of RaA, RaB, RaC, ThB and ThC from a series of measurements on the collected filter paper. The program can be adopted for other decay chains and other problems like growth of radioactivity of ores, build-up of radioactivity in reactor water etc. It is also possible to shorten the program by removing the unwanted options.

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267. Rangarajan, C., Gopalakrishnan, S. S., Eapen, C. D.

The application of least squares analysis for the estimation of low atmospheric concentrations of short-lived radon daughters and studies on their disequilibrium.

PURE APPL. GEOPHYS. 115: 513-522, 1977.

ABSTRACT: The application of the weighted and unweighted least-squares method to the analysis of the individual concentrations of short-lived radon daughters in the open atmosphere, where, unlike in the mines the levels are low, is discussed. The method can be optimized to give minimum counting errors by proper choice of collection times and counting periods. By analysing a large number of samples it is shown that the least squares method gives better accuracy than the simultaneous equations method generally in use. The calculation can be simplified by using the unweighted least-squares analysis without significant loss in accuracy. The levels of RaA, RaB and RaC in surface air at Bombay during the period January-June 1975, calculated using the least-square method, are presented. The activity radios of RaC/RaB are shown to have an average value around 0.6-0.9 even at 18 m height. The RaB/RaA activity ratios however show a much larger scatter than the RaC/RaB values. The possible reasons for these differences are discussed. The application of the least-squares method to the analysis of Th-B and Th-C is also described.

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268. Renoux, A., Barzic, J. Y., Madelaine, G. J., Zettwoog, P.

Characteristics of uranium mine air.

NUCL. TECHNOL. 37(3): 313-327, 03/--/78.

ABSTRACT: The radon content in the atmosphere of a uranium mine, 183 pCi/liter, was found during the varied phases of the excavation (drilling, blasting, and clearing) to vary between 63 and 3600 pCi/liter. Radioactive equilibrium was not found to be reached for radon and its daughter products. By means of a seven-stage Andersen cascade impactor, the particle size distribution for the aerosols of the mine was determined as well as the alpha-particle activities on each disk of the impactor and on the millipore filter placed behind each stage. This yielded the information that the major portion of alpha activity in the test mine is connected with aerosols having a radius of less than 0.4 micrometers. During excavation more than 80% of the radioactivity is located on aerosols with radius smaller than 0.15 micrometers; this radioactive aerosol is the smallest found after blasting. In all cases, the alpha radioactivity associated with large particles (R greater than 1 micrometer) is very small (less than 3%). This indicates that if the Andersen impactor is used carelessly, it may yield an erroneous distribution of the radioactivity in a uranium mine.

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269. Robinson, M.

A modified Deutsch efficiency equation for electrostatic precipitation.

ATMOS. ENVIRON. 1: 193-204, 1967.

ABSTRACT: The Deutsch efficiency equation of electrostatic precipitation is modified to take into account the erosion of collected dust and the non-uniformity of dust concentration over the precipitator cross section. Recent attempts to obviate serious fallacies in the Deutsch equation have led to rather sophisticated and complex analyses.

The present approach, however, represents an effort to retain the simplicity of the original exponential relation, yet at the same time to meet, in some measure, some of the more serious objections to the old theory.

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270. Robinson, M., Brown, R. F.

Electrically supported liquid columns in high-pressure electrostatic precipitators.

ATMOS. ENVIRON. 5: 895-896, 1971.

ABSTRACT: It has been reported that an electric field applied normal to the surface of certain liquids causes a liquid column to rise out of the surface. This effect has important commercial consequences in that it limits the voltage that can be applied in the removal of suspended liquid particles from high-pressure gases by electrostatic precipitation.

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271. Rock, R. L., Lovett, D. B., Nelson, S. C.

Radon-daughter exposure measurement with track etch films.

HEALTH PHYS. 16(5): 617-621, 05/--/69.

ABSTRACT: The registration of alpha particles in cellulose nitrate dielectric films serves as a basis for an exposure integrating device to measure the individual worker's exposure to alpha particle irradiations from radon and radon daughter products in mine atmospheres. These films are insensitive to beta, gamma and light radiations and to alpha activity plated-out on its surface. Tests in mine atmospheres indicated good correlation between film track densities and measurements of the mine atmosphere by standard filtered air samples.

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272. Rock, R. L., Dalzell, R. W., Harris, E. J.

Controlling employee exposure to alpha radiation in underground uranium mines, Volume 2 of two volumes (appendixes for the use of radon- daughter control specialists). 180 p., 1971.

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273. Rodgers, J. C.

Radon progeny exposure measurement using lead-210. 66 p., 10/--/74.

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274. Roessler, C. E., Kautz, R., Bolch, W. E., Jr., Wethington, J. A., Jr.

The effect of mining and land reclamation on the radiological characteristics of the terrestrial environment of Florida's phosphate regions. 22 p.

ABSTRACT: Studies were performed to evaluate the extent and nature of the redistribution of uranium-series radioactivity in phosphate mining, reclamation and land development. Radium-226 was measured in waste materials that enter into land reclamation. Radium-226 surface soil concentrations and depth profile, soil surface radon flux and gamma radiation above the surface were reported for unmined and mined, reclaimed and otherwise altered lands. Mining, land reclamation, and construction site preparation can increase the near-surface soil radium and related characteristics. There is a general pattern with land type. The impact was evaluated in terms of effect on actual and potential indoor radon progeny concentrations in structures. It was concluded that debris lands, resulting from a former mining practice, represent the greatest impact on existing structures. However, a fraction of the lands produced by current practices may exceed criteria for unrestricted use if such criteria are based on limiting predicted indoor radon progeny concentrations in future structures to the lower limit of the Surgeon General's Guidelines. Procedural modifications were identified for producing lands likely to meet criteria for unrestricted use.

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275. Roessler, C. E., Smith, Z. A., Bolch, W. E., Prince, R. J.

Uranium and radium-226 in Florida phosphate materials.

HEALTH PHYS. 37: 269-277, 09/--/79.

ABSTRACT: Input materials, products and by-products from a number of Florida phosphate mines and chemical plants were analyzed for Ra-226 and U-238 by high resolution gamma spectrometry. Concentrations were distinctly lower in North Florida than in Central Florida. In the matrix, the two nuclides were essentially in radioactive equilibrium (North Florida, 8 pCi/g; Central Florida, 38 pCi/g). Following beneficiation, concentrations in rock product, waste clays and sand tailings were approximately 100-300%, 100% and 10-25%, respectively, of those in the matrix. Radioactive equilibrium is markedly disrupted in phosphoric acid production; uranium follows the phosphoric acid while Ra-226 appears in the by-product gypsum (North Florida, 14 pCi/g; Central Florida, 26 pCi/g) and also in sediments and scales. Ammoniated phosphate fertilizers had relatively low levels of Ra-226 but significant U-238 (North Florida, 25 pCi/g; Central Florida, 70 pCi/g). On the other hand, triple superphosphate had significant concentraions of both Ra-226 (North Floria, 12 pCi/g; Central Florida, 20 pCi/g) and U-238 (North Florida, 26 pCi/g; Central Florida, 56 pCi/g). In the electric furnace process, radioactivity is transferred to the slag (Central Florida, 61 pCi/g of each nuclide). Within either region, nearly all sample types showed a considerable range of concentrations.

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276. Rogers, V. C.

The environmental impact of uranium mill tailings generated between 1975 and 2030.

TRANS. AM. NUCL. SOC. 30: 91-92, 1978.

ABSTRACT: The environmental impact of uranium mill tailings generated to meet projected light-water reactor demands to the year 2030, is estimated. By 2030 the total annual population dose rate from the tailings is estimated to be 5.6 x 10(sup)(5) man-rem per year. The Nuclear Regulatory Commission is considering limiting radon exhalation from tailings to twice background. If implemented this would result in a reduction of the predicted population exposures by a factor of about 300.

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277. Rolle, R.

Rapid working level monitoring.

HEALTH PHYS. 22(3): 233-238, 03/--/72.

ABSTRACT: Aspects of efficient Working Level monitoring are considered in recommending procedures and instrumentation for different specifications for the total monitoring error. A reliable procedure of high sensitivity requiring only a single gross-alpha measurement and based on completely general limits of radon-daughter ratios in air, is presented. It is suggested that optimisation of the single gross-alpha measurement procedure to minimise the total monitoring error in this fashion leads to methods which could supplant both existing single measurement methods and those multiple measurement methods in which the overall error exceeds 25% of the Working Level.

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278. Rolle, R.

Radon daughters and age of ventilation air.

HEALTH PHYS. 23(1): 118-120, 07/--/72.

ABSTRACT: In the ventilation of uranium mines a knowledge of the distribution of radon daughters throughout a ventilation system is of considerable importance. The concept of radioactive "age" of air can be valuable in estimating the relative distributions of the daughters. The usefulness of this concept may be increased if the deviations from usual distributions that might occur could also be determined.

