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Radon and man-made vitreous fibers

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Sections

- [Abstract](#)
- [Radon](#)
- [Man-made Vitreous Fibers](#)
- [Conclusions](#)
- [References](#)
- [Appendix](#)
- [Publishing and Reprint Information](#)

- [Previous article](#) in Issue
- [Next article](#) in Issue
- [Drug links](#) from Mosby's DrugConsult
- [Genetic information](#) from OMIM
- Citation of this Article
 - View on [PubMed](#)
 - Download in [citation manager format](#)
 - Download in [Medlars format](#)
- [Related articles](#) in PubMed

Abstract

TOP

Epidemiologic studies of miners have established a causal association between radon exposure and development of lung cancer. During the past decade the focus of attention has turned to the potential risks from exposure to radon in indoor air. Governmental involvement thus far has primarily been aimed at gathering further data and issuing voluntary guidelines for radon control in the indoor environment. The federal government's most recent risk assessment for exposure to indoor radon published in 1992 concluded that exposure to indoor radon results in 13,600 radon-induced lung cancer deaths in the United States each year. As public awareness of such environmental issues continues to grow, physicians will be faced with the need to respond to inquiries regarding potential health effects. Man-made vitreous fibers are silicate glass that have a noncrystalline structure. They have been in production for more than 100 years and are used in numerous applications in residential and commercial settings. The health risks from man-made vitreous fibers that are used in residential and commercial settings are limited to skin and

occasional respiratory tract irritation under circumstances of improper installation or maintenance. When glass fiber contaminates an indoor environment, proper repair measures and thorough cleaning of the indoor environment will lead to resolution of any resultant irritant symptoms. (J ALLERGY CLIN IMMUNOL 1994;94:310-7.)

Bq	Becquerel
EPA	Environmental Protection Agency
MeV	Mega electron volt
MMVF	Man-made vitreous fiber
pCi	Picocurie
WLM	Working level month

(Click on a term to search this journal for other articles containing that term.)

Key words: [Radon](#), [man-made vitreous fiber](#), [glass fiber](#), [indoor air](#), [lung cancer](#)

Radon

TOP

Health studies of miners (including uranium, iron, and tin miners) during the past few decades have established a causal association between radon exposure and the development of lung cancer. ^{1 2} This issue became a matter of more general concern with the discovery of extremely high levels of radon in some homes in the Reading Prong area of Pennsylvania, New Jersey, and New York in the mid-1980s. Public health concerns led to increased governmental efforts to gather more data on the extent of health effects of exposure to indoor radon and mitigation techniques. The governmental programs are for the most part voluntary and are aimed at educating the public rather than mandating control of exposures.

Characteristics of radon

²³⁸Uranium goes through a series of decays resulting in the release of ²²²radon, a noble gas that is odorless and colorless. ²²²Rn has a half-life of 3.8 days and in turn decays to form radon daughters, including ²¹⁸polonium and ²¹⁴polonium (■ Fig. 1). These radon progeny, which can become attached to airborne particles, emit high-energy α -particles that deliver the carcinogenic dose to the epithelial cells of the tracheobronchial tree. ²³⁸U and its decay series are present in most soil and rocks, resulting in the ubiquitous presence of radon in indoor and outdoor air and its status as the greatest source of natural background radiation. Other potential sources of radon include well water, natural gas, building materials (including brick and granite), phosphate ores, and uranium mill-tailings. ^{3 4}

Units of radiation

There are several units for describing the amount of radiation from radon exposure. The units picocurie (pCi) and becquerel (Bq) are measures of radioactivity (number of nuclear transformations per unit of time). The concentration of radon in air is expressed as pCi/L (picocurie per liter) or Bq/m³ (becquerel per cubic meter). The conversion factor is 1 pCi/L equals 37 Bq/m³.⁵ The units of working level and working level month (WLM) relate concentrations of radon progeny to the dose of radiation to tissue and were developed to be used to assess uranium mining exposures. A working level is defined as short-lived radon decay products in 1 L of air that will emit 1.3×10^5 MeV of potential α energy. A WLM is exposure to one working level for 1 month or 170 hours.

