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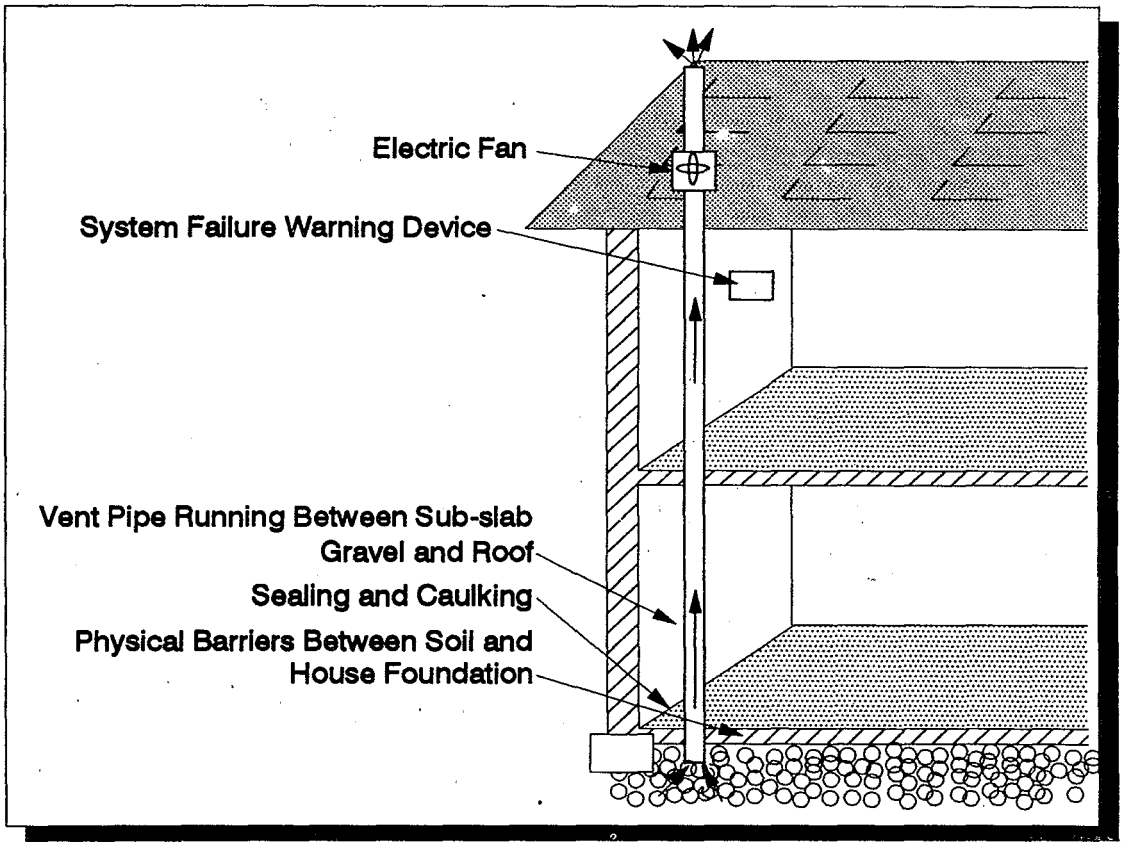
RADON MITIGATION STANDARDS



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RADON MITIGATION STANDARDS

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 contractors 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 mitigation contractors under the RCP Program. Over the past six years, the effectiveness of the basic radon mitigation techniques set forth in the "Interim Standards" has been validated in field applications throughout the United States. This experience now serves as the basis for the more detailed and final Radon Mitigation Standards (RMS) set forth in this document.

2.0 PURPOSE

The purpose of the RMS is to provide radon mitigation contractors 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 RMS is intended to serve as a model set of requirements which can be adopted or modified by state and local jurisdictions to fulfill objectives of their specific radon contractor certification or licensure programs.

3.0 PARTICIPANTS

Minimum requirements are established in the RMS for individuals nationwide who perform radon remediation work and wish to participate in the RCP Program. To participate in EPA's RCP Program, the mitigation contractor shall have completed all RCP training and examination requirements, be listed in the current RCP Listing Report, and shall agree to follow the provisions of the RMS.

4.0 SCOPE

The requirements addressed in the RMS include the following categories of contractor 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 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 RMS includes requirements for installation of radon remediation systems and provides a basis for evaluating the quality of those installations. It may be adopted by state regulatory agencies for state or local radon mitigation contractor

licensure programs. It may also be used as a reference during inspection of in-progress or completed radon mitigation work.

6.2 Contractors shall personally conduct follow-up inspection of any radon mitigation systems installed by their firm or by subcontractors to insure conformance with the requirements of the RMS. This requirement shall include the post-mitigation testing prescribed in paragraph 17.0.

