



# Project Summary

## Technical Basis for a Candidate Building Materials Radium Standard

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**The Florida Radon Research Program (FRRP), sponsored by the Environmental Protection Agency and the Florida Department of Community Affairs, is developing the technical basis for a radon-control construction standard. Results of the research conducted under the FRRP are presented in several technical reports. This report is a summary of the technical basis for a candidate building materials radium standard. The report contains the standard and a summary of the technical basis for the standard.**

***This Project Summary was developed by the National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).***

### Introduction

Residential building materials, principally concrete, can contain small amounts of radium, which generates radon gas that can migrate into residences. Furthermore, radon daughters trapped in concrete emit gamma radiation that can cause exposures to building occupants. This portion of the standard defines acceptable limits for the concentration of radium in building materials.

### **Candidate Building Materials Radium Standard**

The candidate building materials radium standard is:

No material used in concrete for the construction of habitable structures shall have a total radium concentration that exceeds 10 pCi/g, as measured in accordance with procedures contained in "Standard Measurement Protocols, Florida Radon Research Program." The radium concentration in concrete used in the construction of habitable structures shall not have a total radium concentration that exceeds 5 pCi/g.

Radiation exposures from building materials to people can occur either from indoor radon or from external gamma radiation. Both the concentration of indoor radon and the level of gamma radiation from the building materials depend primarily on the total radium concentration in the materials. Thus, limiting the radium concentration in the building material limits the amount of potential exposure to building occupants from both indoor radon and gamma radiation. For typical concrete thicknesses (tens of centimeters), the gamma radiation exposures yield about the same radium concentration limits in building materials as do exposures to indoor radon from the materials.

### **Technical Analysis Supporting the Candidate Standard**

The technical analysis supporting the building materials standard consists three steps:

1. Determine building material performance objectives for potential radon and gamma exposures.
2. Calculate radium limit for indoor radon exposures.

3. Calculate radium limit for external gamma radiation exposures.

Performance objectives were selected according to their consistency with other Florida Radon Research Programs. Specifically, the performance objectives are a selected fraction of the U.S. Environmental Protection Agency's (EPA) indoor radon (as radon-222) concentration guideline of 4 pCi/L and the EPA's external gamma radiation criterion of 20 µR/hr for cleanup of off-pile lands associated with uranium milling.

Indoor radon and gamma exposures to occupants of residences can come from many sources in addition to the building materials. Soils under building structures constitute the major source. Accordingly, a reasonably conservative value of 25% has been selected as the fraction of the radon guidance and gamma radiation criterion attributed to building materials. Thus, the building material performance objectives are:

1. Indoor radon-222 concentration limit - 1 pCi/L
2. External gamma radiation limit - 5 µR/hr.

The calculations of indoor radon concentration from a concrete slab use an established procedure and equation. Rearranging the equation gives

$$Ra = \frac{F}{\rho E \sqrt{\lambda D} \tanh(\sqrt{\lambda/D} X_c)} \quad (1)$$

where:

Ra = radium-226 concentration limit in the concrete (pCi/g)

- F = radon flux (pCi/cm<sup>2</sup> s)  
 ρ = concrete density (g/cm<sup>3</sup>)  
 E = radon emanation coefficient (unitless)  
 λ = radon decay constant (2.06x10<sup>-6</sup>/s)  
 D = radon diffusion coefficient of concrete (cm<sup>2</sup>/s)  
 X<sub>c</sub> = thickness of concrete slab (cm).

A simple approximation for F is available:

$$F = Ch\lambda\sqrt{(3.6 \times 10^6)} \quad (2)$$

where:

- C = indoor radon concentration (pCi/L)  
 h = average indoor height of building (cm)  
 λ<sub>v</sub> = dwelling ventilation rate (air changes/hour)  
 3.6x10<sup>6</sup> = units conversion (cm<sup>3</sup> s/L hr)

Combining Equations (1) and (2) gives:

$$Ra = \frac{Ch\lambda_v}{(3.6 \times 10^6 \rho E \sqrt{\lambda D} X_c)} \quad (3)$$

The following values were used in the calculations:

- C = 1 pCi/L (performance objective)  
 h = 240 cm  
 λ<sub>v</sub> = 0.25 air changes/hour  
 ρ = 2.1 g/cm<sup>3</sup>  
 E = 0.11  
 X<sub>c</sub> = 10 cm  
 D = 2x10<sup>-3</sup> cm<sup>2</sup>/s

Substituting these values into Equation (3) gives a radium limit of 4 pCi/g in the concrete.

This is rounded to 5 pCi/g in the Standard.

The radium concentration limit in concrete readily converts to radium concentration limits in concrete constituents. Since aggregate comprises about 49% of Florida residential concrete, the concrete aggregate radium limit can be estimated as 4 pCi/g/0.49, or 8 pCi/g in the aggregate. A similar limit for sand is 10 pCi/g.

Exposures from gamma-emitting radionuclides in the concrete were estimated by a slab with the same characteristics as given in the full report. A 6x6-m area was assigned to the slab, and the gamma-radiation exposures were calculated with the MICROSIELD computer code.

The MICROSIELD calculations gave a value of 0.95 µR/hr per pCi/g of total radium in the concrete. Thus, a radium limit of about 5 pCi/g for the concrete gives a potential exposure of 5 µR/hr. The corresponding total radium limit in the aggregate is 10 pCi/g, and that for the sand is approximately 13 pCi/g.

## Conclusions from Technical Analysis

Potential exposures from building materials to occupants of dwellings occur from external gamma radiation and from indoor radon. The extent of these potential exposures is mainly determined by the radium concentration in the materials. Both indoor radon exposure limits and external gamma exposure limits yield a 5 pCi/g radium concentration limit in concrete and a 10 pCi/g radium limit in the aggregate for the concrete.

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*The complete report, entitled "Technical Basis for a Candidate Building Materials Radium Standard," (Order No. PB96-157565; Cost: \$17.50, subject to change) will be available only from:*

*National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
Telephone: 703-487-4650*

*The EPA Project Officer can be contacted at:*

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