DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Radiation Protection

DOCUMENT NUMBER: 294-2309-002

TITLE: Pennsylvania Radon Mitigation Standards

EFFECTIVE DATE: March 4, 2023

AUTHORITY: 25 Pa. Code § 240

POLICY: It is the Department's Policy to provide certified radon mitigators guidance for the implementation of applicable regulations.

PURPOSE: This standard helps ensure uniformity, for the purposes of effectiveness and durability, during the installation of radon mitigation systems by certified mitigators.

APPLICABILITY: This document applies to all individuals and/or firms, certified by the Department of Environmental Protection (Department or DEP), to perform radon mitigation work within the Commonwealth.

DISCLAIMER: The policies and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements.

The policies and procedures herein are not an adjudication or a regulation. The Department does not intend to give these rules that weight or deference. This document establishes the framework, within which the Department will exercise its administrative discretion in the future. The Department reserves the discretion to deviate from this policy statement if circumstances warrant.

PAGE LENGTH: 23 pages

TABLE OF CONTENTS

1.0 BACKGROUND

The 1988 Indoor Radon Abatement Act (IRAA) required the Environmental Protection Agency (EPA) to develop a voluntary program to evaluate and provide information on mitigators who offer radon control services to homeowners. The Radon Contractor Proficiency (RCP) Program was established to fulfill this portion of the IRAA. In December 1991, EPA published Interim Radon Mitigation Standards as initial guidelines for evaluating the performance of radon mitigators under the RCP Program. The effectiveness of the basic radon mitigation techniques set forth in the Interim Standards has been validated in field applications throughout the United States. From this process, the EPA published the revised April 1994 version of the Radon Mitigation Standards. Those standards served as the backbone of the 1997 Pennsylvania Radon Mitigation Standards (PA RMS). Since then, additional radon mitigation standards have been published. As of May 2006, the EPA no longer recommends and no longer distributes its own Radon Mitigation Standards (EPA 402-R-93-078). Instead, the EPA references American National Standard Institute/American Association of Radon Scientists and Technologists (ANSI/AARST) Soil Gas Mitigation Standards for Existing Homes (SGM-SF 2017) or the most recent version. These standards and field experience now serve as the impetus for the latest version of the PA RMS.

2.0 PURPOSE

The PA RMS provides radon mitigators with uniform standards that will ensure quality and effectiveness in the design, installation, and evaluation of radon mitigation systems in detached and attached residential buildings with three stories or less. The PA RMS is intended to serve as a model set of requirements which have been adopted by DEP to fulfill the requirements of the Radon Certification Act (63 P.S. §§ 2001-2014), 25 Pa. Code § 240.

3.0 PARTICIPANTS

The minimum requirements for individuals or firms that perform radon remediation work within the commonwealth are established in 25 Pa. Code § 240.112, prerequisites for radon mitigation certification.

4.0 SCOPE

The requirements addressed in the PA RMS include the following categories of activity: general practices, building investigation, worker health and safety, systems design, systems installation, materials, monitors and labeling, post-mitigation testing, and contracts and documentation.

5.0 ASSUMPTION

Before applying the provisions of the PA RMS, it is assumed that appropriate radon/radon decay product measurements have been performed within the structure, and that the owner has decided that radon remediation is necessary.

6.0 IMPLEMENTATION

6.1 The PA RMS includes requirements for installation of radon remediation systems and provides a basis for evaluating the quality of those installations. All-mitigators certified by DEP should follow all requirements set forth in the PA RMS.

6.2 Certified mitigation individuals should personally conduct follow-up inspections of any radon mitigation system installed by their firm that was changed from the original design. Additionally, certified mitigation individuals should inspect 20 percent of all other installations within 30-days of system completion to ensure continued conformance to PA RMS.

6.3 DEP will inspect radon mitigation systems installed by DEP-certified mitigators for compliance with this standard and the DEP Radon Certification Regulations (25 Pa. Code § 240). Violations of these standards and regulations may result in decertification, suspension of certification, or civil penalties.

6.4 Those provisions of the PA RMS that are mandatory are prefaced by the term "shall." Provisions that are considered good practice, but which are not mandatory, are prefaced by the terms "should" or "recommended."

6.5 The PA RMS will be updated as necessary and in response to technological advances and field experience. The scope of the PA RMS will also be expanded when new revised mitigation technologies have been demonstrated in other types of residential and nonresidential buildings.

6.6 For areas of radon mitigation not covered by this standard, the mitigator should follow the guidance outlined in the reference documents (see paragraph 8.0) and their training obtained in DEP-approved radon mitigation courses.

7.0 LIMITATIONS

7.1 Although the provisions of the PA RMS have been carefully reviewed for potential conflicts with other regulatory requirements, adherence to the PA RMS does not guarantee compliance with the applicable codes or regulations of any other federal, state, or local agency having jurisdiction.

7.2 Where discrepancies exist between provisions of the PA RMS and local codes or regulations, local codes should take precedence.

7.3 The PA RMS is not intended to be used as a design manual and compliance with its provisions will not guarantee reduction of indoor radon concentrations to any specific level.

7.4 This standard shall not apply to radon mitigation systems installed prior to its effective date. However, if a radon mitigation system is found that does not comply with this standard, the certified mitigator should recommend in writing to the client that the system be upgraded or altered to meet this standard. The certified mitigator should obtain prior

approval from the client before implementing any of the certified mitigator's written recommendations.

7.5 Because of the wide variation in building design, size, operation and use, the PA RMS does not include detailed guidance on how to select the most appropriate mitigation strategy for a given building. Guidance for that topic is provided in the documents referenced in paragraphs 8.1 and 8.2.

