AIC 599

LBL-9402
EEB-Vent 79-8

#998

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

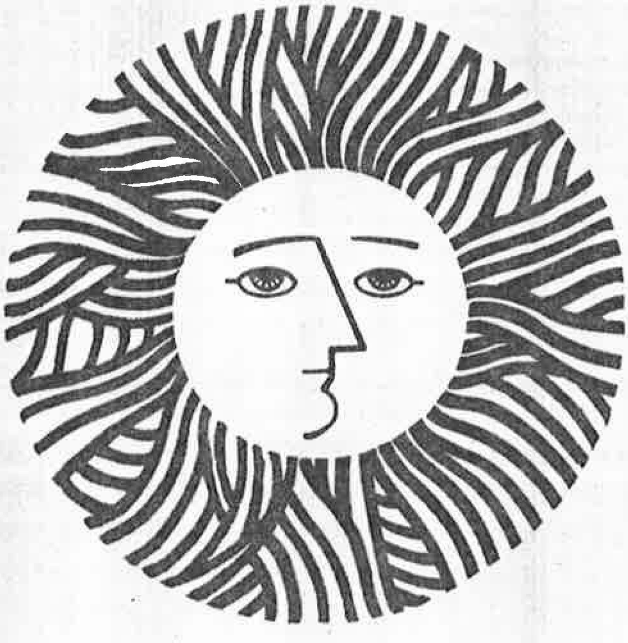
ENERGY & ENVIRONMENT DIVISION

To be presented at the American Nuclear Society Meeting, San Francisco, CA, November 11-16, 1979

RADON-222 IN ENERGY EFFICIENT BUILDINGS

Craig D. Hollowell, Mary L. Boegel, John G. Ingersoll and William W. Nazaroff

June 1979



Prepared for the U. S. Department of Energy under Contract W-7405-ENG-48

To be presented at the American Nuclear Society Meeting,
San Francisco, November 11-16, 1979

LBL-9402
EEB-Vent 79-8

Radon-222 in Energy Efficient Buildings

Craig D. Hollowell, Mary L. Boegel, John G. Ingersoll
and William W. Nazaroff

Energy & Environment Division
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

Radon and its decay daughters are known to contribute a significant portion of natural background radiation exposure to the population. Scattered observations have shown that indoor concentrations of radon and radon daughters are typically higher than outdoor concentrations, presumably because the building structure serves to confine radon entering the indoor environment from various sources. Conservation measures, particularly reduced air exchange rates, may lead to elevated radon concentrations, resulting in increased radiation exposure of occupants.

Any substance containing radium-226 is a potential source of radon. Since radium is a trace element in most rock and soil, sources of indoor radon include building materials, such as concrete or brick, and the soil under building foundations. Tap water may be an additional source if taken from wells or underground springs. Figure 1 illustrates the primary pathways by which radon from soil and building materials enters a building. The relative importance of these pathways depends on the specific location, design, and construction materials and techniques used in a given building.

Figure 2 summarizes observed radon concentrations in air, including measurements of radon outdoors and in houses. The DOE Environmental Measurements Laboratory measured radon concentrations in 21 homes in the New York/New Jersey area.[1] The geometric mean of the annual average radon concentration on the first floor of these homes, 0.83 nCi/m^3, was five times the comparable ambient level of 0.18 nCi/m^3. A study in Salzburg, Austria, found the geometric mean radon concentrations to be 0.42 nCi/m^3 indoors and 0.16 nCi/m^3 outdoors.[2] An EPA study of houses in Florida built on phosphate reclaimed land found the mean indoor radon concentration to be 4.0 nCi/m^3, an order of magnitude higher than measured in other houses in the state.[3]

The Lawrence Berkeley Laboratory has conducted measurements of radon levels in energy efficient buildings in Maryland, Minnesota, and New Mexico. Results indicate that houses with low air exchange rates ($<$ 0.3 air changes per hour) may have higher radon concentrations than conventional houses ($\sim$ 0.75 air changes per hour). Figure 3 is a scatter plot of radon concentration vs. ventilation rate in a number of energy efficient houses. The data shows considerable scatter; however, a correlation between radon concentration and air change rate is apparent. The data reported here is based on grab samples taken on mild days (low wind and small indoor and outdoor temperature differences) with all doors and windows closed, resulting in a worst case estimate. These houses are expected normally to have higher ventilation rates and, therefore, lower radon concentrations. Integrated measurements or large numbers of grab samples under typical living conditions and various climatic conditions are necessary to determine average exposures of building occupants under various ventilation conditions.

Rising energy prices have generated a financial incentive to reduce ventilation rates and thereby reduce heating and cooling losses. The increase in radon levels, the rise in radiation exposure of building occupants, and the potential lung cancer risk that could occur as a result of reduced ventilation demand specific attention.