Exposure to radon

The U.S. Environmental Protection Agency (EPA) estimates that ambient (outdoor) average radon concentrations range from approximately 0.16 to 0.57 pCi/L.¹ Outdoor levels of radon vary with numerous factors including location, weather conditions, height above ground level, and time of day. Ambient levels may be higher in the Western United States than in the Eastern United States because of the presence of uranium deposits.¹ Temperature inversions result in higher levels.⁶ Ambient levels are reduced by half for every 1000 meters above ground level and are higher at night than during the day.⁶

Radon moves into homes through avenues such as cracks or holes in the foundations and accumulates in the indoor environment. It is drawn inside because of gradients between higher air pressures in the soil surrounding home foundations and the lower air pressures in homes, particularly basements.

Indoor radon levels vary from home to home, from state to state within the United States, and from country to country. Causes of variation in radon levels include season (higher in winter),¹ level in home (higher in lower floors),⁸ degree of ventilation (lower with increased ventilation),⁸ type of construction materials (lower with radon-resistant materials),⁹ location (higher in rural homes),⁸ and soil variables (higher in presence of uranium mill byproducts and granite and varies with soil porosity and moisture).³

Complete data, based on long-term sampling in a large sample of homes, on the number and location of U.S. homes with elevated levels of radon are not yet available, but a great deal of information has been analyzed and further data are being gathered. The U.S. EPA has estimated that the average level in homes is 1.25 pCi/L^{1, 10} and that 82% of homes have radon levels below 2 pCi/L, 7% have levels between 2 and 3 pCi/L, 6% have levels between 3 and 5 pCi/L, and 5% have levels above 5 pCi/L.¹ In every state in which the U.S. EPA has performed short-term testing, there are homes with elevated levels, although the percentage varies from state to state.^{8, 11, 12}

FIG. 1. Atomic decomposition (half-lives). (Modified from National Council on Radiation Protection. Control of radon in houses. Bethesda, Maryland: National Council on Radiation Protection, 1989 [report No. 3]; and Nero AV. Radon and its decay products in indoor air: an overview. Elements of a strategy for control of indoor radon. In: Nazaroff WW, Nero A, eds. Radon and its decay products in indoor air. New York: John Wiley & Sons, 1968:1-53, 459-87. Copyright 1968. Reprinted by permission of John Wiley & Sons, Inc.)

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Risk assessment

Only a limited number of epidemiologic studies have been conducted on the risk of indoor radon exposure in the general population, and most have been ecologic studies.^{[1](#), [13](#), [14](#)} The more recent case-control studies that used radon measurements obtained in subjects' homes have produced mixed results on indoor radon exposure and lung cancer risk.^{[1](#), [13](#), [14](#)} Further case-control studies are underway.^{[13](#), [15](#)}

Several models have been developed to project risks from indoor radon based on data from studies of underground miners. Risk assessment for lung cancer resulting from radon exposure in indoor air is generally agreed to be performed most appropriately with a linear, nonthreshold model.^{[1](#), [16](#)} The models for projecting risks to the general population have been developed by the National Institute of Occupational Safety and Health, the National Council on Radiation Protection and Measurements, and the Biological Effects of Ionizing Radiation IV Committee of the National Research Council.^{[1](#), [2](#), [6](#)}

Uncertainties are associated with extrapolating from data from underground miners to the general population.^{[1](#), [10](#), [13](#), [14](#)} These uncertainties include the differences between doses received from mining and indoor environments, demographic differences between miners (primarily adult males) and the general population, limited follow-up of miners, interaction between radon exposure and smoking, changes in cancer risk with time after exposure, and whether children are more sensitive to radon exposure than adults.

Limited data are available on the interaction between radon exposure and smoking, the effect of

age at exposure, and the variation in effect based on exposure rates. Available data suggest that the risk of lung cancer with exposure to radon and smoking are at least additive and most likely multiplicative.^{[1](#) [2](#) [10](#) [16](#)} No definitive data are available on the sensitivity of children to radon exposure.^{[1](#) [10](#)}

The determination of the dose to the respiratory tract resulting from exposure to radon depends on several factors including the amount of air inhaled, use of mouth versus nose breathing, physical characteristics of the air (including size distribution of aerosols and whether the radon daughters are attached to particulates), and physical and biologic characteristics of the airways (including branching pattern and rate of mucociliary clearance).^{[2](#) [5](#) [10](#)}

The U.S. EPA's most recent analysis of the risk from exposure to indoor radon was published in 1992.^{[10](#)} According to this analysis, it is estimated that the average annual exposure to residential radon is 0.242 WLM/yr, resulting in 13,600 radon-induced lung cancer deaths in the United States each year. The EPA analysis recognized the uncertainty in several variables in its risk calculations, resulting in a range between 6740 and 30,600 deaths. The variables that were addressed included the relationship between the dose to the bronchial epithelium for radon exposure that occurs in the home versus that occurring in mines, the average residential exposure, and the average percentage of time a resident spends at home. The U.S. EPA used the following estimates in its calculation of risk associated with indoor radon exposure: (1) dose per WLM for exposure in homes is 30% less than for exposure in mines; (2) average residential radon level is 1.25 pCi/L; and (3) average resident spends 75% of time at home.

