DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Radiation Protection

DOCUMENT NUMBER: 294-2309-002

TITLE: Pennsylvania Radon Mitigation Standards

EFFECTIVE DATE: Upon publication of notice as final in the *Pennsylvania Bulletin*

AUTHORITY: 25 Pa Code § 240

POLICY: This document is being provided to certified radon mitigators for its implementation.

PURPOSE: The purpose of this guidance is to help assure uniformity, for the purposes of effectiveness and durability, during the installation of radon mitigation systems by certified mitigators.

APPLICABILITY: This guidance document applies to all individuals and/or firms, certified by the Department, 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. DEP does not intend to give this guidance that weight or deference. This document establishes the framework, within which DEP will exercise its administrative discretion in the future. DEP reserves the discretion to deviate from this policy statement if circumstances warrant.

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1.0 Background

The 1988 Indoor Radon Abatement Act (IRAA) required the U.S. 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. Over time, 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 the PA RMS was published, additional field experience was gained and additional radon mitigation standards have been published. As of May 2006, the EPA no longer recommends and will no longer distribute its own Radon Mitigation Standards (EPA 402-R-93-078). Instead, the EPA now references ANSI/AARST Soil Gas Mitigation Standards for Existing Homes (SGM-SF 2017) or 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 purpose of the PA RMS is to provide 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 three stories or less in height. The PA RMS is intended to serve as a model set of requirements which have been adopted by the Department of Environmental Protection (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 DEP-certified mitigators are required to follow all requirements set forth in the PA RMS.

6.2 Certified mitigation individuals shall personally conduct follow-up inspection of any radon mitigation system installed by their firm that was changed from the original design. Additionally, certified mitigation individuals shall 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 non-residential buildings.

6.6 For areas of radon mitigation not covered by this standard, the mitigator shall 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 shall 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 shall recommend in writing to the client that the system be upgraded or altered to meet this standard. The certified mitigator shall 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. That guidance 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 shall 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, shall 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 shall 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.

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

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

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

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

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

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

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

8.10 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.

8.11 OSHA Safety and Health Regulations for Construction, Ionizing Radiation, 29 CFR 1926.53.

8.12 OSHA Occupational Safety and Health Regulations, Ionizing Radiation, 29 CFR 1910.96.

8.13 NIOSH Guide to Industrial Respiratory Protection, DHHS (NIOSH) Publication No. 87-116, September 1987.

8.14 NCRP Measurement of Radon and Radon Decay Daughters in Air, NCRP Report No. 97, Nov 1988.

8.15 EPA Handbook, Subslab Depressurization for Low-Permeability Fill Material, EPA/625/6-91/029, July 1991.

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

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

9.0 Description of Terms

For this document, certain terms are defined in this section. Terms not defined herein should have their ordinary meaning within the context of their use. Ordinary meaning is 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 semi-rigid 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 subslab 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 subslab area measured from a single or multiple suction points. (See also paragraph 9.8, Communication Test). For quantitative purposes one must 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, thus 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 subslab 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 subslab 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 subslab 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 (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 per liter of air. (See also the referenced document in paragraph 8.12.)

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 working level 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 are required for all contacts between radon mitigators and client:

10.1 During the initial contact with the client, the mitigator shall request and review recent radon test result(s). The mitigator shall 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 8.4), and "Pennsylvania's Home Buyers' and Sellers' Guide to Radon" (see paragraph 8.6) or subsequent revisions of these documents, the mitigator shall 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 8.5) 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 shall inform the client about the temporary nature of the system. A label that is readable from at least three feet shall be placed on the system. The label shall include a

statement that the system is temporary and that it will be replaced with a permanent system within 30 days. The label shall 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 shall inform the client in writing (this could include a material safety data sheet (MSDS)) of the need to ventilate work areas during and after the use of such sealants. Ventilation shall be provided as recommended by the manufacturer of the material.

11.0 Building Investigation

11.1 The mitigator 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 subslab 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 shall 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 shall not be activated until potential backdraft problems are resolved.

11.4 If installation of a SSD system is contemplated and characteristics of the subslab 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 18.5.)