7.6 The provisions of the PA RMS are limited to proven technologies and methods. Publication of this standard is not intended, however, to inhibit research and evaluation of other innovative radon mitigation techniques. When such research is conducted, a performance standard should be applied (i.e., post-mitigation radon levels shall be less than 4 pCi/L) and the systems design criteria in paragraph 13.0 shall be applied. A certified mitigation individual who expects to deviate from proven radon mitigation technologies and methods (as defined in the PA RMS and other EPA references in Section 8.0) for purposes of research on innovative mitigation techniques or for other reasons, should obtain written approval from DEP prior to initiation of work, document the nonstandard techniques, and inform the client of the deviation from standard procedures.

7.7 At this time, the PA RMS does not include standards for installing systems to mitigate radon in water.

7.8 The PA RMS should apply to any modification(s) to a structure that has the potential to alter the indoor radon concentration, whether intentionally or unintentionally, by the mitigator. This may include but is not limited to radon remediation, liquid water control, or moisture control.

8.0 REFERENCE DOCUMENTS

The following documents are sources of additional radon mitigation information and are recommended reading for mitigators. Always use the most recent version of the reference documents, where applicable.

8.1 Radon Reduction Techniques for Existing Detached Houses, Technical Guidance (Third Edition) for Active Soil Depressurization Systems EPA/625/R-93/011, October 1993.

8.2 Radon and Radon Decay Product Measurement Device Protocols, EPA 402-R-92-004, July 1992.

8.4 Protocols for Radon and Radon Decay Product Measurements in Homes, EPA 402-R-92-003, June 1993.

8.5 Pennsylvania Citizen's Guide to Radon, PA Department of Environmental Protection, 2900-BK-DEP0375.

8.6 Pennsylvania's Consumer's Guide to Radon Reduction, PA Department of Environmental Protection, 2900-BK-DEP1554.

8.7 Pennsylvania's Home Buyers' and Sellers' Guide to Radon, PA Department of Environmental Protection, 2900-BK-DEP1544.

8.8 ASHRAE Standard 62-2019, Appendix B, Positive Combustion Air Supply.

8.9 International Fuel Gas Code, Appendix G, 2015, Recommended Procedure for Safety Inspection of an Existing Appliance Installation.

8.10 Chimney Safety Tests User's Manual, Second Edition, January 12, 1988, Canada Shelter Consortium Inc., for Canada Mortgage and Housing Corp.

8.11 The Spillage Test Method to Determine the Potential for Pressure-Induced Spillage from Vented, Fuel-Fired, Space Heating Appliances, Water Heaters, and Fireplaces. Canadian General Standards Board. CAN/CGSB-51.71-2005, April 2005.

8.12 Occupational Safety and Health Administration (OSHA) Safety and Health Regulations for Construction, Ionizing Radiation, 29 C.F.R. § 1926.53.

8.13 OSHA Occupational Safety and Health Regulations, Ionizing Radiation, 29 C.F.R. § 1910.1096.

8.14 National Institute for Occupational Safety and Health (NIOSH) Guide to Industrial Respiratory Protection, DHHS Publication No. 87-116, September 1987.

8.15 NCRP Measurement of Radon and Radon Decay Daughters in Air, NCRP Report No. 97, November 1988.

8.16 EPA Handbook, Sub-slab Depressurization for Low-Permeability Fill Material, EPA/625/6-91/029, July 1991.

8.17 ASTM E-2121-03, Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings. February 2003.

8.18 ANSI/AARST Soil Gas Mitigation Standards for Existing Homes (SGM-SF 2017).

9.0 DESCRIPTION OF TERMS

This section contains defined terms. Terms not defined herein should be read their ordinary meaning as defined in Webster's Ninth New Collegiate Dictionary.

9.1 Backdrafting: A condition where the normal movement of combustion products up a flue, resulting from the buoyant forces on the hot gases, is reversed so that the combustion products can enter the structure. Backdrafting of combustion appliances (such as fireplaces and furnaces) can occur when depressurization in the structure overwhelms the buoyant force on the hot gases. Backdrafting can also be caused by chimney blockage.

9.2 Backer Rod: A semirigid closed cell foam material resembling a rope of various diameters used to fill around pipes, large cracks, etc. to assist in making a sealed penetration. For example, where a pipe is inserted through a concrete slab, a length of backer rod is compressed into the opening around the pipe. Caulking is then applied to the space above the backer rod and between the outside of the pipe and the slab opening. The purpose of the backer rod is to hold the semifluid caulk in place until it sets or hardens, and act as a bond breaker.

9.3 Block Wall Depressurization (BWD): A radon mitigation technique that depressurizes the void network within a block wall foundation by drawing air from inside the wall and venting it to the outside.

9.4 Certified: A rating applied by DEP to individuals or firms that are authorized to provide radon -related services within the Commonwealth.

9.5 Client: The person, persons, or company that contracts with a radon mitigator to install a radon reduction system in a building.

9.6 Combustion Appliance: Any device which utilizes the ignition of a fuel to perform work for a specific purpose including but not limited to heating, drying, cooling, and refrigeration.

9.7 Combination Foundation: Buildings constructed with more than one foundation type (e.g., basement/crawl space or basement/slab-on-grade).

9.8 Communication Test: A diagnostic test designed to qualitatively measure the ability of a suction field and air flow to extend through the material beneath a concrete slab floor and thus evaluate the potential effectiveness of a sub-slab depressurization (SSD) system. This test is commonly conducted by applying suction to a hole drilled through the slab where a future suction hole might be located and simultaneously measuring the pressure differential or observing the movement of smoke downward into small holes drilled in the slab at locations away from the suction hole. For a quantitative assessment of this test one would use a digital micromanometer to measure the actual pressure differential. (See also paragraph 9.18, Pressure Field Extension.)