6.3 EPA will evaluate reports of non-compliance with the RMS that are referred to the Agency by states and other agencies that monitor radon mitigation services. Based on its evaluation, EPA may initiate established RCP program de-listing procedures against contractors that the Agency or States (with certification programs) find are in violation of the mandatory provisions of the RMS (See paragraph 6.4). In addition, EPA or its agent may conduct inspections of radon mitigation projects. State radon program personnel or their contracted representatives are considered EPA agents for conducting such inspections.

6.4 Those provisions of the RMS that are considered to be 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 RMS will be updated as necessary, and in response to technological advances and field experience.

7.0 LIMITATIONS

7.1 Although the provisions of the RMS have been carefully reviewed for potential conflicts with other regulatory requirements, adherence to the 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 RMS and local codes or regulations, local codes shall take precedence. However, where compliance with local codes necessitates a deviation from the RMS, EPA recommends that RCP listed contractors report the deviation in writing to the appropriate EPA Regional Office and the appropriate state regulatory official within 30 days. It should be noted that EPA is not requiring the reporting that is recommended in this paragraph. States with radon contractor certification programs may require that contractors give prior notification of their intent to deviate from the RMS for research or other purposes.

7.3 The 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 The RMS shall not apply to radon mitigation systems installed prior to its effective date, except when a previously installed system is altered. "Altering" radon mitigation systems does not include activities such as replacing worn out equipment, or providing new filters, while leaving the remainder of the system unchanged. Mitigation systems installed prior to the effective date of the RMS should be in compliance with the requirements in force at that time (i.e. EPA Interim Radon Mitigation Standards, December 15, 1991, as amended by the Addendum on Backdrafting of October 1, 1992). If a radon mitigation system is

found that does not comply with current standards, contractors should recommend to clients that the system be upgraded or altered to meet current standards.

7.5 Because of the wide variation in building design, size, operation and use, the 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, 8.2, and 8.3.

7.6 The provisions of the 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 at or below EPA's action level (currently 4 pCi/L), and the systems design criteria in paragraph 13.0 shall be applied. Contractors who expect to deviate from proven radon mitigation technologies and methods (as defined in the RMS and other EPA references in Section 8.0) for purposes of research on innovative mitigation techniques, shall obtain prior approval from state regulatory offices, document the non-standard techniques, and inform the client of the deviation from standard procedures. In cases where radon mitigation is not regulated by the state, contractors shall obtain prior approval from a Regional EPA office.

7.7 At this time, the RMS does not include standards for installing systems to mitigate radon in water. However, EPA is currently developing a standard that will regulate radon levels in domestic water supplies. Following publication of that standard, the RMS may be revised, as appropriate, to include standards for installation of systems that are effective in reducing radon levels in water.

8.0 REFERENCE DOCUMENTS

The following documents are sources of additional radon mitigation information and are recommended reading for contractors participating in the RCP program.

8.1 EPA Training Manual, "Reducing Radon In Structures," (Third Edition), January 1993.

8.2 "Radon Reduction Techniques for Detached Houses, Technical Guidance (Second Edition)" EPA/625/5-87/019, January 1988.

8.3 "Application of Radon Reduction Methods," EPA/625/5-88/024, August 1988.

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

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

8.6 "A Citizen's Guide To Radon (Second Edition)" EPA 402-K92-001, May 1992.

8.7 "Consumer's Guide to Radon Reduction," EPA, 402-K92-003, August, 1992.

8.8 "Home Buyer's and Seller's Guide to Radon," EPA 402-R-93-003, March, 1993.

8.9 "ASHRAE Standard 62-1989," Appendix B, Positive Combustion Air Supply.

8.10 "National Gas Code," Appendix H (p.2223.1-98), 1988, Recommended Procedure for Safety Inspection of an Existing Appliance Installation.

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

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

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

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

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

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

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

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 house. Backdrafting of combustion appliances (such as fireplaces and furnaces) can occur when depressurization in the house overwhelms the buoyant force on the hot gases. Backdrafting can also be caused by high air pressures or blockage at the chimney or flue termination.

9.2 **Backer Rod:** A semi-rigid foam material resembling a rope of various diameters. Used to fill around pipes, 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 jammed 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 semi-fluid caulk in place until it sets or hardens.

9.3 **Block Wall Depressurization:** 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 **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 slot ("French Drain") or to a sump where it can be drained or pumped away.

9.5 **Certified:** A rating applied by some jurisdictions to individuals or firms that are qualified and authorized to provide radon testing or mitigation services within the area

of their jurisdiction.

9.6 **Client:** The person, persons, or company that contracts with a radon mitigation contractor to install a radon reduction system in a building.

9.7 **Combination Foundations:** Buildings constructed with more than one foundation type, e.g., basement/crawlspace 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 system. This qualitative test is commonly conducted by applying suction on a centrally located hole drilled through the concrete slab and simultaneously observing the movement of smoke downward into small holes drilled in the slab at locations separated from the central suction hole. (See also paragraph 9.16, Pressure Field Extension.)

9.9 **Contractor:** An individual listed in the RCP program, or certified by a state which requires adherence to the RMS.

