Designation: E2121 – 21

Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings[1]

This standard is issued under the fixed designation E2121; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes methods for reducing radon entry into existing attached and detached residential buildings three stories or less in height. This practice is intended for use by trained, certified or licensed, or both, or otherwise qualified individuals.

1.2 These methods are based on radon mitigation techniques that have been effective in reducing radon levels in a wide range of residential buildings and soil conditions. These fan powered mitigation methods are listed in Appendix X1. More detailed information is contained in references cited throughout this practice.

1.3 This practice is intended to provide radon mitigation contractors with a uniform set of practices that will ensure a high degree of safety and the likelihood of success in retrofitting low rise residential buildings with radon mitigation systems.

1.4 The methods described in this practice apply to currently occupied or formerly occupied residential buildings, including buildings converted or being converted to residential use, as well as residential buildings changed or being changed by addition(s) or alteration(s), or both. The radon reduction activities performed on new dwellings, while under construction, before occupancy, and for up to one year after occupancy, are covered by Practice E1465.

1.5 This practice also is intended as a model set of practices, which can be adopted or modified by state and local jurisdictions, to fulfill objectives of their specific radon contractor certification or licensure programs. Radon mitigation performed in accordance with this practice is considered ordinary repair.

1.6 The methods addressed in this practice include the following categories of contractor activity: general practices, building investigation, systems design, systems installation, materials, monitors and labeling, post-mitigation testing, and documentation.

1.7 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* See Section 6 for specific safety hazards.

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E1465 Practice for Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings (Withdrawn 2017)[3]

E1745 Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

2.2 *Government Publications:*

EPA "Asbestos School Hazard Abatement Reauthorization Act," regulation 40 CFR Part 763, Subpart E.[4]

EPA "A Citizen's Guide to Radon (Second Edition)," EPA 402-K92-001, May 1992.[4]

[1] This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.41 on Air Leakage and Ventilation Performance.

Current edition approved Oct. 1, 2021. Published October 2021. Originally approved in 2001. Last previous edition approved in 2013 as E2121 – 13. DOI: 10.1520/E2121-21.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20004, http://www.epa.gov.

EPA "Consumer's Guide to Radon Reduction," EPA 402-K92-003, August 1992.[4]
EPA "Handbook, Sub-Slab Depressurization for Low-Permeability Fill Material," EPA/625/6-91/029, July 1991.[4]
EPA "Home Buyers and Sellers Guide," EPA 402–K-00–008, July 2000.[4]
EPA "National Emission Standard for Asbestos," 40 CFR 61, Subpart M.[4]
EPA " Radon Mitigation Standards," EPA 402-R-93-078, April 1994.[4]
EPA "Radon Reduction Techniques for Existing Detached Houses, Technical Guidance (Second Edition)," EPA/625/5–87/019, revised January 1988.[4]
EPA "Radon Reduction Techniques for Existing Detached Houses, Technical Guidance (Third Edition) for Active Soil Depressurization Systems," EPA/625/R-93-011, October 1993.[4]
NCRP "Measurement of Radon and Radon Daughters in Air," NCRP Report No. 97, 1988.[5]
NIOSH "Guide to Industrial Respiratory Protection," NIOSH Publication No. 87–116.[6]
OSHA "Asbestos Standard for the Construction Industry" 29 CFR 1926.1102.[7]
OSHA "Hazard Communication Standard for the Construction Industry," 29 CFR 1926.59.[7]
OSHA "Occupational Safety and Health Regulations, Ionizing Radiation," 29 CFR 1910.96.[7]
OSHA "Respiratory Protection Standard," 29 CFR 1920.134, 1998.[7]
OSHA "Safety and Health Regulations for Construction, Ionizing Radiation," 29 CFR 1926.53.[7]

3. Terminology

3.1 *Definitions*—Definitions of terms used in this practice are defined in accordance with Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *active soil depressurization (ASD), n*—a family of radon mitigation systems involving mechanically-driven soil depressurization, including sub-slab depressurization (SSD), sump pit depressurization (SPD), drain tile depressurization (DTD), hollow block wall depressurization (BWD), and sub-membrane depressurization (SMD) (see Appendix X2).