9.9 Crawl Space Depressurization (CSD): A radon control technique designed to achieve lower air pressure in the crawl space relative to indoor air pressure by use of a fan powered-vent drawing air from within the crawl space. (See also paragraph 9.14, Mechanically Ventilated Crawl Space System.)

9.10 Diagnostic Tests: Procedures used to identify or characterize conditions within buildings that may contribute to radon entry or elevated radon levels; or may provide information regarding the design installation or performance of a mitigation system.

9.11 Drain Tile Loop: A continuous length of drain tile or perforated pipe extending around all or part of the internal or external perimeter of a basement or crawl space footing.

9.12 Mitigation System: Any system or steps designed to reduce radon concentrations in the indoor air of a building.

9.13 Mitigator: A DEP-certified mitigation individual or a DEP-listed mitigation employee of a DEP-certified mitigation firm.

9.14 Mechanically Ventilated Crawl Space System: A radon control technique designed to increase ventilation within a crawl space, achieve higher air pressure in the crawl space relative to air pressure in the soil beneath the crawl space, or achieve lower air pressure in the crawl space relative to air pressure in the living spaces by use of a fan. (See also paragraph 9.9, Crawl Space Depressurization.)

9.15 Natural Draft Appliance: Any combustion appliance that does not have fan-forced combustion venting and therefore, is more likely to be susceptible to backdrafting.

9.16 pCi/L: The abbreviation for picocuries per liter which is a unit of measure for the amount of radioactivity in a liter of air. There are 2.2 disintegrations per minute of radioactive material in 1 picocurie.

9.17 Perimeter Channel Drain: A means for collecting water in a basement by means of a large gap or channel between the concrete floor and the wall. Collected water may flow to aggregate beneath the channel (French drain) or to a sump where it can be drained or pumped away.

9.18 Pressure Field Extension: The distance that a pressure change is induced in the sub-slab area measured from a single or multiple suction points. (See also paragraph 9.8, Communication Test.) For quantitative purposes, one should use a digital micromanometer.

9.19 Radon: A naturally occurring radioactive element (Rn-222) which exists as a gas and is measured in picocuries per liter (pCi/L).

9.20 Radon Resistant Drain: A floor drain that has a check valve that minimizes air flow if the drain trap dries up or the trapped drain has an automatic supply of priming water.

9.21 Radon Decay Products: The four short-lived radioactive elements (polonium-218, lead-214, bismuth-214, and polonium-214) which exist as solids and immediately follow Rn-222 in the decay chain. They are measured in units of working levels (WL).

9.22 Re-entrainment: The unintended reentry into a building of radon that is being exhausted from a radon mitigation system.

9.23 Soil Gas: The gas mixture present in soil which may contain radon.

9.24 Soil Gas Retarder: A continuous membrane or other comparable material used to retard the flow of soil gases into a building.

9.25 Stack Effect: The overall upward movement of air inside a building that results from heated air rising and escaping through openings in the building envelope, causing indoor air pressure in the lower portions of a building to be lower than the pressure in the soil beneath or surrounding the building foundation.

9.26 Submembrane Depressurization (SMD): A radon control technique designed to achieve lower air pressure in the space under a soil gas retarder membrane laid on the crawl space floor, relative to air pressure in the crawl space, by use of a fan-powered vent drawing air from beneath the membrane. Complete sealing of these membranes is required.

9.27 Subslab Depressurization (Active): A radon control technique designed to achieve lower sub-slab air pressure relative to indoor air pressure by use of a fan-powered vent drawing air from beneath the concrete slab.

9.28 Subslab Depressurization (Passive): A radon control technique designed to achieve lower sub-slab air pressure relative to indoor air pressure by use of a vent pipe (without a fan) routed through the conditioned space of a building and connecting the sub-slab area to the outdoor air. This system relies solely on wind-induced vent pipe draft and the convective flow of warmed air upward in the vent to draw air from beneath the concrete slab.

9.29 Working Level (WL): A unit of radon decay product concentration. Numerically, any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 130,000 million electron-volt 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 per liter of air. (See also the referenced document in paragraph 8.13.)

9.30 Working Level Month (WLM): A unit of exposure used to express the accumulated human exposure to radon decay products. It is calculated by multiplying the average WL to which a person has been exposed by the number of hours exposed and dividing the product by 170.

10.0 GENERAL PRACTICES

The following general practices should be adhered to for all contacts between radon mitigators and client:

10.1 During the initial contact with the client, the mitigator should request and review recent radon test result(s). The mitigator should inform the client when it is determined that previous radon test results were not performed according to current DEP-approved testing protocols and recommend a retest be done.

10.2 Based on guidance contained in the “Pennsylvania Citizen’s Guide to Radon” (see paragraph 8.5), and “Pennsylvania’s Home Buyers’ and Sellers’ Guide to Radon” (see paragraph 8.7) or subsequent revisions of these documents, the mitigator should refer the client to the discussions of interpreting indoor radon test results and the health risk associated with the radon concentration found in the building. The “Pennsylvania Consumer’s Guide to Radon Reduction” (see paragraph 8.6) is an appropriate reference for providing advice on actions to take to reduce indoor radon concentrations.

10.3 When delays in the installation of a permanent radon control system are unavoidable due to building conditions or construction activities and a temporary system is installed, the

mitigator should inform the client about the temporary nature of the system. A label that is readable from at least three feet should be placed on the system. The label should include a statement that the system is temporary and that it will be replaced with a permanent system within 30 days. The label should also include the date of installation, the name, phone number, and DEP certification identification number of the certified mitigation individual or firm. (EXCEPTION: The 30-day limit on use of a temporary mitigation system may be extended in cases where a major renovation or change in building use necessitates a delay in installation of a permanent mitigation system that is optimized to the new building configuration or use. DEP's Bureau of Radiation Protection should be notified in writing when this exception is being applied.)