9.10 **Crawlspace Depressurization:** A radon control technique designed to achieve lower air pressure in the crawlspace relative to indoor air pressure by use of a fan-powered vent drawing air from within the crawlspace. (See also paragraph 9.14, Mechanically Ventilated Crawlspace System.)

9.11 **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 performance of a mitigation system.

9.12 **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 crawlspace footing.

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

9.14 **Mechanically Ventilated Crawlspace System:** A radon control technique designed to increase ventilation within a crawlspace, achieve higher air pressure in the crawlspace relative to air pressure in the soil beneath the crawlspace, or achieve lower air pressure in the crawlspace relative to air pressure in the living spaces, by use of a fan. (See also paragraph 9.10, Crawlspace Depressurization.)

9.15 **pCi/L:** The abbreviation for picocuries per liter which is a unit of measure for the amount of radioactivity in a liter of air. The prefix "pico" means a multiplication factor of 1 trillionth.
A Curie is a commonly used measurement of radioactivity.

9.16 **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.)

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

9.18 **Radon Decay Products:** The four short-lived radioactive elements (Po-218, Pb-214, Bi-214, Po-214) which exist as solids and immediately follow Rn-222 in the decay chain. They are measured in working levels (WL).

9.19 **Re-Entrainment:** The unintended re-entry into a building of radon that is being exhausted from the vent of a radon mitigation system.

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

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

9.22 **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.

9.23 **Sub-Membrane Depressurization:** 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 crawlspace, by use of a fan-powered vent drawing air from beneath the membrane.

9.24 **Sub-Slab 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.

9.25 **Sub-Slab 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 primarily on the convective flow of warmed air upward in the vent to draw air from beneath the concrete slab.

9.26 **Working Level (WL):** A unit of radon decay product exposure rate. Numerically, any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 130,000 MeV of potential alpha energy. This number was chosen because it is approximately the total alpha energy released from the short-lived decay products in equilibrium with 100 pCi of Rn-222 per liter of air. (See also the referenced document in paragraph 8.15.)

9.27 **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 mitigation contractors and clients.

10.1 In the initial contact with a client, the contractor shall review any available results from previous radon tests to assist in developing an appropriate mitigation strategy.

10.2 Based on guidance contained in "A Citizen's Guide to Radon (Second Edition)," (paragraph 8.6) or subsequent revisions of that document, the contractor shall refer the client to the discussions of interpreting indoor radon test results and the health risk associated with the radon level found in the building. The "Consumer's Guide to Radon Reduction," (paragraph 8.7) is an appropriate reference for providing advice on actions to take to reduce indoor radon levels. Similar documents developed by states and mandated for dissemination by state regulations may also be used as references.

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 contractor 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, and the contractor's name, phone number, and RCP Identification Number. (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. The appropriate state or local building official or radon program official should be notified when this exception is being applied.)

10.4 When the selected mitigation technique requires use of sealants, caulks, or bonding chemicals containing volatile solvents, prior to starting work the contractor shall inform the client of the need to ventilate work areas during and after the use of such materials. Ventilation shall be provided as recommended by the manufacturer of the material.

11.0 BUILDING INVESTIGATION

11.1 The contractor shall conduct a thorough visual inspection of the building prior to initiating any radon mitigation work. The inspection is intended to identify any specific building characteristics and configurations (e.g., large cracks in slabs, exposed earth in crawlspaces, open stairways to basements) and operational conditions (e.g., continuously running HVAC systems or operational windows) that may affect the design, installation, and effectiveness of radon mitigation systems. As part of this inspection, clients should be asked to provide any available information on 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 of the most effective radon control system and avoid the costs of installing systems that subsequently prove to be ineffective, it is recommended that the contractor conduct diagnostic tests to assist in identifying and verifying suspected radon sources and entry points. Radon grab sampling, continuous radon monitoring, and use of chemical smoke sticks are examples of the type of diagnostic testing commonly used. (See paragraph 11.4).

11.3 It is recommended that during the building investigation, contractors routinely

perform diagnostic tests to evaluate the existence of, or the potential for, backdrafting of natural draft combustion appliances. Published procedures for conducting backdrafting tests are covered in the Reference Documents listed in Paragraphs 8.9, 8.10, and 8.11. The following checklist has been extracted from material in these references and may be used to test for existing or potential backdrafting conditions:

(1) Close all windows and doors, both external and internal.
(2) Open all HVAC supply and return air duct vents/registers.
(3) Close fireplace and wood stove dampers.
(4) Turn on all exhaust and air distribution fans and combustion appliances EXCEPT the appliance being tested for backdrafting.
(5) Wait 5 minutes.
(6) Test to determine the indoor-outdoor pressure differential in the room where the appliance being tested is located. If the pressure differential is a negative 5 Pascals or more, assume that a potential for backdrafting exists.
(7) To begin a test for actual spillage of flue gases, turn on the appliance being tested. (If the appliance is a forced air furnace, ensure that the blower starts to run before proceeding.)
(8) Wait 5 minutes.
(9) Using either a smoke tube or a carbon dioxide gas analyzer, check for flue gas spillage near the vent hood.
(10) Repeat steps (4) through (9) for each natural draft combustion appliance being tested for backdrafting. Seasonal and extreme weather conditions should be considered when evaluating pressure differentials and the potential for backdrafting.