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279. Rosene, G. D., Berk, J. V., Boegel, M. L., Halsey, H. I., Hollowell, C. D., Rosenfeld, A. H., Turiel, I.

Residential ventilation with heat recovery: Improving indoor air quality and saving energy. LBL-9749 27 p., 05/--/80.

ABSTRACT: Interest in conserving energy is motivating homeowners and builders to

reduce natural infiltration to very low levels. This large reduction in ventilation can lead to indoor moisture problems and, more importantly in terms of human health, increased levels of indoor pollutants such as nitrogen dioxide, formaldehyde, and radon. This paper reports residential air-quality measurements conducted by Lawrence Berkeley Laboratory and, specifically, discusses the use of mechanical ventilation systems with air-to-air heat exchangers as a promising means of pollutant control. A particular advantage of this control strategy is that the heat exchanger permits recovery of a large portion of the heat that would normally be lost in a simple exhaust ventilation system, and therefore maintains the energy efficiency of the house. An economic analysis is presented showing that installation of these systems in newly constructed homes is cost-effective in most regions of the country.

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280. Rundo, J., Markun, F., Sha, J. Y.

Postprandial changes in the exhalation rate of radon produced in vivo.

SCIENCE 199(4334): 1211-1212, 03/17/78.

ABSTRACT: The rate of exhalation of radon by persons with long-standing radium burdens increases about twofold shortly after a meal. The increase is short-lived and "normal" values are regained in 1.5 to 2 hours. The effect may account in part for the poor reproducibility in estimates of the freely emanating part of the radium content.

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281. Rundo, J., Markun, F., Plondke, N. J.

Observation of high concentrations of radon in certain houses.

HEALTH PHYS. 36(6): 729-730, 06/--/79.

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282. Rupp, E. M., Parzyck, D. C., Walsh, P. J., Booth, R. S., Raridon, R. J., Whitfield, B. L.

Composite hazard index for assessing limiting exposures to environmental pollutants: Application through a case study.

ENVIRON. SCI. TECHNOL. 12(7): 802-807, 07/--/78.

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283. Rutherford, E.

Adsorption of the radio-active emanations by charcoal.

NATURE (LONDON) 74(1930): 634, 10/25/06.

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284. Satterly, J.

Some experiments on the adsorption of radium emanation by coconut charcoal.

PHILOS. MAG. 20(118): 778-788, 10/--/10.

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285. Saunders, A. W., Jr., Patterson, R. L., Jr., Lockhart, L. B., Jr., Naval Research Laboratory, Washington, D.C.

The filtration of particles of atomic dimensions. NRL-7047 24 p., 05/12/70.

ABSTRACT: Particles of atomic dimensions, as typified by the primary decay products of radon, are readily removed from an air stream by passage through coarse fibrous filters or even through screens, while the radon parent is unaffected. The inverse relationship between the efficiency of removal and the air velocity indicates the diffusion is the mechanism primarily responsible for the deposition of these small particles. However, if the particles become attached to aerosols, their collection depends both on filter characteristics and air velocity. These particles are readily collected on aerosol particles and provide a radioactive tag by which aerosol or filter behavior may be studied. Such measurements can be extended to size ranges and concentration levels below those convenient for other techniques.

286. Saunders, A. W., Jr., Patterson, R. L., Jr., Lockhart, L. B., Jr., Naval Research Laboratory. Washington, D.C. 20390.

The interaction of radon decay products with aerosols. NRL-6802 24 p., 12/31/68.

ABSTRACT: An instrumented plastic chamber with a 1.2 cubic meters capacity has been constructed and used to study the stability of some submicron dioctyl phthalate (D.O.P.) aerosols and their interaction with the short-lived radioactive decay products of radon (Rn-222). The degree of attachment of the radon decay products to the D.O.P. aerosols in this chamber has been shown to be a function of the relative areas of the aerosol and wall surfaces. At high aerosol concentrations (E5 particles/cubic meters), 90% or more of the short-lived decay products are attached to aerosol particles. At lower aerosol concentrations and particularly when convection increases the availability of the walls for deposition, the airborne radioactivity is much less. Under the proper conditions appreciable quantities of unattached radon descendants will remain airborne. A few preliminary studies with these "free" atoms or simple molecules have shown that they are effectively retained by fibrous filters. They thus provide a useful tool for evaluating the retentivity of filter media toward extremely small particles and for studying the mechanism of particle capture through diffusive processes.

287. Schaefer, H. J.

Radiation exposure in air travel.

SCIENCE 173(3999): 780-783, 08/27/71.

288. Scheibel, H. G., Porstendorfer, J., Wicke, A.

Radon absorption in a gas flow by activated charcoal.

HEALTH PHYS. 38: 83-85, 01/--/80.

289. Schiager, K. J., Savignac, N. F.

Radiation monitoring of uranium miners: A comparison of bioassay, TLD, and the Kusnetz determinations of current exposures. COO-1500-21 237 p., 05/--/72.

290. Schiager, K. J.

Analysis of radiation exposures on or near uranium mill tailings piles.

RADIAT. DATA REP. 15(7): 411-425, 07/--/74.

ABSTRACT: Potential radiation exposures from abandoned uranium mill tailings piles may be predicted in a general manner using minimal input data. If the average radium concentration in the tailings CRa is known, the external gamma exposure rate over the tailings can be estimated. The radon emanation rate can also estimated. The reduction of exposure rates that can be achieved by covering the tailings with earth or concrete also are discussed. Radon progeny inhalation exposures depend upon the dispersion rate of radon in the atmosphere and the time available for progeny ingrowth. Meteorological data for the site are required for making reliable predictions of inhalation exposures. It is shown, however, that contributions to the average annual outdoor radon progeny concentrations exceeding 0.003 WL are very unlikely on or near any tailings pile. The methods used to analyze potential radiation exposures are illustrated by a case study on one abandoned tailings pile.

291. Schiager, K. J.

The 3R-WL air sampling working level survey meter: Calibration and evaluation progress report for the period May 1, 1976 - December 31, 1976. COO-2936-1 54 p., 12/--/76.

ABSTRACT: The design and operation of a direct-reading sampler for air-borne radon

progeny are described. The instrument was designed for use by ventilation personnel in uranium mines and is small, rugged, light-weight and easily carried and operated. Direct readout of the radon progeny concentration in units of working levels, in the range of 0.01 to 10 WL, is accomplished by counting the alpha particles from Po-218 and Po-214 with a single detector and two energy discrimination channels. Unique features include a fixed-volume, gravity-operated pump requiring no power source and minimal calibration, automatic decay, counting and display sequencing, capacity for more than 50 samples on a single roll of membrane filter, and provisions for recording all data directly on the filter tape. For the prototype as built, calibration against the 2-count alpha spectroscopy method of measuring WL indicated an average error of less than 1% in the range from 0.25-25 WL. However, the standard deviation of measurements made with the 3R-WL meter increased from 7% above 10 WL to 71% at 0.25 WL. Sources of error and variability are analyzed and suggestions for improving the precision of the measurements are included.

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292. Schiager, K. J.

The 3R-WL working level survey meter.

HEALTH PHYS. 33: 595-604, 12/--/77.

ABSTRACT: The design and operation of a direct-reading sampler for airborne radon progeny are described. The instrument was designed for use by ventilation personnel in uranium mines and is small, rugged, light-weight and easily carried and operated. Direct readout of the radon progeny concentration in units of working lvels, in the range of 0.01-10 WL, is accomplished by counting the alpha particles for Po-218 and Po-214 with a single detector and two energy discrimination channels. Unique features include a fixed-volume, gravity-operated pump requiring no power source and minimal calibration; automatic delay, counting and display sequencing; capacity for more than 50 samples on a single roll of membrane filter; and provisions for recording all data directly on the filter tape. For the prototype as built, calibration against the 2-count alpha spectroscopy method of measuring WL indicated an average error of less than 1% in the range from 0.25 to 25 WL. However, the standard deviation of measurements made with the 3R-WL meter increased from 7% above 10WL to 71% at 0.25 WL. Sources of error and variability are analyzed and suggestions for improving the precision of the measurements are included.

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293. Schroeder, G. L., Evans, R. D., Kraner, H. W.

Effect of applied pressure on the radon characteristics of an underground mine environment.

TRANS. SOC. MIN. ENG. AIME 235: 91-98, 03/--/66.

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294. Schroeder, G. L., Evans, R. D.

Some basic concepts in uranium mine ventilation.

TRANS. SOC. MIN. ENG. AIME 244: 301-307, 09/--/69.

ABSTRACT: Advanced techniques for control of radon (Rn) daughter product concentrations (working levels, WL) in the uranium mines are discussed. Understanding the physical laws which govern the flux of radon into a mine, the growth and decay of the radon daughters, and the particulate nature of the daughters when suspended in air allows ventilation personnel to improve the quality of mine air with no increase in ventilation rate.