10.4 When the selected mitigation technique requires use of sealants or caulks containing volatile solvents, prior to starting work, the mitigator should inform the client in writing (this could include a material safety data sheet) of the need to ventilate work areas during and after the use of such sealants. Ventilation should be provided as recommended by the manufacturer of the material.

11.0 BUILDING INVESTIGATION

11.1 Per 25 Pa. Code 240.308 (a), 'the certified individual shall conduct a thorough visual inspection of the building prior to initiating any radon mitigation work.'

This inspection should be performed prior to submission of the bid proposal to the client. The inspection is intended to identify any specific building characteristics or configurations (e.g., large cracks in slabs, exposed earth in crawl spaces, open sump pits, wet basement or foundation walls) that may affect the design, installation, and effectiveness of radon mitigation systems. As a part of this inspection, clients should be asked to provide any available information about the building (e.g., construction specifications, pictures, drawings, etc.) that might be of value in determining the radon mitigation strategy.

11.2 To facilitate selection and design of the most effective radon control system and avoid the cost of installing systems that subsequently prove to be ineffective, it is recommended that the mitigator conduct diagnostic tests to assist in identifying and verifying suspected radon sources, entry points, and sub-slab communication. Radon grab sampling, communication tests, and use of chemical smoke sticks are examples of the type of diagnostic testing commonly used. (See paragraph 11.4.)

11.3 If a contractor has concerns about backdrafting potential at a particular site, the contractor should recommend that a qualified person inspect the natural draft combustion appliance and venting systems for compliance with local codes and regulations. An active soil depressurization system should not be activated until potential backdraft problems are resolved.

11.4 If installation of a SSD system is contemplated and characteristics of the sub-slab material are unknown, a communication test as defined in paragraph 9.8 is recommended.

11.5 As part of the building investigation, a floor plan sketch should be developed (if not already in existence and readily available) that includes illustrations of the building

foundation (slab-on-grade, basement, or crawl space area). The sketch should include the location of load-bearing walls, drains, sump pits, HVAC systems, and natural draft appliances. It should be annotated to include the anticipated layout of any radon mitigation system piping and the anticipated locations of any vent fan and system-warning devices for the envisioned mitigation systems. The sketch should be finalized during installation and should be included in the homeowner information package. (See paragraph 18.4.)

11.6 Care should be exercised during drilling to avoid potential buried gas, water, or electric lines. Careful evaluations should be made for radiant heat systems within or under slabs and for steel tendons within post-tension slabs that, if ruptured, can result in serious bodily harm.

12.0 WORKER HEALTH AND SAFETY

12.1 The mitigator shall comply with all OSHA, state, and local standards or regulations relating to worker safety and occupational radon exposure. Applicable references in the Code of Federal Regulations and NIOSH publications (or subsequent updates) are listed in paragraphs 8.12, 8.13, and 8.14.

12.2 In addition to the OSHA and NIOSH standards, the following requirements that are specifically or uniquely applicable for the safety and protection of radon mitigation workers should be met:

12.2.1 The certified mitigation individual should advise firm employees of the hazards of exposure to radon and the need to apply protective measures when working in areas of elevated radon concentrations.

12.2.2 The certified mitigation individual should have a worker health and safety plan on file that is available to all employees and is approved by DEP.

12.2.3 The certified mitigation individual should ensure that appropriate safety equipment such as hard hats, face shields, ear plugs, and protective gloves are available on the job site during cutting, drilling, grinding, polishing, demolishing, or other hazardous activity associated with radon mitigation projects. Appropriate air filtration masks should be worn during drilling activities to protect against Silica dust exposure. All personnel should be appropriately trained in the use of equipment and the wearing of personal protective equipment. The certified mitigation individual should ensure that all new firm employees have been informed about all relevant portions of the company worker health and safety plan. All relevant portions of the worker health and safety plan should be reviewed with each employee at least once a year. Confirmation of employees' knowledge of relevant portions of the worker health and safety plan should be recorded with the firm employees' signature and date.

12.2.4 All electrical equipment used during radon mitigation projects should be properly grounded. Circuits used as a power source should be protected by Ground-Fault Circuit Interrupters.

12.2.5 When work is required at elevations above the ground or floor, the mitigator should ensure that ladders or scaffolding are safely installed and operated per OSHA health and safety protocols.

12.2.6 Work areas should be ventilated when practical to reduce worker exposure to radon decay products, dust, or other airborne pollutants.

12.2.7 Where combustible materials exist in the specific area of the building where radon mitigation work is to be conducted and the mitigator is creating any temperatures high enough to induce a flame, the mitigator should ensure that a fire extinguisher suitable for type A, B, and C fires is available in the immediate work area.

12.2.8 The certified mitigation individual should record employee exposure to radon at each work site based on the highest pre-mitigation indoor radon or WL measurement available and the time employees are exposed (without respirator protection) at that level (see paragraph 12.2.6). The certified mitigation individual should ensure that employees are exposed to no more than 4 WLM over a 12-month period. (An equilibrium ratio of 50 percent shall be used to convert radon exposure to WLM.) If a certified mitigation individual is a sole proprietor of a radon mitigation company, the individual is still responsible for recording and maintaining their own occupational radon/radon progeny exposure.

12.2.9 In any area where building materials containing friable asbestos have been identified or it is suspected that friable asbestos may exist, radon mitigation work should not be conducted without the approval of an asbestos building inspector or asbestos abatement contractor certified under provisions of the Asbestos Hazards Emergency Response Act and the Pennsylvania Department of Labor and Industry Act 194.

12.2.10 When mitigation work requires the use of sealants, adhesives, paints, or other substances that may be hazardous to health, the certified mitigation individual shall provide employees with the applicable Safety Data Sheets (SDS) and explain the required safety procedures. SDS hard copy documentation should be available for all hazardous chemicals used on the job site.