If spillage is confirmed from any natural draft combustion appliance, clients shall be advised of the backdrafting condition and that active (fan-powered) radon mitigation systems cannot be installed until the condition has been corrected. Contractors should advise the client to contact an HVAC contractor if correcting an existing or potential backdrafting condition is necessary. (See paragraph 17.3 for post-mitigation backdrafting testing.)

11.4 If installation of a sub-slab depressurization 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 shall be developed (if not already in existence and readily available) that includes illustrations of the building foundation (slab-on-grade, basement or crawlspace area.) The sketch should include the location of load-bearing walls, drain fixtures and HVAC systems. It should be annotated to include suspected or confirmed radon entry points, results of any diagnostic testing, 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 shall be finalized during installation and shall be included in the documentation. (See paragraph 18.2 and Appendix A.)

12.0 WORKER HEALTH AND SAFETY

12.1 Contractors 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 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 shall be met:

12.2.1 The contractor shall advise workers 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 contractor shall have a worker protection plan on file that is available to all employees and is approved by any state or local regulating agencies that require such a plan. Exception: A worker protection plan is not required for a contractor who is a sole proprietor unless required by state or local regulations.

12.2.3 The contractor shall ensure that appropriate safety equipment such as hard hats, face shields, ear plugs, steel-toe boots and protective gloves are available on the job site during cutting, drilling, grinding, polishing, demolishing or other activity associated with radon mitigation projects.

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 Ground-fault Circuit Interrupters (GFCI).

12.2.5 When work is required at elevations above the ground or floor, the contractor shall ensure that ladders or scaffolding are safely installed and operated.

12.2.6 Work areas shall be ventilated to reduce worker exposure to radon decay products, dust, or other airborne pollutants. In work areas where ventilation is impractical or where ventilation cannot reduce radon levels to less than 0.3 WL (based on a short term diagnostic test, e.g., grab sample), the contractor shall ensure that respiratory protection conforms with the requirements in the NIOSH Guide to Industrial Respiratory Protection. (See paragraph 8.14.) (Note: If unable to make working level measurements, a radon level of 30 pCi/L shall be used.)

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

12.2.8 Pending development of an approved personal radon exposure device and a protocol for its use, contractors shall record employee exposure to radon at each work site, based on: (1) the highest pre-mitigation indoor radon or working level measurement available, and (2) the time employees are exposed (without respirator protection) at that level (See paragraph 12.2.6.) (Note: This approach is not intended to preclude the alternative use of on-site radon or radon decay product measurements to determine exact exposure.)

Consistent with OSHA Permissible Exposure Limits, contractors shall ensure that employees are exposed to no more than 4 working level months (WLM) over a 12 month period. (An equilibrium ratio of 50 percent shall be used to convert radon exposure to WLM.)

12.2.9 In any planned work area where it is suspected that friable asbestos may exist and be disturbed, radon mitigation work shall not be conducted until a determination is made by a properly trained or accredited person that such work will be undertaken in a manner which complies with applicable asbestos regulations.

12.2.10 When mitigation work requires the use of sealants, adhesives, paints, or other substances that may be hazardous to health, contractors shall provide employees with the applicable Material Safety Data Sheets (MSDS) and explain the required safety procedures.

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.

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 and in consideration of the need to minimize excess energy usage, to avoid compromising moisture and temperature controls and other comfort features, and to minimize 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 RMS shall also be in compliance with the applicable mechanical, electrical, building, plumbing, energy and fire prevention codes, standards, and regulations of the local jurisdiction.

14.1.2 The contractor 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 pipes or ducts to penetrate a firewall 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, 14.7.4, 15.7, and 15.8.)

14.2 Radon Vent Pipe Installation Requirements

14.2.1 All joints and connections in radon mitigation systems using plastic vent pipes shall be permanently sealed with adhesives as specified by the manufacturer of the pipe material used. (See paragraph 14.3.7 for exception when installing fans, and paragraph 14.2.7 for exception when installing vent pipes in sumps.) Joints or connections in other vent pipe materials shall be made air tight.

14.2.2 Attic and external piping runs in areas subject to sub-freezing conditions should be protected to avoid the risk of vent pipe freeze-up.

14.2.3 Radon vent pipes shall be fastened to the structure of the building with hangers, strapping, or other supports that will adequately secure the vent material. 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 6 feet on horizontal runs. Vertical runs shall be secured either above or below the points of penetration through floors, ceilings, and roofs, or at least every 8 feet on runs that do not penetrate floors, ceilings, or roofs.

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 or sump pits, or into the soil beneath an aggregate layer under a slab.

14.2.6 Radon vent pipes shall be installed in a configuration that ensures that any rain water or condensation within the pipes drains downward into the ground beneath the slab or soil-gas retarder membrane.