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295. Schroeder, G. L.

Falling barometer nullifies rock sealant effectiveness.

MIN. ENG. (N.Y.) 29(6): 38-39, 06/--/77.

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296. Scott, A. G., Gordon, G. W. S.

Radon diffusion through concrete. 4 p.

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297. Seymore, F. W., Ryan, R. M., Corelli, J. C.

Radon and radon daughter levels in Howe Caverns.

HEALTH PHYS. 38: 858-859, 05/--/80.

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298. Shapiro, M. H., Melvin, J. D., Coppins, N. A., Tombrello, T. A., Whitcomb, J. H.

Automated radon-thoron monitoring for earthquake prediction research. 15 p.

ABSTRACT: We describe an automated instrument for earthquake prediction research which monitors the emission of radon and thoron from rock. The instrument employs aerosol filtration techniques and beta counting to determine radon and thoron levels; a programmable microcomputer which controls mechanical operations, collects data, and monitors condition of key components; and a call-up telemetry system for the transmission of data to a central location over standard telephone lines. Data from the first year of operation of a field prototype suggests an annual cycle in the radon level at the site that is related to thermoelastic strains in the crust. Two anomalous increases in the radon level of short duration have been observed during the first year of operation. One of these anomalies appears to have been a precursor for a 3.1 M earthquake nearby, while the second may have been associated with changing hydrological conditions resulting from heavy rainfall.

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299. Shapiro, M. H.

Experimental tests of turbulent diffusion models by high-resolution gamma ray spectroscopy of radon daughters. 17 p.

ABSTRACT: High-resolution gamma-ray spectroscopy has been used to carry out two series of measurements of atmospheric Bi-214/Pb-214 ratios at Fullerton, CA (33 degrees 52 feet north, 117 degrees 55 feet west), at a height of 20 m. In both series of measurements a wide range of Bi-214/Pb-214 ratios was observed including, on a number of occasions, abnormal ratios. Most of the abnormal ratios were associated with the advection of maritime air into the sampling location. The results of this work have been used to test the predicions of turbulent diffusion models with and without advection.

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300. Shearer, S. D., Jr., Sill, C. W.

Evaluation of atmospheric radon in the vicinity of uranium mill tailings.

HEALTH PHYS. 17(1): 77-88, 07/--/69.

ABSTRACT: A field study is currently being concluded at Grand Junction and Durango, Colorado, and at Monticello and Salt Lake City, Utah, to evaluate the public health aspects of atmosphere Rn-222 in the vicinity of uranium tailings piles. Air is collected continuously for 48 hour periods from each station in order to average out diurnal fluctuations. The integrated sample is then analyzed for Rn-222. A total of 57 stations is in operation. Each station is re-sampled every three weeks for one calendar year to include seasonal fluctuations and to permit a more realistic estimate of the yearly dose to people in the immediate vicinity. This paper presents data and conclusions from the 1 year study. Of the 13 stations directly over tailings, average radon concentrations ranged from 3.5 pCi/liter to 16 pCi/liter. Of the 44 stations not over tailings, only two averaged greater than 1 pCi/liter. The results indicate negligible radiation exposure of the surrounding population from this source.

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301. Shleien, B.

The simultaneous determination of atmospheric radon by filter paper and charcoal adsorptive techniques.

AM. IND. HYG. ASSOC. J. 24(2): 180-187, 03/--/63.

ABSTRACT: A method is described for the simultaneous collection of radon and its daughters from environmental air samples by a two-stage sampling device. The radon daughter products are separated from the air stream by means of a membrane filter and radon itself is then adsorbed on activated charcoal in the sampler's second stage. Subsequent to

collection, radon daughter activity is measured by alpha scintillation techniques and gaseous radon concentration is determined by gamma spectrometry of the charcoal adsorption bed. Samples were taken under varying external environmental conditions, as well as indoors. Results are presented comparing atmospheric radon concentrations determined by direct and filter paper techniques.

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302. Shreve, W. B., Wachtel, L. W., Pelleu, G. B., Jr.

Air cleaning devices for reduction in number of airborne bacteria.

J. DENT. RES. 49(5): 1078-1082, 09/--/70.

ABSTRACT: Air cleaning by electrostatic precipitation or HEPA filtration was evaluated for effectiveness in reducing concentrations of aerosolized Bacillus subtilis spores in a closed space. It was found that air cleaning devices were effective as forced ventilation at the same airflow rate.

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303. Silker, W. B., Wogman, N. A., Thomas, C. W., Carr, D. B., Heasler, P. C.

Measurement of radon diffusion and exhalation from uranium mill tailings piles.

ENVIRON. SCI. TECHNOL. 13(8): 962-964, 08/--/79.

ABSTRACT: The concentrations of Ra-226 and Rn-222 (Pb-214) were measured as a function of depth within a uranium mill tailings pile by in situ gamma-ray spectrometry. Radon diffusion and exhalation rates were determined from the concentration gradients by employing an integral solution of the diffusion equation that accommodates a nonuniform depth distribution of the parent radium. Radon diffusion coefficients of 0.0002 and 0.0017 square centimeters/second and exhalation rates of 60-275 atom/square centimeter/second were determined for two locations with differing soil moisture content. This method evaluates diffusion and exhalation parameters from radon concentration changes that have occured over time periods of several days. It, therefore, integrates short-term variations due to changes in atmospheric and meteorological conditions that would ordinarily be measured by methods involving surface radon collection or accumulation techniques commonly applied to field studies.

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304. Smith, D.

Ventilation rates and their influence on equilibrium fraction. 4 p.

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305. Snihs, J. O., Ehdwall, H., National Institute of Radiation Protection. Fack. S-104 01 Stockholm Sweden.

Supervision of radon daughter exposure in mines in Sweden. SSI: 1976-023, 1976.

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306. Spitz, H. B., Wrenn, M. E., Cohen, N.

Diurnal variation of radon measured indoors and outdoors in Grand Junction, Colorado and Teaneck, New Jersey and the influence that ventilation has upon the buildup of radon indoors. 24 p.

ABSTRACT: "Continuous" measurements of Rn-222 were performed indoors and outdoors in two localities which differ primarily in the amount of radon source material within, under, and around building foundations. Grand Junction represents an area where uranium mill tailings have been incorporated into several residential and commercial structures. There is also a uranium mill tailings pile within the boundary of the city. The radon concentration measured in the basement of a residential structure in Grand Junction known to have no uranium mill tailings within or around the foundation (i.e., a "control" house) was 0.9 plus or minus 0.2 pCi/liter (mean plus or minus 1 S.D. of the mean). Results of continuous measurements of radon in other structures in Grand Junction indicate that the presence of uranium mill tailings increased the average indoor radon concentraion by at least a factor of ten compared to the structure without tailings. The outdoor radon concentration averaged 0.7 pCi/liter with a range of 0.3 to 1.6 pCi/liter.

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307. Stehny, A. F., Norris, W. P., Lucas, H. F., Jr., Johnston, W. H.

A method for measuring the rate of elimination of radon in breath.

AM. J. ROENTGENOL., RADIUM THER. NUCL. MED. 73(5): 774-784, 05/--/55.

ABSTRACT: Equipment and procedures are described for measuring the time rate of elimination of radon in exhaled air. The accuracy and sensitivity of the analysis are improved by sampling large volumes of exhaled air from which radon is adsorbed on charcoal. Interference with normal breathing is negligible, because subjects breathe through large diameter tubing into a flexible bag from which the sample is drawn through the collection apparatus under a small vacuum. Sampling periods of thirty minutes' duration are common. The radon is measured in a low background proportional counter or in an ionization chamber which is connected to an electrometer. The feasibility of extending radon analyses to normal body burdens of the order of E-10 gram Ra is discussed.

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308. Stein, L.

Ionic radon solutions.

SCIENCE 168: 362-364, 04/17/70.

ABSTRACT: Radon is oxidized between -195 degrees and 25 degrees C by chlorine fluorides, bromine fluorides, iodine heptafluoride, and NiF6(2-) ion in hydrogen fluoride with the formation of stable solutions of radon fluoride. Electromigration studies show that the radon is present as cation, possibly Rn(2+) or RnF(1+), in several conducting solutions.

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309. Stein, L.

Chemical methods for removing radon and radon daughters from air.

SCIENCE 175: 1463-1465, 03/31/72.

ABSTRACT: Liquid bromine trifluoride and the solid complexes ClF2SbF6, BrF2SbF6, BrF4Sb2F11, IF4(SbF6)3, and BrF2BiF6 react spontaneously with radon and radon daughters at 25 degrees C, converting the radioelements 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 degrees C and are less hazardous to handle than liquid halogen fluorides.

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310. Stein, L.