13.0 SYSTEMS DESIGN

13.1 All radon mitigation systems should be designed and installed as permanent, integral additions to the building, except where a temporary system has been installed in accordance with paragraph 10.3. The radon mitigation system should exist as a stand-alone system and not incorporate other house systems or features in its design except in the case where a sump hole is used as a suction point.

13.2 All radon mitigation systems should be designed to avoid the creation of other health, safety, or environmental hazards to building occupants such as backdrafting of natural draft combustion appliances.

13.3 All radon mitigation systems should be designed to maximize radon reduction while minimizing excess energy usage, avoiding compromise of moisture and temperature controls and other comfort features, and minimizing noise.

13.4 All radon mitigation systems and their components shall be designed to comply with the laws, ordinances, codes, and regulations of relevant jurisdictional authorities including applicable mechanical, electrical, building, plumbing, energy, and fire prevention codes.

14.0 SYSTEMS INSTALLATION

14.1 General Requirements

14.1.1 All components of radon mitigation systems installed in compliance with provisions of the PA RMS shall also follow the applicable mechanical, electrical, building, plumbing energy, and fire prevention codes, standards, and regulations of the local jurisdiction.

14.1.2 The mitigator should obtain all required licenses and permits and display them in the work areas as required by local ordinances.

14.1.3 Where portions of structural framing material should be removed to accommodate radon vent pipes, material removed shall be no greater than that permitted for plumbing installations by applicable building or plumbing codes.

14.1.4 Where installation of a radon mitigation system requires pipe or ducts to penetrate a fire wall or other fire resistance-rated wall or floor, penetrations shall be protected in accordance with applicable building, mechanical, fire, and electrical codes.

14.1.5 When installing radon mitigation systems that use sump pits as the suction point for active soil depressurization, if sump pumps are needed, it is recommended that submersible sump pumps be used. (See paragraphs 14.5.1, 15.7, and 15.8.)

14.2 Radon Vent Pipe Installation Requirements

14.2.1 All joints and connections in radon mitigation system vent pipes should be airtight and permanently sealed as specified by the manufacturer, with the exception that flexible rubber couplings are an allowable alternative method.

14.2.2 Radon vent pipe runs subjected to cold environments should be insulated to prevent vent pipe freeze up. Radon vent pipes in attics where warm, moist environments exist should also be insulated to reduce condensation on exterior pipe surfaces.

14.2.3 Radon vent pipes should be fastened to the structure of the building with appropriate hangers, strapping, or other supports that will adequately secure the radon vent piping. Existing plumbing pipes, ducts, or mechanical equipment should not be used to support or secure a radon vent pipe.

14.2.4 Supports for radon vent pipes should be installed at least every six feet on horizontal runs. Vertical runs should be secured either above or below the points of penetration through floors and ceilings, or at least every 10 feet on runs that do not penetrate floors and ceilings. Outside vent piping should be properly secured within three feet of its termination point, measured along the pipe.

14.2.5 To prevent blockage of air flow into the bottom of radon vent pipes, these pipes should be supported or secured in a permanent manner that prevents their downward movement to the bottom of suction pits, sump pits, or into the soil below the soil gas retarder membrane.

14.2.6 Radon vent pipes should be installed in a configuration that ensures that any rainwater or condensation within the pipes drains downward onto the ground beneath the slab or beneath the soil gas retarder membrane. A slope of 1/8 inch per foot of pipe run is recommended.

14.2.7 Radon vent pipes should not block access to any areas requiring maintenance or inspection unless the vent pipe is designed for easy removal and airtight replacement. Radon vent pipes shall not be installed in front of, or interfere with, any light, opening, door, window, or equipment access area required by code. If radon vent pipes are installed in sump pits (with sump pumps), the system should be designed with removable, airtight couplings to facilitate removal and reinstallation of the vent pipes and sump pit cover for sump pump maintenance.

14.2.8 Per 25 Pa. Code 240.308 (b)(1-5)(6i, 6ii) 'Terminal discharge. To prevent re-entrainment of radon, discharges of depressurization systems, whether fan-powered or passive, must meet all of the following requirements:

(1) The termination point shall be above the immediate edge of the roof for vent pipes attached to the side of the building.

(2) The termination point must be vertical, upward, outside the structure and discharging to the atmosphere. A 45-degree elbow is permitted. Rain caps may not be used.

(3) The termination point must be 10 feet or more above the ground level nearest to the point of discharge.

(4) The termination point must be 10 feet or more from an operable window unit, door or other opening into conditioned spaces unless it is 2 feet above the top of the openings. The 10-foot distance may be measured directly between the opening and the exhaust point or with a flexible tape following the shortest path possible around intervening solid objects. A chimney is not considered an opening into conditioned spaces.

(5) The termination point must be at least 5 feet horizontally from a vertical wall that extends above the roof or higher than the vertical.

(6) The termination point must be 10 feet or more from an opening into an adjacent structure and be: (i) at least 12 inches above the surface of the roof for vent pipes that penetrate the roof, and (ii) at least 10 feet from any openings of conditioned spaces in the structure.'

14.2.10 When a radon mitigation system is designed to draw soil gas from a perimeter drain tile loop (internal or external) that discharges water through a drain line to daylight or a soak away, a one-way valve, water trap or other control device should be installed in or on the discharge line to prevent outside air from entering the system while allowing water to flow out of the system.

14.3 Radon Vent Fan Installation Requirements

14.3.1 Vent fans should be designed specifically for radon removal applications.

14.3.2 Radon vent fans should be sized to provide the pressure difference and air flow characteristics necessary to achieve the radon reduction goals established for the specific mitigation project. Guidelines for sizing vent fans and piping can be found in the references cited in paragraphs 8.1, 8.16, and 8.18.