14.2.7 Radon vent pipes shall not block access to any areas requiring maintenance or inspection. Radon vents 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, the system shall be designed with removable or flexible couplings to facilitate removal of the sump pit cover for sump pump maintenance.

14.2.8 To prevent re-entrainment of radon, the point of discharge from vents of fan-powered soil depressurization and block wall depressurization systems shall meet all of the following requirements: (1) be above the eave of the roof, (2) be ten feet or more above ground level, (3) be ten feet or more from any window, door, or other opening into conditioned spaces of the structure that is less than two feet below the exhaust point, and (4) be ten feet or more from any opening into an adjacent building. The total required distance (ten feet) from the point of discharge to openings in the structure may be measured either directly between the two points or be the sum of measurements made around intervening obstacles. Whenever possible, the exhaust point should be positioned above the highest eave of the building and as close to the roof ridge line as possible.

14.2.9 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 soakaway, a one-way flow 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 used in radon mitigation systems shall be designed or otherwise sealed to reduce the potential for leakage of soil gas from the fan housing.

14.3.2 Radon vent fans shall 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 8.17.

14.3.3 Radon vent fans used in active soil depressurization or block wall depressurization systems shall not be installed below ground nor in the conditioned (heated/cooled) space of a building, nor in any basement, crawlspace, 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 buildup in the fan housing. Whenever possible, fans should be installed in vertical runs of the vent pipe.

14.3.5 Radon vent fans mounted on the exterior of buildings shall be rated for outdoor use or installed in a water tight 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 couplings or flexible connections that can be tightly secured to both the fan and the vent pipe.

14.3.8 The intakes of fans used in crawlspace pressurization, or in pressurizing the building itself, shall be screened or filtered to prevent ingestion of debris or personal injury. 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 also be included in the documentation. (See paragraph 18.5)

14.4 Suction Pit Requirement for Sub-Slab Depressurization (SSD) Systems

14.4.1 To provide optimum pressure field extension of the sub-slab communication zone, adequate material shall be excavated 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 a sub-slab depressurization system shall be covered and sealed. The covers on sumps that previously provided protection or relief from surface water collection shall be fitted with a water or mechanically trapped drain. Water traps should be fitted with an automatic supply of priming water. (See paragraph 15.7 for details on sump cover and sealing materials.)

14.5.2 Openings around radon vent pipe penetrations of the slab, the foundation walls, or the crawlspace soil-gas retarder membrane shall be cleaned, prepared, and sealed in a permanent, air-tight 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 Block Wall Depressurization (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 polyurethane or equivalent caulks, expandable foams, or other fillers and sealants. (See paragraphs 15.5 and 15.6.) Openings or cracks that are determined to be inaccessible or beyond the ability of the contractor to seal shall be disclosed to the client and included in the documentation.

14.5.4 Openings, perimeter channel drains, or cracks that exist where the slab meets the foundation wall (floor-wall joint), shall be sealed with urethane caulk or equivalent material. When the opening or channel is greater than 1/2 inch in width, a foam backer rod or other comparable filler material shall be inserted in the channel before application of the sealant. This sealing technique shall be done in a manner that retains the channel feature as a water control system. Other openings or cracks in slabs or at expansion or control joints should also be sealed. Openings or cracks that are determined to be inaccessible or beyond the ability of the contractor to seal shall be disclosed to the client and included in the documentation.

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 blockwall shall be closed and sealed as prescribed in paragraph 14.5.3.

14.5.6 Any seams in soil-gas retarder membranes used in crawlspaces for sub-membrane depressurization systems shall be overlapped at least 12 inches and should be sealed. To enhance the effectiveness of sub-membrane depressurization systems, the membrane should also be sealed around interior piers and to the inside of exterior walls.

14.5.7 In combination basement/crawlspace foundations, where the crawlspace has been confirmed as a source of radon entry, access doors and other openings between the basement and the adjacent crawlspace shall be closed and

sealed. Access doors required by code shall be fitted with air tight gaskets and a means of positive closure, but shall not be permanently sealed. In cases where both the basement and the adjacent crawlspace areas are being mitigated with active SSD and SMD systems, sealing of the openings between those areas is not required.

14.5.8 When crawlspace depressurization 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, shall be identified, closed, and sealed. Sealing of openings around hydronic heat or steam pipe penetrations shall be done using non-combustible materials. Openings or cracks that are determined to be inaccessible or beyond the ability of the contractor to seal shall be disclosed to the client and included in the documentation.

14.6 Electrical Requirements

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

14.6.2 Wiring may not be located in or chased through the mitigation installation ducting or any other heating or cooling ductwork.

14.6.3 Any plugged cord used to supply power to a radon vent fan shall be no more than 6 feet in length.

14.6.4 No plugged cord may penetrate a wall or be concealed within a wall.

14.6.5 Radon mitigation fans installed on the exterior of buildings shall be hard-wired into an electrical circuit. Plugged fans shall not be used outdoors.