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 Occupational Safety and Health Administration (OSHA), state, and local standards or regulations relating to worker safety and occupational radon exposure. Applicable references in the Code of Federal Regulations and National Institute for Occupational Safety and Health (NIOSH) publications (or subsequent updates) are listed in paragraphs 8.11, 8.12, and 8.13.

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 shall be met:

12.2.1 The certified mitigation individual shall 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 shall 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 shall 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 shall be appropriately trained in the use of equipment and the wearing of personal protective equipment. The certified mitigation individual shall 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 shall be reviewed with each employee at least once a year. Confirmation of employees' knowledge of relevant portions of the worker health and safety plan shall be recorded with the firm employees' signature and date.

12.2.4 All electrical equipment used during radon mitigation projects shall be properly grounded. Circuits used as a power source should be protected by GroundFault- Circuit Interrupters (GFCI).

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

12.2.6 Work areas shall 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 shall 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 shall 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 shall 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 shall 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 (AHERA) 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 shall 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 shall 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 shall 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 shall 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 shall 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 must 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 shall 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 shall 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 shall not be used to support or secure a radon vent pipe.

14.2.4 Supports for radon vent pipes shall be installed at least every six feet on horizontal runs. Vertical runs shall 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 shall 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 shall 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 shall 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 shall 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 shall 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 The termination points of radon vent pipes must be vertical, outside the structure, and discharging to the atmosphere. A 45-degree elbow is permitted. Rain caps cannot be used. Vent pipes that are attached to the side of a building shall have the termination point above the immediate edge of the roof. Vent pipes that penetrate the roof must be at least 12 inches above the surface of the roof. The termination point shall be 10 feet or more above the ground level nearest to the point of discharge.

14.2.9 The termination point shall be 10 feet or more from an operable window unit, door, or other opening into conditioned spaces of any structure, unless it is two feet above the top of such openings (a chimney is not considered an opening into conditioned spaces). The 10-foot distance may be measured directly between the opening and exhaust point or with a flexible tape following the shortest path possible around intervening solid objects. The termination point shall be five feet or more horizontally from a vertical wall without any openings to conditioned spaces that extends above the roof.

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 shall 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, 8.15, and 8.17.

14.3.3 Radon vent fans used in active soil depressurization or block wall de-pressurization (BWD) systems shall not be installed below grade, in the conditioned (heated/cooled) space of a building, in any basement, crawl space, or other interior location directly beneath the conditioned 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 shall be installed in a configuration that avoids condensation or other water accumulation buildup in the fan housing. Radon vent fans shall 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 shall be rated for outdoor use or installed in a watertight protective housing.

14.3.6 Radon vent fans shall 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 shall 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 shall be screened or filtered to prevent personal injury or ingestion of debris. Screens or filters shall be removable to permit cleaning or replacement and building owners shall be informed of the need to periodically replace or clean such screens and filters. This information shall be included in the documentation. (See paragraph 18.5.)

14.4 Suction Pit Requirement for SSD Systems

14.4.1 To provide optimum pressure field extension of the subslab communication zone, a minimum of 1/2 cubic foot (i.e., approximately half of a five gallon bucket) of material shall 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 Sump pits that permit entry of soil gas or that would allow conditioned air to be drawn into an SSD system shall be covered and sealed. The sump cover shall 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.

14.5.2 Openings around radon vent pipe penetrations of the slab, the foundation walls, and the crawl space soil gas retarder membrane shall be cleaned, prepared, and sealed in a permanent, airtight manner using compatible caulks or other sealant materials. (See paragraph 15.5.) Openings around other utility penetrations of the slab, walls, or soil gas retarder shall also be sealed.

14.5.3 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 shall 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 shall be disclosed to the client and included in the documentation.

14.5.4 Accessible openings, perimeter channel drains, or cracks that exist where the slab meets the foundation wall (floor-wall joint) shall be sealed using methods and materials that are permanent and durable. 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 in the channel before application of the sealant. Materials inserted into the channel shall leave adequate space below the filler material to allow sub-surface drainage from the channel into the subslab material (see paragraph 14.7.3). 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 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.