14.3.3 Per 25 Pa. Code 240.308 (c) (1 &2) 'A radon fan used in active soil depressurization or block wall depressurization system may not be installed: (1) Below grade, in a window well or egress window well, or in the conditioned space of a building. (2) In a basement, crawl space or other interior location directly beneath the heated or cooled spaces of a building.'

Acceptable locations for radon vent fans include attics not suitable for occupancy (including attics over living spaces and garages), garages that are not beneath conditioned spaces, or on the exterior of the building.

14.3.4 Radon vent fans should be installed in a configuration that avoids condensation or other water accumulation buildup in the fan housing. Radon vent fans should be installed in vertical runs of the vent pipe. Condensate bypasses around the fans should be installed and insulated.

14.3.5 Radon vent fans mounted on the exterior of buildings should be rated for outdoor use or installed in a watertight protective housing.

14.3.6 Radon vent fans should be mounted and secured in a manner that minimizes transfer of vibration to the structural framing of the building.

14.3.7 To facilitate maintenance and future replacement, radon vent fans should be installed in the vent pipe using removable, airtight couplings, or flexible connections that can be tightly secured to both the fan and the vent pipe.

14.3.8 Intakes of fans used in pressurization systems should be screened or filtered to prevent personal injury or ingestion of debris. Screens or filters should be removable to permit cleaning or replacement and building owners should be

informed of the need to periodically replace or clean such screens and filters. This information should be included in the documentation. (See paragraph 18.4.)

14.4 Suction Pit Requirement for SSD Systems

14.4.1 To provide optimum pressure field extension of the sub-slab communication zone, a minimum of 1/2 cubic foot (i.e., approximately half of a five -gallon bucket) of material should be excavated (unless bedrock prohibits this) from the area immediately below the slab penetration point of SSD system vent pipes.

14.5 Sealing Requirements

14.5.1 Per 25 Pa. Code 240.308 (d)(1)(i-v) 'When accessible, the following are required to be adequately sealed with urethane caulk or equivalent material using methods and materials that are permanent and durable when installing a mitigation system: (i) Perimeter channel drains, (ii) cracks that exist where the slab meets the foundation wall (floor wall joint), (iii) expansion or control joints, (iv) openings around utility penetrations of foundation walls, (v) sump pits that allow entry of soil gas or that allow conditioned air to be drawn into a sub-slab depressurization system.'

The sump cover should have a radon-resistant drain (see paragraph 9.20) if there is no other available floor drain. (Homeowner information should indicate periodic filling, if applicable.) See paragraphs 14.7.3 and 15.7 for further details on sump cover and sealing materials.

Openings around other utility penetrations of the slab, walls, or soil gas retarder should also be sealed.

14.5.2 Where a BWD system is used to mitigate radon, openings in the tops of such walls and all accessible openings or cracks in the interior surfaces of the walls should be closed and sealed with urethane or equivalent caulks, expandable foams, rigid board stock caulked in place, non-shrink grout, or other comparable materials. (See paragraphs 15.5 and 15.6.) Openings or cracks that are determined to be inaccessible or beyond the ability of the mitigator to seal should be disclosed to the client and included in the documentation.

14.5.3 Per 25 Pa. Code 240.308(d)(2) 'When the opening or channel is greater than 1/2 inch in width, a foam backer rod or other equivalent filler material shall be inserted into the channel before application of the sealant. Materials inserted into the channel must leave adequate space below the filler material to allow subsurface drainage from the channel into the sub-slab material.'

Other openings or cracks in slabs or at expansion or control joints shall also be sealed using methods and materials that are permanent and durable. Urethane and polyurethane sealants, complying to American Society for Testing and Materials (ASTM) standard C920 class 25 or greater, are generally recommended for these applications due to their adhesion and durability characteristics. Expanding foam is not appropriate for this application. Openings or cracks that are determined to

be inaccessible or beyond the ability of the mitigator to seal shall be disclosed to the client and included in the documentation.

Per Pa. Code 240.308(d)(3)(i-iii) 'If the mitigator and homeowner determine that the perimeter channel drain cannot be sealed for water control reasons, then the mitigator may leave those areas unsealed and shall provide the following written statements to the homeowner: (i) this technique may contribute to an increased heating and cooling costs; (ii) this technique may reduce the effectiveness of the radon mitigation system; (iii) this technique may increase the potential for backdrafting natural draft combustion appliances.'

14.5.4 When installing baseboard type suction systems, all seams and joints in the baseboard material should be joined and sealed using materials recommended by the manufacturer of the baseboard system. Baseboards shall be secured to walls and floors with adhesives designed and recommended for such installations. If a baseboard system is installed on a block-wall foundation, the tops of the block wall should be closed and sealed as prescribed in paragraph 14.5.3.

14.5.5 Any seams in soil gas retarder membranes used in crawl spaces for SMD systems should be overlapped at least 12 inches and should be sealed. To enhance the effectiveness of SMD systems, the membrane should also be sealed around interior piers and to all crawl space wall surfaces. All sealants should be long-lived. Duct tape not specifically designed to seal the membrane and expanding foam are not long-lived sealants and therefore, not permitted for this use.

14.5.6 In combination basement/crawl space foundations where the crawl space has been confirmed as a source of radon entry and SMD is not a viable mitigation option, access doors and other openings between the basement and the adjacent crawl space should be closed and sealed. Access doors required by code should be fitted with airtight gaskets and a means of positive closure but should not be permanently sealed. In cases where both the basement and the adjacent crawl space areas are being mitigated with active SSD and SMD systems, sealing of the openings between those areas is not required.