14.6.6 If the rated electricity requirements of a radon mitigation system fan exceeds 50 percent of the circuit capacity into which it will be connected, or if the total connected load on the circuit (including the radon vent fan) exceeds 80 percent of the circuit's rated capacity, a separate, dedicated circuit shall be installed to power the fan.

14.6.7 An electrical disconnect switch or circuit breaker shall be installed in radon mitigation system fan circuits to permit deactivation of the fan for maintenance or repair by the building owner or servicing contractor (Disconnect switches are not required with plugged fans).

14.7 Drain Installation Requirements

14.7.1 If drains discharge directly into the soil beneath the slab or through solid pipe to a soakaway, the contractor should install a drain that meets the requirements in paragraph 14.5.1.

14.7.2 If condensate drains from air conditioning units terminate beneath the floor slab, the contractor shall install a trap in the drain that provides a minimum 6-inch standing water seal depth, reroute the drain directly into a trapped floor drain, or reconnect the drain to a condensate pump.

14.7.3 Perimeter (channel or French) drains should be sealed with backer rods and urethane or comparable sealants in a manner that will retain the channel feature

as a water control system. (See paragraph 14.5.4.)

14.7.4 When a sump pit is the only system in a basement for protection or relief from excess surface water and a cover is installed on the sump for radon control, the cover shall be recessed and fitted with a trapped drain meeting the requirements of paragraph 14.5.1.

14.8 HVAC Installation Requirements

14.8.1 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.

14.8.2 Foundation vents, installed specifically to reduce indoor radon levels by increasing the natural ventilation of a crawlspace, shall be non-closeable. In areas subject to sub-freezing conditions, the existing location of water supply and distribution pipes in the crawlspace, and the need to insulate or apply heat tape to those pipes, should be considered when selecting locations for installing foundation vents.

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

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

14.8.5 Contractors 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. Contractors 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.

14.8.6 Both internal and external intake and exhaust vents in HRV systems shall be covered with wire mesh or screening to prevent entry of animals or debris or injury to occupants.

15.0 MATERIALS

15.1 All mitigation system electrical components shall be U.L. listed or of equivalent specifications.

15.2 As a minimum, all plastic 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 weathering or physical damage.

15.3 Vent pipe fittings in a mitigation system shall be of the same material as the vent pipes. (See paragraph 14.3.7 for exception when installing vent fans, and paragraph 14.2.7 for exception when installing radon vent pipes in sump pit covers.

15.4 Cleaning solvents and adhesives used to join plastic pipes and fittings shall be as recommended by manufacturers for use with the type of pipe 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.

15.6 When sealing holes for plumbing rough-in or other large openings in slabs and foundation walls that are below the ground surface, non-shrink mortar, grouts, expanding foam, or similar materials designed for such application shall be used.

15.7 Sump pit covers shall be made of durable plastic or other rigid material and designed to permit air-tight sealing. To permit easy removal for sump pump servicing, the cover shall be sealed using silicone or other non-permanent type caulking materials or an air-tight gasket.

15.8 Penetrations of sump covers to accommodate electrical wiring, water ejection pipes, or radon vent pipes shall be designed to permit air-tight sealing around penetrations, using caulk or grommets. Sump covers that permit observation of conditions in the sump pit are recommended.

15.9 Plastic sheeting installed in crawlspaces as soil-gas retarders shall be a minimum of 6 mil (3 mil cross-laminated) polyethylene or equivalent flexible material. Heavier gauge sheeting should be used when crawlspaces are used for storage, or frequent entry is required for maintenance of utilities.

15.10 Any wood used in attaching soil-gas retarder membranes to crawlspace walls or piers shall be pressure treated or naturally resistant to decay and termites.

16.0 MONITORS AND LABELING

16.1 All active soil depressurization and block wall depressurization radon mitigation systems shall include a mechanism to monitor system performance and warn of system failure. The mechanism shall be simple to read or interpret and be located where it is easily seen or heard by building occupants and protected from damage or destruction.

16.2 Electrical radon mitigation system monitors (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. Battery operated monitoring devices shall not be used unless they are equipped with a low-power warning feature.

16.3 Mechanical radon mitigation system monitors, such as manometer type pressure gauges, shall be clearly marked to indicate the range or zone of pressure readings that existed when the system was initially activated.

16.4 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: "Radon Reduction System," the installer's name, phone number, and RCP Identification Number, the date of installation, and an advisory that the building should be tested for radon at least every two years or as required or recommended by state or local agencies. 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 read, "Radon Reduction System."

16.5 The circuit breakers controlling the circuits on which the radon vent fan and system failure warning devices operate shall be labeled "Radon System."

17.0 POST-MITIGATION TESTING

17.1 After installation of an active radon control system (e.g., SSD), the contractor shall re-examine and verify the integrity of the fan mounting seals and all joints in the interior vent piping.