3.2.2 *backdrafting, n*—a condition where the normal movement of combustion products up a flue (due to the buoyancy of the hot flue gases), is reversed, so that the combustion products enter the building (see *pressure-induced spillage*).

3.2.3 *communication test, n*—a diagnostic test to evaluate the potential effectiveness of a sub-slab depressurization system by applying a vacuum beneath the slab and measuring, either with a micromanometer or with a heatless smoke device, the extension of the vacuum field. Also called *pressure-field extension test.*

3.2.4 *contractor, n*—for the purposes of this practice, a contractor is one who contracts to performs radon reduction activities or is an employee of one who contracts to perform or performs radon reduction activities, with the expectation that payment will be received for the work performed. A person who does radon reduction activities as an employee of a building owner is also a contractor for purposes of this practice. Persons whose normal activity is not radon reduction, but who do work related to radon reduction like indoor air quality consultants, radon consultants, plumbers, building contractors, or employees of these persons are all viewed as contractors when performing radon reduction activities covered by this practice.

3.2.5 *crawlspace depressurization (CSD) (active), n*—a radon mitigation technique designed to achieve lower air pressure in the crawlspace than in the rooms bordering and above the crawlspace. A radon fan, draws air from the crawl space and exhausts that air outside the building. Crawlspace depressurization (CSD) is intended to mitigate rooms bordering and above the crawlspace but not the crawlspace itself. All CSD systems, for purposes of this practice, are active.

3.2.6 *depressurization, n*—a negative pressure induced in one area relative to another.

3.2.7 *diagnostic tests, n*—procedures used to identify or characterize conditions under, beside and within buildings that may contribute to radon entry or elevated radon levels or that may provide information regarding the performance of a mitigation system.

3.2.8 *drain tile depressurization (DTD) (active), n*—a type of active soil depressurization radon mitigation system where the suction point piping attaches to a drain tile or is located in gas-permeable material near the drain tile. The drain tile or perimeter drain may be inside or outside the footings of the building.

3.2.9 *hollow wall depressurization (BWD) (active), n*—a radon mitigation technique that depressurizes the void space within a foundation wall (usually a block wall). A radon fan installed in the radon system piping draws air from within the wall.

3.2.10 *manifold piping, n*—this piping collects the flow of soil-gas from two or more suction points and delivers that collected soil-gas to the vent stack piping. In the case of a single suction point system, there is no manifold piping since the suction point piping connects directly to the vent stack piping. The manifold piping starts where it connects to the suction point piping and ends where it connects to the vent stack piping.

3.2.11 *mechanically-ventilated crawlspace system, n*—a radon-control technique designed to increase ventilation within a crawlspace by use of a fan.

3.2.12 *mitigation system, n*—any system or steps designed to reduce radon concentrations in the indoor air of a building.

[5] Available from the National Commission on Radiation Protection and Measurement (NCRP), 7910 Woodmont Avenue, Suite 400, Bethesda, MD 20814-3095, http://www.ncrponline.org.
[6] Available from Centers for Disease Control and Prevention (CDC), 1600 Clifton Rd., Atlanta, GA 30329-4027, http://www.cdc.gov.
[7] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

3.2.13 *natural draft combustion appliance, n*—any fuel burning appliance that relies on natural convective flow to exhaust combustion products through flues to outside air.

3.2.14 *occupiable spaces, n*—for purposes of this practice, are areas of buildings where human beings spend or could spend time, on a regular or occasional basis.

3.2.14.1 *Discussion*—Examples of occupiable spaces are those that are or could be used for sleeping, a work shop, a hobby, reading, student home work, a home office, entertainment (TV, music, computer, etc.), physical work-out, laundry, games, or child's play.

3.2.15 *pressure-field extension, n*—the distance that a pressure change, created by drawing soil-gas through a suction point extends outward in a sub-slab gas permeable layer, under a membrane, behind a solid wall, or in a hollow wall (see *communication test*).

3.2.16 *pressure-induced spillage, n*—the unintended flow of combustion gases from an appliance/venting system into a dwelling, primarily as a result of building depressurization (see *backdrafting*).