References

1. A.C. George and A.J. Breslin, "The Distribution of Ambient Radon and Radon Daughters in Residential Buildings in the New Jersey and New York Area," Presented at the Symposium on the Natural Radiation Environment III, Houston, TX, April 23-28, 1978.

2. F. Steinhausler, W. Hofmann, E. Pohl, J. Pohl-Ruling, "Local and Temporal Distribution Pattern of Radon and Daughters in an Urban Environment and Determination of Organ Dose Frequency Distributions with Demoscopical Methods," Presented at the Symposium on the Natural Radiation Environment III, Houston, TX, April 23-28, 1978.

3. J.E. Fitzgerald, Jr., R.J. Guimond, R.A. Shaw, "A Preliminary Evaluation of the Control of Indoor Radon Daughter Levels in New Structures," EPA-520/4-76-018, Office of Radiation Programs, Washington, D.C. 20640 (1976).

4. D.J. Bressan, Naval Research Laboratory, Washington, D.C., Private Communication, February 1978.

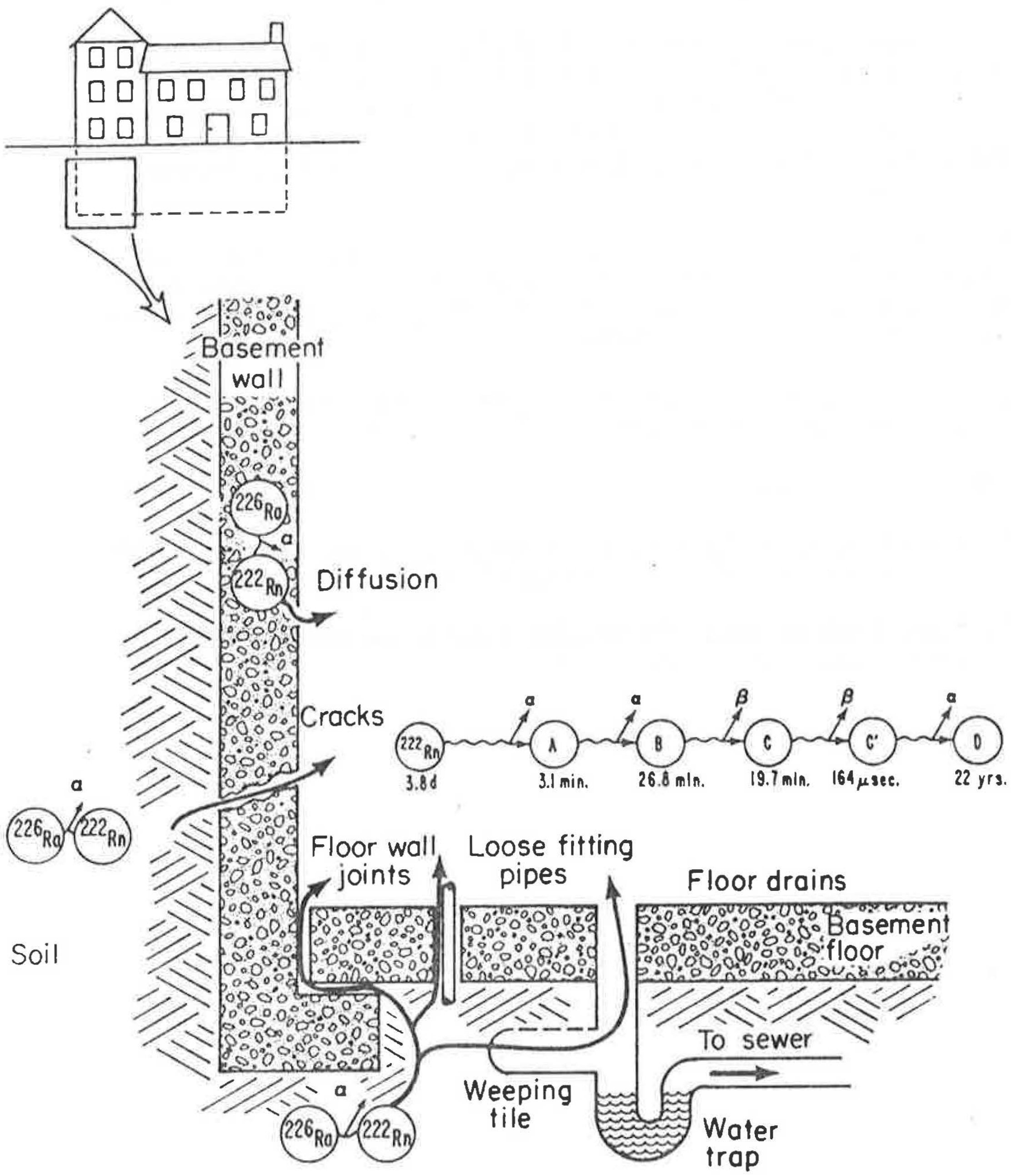
5. Federal Register, Vol. 34, No. 11, January 16, 1969.