EPA recommendations for testing and mitigation

As the only way to determine indoor radon levels is through testing, the EPA recommends that single-family homes, mobile homes with permanent foundations, and units below the third floor in multi-unit housing be tested.^{[1](#)} This constitutes 83 million housing units, approximately 6% of which have been tested.^{[1](#)} In addition to initial testing, the EPA recommends testing before and after renovations and after mitigation is completed for previously documented high radon levels.^{[1](#)}

There are two general types of testing: short-term and long-term.^{[1](#)} Short-term testing involves 2 to 90 days of testing with a variety of methods, such as charcoal canisters or α -track detectors. Charcoal canisters contain activated charcoal that adsorbs radon. Alpha track detectors consist of a piece of film or plastic enclosed in a container with a filter cover, and α -particles released by radon decay products hit the detector and produce recordable tracks. Long-term testing requires more than 90 days and takes into account seasonal and ventilation fluctuations and therefore provides a more accurate measurement of radon levels. Long-term testing may be done through a variety of methods including α -track detectors and electret ion chamber detectors. The EPA recommends the use of tests that are labeled as meeting EPA recommendations.^{[17](#)}

The U.S. EPA recommends initial short-term testing on the lowest lived-in level with windows and doors closed as much as possible.^{[1](#)} If the initial short-term test is elevated above the action level of

4 pCi/L (150 Bq/m³), second confirmatory short-term or long-term testing is recommended in lowest lived-in areas of the home and testing of well water if present.¹ The EPA recommends, but does not require, that mitigation measures be undertaken in homes when the radon level is greater than the action level.¹ It also recommends that mitigation measures be considered if the level is 2 to 4 pCi/L.¹ The EPA estimates that less than 3% of homes with radon levels greater than 4 pCi/L have been mitigated.¹ International organizations, including the World Health Organization and International Commission on Radiation Protection, recommend lower levels of 100 Bq/m³ (approximately 3 pCi/L) for new buildings.¹⁸

The U.S. EPA's decision to establish 4 pCi/L as the action level for remediation in homes is based on technology limitations.¹ Studies of mitigation effectiveness have suggested that elevated radon levels could be reduced to 4 pCi/L in more than 95% of cases, and in up to 30% of cases the level could not be reduced to 2 pCi/L. Also, the radon indoor measurement testing error is 50% at 2 pCi/L with available technology.

The U.S. EPA's Citizen's Guide specifically states that no safe level has been established.¹⁷ It estimates that for every 1000 persons exposed to a radon level of 4 pCi/L over a lifetime, that among smokers, 29 would develop lung cancer and among those who never smoked, two would develop lung cancer.¹⁷ To put this into perspective, the risk of dying of radon-induced lung cancer is less than the risk of dying in an automobile accident from "drunk driving" but is greater than the risk of dying in a drowning accident, fire, or airline crash.¹⁷

The estimated cost is \$28 for short-term testing, and \$100 for long-term testing,¹ which includes the cost of the test kit and report of results. The cost of remedial measures to a home ranges from \$500 to \$2500 (with an average of \$1200).¹ Annual operating costs can range from \$70 to \$700, according to the EPA.¹ One study concluded that the average cost of mitigation measures could be as high as \$5600.¹⁹

The U.S. EPA recommends that mitigation be done by contractors who have passed the agency's proficiency test.¹ Lists of such contractors are available from state radon offices. The mitigation measures will vary but are generally aimed at reducing radon entry, increasing ventilatory rate, filtering indoor air, avoiding building on sites with high soil radon content, and using radon-resistant construction techniques.^{1 20} Depressurization of soil, including sub-slab depressurization, which basically vents the radon to the outdoor environment rather than to the home, is one of the most common techniques to reduce radon entry.