3.2.17 *radon system piping, n*—this active or passive soil depressurization piping is composed of three parts: suction point piping, manifold piping, and vent stack piping.

3.2.18 *re-entrainment, n*—the unintended re-entry of radon into a building from leaks in the radon system piping, from leaks in the fan housing, or from the discharge of the vent stack piping.

3.2.19 *soil-gas, n*—the gas mixture present in soil, which may contain radon.

3.2.20 *soil-gas-retarder, n*—a continuous membrane or other comparable material used to retard the flow of soil gases into a building. See Specification E1745 for permeance and durability of water vapor retarders that may be used as soil-gas-retarders.

3.2.21 *submembrane depressurization (SMD) (active), n*—a radon mitigation technique designed to achieve lower air pressure under a soil-gas-retarder membrane than above it. For example, a soil-gas-retarder membrane could be used to cover the soil found on a crawlspace floor. A radon fan installed in the radon system piping draws air from below the soil-gas-retarder membrane.

3.2.22 *sub-slab depressurization (SSD) (active), n*—a radon mitigation technique designed to achieve lower air pressure under a floor slab than above it. A radon fan installed in the radon system piping draws soil-gas from below the floor slab.

3.2.23 *sub-slab depressurization (passive), n*—a radon mitigation technique designed to achieve lower air pressure under a floor slab than above it. The radon system piping is routed through the conditioned (heated and cooled) space of a building.

3.2.24 *suction point piping, n*—one end of this piping penetrates the slab, the solid wall, the hollow wall, the membrane, the sump cover, or the drain tile. The other end extends outward to the first accessible pipe connection beyond the penetration of the soil-gas barrier.

3.2.25 *sump pit depressurization (SPD) (active), n*—a type of active soil depressurization radon mitigation system where the suction point piping enters the sump pit, that has a sealed gasketed cover, through the side or through the cover.

3.2.26 *vent stack piping, n*—this piping collects the soil-gas from the suction point pipe of single suction point systems or from the manifold piping of multi-suction point systems. There are no branches in vent stack piping; soil-gas is collected at one end of the vent stack piping and is discharged from the building at the other end. In active soil depressurization systems, the radon fan is installed in the vent stack piping.

3.2.27 *ventilation, n*—the process of introducing outdoor air into a building.

3.2.28 *working level (WL), n*—a unit of radon decay product exposure. Numerically, any combination of short-lived radon decay products in one litre of air that will result in the ultimate emission of 130 000 MeV of potential alpha energy. This number was chosen because it is approximately the total alpha energy released from the short lived decay products in equilibrium with 100 pCi of Rn-222.

3.2.29 *working level month (WLM), n*—a unit of exposure used to express the integrated human exposure to radon decay products. It is calculated by multiplying the average working level to which a person has been exposed by the number of hours exposed and dividing the product by 170.

4. Summary of Practice

4.1 This practice describes methods for mitigating elevated levels of radon in existing attached and detached residential buildings three stories or less in height.

4.2 The mitigation process is described in terms of the categories of activity associated with radon mitigation and includes: general practices, building investigation, systems design, systems installation, materials, monitors and labeling, post-mitigation testing, and contracts and documentation.

4.3 The systems installation category contains subsections describing the specific requirements applicable to each of the components of radon mitigation systems, for example, radon system piping, radon fans, sealing, electrical, etc.

5. Significance and Use

5.1 The purpose of the methods, systems, and designs described in this practice is to reduce radiation exposures for occupants of residential buildings caused by radon and its progeny. The goal of mitigation is to maintain reduced radon concentrations in occupiable areas of buildings at levels as low as reasonably achievable. This practice includes sections on reducing radiation exposure caused by radon and its progeny for workers who install and repair radon mitigation systems. The goal for workers is to reduce exposures to radon and its progeny to levels as low as reasonably achievable.

5.2 The methods, systems, designs, and materials described here have been shown to have a high probability of success in mitigating radon in attached and detached residential buildings, three stories or less in height (see EPA, "Radon Reduction Techniques for Existing Detached Houses, Technical Guidance