If it is determined between the mitigator and homeowner that the perimeter channel drain cannot be sealed for water control reasons, the mitigator may leave this perimeter channel drain unsealed. However, the mitigator shall provide in writing to the homeowner the following: (1) this technique may contribute to an increased heating and cooling penalty; (2) the efficiency of the radon mitigation system may be decreased; (3) there may be an increase in the potential for backdrafting natural draft combustion appliances; and, (4) radon levels should still be reduced to less than 4.0 pCi/L.

14.5.5 When installing baseboard type suction systems, all seams and joints in the baseboard material shall 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 shall be closed and sealed as prescribed in paragraph 14.5.3.

14.5.6 Any seams in soil gas retarder membranes used in crawl spaces for submembrane depressurization (SMD) systems shall be overlapped at least 12 inches and shall

be sealed. To enhance the effectiveness of SMD systems, the membrane shall also be sealed around interior piers and to all crawl space wall surfaces. All sealants shall 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.

14.5.7 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 shall be closed and sealed. Access doors required by code shall be fitted with airtight gaskets and a means of positive closure but shall 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.

14.5.8 When crawl space depressurization (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.

14.5.9 CSD shall 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 shall 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 shall 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 shall be no more than six feet in length.

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

14.6.5 All radon fans shall have a means of disconnect. For fans on the interior of the building, the disconnect shall 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 HP the disconnect switch may be on interior. Exterior wiring and disconnect switches shall be weatherproof and rated for exterior use. Interior and exterior disconnect switches shall be within sight of the fan.

14.7 Drain Installation Requirements

14.7.1 A radon resistant drain (see paragraph 9.20) shall 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 shall 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 shall be provided. This alternative system may be a new trapped floor drain leading to the sump or subslab 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 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, shall be non-closeable. Insulation shall be provided where needed to protect against freezing and unnecessary energy loss.

14.8.4 Heat Recovery Ventilation (HRV) Systems shall not be installed in rooms that contain friable asbestos.

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

14.8.6 Mitigators installing HRV Systems shall verify that the incoming and outgoing airflow is balanced to ensure that the system does not create a negative pressure within the building. Mitigators shall inform building owners that periodic filter replacement and inlet grill cleaning are necessary to maintain a balanced airflow.

This information shall 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 shall 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 shall be Underwriter's Laboratory-listed or of equivalent specifications.

15.2 At a minimum, vent pipes in mitigation systems shall be made of Schedule 20 PVC, ABS 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 shall 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 shall 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 shall 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 shall be used.

15.7 Sump pit covers shall 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 shall be sealed to the slab surface using silicone or other nonpermanent-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 shall 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 shall 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 shall include a mechanism to monitor fan performance by use of a magnehelic gauge, manometer, air flow, or amperage meter. The mechanism shall 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 shall 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) shall be installed on non-switched circuits and be designed to reset automatically when power is restored after service or power supply failure. Audible alarms shall include a disconnect mechanism separate from the radon system. Battery-operated monitoring devices shall 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 A system description label shall be placed on the mitigation system, the electric service entrance panel, or other prominent location. This label shall be legible from a distance of at least three feet and include the following information: indication that this is a radon system; "Radon Reduction System;" the certified mitigation individual's or firm's name; phone number; DEP certification number; the date of installation; and an advisory that the building should be tested for radon at least every two years. In addition, all exposed and visible interior radon mitigation system vent pipe sections shall be identified with at least one label on each floor level. The label shall indicate that it is part of a radon reduction system and 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 shall be labeled "Radon Reduction System."

17.0 Postmitigation Testing

17.1 After installation of an active radon control system, the mitigator should reexamine 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 NRPP/NRSB-listed test device and in accordance with 25 Pa. Code § 240.310(a)(11), is conducted no sooner than 24 hours nor later than 30 days following completion and activation of the mitigation system(s).

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 shall 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 shall 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 shall 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, shall be maintained indefinitely.

18.4 Upon completion of the mitigation project, the mitigator shall provide clients with an information package that shall include, but is not limited to:

(1) Copies of contracts and warranties.

(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 how to interpret warning devices.

(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 two 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."