Removal of radon from air by oxidation with bromine trifluoride.

J. INORG. NUCL. CHEM. 35: 39-43, 1973.

ABSTRACT: An oxidation method for removing radon from air with liquid bromine trifluoride was tested with samples of ambient air containing 0.098-0.189 pCi/l of Rn-222. 95% of the radon was removed in a two-stage gas-scrubbing unit (20 milliliters liquid volume) at a flow rate of 130 milliliters/minute, and smaller percentages were removed at higher flow rates (minimum of 76% at 640 milliliters/minute). The possibility of purifying air in uranium mines with bromine trifluoride and other oxidants is discussed.

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311. Stein, L.

Removal of xenon and radon from contaminated atmospheres with dioxygenyl hexafluoroantimonate, O2SbF6.

NATURE (LONDON) 30-32, 05/04/73.

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312. Stein, L.

Atmosphere purification of radon and radon daughter elements. U.S. Patent No. 3,778,499 3 p., 12/11/73.

ABSTRACT: A method for purifying an atmosphere of radon and radon daughter elements which may be contained therein by contacting the atmosphere with a fluorinating solution, whereby the radon and radon daughters are oxidized to their respective fluorides. The fluorides dissolve in the fluorinating solution and are removed from the atmosphere, which may then be recirculated.

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313. Stein, L.

Atmosphere purification of xenon, radon & radon daughter elements. U.S. Patent No. 3,829,551 4 p., 08/13/74.

ABSTRACT: A method of purifying an atmosphere of xenon, radon and radon daughter elements by passing the atmosphere containing these elements through a reaction bed of dioxygenyl hexafluoroantimonate, which oxidizes the xenon, radon and radon daughter elements to their respective fluorides which remain in the reaction bed and are thus removed from the atmosphere, and recirculating the purified atmosphere. The method is also useful for separating the before-named elements from krypton.

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314. Steinhausler, F., Hofman, W., Pohl, E., Pohl-Ruling, J.

Local and temporal distribution pattern of radon and daughters in an urban environment and determination of organ dose frequency distributions with demoscopial methods. 15 p.

ABSTRACT: In a normal urban environment inhaled radon and its decay products cause an important part of the human radiation burden not only for the respiratory tract but also for several other organs. Measurements of the air activity are, however, complicated by the fact that large local and temporal fluctuations occur outdoors and even more indoors, where an urban population mainly lives. In order to obtain proper information concerning the dose distribution within an urban population it it necessary to use demoscopical methods which means to select testpersons and determine their individual mean annual doses for the most important organs and tissues. We made such a study in Salzburg town, Austria (150,000 inhabitants), with 729 testpersons. From each of them the living activity was inquired, i.e. their mean times spent on the individual sleeping-, living- and working places and their corresponding physical activities, strongly influencing the respiratory minute volume and consequently the inhaled radioactivity. At all places and additionally also in other buildings and outdoors, annual means of the external gamma radiation as well as of the air content of Rn-222 and its short-lived decay products were determined. Because of the great short- and long-time fluctuations of the air activity we developed a special method to obtain significant annual mean values with a limited number of measurements: At five "control situations" (in different buildings) measurements were made once or twice a day to receive information on the temporal variations. This supplies correction factors for all the other sites where only grab-sampling (four times a year) was done. RaD, Rn-220 and ThB were determined only at the control stations and outdoors. From all these measurements (more than 8,000) and information inquired we calculated mean annual organ doses of each testperson. The doses due to cosmic radiation, 40K and other radionuclides incorporated were added. Dose frequency distributions for eight organs and tissues are given in the paper. The range of the mean annual doses in mrem for gonads is only 73 to 126, amounts to 70 to 336 for the kidneys and finally reaches 117 to 10,700 for the basal cells of the bronchial epithelium.

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315. Steinhausler, F.

Long-term measurements of Rn-222, Rn-220, Pb-214, and Pb-212 concentrations in the air of private and public buildings and their dependence on meteorological parameters.

HEALTH PHYS. 29: 705-713, 11/--/75.

ABSTRACT: The concentration of Rn-222, Rn-220 and their short-lived daughter products were measured simultaneously inside public and private buildings in Innsbruck, Austria. Approximately 750 measurements were carried out with two double-filter devices, a single-filter device and air sampling in specially designed air-bags for a period of almost 1 year. The buildings were made out of brick, concrete, stone, and wood. At all test stations the rooms were not ventilated. The concentration data, together with 24 meteorological variables, were used for a comprehensive regression analysis with a stepwise elimination of variables. It was possible to determine those variables which account for the time variation of radioactivity in the air of a given (nonventilated) room as there are

the changes of (a) the barometric pressure, (b) the soil temperature, (c) the daily mean temperature in the open atmosphere, (d) the daily mean wind speed, (e) the relative humidity, and (f) the daily range of the temperature in the open atmosphere and the absolute value of the vertical temperature gradient outdoors.

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316. Steinhausler, F.

Long-term measurements of Rn-222, Rn-220, Pb-214 and Pb-212 concentrations in the air of private and public buildings and their dependence on meteorological parameters.

HEALTH PHYS. 29: 705-713, 11/--/75.

ABSTRACT: The concentration of Rn-222, Rn-220 and their short-lived daughter products were measured simultaneously inside public and private buildings in Innsbruck, Austria. Approximately 750 measurements were carried out with two double-filter devices, a single-filter device and air sampling in specially designed air-bags for a period of almost 1 yr. The buildings were made out of brick, concrete, stone and wood. At all tests stations the rooms were not ventilated. The concentration data, together with 24 meteorological variables, were used for a comprehensive regression analysis with a stepwise elimination of variables. It was possible to determine those variables which account for the time variation of radioactivity in the air of a given (non-ventilated) room as there are the changes of (a) the barometric pressure, (b) the soil temperature, (c) the daily mean temperature in the open atmosphere, (d) the daily mean wind speed, (e) the relative humidity, and (f) the daily range of the temperature in the open atmosphere and the absolute value of the vertical temperature gradient outdoors.

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317. Strain, C. D., Watson, J. E., Jr., Fong, S.

An evaluation of Ra-226 and Rn-222 concentrations in ground and surface water near a phosphate mining and manufacturing facility.

17:57 SYSTEM TIME CANCELLED...SYSTEM WILL REMAIN UP TONIGHT....

HEALTH PHYS. 37: 779-783, 12/--/79.

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318. Stranden, E., Berteig, L., Usletveit, F.

A study on radon in dwellings.

HEALTH PHYS. 36(3): 413-421, 03/--/79.

ABSTRACT: Values of the radon and radon daughter concentration in different types of Norwegian dwellings are reported. The mean radon concentrations found were 1.3 pCi/liter, 2.0 pCi/liter and 1.0 pCi/liter for buildings with outer walls of wood, concrete and brick, respectively. An equilibrium factor of 0.5 was found to be representative for the dwellings. The variations of the radon concentration due to ventilation and atmospheric pressure were investigated by continuous measurements with an ionization chamber inside a room with very poor ventilation and a room with strong artificial ventilation. A daily decrease of 1 mmHg was found to give an increase in the radon concentration of about 6% of the mean value. The population average dose to the bronchial epithelium from inhalation of radon's short-lived daughters was found to be about 220 mrad/year in Norway.

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319. Stranden, E.

A two-count filter method for measurement of Rn-220 and Rn-222 daughters in air.

HEALTH PHYS. 38: 73-76, 01/--/80.

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320. Stranden, E.

Radon in dwellings and lung cancer: A discussion.

HEALTH PHYS. 38: 301-306, 03/--/80.

ABSTRACT: 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.

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321. Stranden, E.

Thoron and radon daughters in different atmospheres.

HEALTH PHYS. 38: 777-785, 05/--/80.

ABSTRACT: The radon and thoron daughter concentrations in different atmospheres are discussed in this paper. If the daughter concentrations are expressed in WL, the calculations show that the thoron daughter concentration may well exceed the radon daughter concentration. This has also been verified by a few experimental results in basements. In dwellings, lining materials on walls and floor act as a shield for the thoron exhalation, but even in such houses, experiments show that the thoron daughter concentration may be significant.

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322. Stringer, C. W.

Removal of radioactive radon daughters from air. U.S. Patent No. 3,853,501 7 p., 12/10/74.

ABSTRACT: An improved process for controlling radioactive radon daughters in the air in a working environment in a mine or during ore processing is described. The described process involving a filter for water contaminated with radon daughters is used in conjunction with air cleaning systems which employ water as a trap for radon daughters. The filer medium involves use of granular substrate which has been dried and oil-wetted with a normally-liquid hydrocarbon material.

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323. Stromwold, D. C.

Monitoring of the airport calibration pads at Walker Field, Grand Junction, Colorado for long-term radiation variations. GJBX-99(78) 35 p., 08/--/78.