17.2 After installation of any active radon mitigation system, the contractor shall measure suctions or flows in system piping or ducting to assure that the system is operating as designed. (Note: When SSD systems are installed and activated, a test of pressure field extension is a good practice, particularly when there is uncertainty regarding the permeability of materials under all parts of the slab.)

17.3 Immediately after installation and activation of any active (fan-powered) sub-slab depressurization or block wall depressurization system in buildings containing natural draft combustion appliances, the building shall be tested for backdrafting of those appliances. Any backdrafting condition that results from installation of the radon mitigation system shall be corrected before the system is placed in operation. (Procedures and a checklist for conducting backdrafting tests are covered in the reference documents listed in paragraphs 8.9, 8.10, and 8.11, and in paragraph 11.3.)

17.4 Upon completion of radon mitigation work, a test of mitigation system effectiveness shall be conducted using an RMP listed test device and in accordance with EPA testing protocols or state requirements. This test should be conducted no sooner than 24 hours nor later than 30 days following completion and activation of the mitigation system(s). This test may be conducted by the contractor, by the client, or by a third party testing firm. If this test is conducted by the mitigation contractor, and the test results are accepted by the client as satisfactory evidence of system effectiveness, further post-mitigation testing is not required. However, to avoid the appearance of conflict of interest, the contractor shall recommend to the client that a mitigation system effectiveness test be conducted by an independent RMP listed or state certified testing firm or by the client. The contractor should request a copy of the report of any post-mitigation testing conducted by the client or by an independent testing firm.

17.5 To ensure continued effectiveness of the radon mitigation system(s) installed, the contractor shall advise the client to retest the building at least every two years or as required or recommended by state or local authority. Retesting is also recommended if the building undergoes significant alteration.

18.0 CONTRACTS AND DOCUMENTATION

18.1 EPA recommends that contractors provide the following written information to clients prior to initiation of work:

(1) The contractor's RCP Program identification number.
(2) A statement that describes the planned scope of the work and that includes an estimate of the time needed to complete the 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 EPA 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) An estimate of the installation cost and annual operating costs of the system.
(7) The conditions of any warranty or guarantee.

18.2 EPA recommends that RCP listed contractors keep records of all radon mitigation work performed and maintain those records for 3 years or for the period of any warranty or guarantee, whichever is longer. These records should include:

(1) The Building Investigation Summary and floor plan sketch. (See Appendix A.)
(2) Pre- and post-mitigation radon test data.
(3) Pre- and post-mitigation diagnostic test data.
(4) Copies of contracts and warranties.
(5) A narrative or pictorial description of mitigation system(s) installed.

18.2.1 Appendix A contains a suggested standard format for compiling mitigation project records.

18.3 Other records or bookkeeping required by local, state, or Federal statutes and regulations shall be maintained for the period(s) prescribed by those requirements.

18.4 EPA recommends that health and safety records, including worker radon exposure logs, be maintained for a minimum of 20 years.

18.5 Upon completion of the mitigation project, contractors shall provide clients with an information package that includes:

(1) Any building permits required by local codes.
(2) Copies of the Building Investigation Summary and floor plan sketch. (See Appendix A.)
(3) Pre-and post-mitigation radon test data.
(4) Copies of contracts and warranties.
(5) A description of the mitigation system installed and its basic operating principles.
(6) A description of any deviations from the RMS or State requirements.
(7) A description of the proper operating procedures of any mechanical or electrical systems installed, including manufacturer's operation and maintenance instructions and warranties.
(8) A list of appropriate actions for clients to take if the system failure warning device indicates system degradation or failure.
(9) The name, telephone number, and RCP Identification Number of the contractor, and the phone number of the state radon office.

APPENDIX A

MITIGATION PROJECT RECORD

RCP Contractor's Name (System Designer) _____ _____
RCP Identification Number _____
Contractor's Address _____
Company Name _____
Company Address _____

Client's Name _____
Client's Address _____

Type of Building:
- ☐ Detached Home
- ☐ Townhome
- ☐ Other (Describe) _____

Pre-Mitigation Test	Results	Test Device(s) Used
☐ Homeowner	_____	☐ Activated Charcoal
☐ RMP Listed Company	_____	☐ Electret
☐ Mitigation Contractor	_____	☐ Alpha Track
		☐ Continuous Monitor (Type)_____

Post Mitigation Test	Results	Test Device(s) Used
☐ Homeowner	_____	☐ Activated Charcoal
☐ RMP Listed Company	_____	☐ Electret
☐ Mitigation Contractor	_____	☐ Alpha Track
		☐ Continuous Monitor (Type)_____

Mitigation Method Used:
- ☐ Sub-slab depressurization
- ☐ Sub-membrane depressurization
- ☐ Block wall depressurization
- ☐ Ventilation
- ☐ Pressurization
- ☐ Other (Describe)_____

Building Investigation Summary and Floor Plan Sketch (See Paragraphs 11.0, 11.5, and 18.2 in the Mitigation Standard.)