Regulation of indoor radon

Federal regulatory efforts related to indoor air quality issues, including radon, are rather unique; the goal is to provide homeowners with information and allow them to make the decision regarding

testing and mitigation. At the federal level the emphasis for radon is on gathering further data on the risks of indoor radon exposure and educating the public regarding recommendations for reducing the risk. Federal activities are to be coordinated by the Interagency Committee on Indoor Air Quality. The federal programs do not require radon testing in homes, mitigation activities, or licensing of contractors or testing firms. A 1991 federal government study of its efforts, "Indoor Air Pollution: Federal Efforts Are Not Effectively Addressing A Growing Problem," concluded that more funding was required to address indoor air problems.²¹ At the state and local level, several more specific regulatory measures, including licensing of radon testing and mitigation companies, specifying new construction standards related to indoor air quality and requiring disclosure of radon levels in real estate transactions, are mandated in some jurisdictions.

The federal Indoor Radon Abatement Act, a part of the Toxic Substances Control Act, sets a long-term goal of lowering indoor radon levels to ambient levels.²² The program also requires the EPA to: (1) publish revised copies of "A Citizen's Guide to Radon" as necessary; (2) develop model standards for controlling radon levels in new buildings; (3) provide assistance to state radon programs; and (4) study radon levels in school buildings.

The federal Radon Gas and Indoor Air Quality Research Programs under the Superfund Act requires that the federal EPA: (1) identify locations with elevated radon levels; (2) assess radon levels; (3) determine the radon level that presents a threat to human health; (4) determine methods to reduce radon levels; and (5) disseminate information to the public regarding radon.²³

The array of federal programs also includes regulation of occupational radon exposure of underground miners to 4 WLM/yr,²⁴ regulation of uranium mill tailings,²⁵ listing of radon as a hazardous pollutant under the Clean Air Act,²⁶ study of radon levels in federal buildings,²² and compensation of certain uranium mine workers.²⁷

Future regulatory options for controlling indoor radon levels include mandating the reduction of the average level of radon in all homes or identifying homes with extremely high levels of radon and remediating only those situations.¹⁹ Recent proposed legislation would require licensing of testing and mitigation companies, require the Occupational Safety and Health Administration to survey radon levels in workplaces, and require identification of buildings with very high levels.

With increasing public awareness of and concern about environmental exposures, physicians can expect more patient inquiries on the effects of such exposures, including radon, and can expect requests for input into the development of and compliance with regulations. The American Medical Association¹⁶ and the American College of Occupational and Environmental Medicine⁷ have reviewed the role of physicians related to radon exposure of patients. The American Medical Association concluded that regarding radon, physicians should advise patients to stop smoking and "should consider the risk of continued exposure and the costs and efficacies of different types of remedial action. Of course, concerns about health always should take precedence."¹⁶ Physicians must also remain informed as further guidance becomes available about the risks of indoor radon exposure, control measures, and regulatory requirements. One study of the public's perception of the radon issue has suggested the need for further public education on the need for radon testing,

health risks of radon, and the costs and benefits of mitigation techniques.²⁸

Several governmental agencies, including the EPA, are required to provide information on radon to citizens on request. The EPA has readily available informative guides: “The 1992 Citizen's Guide to Radon,”¹⁷ “Consumer's Guide to Radon Reduction,”²⁰ and “Technical Support Document for the 1992 Citizen's Guide to Radon.”¹ Other sources of information include state radon offices, state or local health departments, and the American Medical Association. The Appendix gives a list of sources to contact for additional information.

Man-made Vitreous Fibers

TOP

The term “man-made mineral fiber” is commonly used in the governmental, trade, and medical literature. The term “man-made vitreous fiber” (MMVF) is more appropriate because a mineral is a naturally occurring, inorganic compound and cannot be man-made.²⁹ The three main categories of MMVF are glass fiber (glass wool, continuous glass filament, and special-purpose glass fiber), mineral wool (rock wool and slag wool), and ceramic fiber (ceramic textile fiber and refractory ceramic fiber). Glass fiber is commonly referred to as fibrous glass or fiber glass.

Typical end uses of glass wool and to a lesser extent slag and rock wool include acoustic ceiling board and wall panels and insulation batts, blankets, and blowing wool. Glass wool also commonly is used in air handling systems. Continuous glass filament can be woven into fabric and is used as a plastic reinforcement agent. Ceramic fiber and special-purpose glass fiber are predominately used in specialty industrial settings and not in residential or commercial applications.³⁰