ABSTRACT: Monitoring of radiation from the U.S. Department of Energy Calibration Pads located at Walker Field Airport, Grand Junction, Colorado has been initiated to detect possible long-term variations in the radioactive character of the pads. A NaI detector is being used to collect spectral data over the energy range 0.5 MeV to 3 MeV. For the first 7 months of the monitoring, the period covered by this report, an increase of approximately 10 percent in the apparent uranium concentration of the pads was detected during the winter of 1978. This increase is attributed to radon buildup in the pads due to meteorolical effects. Information is also presented on the physical description of the pads, their radiometric concentrations and uniformity, and the effects of rainwater on observed radiation.

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324. Strong, J. C., Duggan, M. J.

The effect of the presence of thoron daughters on the measurement of radon daughter concentrations.

HEALTH PHYS. 25: 299-300, 09/--/73.

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325. Strong, J. C., Duggan, M. J.

The effect of the presence of thoron daughters on the measurement of radon daughter concentrations.

HEALTH PHYS. 25: 299-300, 09/--/73.

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326. Strong, K. P., Levins, D. M.

Dynamic adsorption of radon on activated carbon.

PROCEEDINGS OF THE FIFTEENTH DOE NUCLEAR AIR CLEANING CONFERENCE 627-639, 02/--/79.

ABSTRACT: The adsorption of Rn-222 from air onto activated carbon was studied over the range 0-55 degrees C. A sharp pulse of radon was injected into an air stream that flowed through a bed of activated carbon. The radon concentration in the exit from the column was continuously monitored using a zinc sulfide alpha-scintillation flow cell. Elution curves were analysed to determine the dynamic adsorption coefficient and the number of theoretical stages. Five types of activated carbon were tested and the dynamic adsorption coefficient was found to increase linearly with surface area in the range 1000-1300 square meters/gram. The adsorptive capacity of activated carbon was reduced by up to 30 per cent if the entering gas was saturated with water vapor and the bed was initially dry. If the bed was allowed to equilibrate with saturated air, the adsorptive capacity was too low to be of practical use. The minimum height equivalent to a theoretical stage (HETS) was about four times the particle diameter and occurred at superficial velocities within the range 0.002-0.02 meters/second. For superficial velocities above 0.05 meters/second, the HETS was determined by the rate of mass transfer. The application of these results to the design of activated carbon systems for radon retention is discussed.

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327. Subba Ramu, M. C.

Calibration of a diffusion sampler used for the measurement of unattached radon daughter products.

ATMOS. ENVIRON. 14: 145-147, 1980.

ABSTRACT: A diffusion sampler for the collection of unattached radon daughter products has been calibrated and found to have an efficiency of about 90% at a flow rate of 1 liter/minute. Previous lower efficiencies appear to have been caused by insufficient precautions in excluding aerosols from the calibration systems. Studies show 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 radon daughter atoms or ions to aerosols.

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328. Sundell, J.

Energy vs. indoor air quality in Sweden. 7 p.

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329. Suomela, M., Kahlos H.

Studies on the elimination rate and the radiation exposure following ingestion of Rn222 rich water.

HEALTH PHYS. 23(5): 641-652, 11/--/72.

ABSTRACT: Radon-222 and its daughter in drinking water causes a radiation dose to the stomach of the order of Maximum Permissible Dose if water containing 100 nCi Rn-222/liter is consumed regularly. To evaluate the radiation dose in real conditions two types of experiments were performed with a whole-body counter. In the first series of measurements the elimination of Bi-214 from the body was followed in test subjects who had ingested radon-rich water in a single intake. A one-component exponential function with a biological half-life varying from 30 to 50 minutes was found to describe the elimination of radon. Special attention was paid to the escape of radon from the water and its effect on the state of disequilibrium between radon and its daughters after intake. In the second series of measurements a group of persons who had consumed radon-rich water daily was studied. The daily radon intake of these persons was estimated at 60 nCi, obtained in two or three portions. From the results of the experiments the dose equivalent of 240-440 mrem/microCi Rn-222 was derived and the maximum daily intake was set at 0.1 microCi for Rn-222 in drinking water.

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330. Swedjemark, G. A.

Radiation dose increase associated with energy conservation attributable to reduced ventilation. SSI: 1978-014 8 p., 07/--/78.

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331. Swedjemark, G. A.

Ventilation requirements in relation to the emanation of radon from building materials.

INDOOR CLIMATE: EFFECTS ON HUMAN COMFORT, PERFORMANCE, AND HEALTH IN RESIDENTIAL, COMMERCIAL, AND LIGHT-INDUSTRY BUILDINGS. PROCEEDINGS OF THE FIRST INTERNATIONAL INDOOR CLIMATE SYMPOSIUM., 1979.

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332. Swedjemark, G. A.

Radioactivity in houses built of aerated concrete based on alum shale. SSI:1980-14 6 p., 02/28/80.

ABSTRACT: The highest activities in commonly used Swedish building materials are found in aerated concrete based on alum shale. The enhanced activity level is due to the high content of radium-226. The average activity concentration of radium-226 varies between different producers of aerated concrete based on alum shale from 20 pCi/g to 65 pCi/g. Houses built in the same way with the same amounts of aerated concrete can therefore have very different gamma levels and very different concentrations of radon in the air with the same air exchange rate. Aerated concrete based on alum shale was used as a building material in Sweden from 1930 to 1975. The average concentration of radon daughters found in houses built of aerated concrete based to a major extent on alum shale is about 2.7 pCi/l. The highest radon concentrations have been found in houses built entirely of aerated concrete based on alum shale. A group of 9 houses with natural draught ventilation systems has been investigated with regard to the concentration of radon, the equilibrium equivalent concentration of radon (EEC) and the gamma dose rate. The air exchange rates varied between the houses from 0.21 to 0.43/hour and the radon concentration from 15 pCi/l to 31 pCi/l. The values given are averages for each house.

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333. Swedjemark, G. A., National Institute of Radiation Protection. Fack S-104 01 Stockholm Sweden.

Radon in dwellings in Sweden. SSI: 1978-013 24 p., 04/--/78.

ABSTRACT: Studies on the specific activities in building materials, the gamma-radiation levels in dwellings, the concentrations of radon and daughters in the air indoors and the concentration of radon in tap water are in progress in Sweden. On basis of these investigations and of the investigation of Hultqvist from the beginning of the 1950's, an attempt has been made to show how the radiation doses in dwellings have changed by human activities and what these changes imply in terms of collective dose. The annual collective absorbed dose in the basal cells of the critical bronchial region have increased from 11 x E3 manGy for the occupants of dwellings existing in 1950 to 25 x E3 manGy for dwellings existing in 1975. If the building of houses continues as at present it can be estimated that the annual collective dose will be between 25 and 31 x E3 manGy for the dwellings of 1985.

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334. Swedjemark, G. A., National Institute of Radiation Protection. Fack. S-104 01 Stockholm Sweden.

The ionizing radiation in dwellings related to the building materials. SSI: 1977-004 9 p. , 1977.

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335. Taniguchi, H., Vasudev, P.

Radon and radon daughters due to natural uranium occurrences in a rural Ontario community. 12 p.

ABSTRACT: The results of a survey of radon-222 and its short-lived radon daughters in 343 homes in the rural community of March Township, near Ottawa, Canada, are reported. Aerial gamma-ray spectrometry carried out over the 90 square kilometer area had shown the presence of up to 5 ppm uranium. The arithmetic average value of the radon daughters in the basement of these homes was 0.014 plus or minus 0.026 WL. Thirteen percent of the

homes had radon daughter concentrations exceeding an arbitrary reference value of 0.02 WL and the highest was 0.19 WL. The most frequently observed radon gas values for the homes in this category was in the 5 to 10 pCi/liter interval. From these measurements, the equilibrium factor between radon and its daughters was shown to be 0.33 plus or minus 0.19.

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336. Taniguchi, H.

Present practices of the Department of National Health and Welfare for the area monitoring of radon and daughter products.

PROCEEDINGS OF THE SPECIALIST MEETING ON PERSONAL DOSIMETRY AND AREA MONITORING SUITABLE FOR RADON AND DAUGHTER PRODUCTS. 251-254

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337. Tanner, A. B., Adams, J. A. S. (ed.), Lowder, W. A. (ed.)

Chapter 9. Radon migration in the ground: A review.

THE NATURAL : .IATION ENVIRONMENT. 161-190, 1964.

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338. Tappan, J. T.

Phase II demonstration of electrostatic filtration system as a uranium mill tailings remedial action. 27 p., 02/09/79.

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339. Tell, W.

Measures taken by the building authorities in order to reduce radiation risks in buildings. 3 p., 03/06/80.

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340. Thomas, J.

A method for calculation of the absorbed dose to the epithelium of the respiratory tract after inhalation of daughter products of radon

ANN. OCCUP. HYG. 7(3): 271-284, 09/--/64.