14.5.7 When CSD is used for radon mitigation, openings and cracks in floors above the crawl space which would permit conditioned air to pass out of the living spaces of the building should be sealed in a permanent manner. Sealing of openings around hydronic heat or steam pipe penetrations should be done using noncombustible materials. Openings and cracks that are determined to be inaccessible or beyond the ability of the mitigator to seal shall be disclosed to the client and included in the documentation.

14.5.8 CSD should not be used as a radon control system when combustion appliances are installed within the crawl space, or where adequate isolation cannot be created between the crawl space and surrounding spaces containing combustion appliances. CSD should also not be used if such depressurization will likely cause damage to building components or adversely impact the operation of any combustion appliance.

14.6 Electrical Requirements

14.6.1 Wiring for all active radon mitigation systems shall conform to provisions of the most current version of the National Electric Code and any additional local regulations.

14.6.2 No type of wiring should be located in or chased through the mitigation installation ducting or any heating or cooling duct.

14.6.3 Any plugged cord used to supply power to a radon vent fan should be no more than six feet in length.

14.6.4 No plugged cord should penetrate a wall or be concealed within a wall, with the exception of the class 2 fan(s) with low voltage and the direct current (DC) current low voltage fans.

14.6.5 All radon fans should have a means of disconnect. For fans on the interior of the building, the disconnect should be a plugged cord or a disconnect switch. Fans mounted on the exterior of the building shall have an exterior disconnect switch (no plugged cord), or if less than 1/8 horsepower the disconnect switch may be on interior. Exterior wiring and disconnect switches should be weatherproof and rated for exterior use. Interior and exterior disconnect switches should be within sight of the fan.

14.7 Drain Installation Requirements

14.7.1 A radon resistant drain (see paragraph 9.20) should be installed in any drain that discharges directly into the soil beneath the slab or through solid pipe to a dry well or has other exposure to the soil.

14.7.2 If condensate drains from the return side of heating or air conditioning units terminate beneath the floor slab, the mitigator should install a trap in the drain that provides a three to six-inch trap of standing water, or reroute the drain directly into a trapped floor drain or condensation pump.

14.7.3 When a sump pit or other openings that provided the only relief from excess surface water are sealed, an alternative drainage system should be provided. This alternative system may be a new trapped floor drain leading to the sump or sub-slab drainage or a radon resistant drain (see paragraph 9.20) installed in a sump pit cover that is flush with the slab or lower.

14.8 HVAC and Heat Recovery Ventilation (HRV) Installation Requirements

14.8.1 Modifications to HVAC systems, building pressurization, and building air dilution all require special skills and diagnostic testing to avoid unintended consequences and to assure adequate radon reduction.

14.8.2 Modifications to an existing HVAC System, which are proposed to mitigate elevated levels of radon, should be reviewed and approved by the original designer of the system (when possible) or by a licensed mechanical contractor.

14.8.3 Foundation vents, installed specifically to reduce indoor radon levels by increasing the natural ventilation of a crawl space, should be non-closeable. Insulation should be provided where needed to protect against freezing and unnecessary energy loss.

14.8.4 HRV Systems should not be installed in rooms that contain friable asbestos.

14.8.5 In HRV installations, supply and return vents in the interior should be located a minimum of 12 feet apart. The exterior intake and exhaust vents should be positioned to avoid blockage by snow or leaves and be a minimum of 10 feet apart.

14.8.6 Mitigators installing HRV Systems should verify that the incoming and outgoing airflow is balanced to ensure that the system does not create a negative pressure within the building. Mitigators should inform building owners that periodic filter replacement and inlet grill cleaning are necessary to maintain a balanced airflow. This information should also be included in the documentation. A monitor should be installed across the intake filter to indicate the need for filter cleaning or replacement.

14.8.7 Both internal and external intake and exhaust vents in HRV Systems should be covered with wire mesh or screening, typically 1/4” by 1/4”, to prevent entry of animals, debris, or injury to occupants.

15.0 MATERIALS

15.1 All mitigation system electrical components should be Underwriter’s Laboratory-listed or of equivalent specifications.

15.2 At a minimum, vent pipes in mitigation systems should be made of Schedule 20 Polyvinyl Chloride (PVC), Acrylonitrile-butadiene-styrene, or equivalent piping material. Schedule 40 piping or its equivalent should be used in garages and in other internal and external locations subject to physical damage. PVC pipe exposed to sunlight should be formulated for outdoor use and painted to provide protection against ultraviolet radiation. For exterior runs, PVC schedule 40 is recommended, however, aluminum or PVC down spouting may be used. If transitioning from 4” diameter PVC to down spouting, 3x4” down spouting should be used.

15.3 Vent pipe fittings in a mitigation system should be of the same material as the vent pipes unless flexible, airtight rubber couplings are used. (See paragraph 14.3.7 for exceptions when installing vent fans, paragraph 14.2.7 for exceptions when installing radon vent pipes in sump pit covers, and paragraph 15.2 for exceptions when using down spouting).

15.4 Cleaning solvents and adhesives used to join pipes and fittings should be as recommended by manufacturers for use with the type of piping material used in the mitigation system.

15.5 When sealing cracks in slabs and other small openings around penetrations of the slab and foundation walls, caulks and sealants designed for such application should be used. Urethane sealants are recommended because of their durability. Expanding foam is not permitted for this use.

15.6 When sealing holes for plumbing rough-in or other large openings of limited access, non-shrink mortar, grouts, expanding foam, or other comparable materials for such application should be used.

15.7 Sump pit covers should be made of durable plastic, galvanized sheet metal, aluminum, or other rot-resistant rigid material and designed to permit airtight sealing to the extent possible to the slab surface surrounding the sump pit. To permit easy removal for sump pump servicing, the cover should be sealed to the slab surface using silicone or other non-permanent-type caulking materials or an airtight gasket. Sump covers should have a window to observe conditions in the sump pit.