Determinants of biologic effects

The type of glass, rock, and slag wool used in residential and commercial settings has a very low order of respiratory toxicity. The vast majority of the fibers are not of respirable size and therefore do not penetrate to the alveoli portion of the lung. Fibers considered respirable size are less than 3.0 to 3.5 μm in diameter and less than 200 μm in length. Glass wool averages 3 to 10 μm in diameter and mineral wool 3.5 to 7 μm in diameter.^{30, 31} The average diameter of glass wool found in building insulation is 6 to 8 μm .³² However, the glass, rock, and slag wool manufacturing process produces wide distribution in fiber diameter, and this results in the production of some fibers that fall within the respirable range. The fibers that are of respirable size and do become airborne are generally felt to have limited lung retention.^{31, 33}

Airborne concentrations

Airborne concentrations of MMVF during installation in commercial and residential settings can vary according to installation techniques and average fiber diameter. Overall about two thirds of airborne MMVF measured by transmission electron microscopy during loft installation are within the respirable range. Airborne concentrations are higher for blown glass fiber insulation versus blanket insulation, and in unusual circumstances when special purpose glass fibers with diameters less

than 3 μm are used. During glass fiber installation in lofts, respirable fiber concentrations by transmission electron microscopy are generally less than 0.1 fiber/cc, and corresponding living space concentration less than 0.006 fiber/cc. The blown glass method of insulation corresponds to living space concentrations up to 0.02 fiber/cc.³⁴ Follow-up studies have demonstrated that MMVF concentrations decrease to 0.005 fiber/cc or less within 24 hours of installation of new insulation or disturbance of old insulation and subsequently can drop to 0.0002 fiber/cc or less.³⁵

Measurements of airborne concentrations of respirable MMVF by the less-sensitive phase contrast microscopy in buildings with MMVF ceiling boards are 0.0002 fiber/cc or less. The concentrations of respirable MMVF are lower in rooms with mechanical ventilation. For nonrespirable MMVF, concentration decreases with increased quality of room cleaning and is not affected by ventilation rate. Surface sampling of furniture appears to be a sensitive method for detecting MMVF in indoor environments.³⁶

The ranges of airborne glass fiber concentration in typical environmental exposure situations have been summarized in a monograph by the World Health Organization.³⁷ Ambient area concentration in rural areas and in buildings with thermal insulation is “ultra low” at less than 0.0001 fiber/cc. Ambient air concentrations in urban areas and in buildings with ceiling boards and ventilation systems are “extremely low” at 0.0001 to 0.001 fiber/cc. Buildings with some damage have “very low” concentrations at 0.001 to 0.01 fiber/cc, and buildings with severe damage have “low” concentration at 0.01 to 0.1 fiber/cc. “Medium” (0.1 to 1.0 fiber/cc) and “high” concentrations (greater than 1.0 fiber/cc) are found in some glass fiber manufacturing and secondary production industries and with blowing of glass wool into attics.³⁸ In general, levels in indoor air are on the order of 100 to 1000 times less than those found in the occupational environment.³⁷

Air handling systems

Glass fiber has been used extensively in the construction of fiber glass air handling systems. The fiber glass may be used inside or outside of metal air ducts, or the air ducts can be constructed entirely of rigid fiber glass duct board. The benefits of using fiber glass in air handling systems include thermal and acoustic insulating properties and control of condensation.^{39 40}

Properly designed and maintained fibrous glass ventilation ducts do not entrain fibers into the air.⁴¹
⁴² Peak levels of glass fiber during installation of fiber glass air handling products has been reported to be 0.2 fiber/cc by the North American Insulation Manufacturers Association study group.³⁹ The level of glass fiber in an occupied space during the first day use of a fiber glass air filter within a ventilation system was measured at 0.001 fiber/cc. Subsequent measures for the life of the filter were at ambient background levels.⁴³

When properly designed, installed, operated, and maintained, fiber glass air handling systems do not present a fungal or bacterial contamination problem. Microorganisms such as human-shed bacteria and spores of fungi commonly found in outdoor air can be found normally in air handling systems. When fiber glass becomes wetted, particularly in areas in which dust and dirt accumulate,

higher concentration of unusual taxa can occur, and bioaerosols can be released into the air supply system. This can occur particularly during remediation activities of water-damaged air handling units. Demonstration of high concentrations of unusual organisms for an indoor environment within the breathing zone of occupants can help determine a potential link with respiratory illnesses such as hypersensitivity pneumonitis. ^{39 40}

Dermatitis

Irritation from glass fiber exposure has been reported in office buildings when improper construction facilitated entry of glass fiber into indoor air and onto office furniture. Release of MMVF from ceiling boards may occur through direct physical damage or indirectly through movement of boards by unusual building vibration or room pressure changes when doors are opened and closed. Ceiling boards made with water soluble resin can disintegrate and release fiber into a room after water damage. Symptoms have ranged from intense itching, especially involving the neck and forearms, to burning eyes, sore throat, and coughing. Corrective measures resulted in the resolution of symptoms of office workers. ^{44 46}