6. Federal-Provincial Task Force on Radioactivity, Canada, Working Party on "Radiation Criteria; Recommendations," December 1976.

7. J. Cook, Environmental Protection Agency, Washington, D.C., Private Communication, June 1979.

Figure 1

PRIMARY PATHWAYS FOR RADON ENTRY IN BUILDINGS



XBL 796-1661

Figure 2

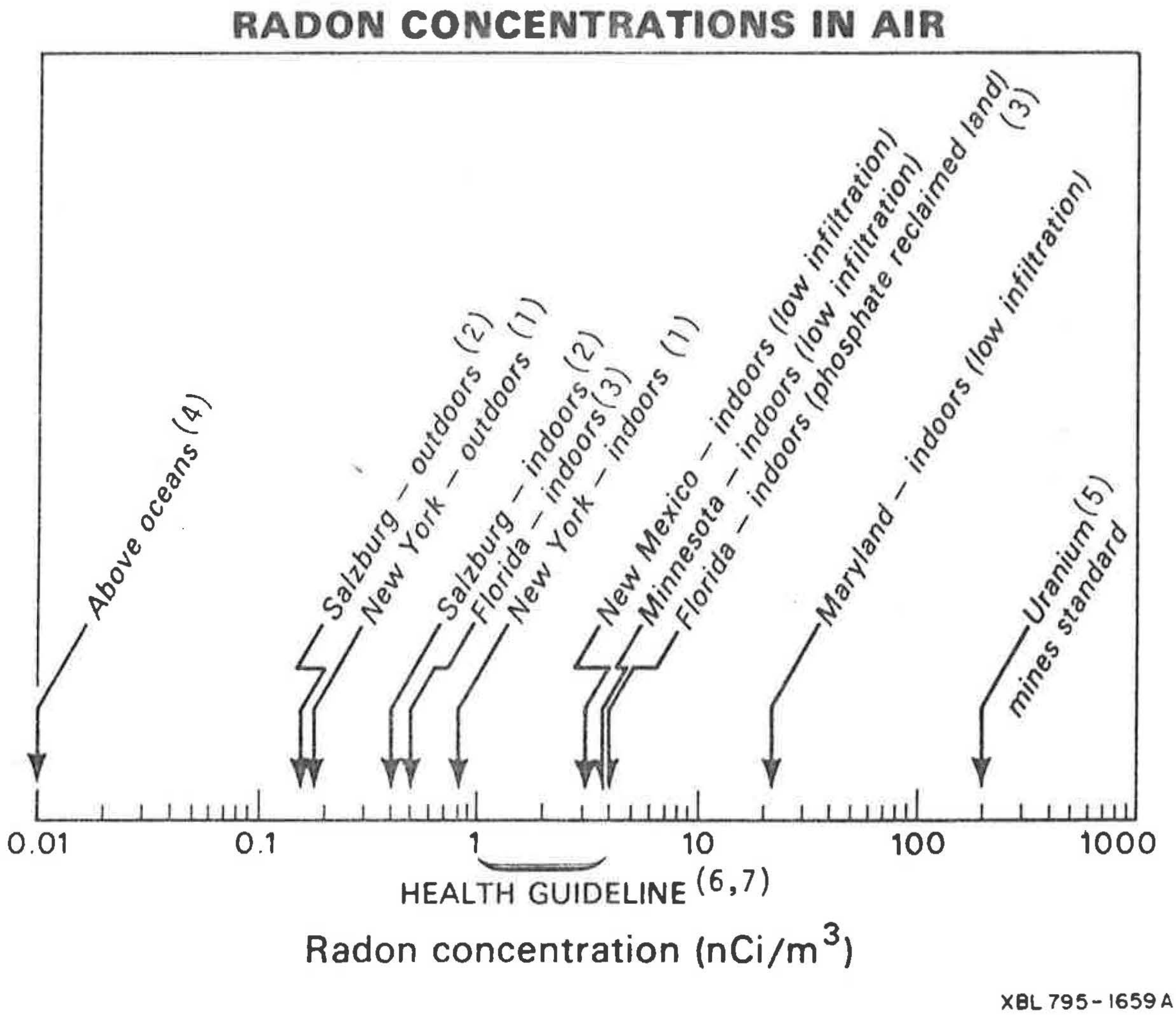
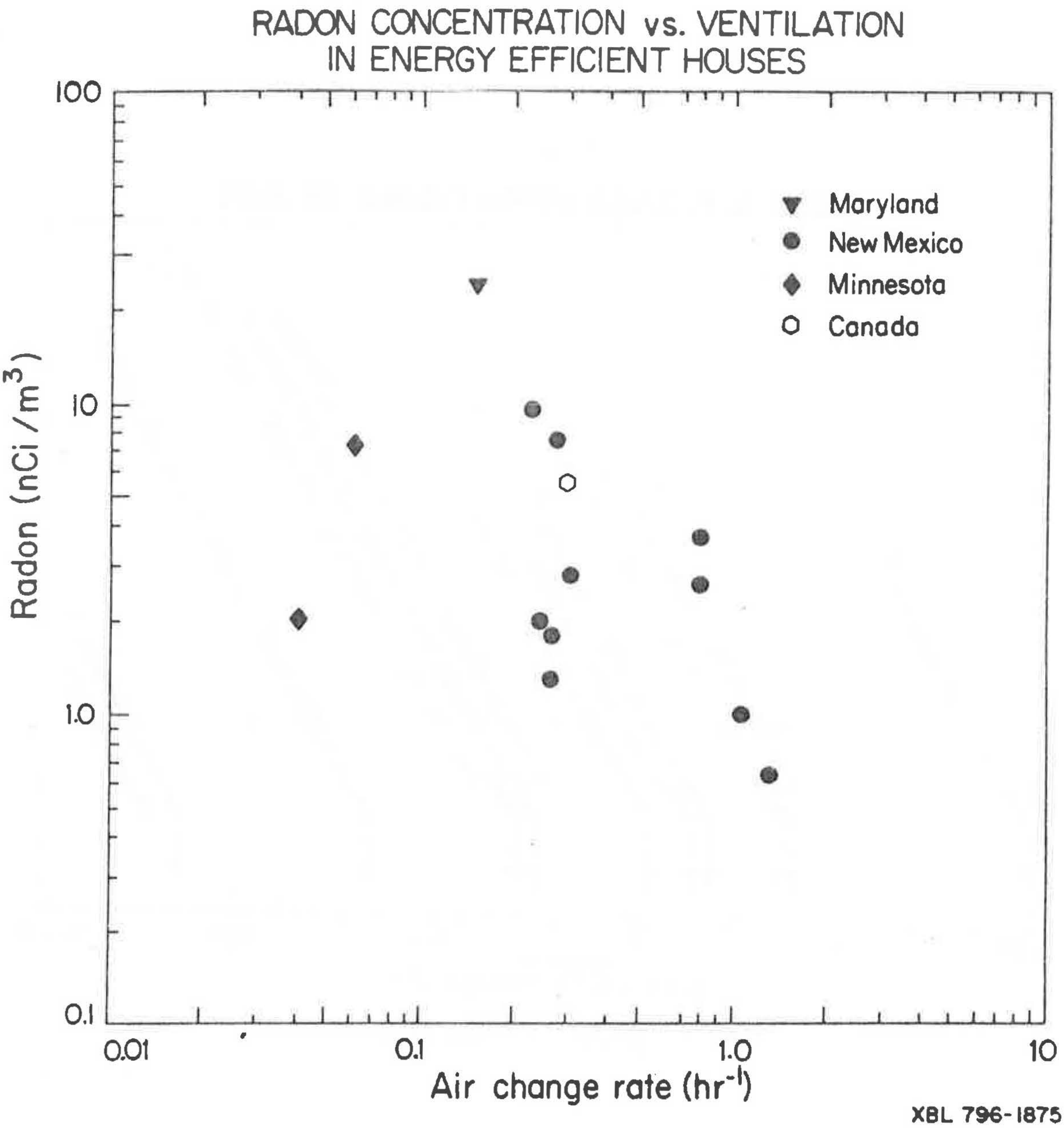

RADON CONCENTRATIONS IN AIR
Above oceans (4)
Salzburg – outdoors (2)
New York – outdoors (1)
Salzburg – indoors (2)
Florida – indoors (3)
New York – indoors (1)
New Mexico – indoors (low infiltration)
Minnesota – indoors (low infiltration)
Florida – indoors (phosphate reclaimed land) (3)
Maryland – indoors (low infiltration)
Uranium (5) mines standard
0.01
0.1
1
10
100
1000
HEALTH GUIDELINE (6,7)
Radon concentration (nCi/m3)
XBL 795-1659 A

Figure 3


RADON CONCENTRATION vs. VENTILATION
IN ENERGY EFFICIENT HOUSES
Maryland
New Mexico
Minnesota
Canada
Radon (nCi / m3)
100
10
1.0
0.1
0.01
0.1
1.0
10
Air change rate (hr-1)
XBL 796-1875

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720