15.8 Penetrations of sump covers to accommodate electrical wiring, water ejection pipes, or radon vent pipes should be designed to permit airtight sealing to the extent possible around penetrations using caulk or grommets.

15.9 Plastic sheeting installed in crawl spaces as soil gas retarders should be a minimum of six mil (or three mil cross -laminated) polyethylene, or equivalent flexible material. Heavier gauge sheeting should be used when crawl spaces are used for storage, or frequent entry is required for maintenance of utilities.

15.10 Any wood in contact with soil or soil gas, used to attach soil gas retarder membranes to crawl space walls or piers shall be treated to be rot -resistant or naturally resistant to decay and termites.

16.0 MONITORS AND LABELING

16.1 All active radon mitigation systems should include a mechanism to monitor fan performance by use of a magnehelic gauge, manometer, air flow, or amperage meter. The mechanism should be simple to read or interpret, be located where it is easily seen by building occupants, and in an area where it would be unlikely to be damaged. The final system vacuum, air flow, or amperage should be indicated on a label for future reference as measured at the gauge/meter location.

16.2 Electrical radon mitigation system monitors, if used (whether visual or audible) should be installed on non-switched circuits and be designed to reset automatically when power is restored after service or power supply failure. Audible alarms should include a disconnect mechanism separate from the radon system. Battery-operated monitoring devices should not be used unless they are equipped with a low-power warning feature. The “active” radon system monitors add an additional layer of radon system failure awareness compared to the “passive” monitors.

16.3 Per 25 Pa. Code 240.308(e) (1)(i-v) 'If the mitigation system is accessible and visible, a system description label shall be prominently and permanently affixed to the mitigation system piping. If the mitigation system is concealed or not accessible, then the label shall be placed in another prominent location. The label must be legible from a distance of at least 3 feet and include all of the following information: (i) "Radon Reduction System," (ii) The name and certification number of the mitigation certified individual or firm, (iii) the contact telephone number of the mitigation certified individual or firm, (iv) the date of installation, (v) "Building should be tested for radon at least every two years."

Per 25 Pa. Code 240.308(e)(2) 'Each exposed and visible interior radon mitigation system vent pipe section shall be identified with at least one label on each floor level. The label must read: "Radon Reduction System."

16.4 The circuit breaker(s) controlling the circuit(s) on which the radon vent fan and system failure warning devices operate should be labeled "Radon Reduction System."

17.0 POST-MITIGATION TESTING

17.1 After installation of an active radon control system, the mitigator should re-examine and verify the integrity of the fan mounting seals and all joints in the vent piping.

17.2 After installation of any active radon mitigation system, the mitigator should measure the suction in the system piping. Measurement of system airflow should also be performed to help assess system performance. Finally, a pressure field extension measurement should be made at the most distant point from a penetration (this can be done using either smoke or a digital micromanometer) to assure that the system is operating as designed.

17.3 To provide an initial measure of effectiveness, the certified mitigation individual shall ensure that a short-term radon measurement, using an National Radon Proficiency Program/National Radon Safety Board (NRPP/NRSB)-listed test device and in accordance with 25 Pa. Code § 240.310(a)(11), 'is conducted no sooner than 24 hours or later than 30 days following the completion and activation of the mitigation system or an alteration to an existing system unless unforeseen circumstances prohibit the testing being performed within this timeframe, such as the owner or occupier refusing or ignoring requests to complete the post-mitigation test.'

17.4 The certified mitigation individual shall continue to abide by the reporting requirements (25 Pa. Code § 240.303) of the Radon Certification Regulations.

18.0 CONTRACTS AND DOCUMENTATION

18.1 The following information should be provided to the clients in writing prior to initiation of work:

(1) The name and DEP identification number of the certified mitigation individual.

(2) A statement that describes the planned scope of work.

(3) A statement describing any known hazards associated with chemicals used in or as part of the installation.

(4) A statement indicating compliance with and implementation of all DEP standards and those of other agencies having jurisdiction (e.g., code requirements).

(5) A statement describing any system maintenance that the building owner would be required to perform.

(6) The installation cost and an estimate of the annual operating costs of the system.

(7) The terms of any warranty or guarantee.

(8) Notice to Clients.

18.2 Certified mitigation individuals should keep records of all radon mitigation work performed and maintain those records for five years or for the period of any warranty or guarantee, whichever is longer. These records should include the information as outlined in the Radon Certification Regulations, 25 Pa. Code § 240.303. Additional records that should be kept include:

(1) The Building Investigation Summary and floor plan sketch.

(2) Pre and post-mitigation diagnostic test data.

(3) Copies of contracts and warranties.

(4) A narrative or pictorial description of mitigation system(s) installed.

18.3 Health and safety records including worker radon exposure logs, should be maintained indefinitely.

18.4 Per 25 Pa. Code 240.308(f)(1-6) 'Upon completion of the mitigation project, the mitigator shall attach an information package to the mitigation system in a secure and permanent manner, visible location and labeled "Radon Mitigation Information." The information package must include all of the following:

(1) A copy of contracts and warranties for the mitigation system.

(2) A description of the installed mitigation system and its basic operating principles.

(3) A description of the proper operating procedures of any installed mechanical or electrical systems, including manufacturer's operation and maintenance instructions, drain -filling instructions, and warning device interpretations.

(4) A list of appropriate actions for the client to take if the system failure warning device indicates system degradation or failure.

(5) A recommendation to retest at least every 2 years.

(6) A recommendation to have an electrical inspection performed on the applicable components of the installed system.

This information package shall be attached to the mitigation system in a secure and permanent manner, in a visible location, and labeled "Radon Mitigation Information."