Skin irritation is the most frequent health effect from exposure to glass fiber. The irritation is from physical injury from fibers greater than 4 to 5 μm in diameter. ^{47 48} Glass fiber can be found to penetrate the stratum corneum and occasionally deeper into the epidermis. Intense itching of the skin without objective findings other than excoriation from scratching is the hallmark complaint, especially where bare skin comes in contact with a surface contaminated with glass fiber such as the forearm, within skin folds, or where clothing is in tight contact with the skin, such as the neck area. Other cutaneous signs may include transient, small erythematous papules that are often follicular, less frequent erythematous papules, urticaria, petechiae, erosions, and rarely nummular eczema. Allergic contact dermatitis is rare because of thermosetting of the phenol-formaldehyde resins used to bind the fibers together. ^{32 49}

The irritation from glass fiber is from direct skin contact with the fiber on a surface such as a desk or table top, or arms or seat of a chair. A practical procedure to determine if glass fiber is the etiologic agent is to sample for glass from the affected area by use of cellophane tape to lift adherent debris and cells from the stratum corneum. Microscopic examination of the sample will demonstrate rodlike fibers. ^{32 49}

Man-made vitreous fibers can have the same type of reversible mechanical effect on the eye as on the skin. Eye symptoms have been related to work conditions in a MMVF manufacturing plant. ⁵⁰

Upper and lower respiratory tract symptoms

Transient symptoms of the upper and lower respiratory tracts have been reported in persons who worked directly with fiber glass in various dusty types of occupational settings. ⁵¹ There also have been isolated reports of upper and lower respiratory tract symptoms from fibers released from residential air conditioning systems and compressed mineral wool ceilings. ^{37 52} A family with an improperly installed air conditioning duct lined with fiber glass had a massive home contamination.

There was observed accumulation of dust throughout the home, and the family was forced to vacate the premises because of the severity of the respiratory symptoms including nasal congestion, cough, sneezing, shortness of breath, and exacerbation of a previously existing asthmatic condition. The diameter of the fiber glass from the duct lining ranged from 0.5 to 14 μm and bronchial washings from one of the family members revealed diameters ranging from 0.5 to 0.7 μm . The family was able to reoccupy the home after disposal of all upholstered furniture, carpets, and draperies and thorough cleaning with vacuums with filters capable of removing particulates as small as 0.3 μm .^{[52](#)}

Conclusions

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Dermatitis is the primary health abnormality associated with MMVF building products used in residential and commercial buildings. This can occur if glass wool insulation is not properly isolated from the living or work environment, or ceiling boards or fiber glass ventilation ducts are damaged and fibers are entrained into the air handling system. Proper construction and maintenance procedures, and regular cleaning of the work environment will solve any glass fiber-related skin problems. Acute symptoms of the upper and lower respiratory tracts can occur in situations with unusually high exposures because of improper construction, maintenance, or damage. The risk for any significant long-term health-related problems to occupants from exposure to MMVF used in residential and commercial applications is nil.^{[33](#) [37](#)}

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[TOP](#)

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Appendix

TOP

The following is a list of resources for information on radon:

U.S. EPA Public Information Center

(202) 260-2080

EPA Regional Radon Offices

Region 1 (CT, ME, MA, NH, RI, and VT)

(617) 565-4502

Region 2 (NJ, NY, PR, and VI)

(212) 264-6459

Region 3 (DE, DC, MD, PA, VA, and WV)

(215) 597-4084

Region 4 (AL, FL, GA, KY, MS, NC, SC, TN)

(404) 347-3907

Region 5 (IL, IN, MI, MN, OH, and WI)

(800) 572-2515(IL)

(800) 621-8431 (other states)

Region 6 (AR, LA, NM, OK, and TX)

(214) 655-7223

Region 7 (IA, KS, MO, and NE)

(913) 551-7020

Region 8 (CO, MT, ND, SD, UT, and WY)

(303) 293-0988

Region 9 (AZ, CA, HI, NV, AS, and GU)

(415) 744-1045

Region 10 (AK, ID, OR, and WA)

(206) 553-7299

Bonneville Power Administration (regarding mitigation)

(503) 230-5475

Publishing and Reprint Information

TOP

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