Use the grid pattern sheet on page 2 of this form to sketch the foundation plan and dimensions of the building. At the top of page 2 is a list of suggested items for entry on the sketch. If a sub-slab or sub-membrane depressurization system is installed, the routing of the vent piping in the basement and/or crawlspace areas should be included, as well as pipe drops into the concrete slab or plastic membrane. If a fan has been included in the system, describe its location and the location of any monitoring or system failure warning device(s).

Signature
The contractor performing the Building Investigation, designing the mitigation system, and certifying its operational performance should sign this Project Record.

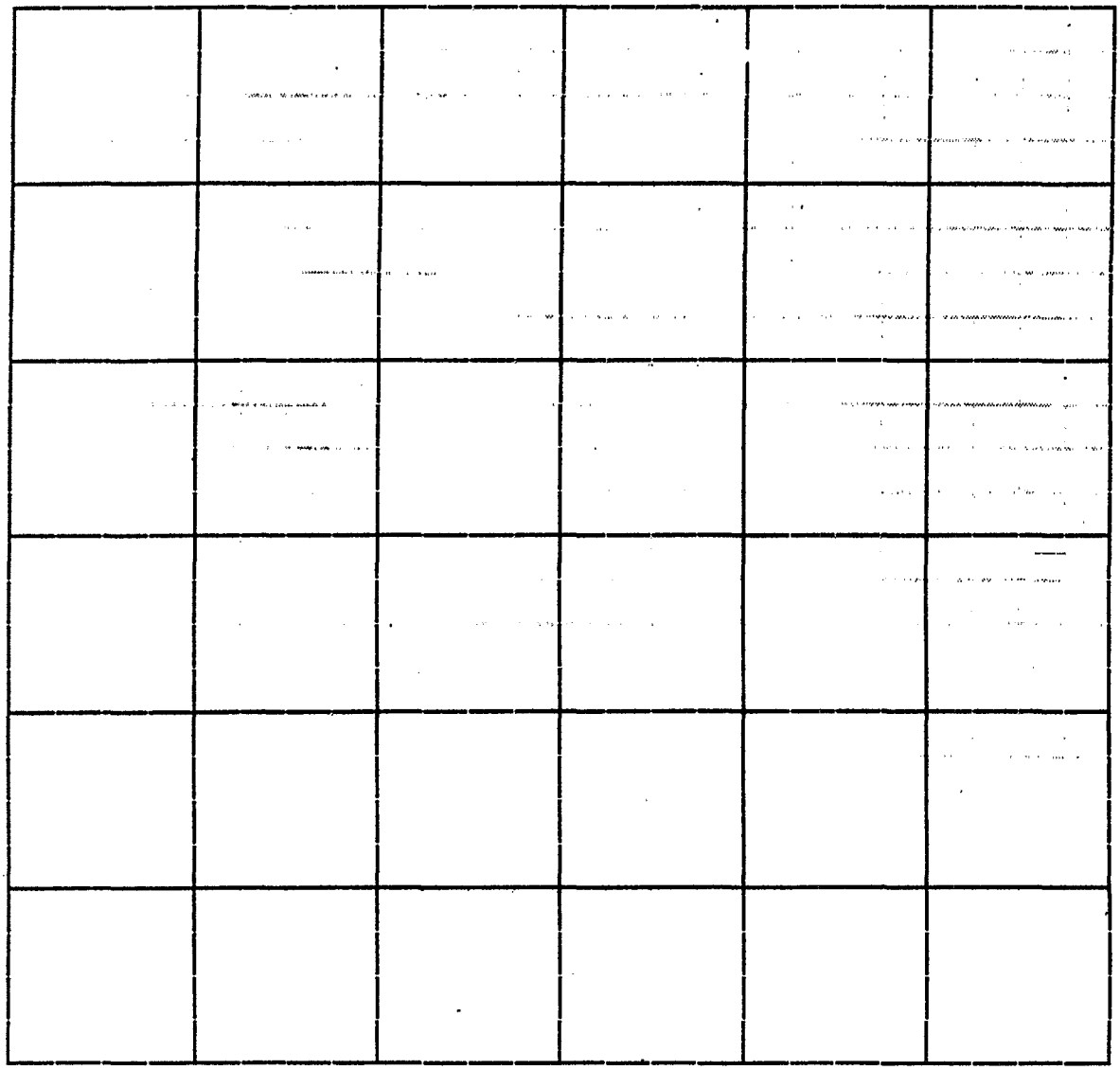
_____ _____
Mitigation Contractor Date

APPENDIX A (Continued)

Floor Plan Sketch
(Scale:_____)

Suggested items to include in the sketch:

Foundation dimensions.
Stairways.
Grade-level, walk-out areas from basement.
Heating, Ventilating, Air Conditioning Equipment.
Ductwork.
Ductwork under slabs.
Foundation vents.
Access doors to crawlspaces.
Locations of radon entry.
Open areas to crawlspaces from basements.
Piers and Lolly columns.
Footings located inside the foundation perimeter.
Sump holes/pumps.
Floor drains.



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