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341. Thomas, J. W., LeClare, P. C.

A study of the two-filter method for radon-222.

HEALTH PHYS. 18(2): 113-122, 02/--/70.

ABSTRACT: A basic equation for calculating radon concentration in the two-filter method from alpha counts of the exit filter has been developed, eliminating the need for calibrations. The equation takes into account the sampling time, counting time, flow rate tube length and volume, and includes a correction factor for diffusion loss in the two-filter tube. An experimental confirmation of the equation was obtained over a wide range of variables by comparing radon concentrations with a National Bureau of Standards source, when the diffusion rate of radium-A was taken to be 0.085 square centimeter/second. This value is considerably higher than the values cited in the literature which, however, were obtained with older radium-A atoms. Variations in relative humidity did not affect results in the 20-90% range. The two-filter method having the important advantage of simplicity, not requiring specialized instrumentation or elaborate gas handling techniques, is also accurate as shown by the verified basic equation developed in this work. Calculations have indicated that the sensitivity of the method is in the range of 0.1-10 pCi/liter of radon, depending on tube size, sampling time and counting time.

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342. Thomas, J. W.

Modification of the Tsivoglou method for radon daughters in air.

HEALTH PHYS. 19(5): 691, 11/--/70.

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343. Thomas, J. W.

An automated atmospheric radon sampling system.

ATMOS. ENVIRON. 6(4): 285, 1972.

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344. Thomas, J. W.

Measurement of radon daughters in air.

HEALTH PHYS. 23(6): 783-789, 12/--/72.

ABSTRACT: A simple method for determination of RaA, RaB and RaC has been developed which has a sensitivity of the order of 1 pCi/liter for each nuclide. An air sample is obtained and the total alpha disintegrations in three selected time intervals after the end of air sampling determined. The concentration of each nuclide is then obtained from an equation involving the alpha disintegrations, the sampling flow rate, and known numerical coefficients. Simple equations giving the standard deviation of the nuclide concentrations have also been derived. The method was optimized for accuracy by investigating a large number of sampling times and counting intervals, and it is recommended that 5 minute air sampling be used, followed by alpha counts from 2 to 5, 6 to 20 and 21 to 30 minutes after the end of sampling.

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345. Thomas, J. W.

Noble gas absorption process. U.S. Patent No. 3,890,121 9 p., 06/17/75.

ABSTRACT: The method of removing a noble gas from air comprising the use of activated carbon filters in stages in which absorption and desorption steps in succession are conducted in order to increase the capacity of the filters.

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346. Thomas, J. W., Fisenne, I. M.

Continuous monitoring of urban radon-222 concentrations. HASL-298

HASL ENVIRONMENTAL QUARTERLY. I 2-I 4, 01/01/76.

ABSTRACT: An environmental radon monitor (ERM-2) has been used to continuously measure variations in Rn-222 concentration in New York City. The average ground level concentration was found to be about 100 pCi/cubic meter, with very little diurnal variation.

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347. Thomas, J. W.

A system for continuous radon determination. HASL-327 14 p., 07/--/77.

ABSTRACT: A system for continuous radon determination based on alpha counting has been developed which takes into consideration deposition of radon daughters in the radon detecting volume. The radon concentration is calculated from the total number of alpha counts obtained in successive 2000s time intervals, the detector volume and counting efficiency, an an experimetally determined radon daughter deposition factor.

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348. Thomas, J. W., Countess, R. J.

Continuous radon monitor.

HEALTH PHYS. 36(6): 734-738, 06/--/79.

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349. Thomas, J. W., Health and Safety Laboratory. U.S. Atomic Energy Commission. New York NY

10014.

Measurement of radon daughters in air by alpha counting of air filters. HASL-256 24 p., 04/--/72.

ABSTRACT: A simple method for determination of RaA, RaB and RaC has been developed which has a sensitivity of the order of 1 pCi/liter for each nuclide. An air sample is obtained and the total alpha disintegrations in three selected time intervals after the end of air sampling determined. The concentrations of each nuclide is then obtained from an equation involving the alpha disintegrations, the sampling flow rate, and known numerical coefficients. Simple equations giving the standard deviation of the nuclide concentrations have also been derived. The method was optimized for accuracy by investigating a large number of sampling times and counting intervals, and it is recommended that 5 minute air sampling be used, followed by alpha counts from 2 to 5, 6 to 20, and 21 to 30 minutes after the end of sampling.

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350. Thomas, J. W., Health and Safety Laboratory. U.S. Atomic Energy Commission. New York NY.

Determination of radon progeny in air from alpha activity in air samples. HASL-202 27 p., 11/--/68.

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351. Toth, A., Feher, I., Novotny Lakatos, S., Koszoros, L., Keszthelyi, B.

Fitting normal distributions of the observed thorium, radium, emanating radium, potasium and emanating power data for the concretes and bricks in Hungary. 16 p.

ABSTRACT: Natural radioactive isotope concentrations and emanation factors were measured on concrete and brick samples produced in different parts of Hungary. The natural activity parameters measured on samples produced in a given factory within a period of 1-2 years show normal distribution at a confidence level of 0.05 in 95% of the cases. Samples received at different times from all the building factories under investigation (mixed distributions) showed about half and half normal and lognormal distributions of natural activity parameters at a confidence level of 0.05. Calculating with the arithmetical means obtained for each of the natural activities substituted into simple models it was found that the radon and thoron activity is expected to increase by about 25% while the burden from external radi[illegible] to decrease by a factor of 2.3 in the new prefabricated apartments made of concrete [illegible] th the conventional apartments with brick walls and concrete ceilings. The dat[illegible] the masurements were used to establish reference levels for the radiolo[illegible] concrete and brick produced in Hungary.

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352. Toth, A.

Determining the respiratory dosage from RaA, RaB, and RaC inhaled by the population in Hungary.

HEALTH PHYS. 23: 281-289, 09/--/72.

ABSTRACT: The report describes the determination of short-lived radon decay products found in unventilated living rooms in Hungary. Altogether 841 analyses were carried out in 14 different towns and villages of our country. In 92% of the investigations the rooms had not been aired for at least 8 hours prior to taking the air sample. The building materials making up the walls and the distances of the rooms from ground level were different in our studies. The characteristics of the relative frequency distributions of the concentrations can generally be said to have been logarithmic-normal. The arithmetical averages of the Radium A, Radium B, and Radium C concentrations obtained through the 841 measurements were: 3.05, 2.64, and 2.49 pCi/liter, respectively. The standard deviations of the individual concentration determinations with reference to the RaA-, RaB- and RaC-concentrations were: plus or minus 3.66, plus or minus 3.38, plus or minus 3.27 pCi/liter. On the basis of these radon daughter product concentrations and of certain assumptions elaborated in the text, the following weighted average alpha-dose-rates were obtained for the Hungarian population: bronchial epithelium: 800 mrad per annum, while for the whole of the lungs: 120 mrad per annum.

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353. Travis, C. C., Watson, A. P., McDowell-Boyer, L. M., Cotter, S. J., Randolph, M. L., Fields, D. E.

Natural and technologically enhanced sources of radon-222.

NUCL. SAF. 20(6): 722-728, 11/--/79.

ABSTRACT: An assessment of Rn-222 releases (curies/year) from major natural and technologically enhanced sources in the United States is presented. The resulting inhalation population dose commitments to the bronchial epithelium of the lung (lung-rem) are also estimated. The sources of radon considered are natural soil, evapotranspiration, potable water supplies, building materials, natural gas, uranium mining and milling, coal and phosphate mining, phosphate fertilizer, liquefied petroleum gas, geothermal power facilities, coal-fired power plants, and gas and oil wells. The most important natural source of Rn-222 is decay of Ra-226 in the soil and rocks of the earth's crust. This source results in approximately 40% of the total population dose from all sources of radon. The largest technologically enhanced contributor to population dose is airborne Rn-222 in building interiors, which is estimated to contribute 55% to the total population exposure to Rn-222. Each of the other sources is estimated to contribute less than 3% of the total.

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354. Tremblay, R. J., Leclerc, A., Townsend, M. G., Mathieu, C., Pepin, R.

Measurement of radon progeny concentration in air by alpha-particle spectrometric counting during and after air sampling.

HEALTH PHYS. 36(3): 401-411, 03/--/79.

ABSTRACT: A procedure is presented for calculating air concentrations of the short-lived progeny of radon-222 by the use of a alpha-particle spectrometry. The procedure, essentially an extension of those of Kerr and Martz, allows the determination of the concentrations of RaA, RaB and RaC from one integral alpha-count of RaA and two integral alpha-counts of RaC' with counting intervals during and/or after air sampling. A computer program is presented which calculates the concentrations of RaA, RaB and RaC in air and the accuracies in these calculated concentrations, for overlapping or non-overlapping counting and sampling intervals. The advantages of counting during sampling are discussed and the counts compared with those taken after the termination of sample collection.

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355. Tsivoglou, E. C., Ayer, H. E., Holaday, D. A.

Occurrence of nonequilibrium atmospheric mixtures of radon and its daughters.

NUCLEONICS 11(9): 40-45, 09/--/53.

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356. Van Dilla, M. A., Taysum, D. H.

Scintillation counter for assay of radon gas.

NUCLEONICS 13(2): 68-69, 02/--/55.

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357. Vivyurka, A.

Assessment of subfloor ventilation systems. 8 p.

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358. Waller, M. D.

Radon and its daughters products in mine atmospheres: An introduction to its occurrence, detection and control.

CAMBORNE SCH. MINES J. 77: 38-42, 1977.

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359. Walsh, P. J., Killough, G. G., Rohwer, P. S.

Composite hazard index for assessing limiting exposures to environmental pollutants: Formulation and derivation.

ENVIRON. SCI. TECHNOL. 12(7): 799-802, 07/--/78.

ABSTRACT: A calculational index methodology is developed for limiting human exposure to environmental pollutants. Hazard index is defined as Q/QL, where Q is a measure of exposure, such as an organ's burden of a pollutant from all environmental pathways, and QL is a corresponding limit that should not be exceeded because of health risk to human beings. Mathematical formulations relating hazard indices to environmental pollutant concentration are developed for each sampling medium corresponding to each effluent mode. These formulations are used to derive limiting pollutant concentrations such that the resultant measure of exposure will not exceed the health risk limit. Mathematical formulations for composite hazard indices for multiple pollutants are presented.

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360. Walsh, P. J.

Dose conversion factors for radon daughters.

HEALTH PHYS. 36(5): 601-609, 05/--/79.

ABSTRACT: Dose conversion factors that are consistent with present epidemiological, toxicological and theoretical evidence about radiogenic lung cancer are suggested for short-lived radon daughters. These dose conversion factors are based upon risk estimates derived from epidemiological studies that have demonstrated an association between exposure of the lung to ionizing radiation and lung cancer. Various risk estimators are compared including absolute risk, relative risk, percent increase in excess cases, and excess cases as a fraction of observed cases. The nature of risk per unit exposure as a function of exposure is shown to be dependent on the risk estimator used. The hypthesis is supported in the range of available data. The nature of exposure response relationships at low exposures is uncertain because of uncertainties in individual exposure estimates. Risks could be overestimated or underestimated depending on the risk estimator used when exposures approach background exposures, especialy if background exposures are not included in exposure estimates.

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361. Ward, W. J., III, Fleischer, R. L., Mogro-Campero, A.

Barrier technique for separate measurement of radon isotopes.

REV. SCI. INSTRUM. 48(11): 1440-1441, 11/--/77.

ABSTRACT: Longer-lived radioactive isotopes of elements can be separated from a mixture of isotopes in passing from one volume to a second by the use of an appropriate intervening barrier so that the shorter-lived isotopes decay before reaching the detector. The separation can most effectively be created by use of a membrane; a purely diffusional barrier is also effective. The techniques are demonstrated in experiments with 3.8-day Rn-222 and 56-s Rn-220.

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362. Washington, R. A., Chi, W., Regan, R.

The use of vermiculite to control dust and radon daughters in underground uranium mine air.

TRANS. CAN. INST. MIN. METALL. 76: 52-60, 1973.

ABSTRACT: In uranium mines, the purification of underground mine air can be accomplished by the removal of dust particles and radon daughters using filters. Full-scale statiscally designed experiments with flow rates up to 10,000 cfm have been conducted at Denison Mines Ltd. on mine air filtration with vermiculite as a filter material. Various filtration bed thicknesses were chosen, with different face velocities through each bed thickness. Results on total dust, respirable dust and radon daughter collection efficiencies were analysed statistically. It is shown that these collection efficiencies are directly related to the filter bed thickness. However, the different face velocities seem to affect only the collection of radon daughter. Optimum collection efficiencies for a clean bed of about 30% were found for respirable dust and radon daughters, and about 40% for total dust, using an 8 inch thick bed and a face velocity of 500 fpm. Dust build-up on the filter bed during operation led to an increase in collection efficiency, reaching 40 to 60% after two weeks.

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363. Werner, Jan

Radon in Swedish buildings.

364. White, O., Jr., Health and Safety Laboratory. U.S. Atomic Energy Commission. New York Operations Office.

An evaluation of six radon dosimeters. HASL Technical Memorandum 69-23A. 21 p., 10/29/69.

ABSTRACT: Six different types of dosimeter were evaluated for suitability in monitoring the exposures of uranium miners. All are sufficiently compact to be worn continuously by miners while performing regular work. Four of the dosimeters are intended for the measurement of radon daughters; two are intended for radon. The performance of three of the dosimeters was fair to good in the laboratory in a series of exposures to simulated uranium mine atmospheres. None of the dosimeters were satifactory in month-long periods of actual use in two uranium mines.

365. White, O., Jr., Health and Safety Laboratory. U.S. Atomic Energy Commission. New York Operations Office.

Evaluation of MIT and ORNL radon daughter dosimeters. HASL Technical Memorandum 70-3 28 p., 07/28/70.

ABSTRACT: Two radon daughter dosimeters designed at Massachusetts Institute of Technology and Oak Ridge National Laboratory, respectively, for measuring the exposures of uranium miners were tested in the laboratory and the field. In laboratory tests, responses of both instruments correlated well with exposures but were relatively imprecise. In two-week use-tests in a uranium mine, neither dosimeter gave reliable indications of exposure, the ORNL unit being in error by as much as a factor of three and the MIT unit by as much as a factor of thirty. The latter instrument's poor response data are attributable in large part to one or more malfunctions that affected nearly every instrument during the field tests. Deficiencies in the air-flow systems, which were investigated in detail, contributed to poor performance in both instruments. Preparation and analysis of detectors were performed at MIT and ORNL and hence, were not examined as possible sources of error.

366. White, O., Jr., Health and Safety Laboratory. U.S. Atomic Energy Commission. New York Operations Office.

Evaluation of MOD and ORNL radon daughter dosimeters. HASL Technical Memorandum 71-17 23 p., 10/08/71.

367. Wilkening, M.

Radon transport processes below the earth's surface. 17 p.

ABSTRACT: Processes by which Rn-222 is transported from the soil to the earth's surface are reviewed. The Rn-222 formed in the earth's crust by the decay of Ra-226 is free to move only if the Rn-222 atoms find their way into soil pores and capillaries. The mechanisms effective in transporting Rn-222 to the surface are related to the size and configuration of the spaces occupied by the soil gas which may vary from molecular interstices to large underground caverns. The near-surface transport processes are divided into two categories: a microscopic one which includes molecular diffusion and viscous flow in fine capillaries, and macroscopic flow in fissures and channels. Molecular diffusion is divided into two cases, one called Knudsen diffusion where the mean free path is long compared with the diameter of an equivalent capillary by which the physical structure of the soil is approximated, and the other is ordinary bulk diffusion in the soil where the mean free path is short with respect to the dimensions of the pore spaces. Poiseuille flow is a third concept useful where transport can be accomplished by laminar flow through capillaries where pressure gradients exist. Underground air rich in Rn-222 can also reach the surface through cracks, fissures and underground channels. This type of transport is demonstrated for 1) a horizontal tunnel penetrating a fractured hillside, 2) a large underground cave, and 3) volcanic activity. Pressure differentials having various natural origins and thermal gradients are shown to be responsible for the transport in these examples.

368. Wilkening, M. H.

Natural radioactivity as a tracer in the sorting of aerosols according to mobility.

REV. SCI. INSTRUM. 23(1): 13-16, 01/--/52.

ABSTRACT: Natural radioactivity in the atmosphere is used as a "tracer" in the study of aerosol particle size distribution in the submicroscopic range. Particulate matter is collected by a device which first ionizes the particles and then separates them according to their mobilities. The results indicate that most of the natural radioactivity in the atmosphere attaches itself to particles having diameters in the range 0.001 to 0.04 micron. A predominant grouping of the activity occurs in the vicinity of two particle diameters: 0.009 and 0.018 micron. The relationship between the distribution of radioactivity and the abundance of particles in different size ranges is discussed.

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369. Wilkening, M. H., Watkins, D. E.

Air exchange and 222-Rn concentrations in the Carlsbad Caverns.

HEALTH PHYS. 31: 139-145, 08/--/76.

ABSTRACT: Radon 222 concentrations in th air in Carlsbad Caverns have been measured at different times of the year in order to define certain features of the natural circulation of the cave atmosphere and to estimate the internal radiation exposure to vistors and Park Service personnel. Concentrations average 48 pCi/liter in the summer when the temperature lapse rate provides a stable cave atmosphere. In the winter months air from outside having a Rn-222 concentration of only about 0.2 pCi/liter mixes with the cave air reducing radon levels to about 15 pCi/liter. A simple model obtained by equating the input of Rn-222 atoms from the rocks and soils of the cave's interior surfaces to the sum of terms for radioactive decay and dilution of the cave atmosphere by outdoor air enables one to predict, for steady-state conditions, the approximate levels of activity to be expected for all months of the year. If it is assumed that the short-lived daughter products of Rn-222 are present in equilbrium amounts, Park Service personnel spending most of their time underground approach the 4 WM/year (working level months per year) exposure limit established for the uranium industry. A visitor on a 3 hour trip through the Caverns would receive only a few per cent of the exposure guides for the general population.

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370. Williams, R. H., Ross, M. H.

Drilling for oil and gas in our houses.

TECHNOL. REV. 24-36, 03/--/80.

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371. Windham, S. T., Savage, E. D., Phillips, C. R.

The effects of home ventilation systems on indoor radon-radon daughter levels.
EPA-520/5-77-011 24 p., 10/--/78.

ABSTRACT: 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.

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372. Wrenn, M. E., Rosen, J. C., Van Pelt, W. R.

Steady state solutions for the diffusion equations of radon-222 daughters.

HEALTH PHYS. 16: 647-656, 1969.

ABSTRACT: A mathematical model describing steady state diffusion of Rn-222 daughters, based on a uniform distribution of radon has been developed. Solutions are generated for four coupled, non-homogenous differential equations satisfying the boundary conditions that the concentrations of all daughters vanish at the walls for cylindrical geometry. The solutions of these equations give the concentration of RaA, RaB, RaC and RaD as a function

of the distance from the center of the containing vessel in terms of the diffusion coefficient, the radioactive decay constants, and the dimensions of the containment vessel. The results, integrated over the volume of the container and expressed as a fraction of the radon concentration, yield parent-daughter equilibrium values for cylinders of various dimensions. When the cylindrical geometry is used to approximate a uranium mine tunnel with a diameter of 8 feet, the model indicates that a significant parent-daughter disequilibrium exists using a value of the diffusion constant characteristic of unattached ions or atoms. Under non-static conditions, convective or turbulent mixing would further decrease the daughter concentrations relative to radon due to an increase concentration gradient at the wall; however, the presence of aerosols would tend to reduce the rate of diffusion to the walls.

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373. Wrenn, M. E., Eisenbud, M., Costa-Ribeiro, C., Hazle, A. J., Siek, R. D.

Reduction of radon daughter concentrations in mines by rapid mixing without makeup air.

HEALTH PHYS. 17: 405-414, 1969.

ABSTRACT: Measurements of radon daughter concentrations and their relative states of equilibrium were made in closed sections of two uranium mines to investigate the removal of radon daughters from the atmosphere by rapid mixing. Recirculation of the air within the enclosed space once per minute reduced the working level by a factor of 20. This reduction was associated with extreme disequilibrium among the radon daughters. The lowest ratio observed between Ra-A and Ra-B was 0.08. In this sample Ra-C was not measurable. The mechanism involved may be convective or turbulent diffusion to the walls of the mine. Because the atmosphere sampled became extremely clean (less than 200 particles/cubic centimeter measured with a condensation nuclei counter) the diffusion constant was probably that associated with free atoms. The state of equilibria measured indicates that removal of Ra-B and Ra-C was more efficient than that of Ra-A, probably because the Ra-B and Ra-C have longer mean lives. It appears that with adequate stirring it may be possible to remove radon daughters from mine atmospheres without the introduction of burdensomely large amounts of fresh air. These results may not be applicable to atmospheres with higher particle concentrations. These results strongly suggest that further research should go into methods of ventilation in which large amounts of makeup air are not required.

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374. Wrenn, M. E., Spitz, H., Cohen, N.

Design of a continuous digital-output environmental radon monitor.

IEEE TRANS. NUCL. SCI. NS-22: 645-647, 02/--/75.

ABSTRACT: A new field instrument for the continuous measurement of radon concentrations has been developed to investigate the magnitude and variability of environmental levels of Rn-222. Passive diffusion of radon, but not its daughters, occurs through an open pore polyurethane foam into a sensitive volume where a static electric field directs the positively ionized radon daughter products to a central collecting electrode. Pulses in a ZnS(Ag) scintillator, resulting from the alpha emission of Po-218 and Po-214, are observed with a photomultiplier tube and counted using standard NIM electronics. The detector unit has been fabricated into a small, convenient package for indoor air sampling without the use of air movers or pumps. The unit is unobtrusive and acceptable into a daily routine without disrupting normal family or business activities. The monitor can detect as little as 0.3 pCi/liter for a 40 minute count (alpha = .05). The equilibrium detection efficiency of the instrument is 0.7 cpm/pCi/liter.

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375. Wright, E. S., Couves, C. M.

Radiation-induced carcinoma of the lung: The St. Lawrence tragedy.

J. THORAC. CARDIOVASC. SURG. 74(4): 495-498, 10/--/77.

ABSTRACT: This paper reviews the problem of radiation-induced carcinoma of the lung in the fluorspar mines of Newfoundland. Seventy-eight workers have died from this disease since commercial operation commenced in 1933. In 1959 the source of the radiation was identified as radon, and its daughter nucleotides present as contaminants in water seeping into the mines. Heavy-smoking is probably a synergistic cocarcinogen. The histology in this group of patients with radiation-induced lung cancer is unusual, since squamous cell carcinoma accounts for 90 percent of all cases. There have been four patients with second primary lung cancers. Radical radiotherapy has been the primary mode of treatment based on the reluctance of the miners to undergo operation. Surprisingly good results have been

obtained, with an average survival time of 34 months after treatment. Institution of improved ventilation has reduced radiation to safe levels, but an estimated 120 miners from the pre-1960 era are still at risk.

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376. Yashita, S., Leber, R. E.

Searching for volatile superheavy elements. LBL-6575

NUCLEAR SCIENCE: ANNUAL REPORT FOR THE PERIOD JULY 1, 1976-JUNE 30, 1977. 35-36

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377. Yeates, D. B., Goldin, A. S., Moeller, D. W.

Natural radiation in the urban environment.

NUCL. SAF. 13(4): 275-286, 07/--/72.

ABSTRACT: Natural radiation is the largest source of population dose and is important as a base line with which radiation-protection standards may be compared. In this article previous work on natural background radiation levels is summarized, and some new data from Boston, Mass., are reported. Gamma dose rates, corrected for cosmic radiation, were measured with large ionization chambers: dose rates inside wooden single-family dwellings were 25 to 50% lower than those outside; in masonry multiple-family dwellings, they were about 10% lower. Concentrations of radon daughters in the air were measured by predecay and postdecay alpha spectrometry: concentrations in dwellings were comparable with outdoor concentrations, but concentrations in basements were higher by a factor of about 5. Concentrations in office buildings were quite low, the radon daughters being removed by the ventilation system. Effects of building type, construction materials, and ventilation on human dose are discussed, as are possible ways of reducing population dose.

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378. Yuan, Y. C., Roberts, C. J., Momeni, M. H.

Radiological assessment methodology for uranium mills.

TRANS. AM. NUCL. SOC. 30: 94, 1978.

ABSTRACT: The Uranium Dispersion and Dosimetry (UDAD) computer code has been developed to provide estimates of potential radiation exposure to individuals and to the general population within a 80-km radius of a reference mill site. The code is based on a model which includes as sources of radioactive releases, the ore storage pad, ore crushing and grinding operations, yellowcake drying and packaging, and the stored mill tailings. Only transport through the air is considered.

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379. Zimmerman, D. W., Rhyner, C. R., Cameron, J. R.

Thermal annealing effects on the thermoluminescence of LiF.

HEALTH PHYS. 12(4): 525-531, 04/--/66.

ABSTRACT: Isothermal annealing before or after irradiation is found to have a definite affect upon the thermoluminescent glow curve of LiF (TLD-100). Post-irradiation annealing, by thermally releasing electrons from their traps, reduces the size of each peak in the glow curve. The two main dosimetry peaks each have a simple exponential decay consistent with the model of Randall and Wilkins, indicating trap depths of 1.19 and 1.25 eV respectively with frequency factors between E11 and E12 sec-1. Pre-irradiation annealing at 80 degrees C for 24 hours reduces the area of the low temperature peaks by a factor of 10, while annealing at 125 degrees C, 145 degrees C or 175 degrees C for 3 hours reduces the area of the main dosimetry peaks by a factor of one and one-half-3. The rate of cooling from temperatures greater than about 150 degrees C affects the glow curve also. Rapid cooling ten times of the order of seconds increases the heights of the low temperature peaks up to a factor of 4 compared to cooling in several minutes or more.

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