

CODES FOR RADON MITIGATION IN RESIDENTIAL STRUCTURES

by: Mitigation Committee
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ABSTRACT

The purpose of this document is to set forth standards for the installation of commonly installed residential building mitigation systems. Because of the tremendous variation in house construction and soil types, this document cannot define all systems or all situations that can occur, nor is the document meant to discourage innovative solutions to radon problems. This document does discuss common types of mitigation practices, such as passive systems, sub-slab depressurization, block wall depressurization, heat recovery ventilation, and radon in water mitigation.

This code sets minimum standards for those who advertise compliance with this code and those who are involved with mitigation installations.

This document assumes that appropriate radon/radon decay product screening and/or follow-up measurements have been performed within the structure, and that the owner of the structure has decided upon remediation to reduce the indoor radon concentration.

These codes require a knowledge of basic building design, construction materials, building pressurization/depressurization conditions and measurement procedures, measurement and diagnostic procedures for radon and radon decay products, and radon reduction techniques.

Knowledge of these codes is not a substitute for proper training and supervision.

In practice, the methods described may involve hazardous materials, operations and/or equipment. This standard does not address all possible safety problems associated with the work necessary to carry out these codes. It is the responsibility of whoever uses this standard to consult and properly apply the applicable documents and manuals for the equipment being used, establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use. All applicable laws, regulations, and ordinances should be complied with; nothing in this code should be construed or interpreted to be in violation of such laws, regulations, or ordinances.

**CODES FOR
RADON MITIGATION
OF RESIDENTIAL STRUCTURES**

**EASTERN PENNSYLVANIA CHAPTER
AMERICAN ASSOCIATION OF RADON SCIENTISTS AND
TECHNOLOGISTS**

**This version includes all the comments as of our last Mitigation Committee
meeting on 9/4/91.**

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INTRODUCTION:

This document contains minimum codes for contractors and consultants involved in the reduction of radon in residential buildings. Nothing in this code is intended to prohibit higher standards or the offering of additional services than set forth here.

It is the intent of this document to require all mitigators who comply with these codes to follow all local codes for the township where the mitigation is located. If no local codes have been adopted, the standards set forth by the Building Officials & Code Administrators series of codes and the National Fire Protection Association (see Section 200.0) shall be abided by.

Radon levels in a structure are determined by the amount of radon in the soil surrounding the structure, the permeability of the materials surrounding the structure, the size of the entry routes into the structure, and the air pressure differences between the structure and the surrounding soil.

Excessive exposure to radon and radon decay products can significantly increase the risk of lung cancer. The Congress of the United States has set a national goal that indoor radon levels be as low as ambient outdoor levels. This code sets forth permanent performance criteria to reduce radon levels indoors as low as is reasonably possible. The intent is to achieve this goal with reasonable initial cost, maximum effectiveness and longevity, minimal maintenance requirements, minimal impact to the structure and occupant, and minimal energy penalty.

Before any radon reduction methods are applied to a structure, it is important to quantify the radon levels within the structure using standardized measurement techniques, protocols and appropriate instrumentation. It is recommended that the testing be performed according to guidelines in the most recent version of the "Citizens Guide to Radon" and the EPC-AARST "Guidelines for Radon/Radon Decay Product Testing in Real Estate Transactions of Residential Dwellings".

PURPOSE:

The purpose of this document is to set forth standards for the installation of commonly installed residential building mitigation systems. Because of the tremendous variation in house construction and soil types, this document cannot define all systems or all situations that can occur, nor is the document meant to discourage innovative solutions to radon problems.

Adherence to the provisions of this code is voluntary. However, full adherence to the entire document is necessary to fully comply. Mitigators are free to contract for different services.

100.0 SCOPE:

101.0 General: This code sets minimum standards for those who promote compliance with this code and those who are involved with mitigation installations.

This document assumes that appropriate radon/radon decay product screening and/or follow-up measurements have been performed within the structure, and that the owner of the structure has decided upon remediation to reduce the indoor radon concentration.

These codes require a knowledge of basic building design, construction materials, building pressurization/depressurization conditions and measurement procedures, measurement and diagnostic procedures for radon and radon decay products, and radon reduction techniques.

Knowledge of these codes is not a substitute for proper training and supervision.

In practice, the methods described may involve hazardous materials, operations and/or equipment. This standard does not address all possible safety problems associated with the work necessary to carry out these codes. It is the responsibility of whoever uses this standard to consult and properly apply the applicable documents and manuals for the equipment being used, establish appropriate safety and health practices, and determine the

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applicability of government regulations and other limitations prior to use. All applicable laws, regulations, and ordinances shall be complied with; nothing in this code should be construed or interpreted to supersede or to be in violation of such laws, regulations, or ordinances.

This is a living document and, as such, will be reviewed for content and applicability by the Mitigation Committee on an annual basis or more often as deemed necessary by the committee. It is expected that revised versions will be issued on an annual basis.

200.0 APPLICABLE DOCUMENTS:

201.0 EPA DOCUMENTS (latest versions)

201.1 Radon Resistant Residential New Construction

201.2 Radon Reduction Techniques for Detached Houses, Technical Guidance

201.3 Indoor Radon and Radon Decay Product Measurement Protocols

201.4 Interim Protocols for Screening and Follow-up Radon and Radon Decay Product Measurements

202.0 American Society for Testing and Materials, All applicable Specifications and Tests relating to radon.

203.0 *National Electrical Code 1990*, National Fire Protection Association, Quincy, MA, 1989.

204.0 *The BOCA National Building Code 1990* version, Building Officials and Code Administrators International, Inc., Country Club Hills, IL, 1990.

205.0 *The BOCA National Plumbing Code 1990* version, Building Officials and Code Administrators International, Inc., Country Club Hills, IL 1990.

206.0 Occupational Safety and Health Administration, all regulations relating to radon mitigation.

300.0 DEFINITIONS: For the purposes of this standard, the following terms are defined as:

300.1 Block Wall Depressurization: An installed system that exhausts air to the outside from the void network of a block wall of a structure that causes the air pressure in the block wall to be lower than the air directly outside the wall.

300.2 Certified: Having certification from to the Pennsylvania Department of Environmental Resources to offer radon testing services or radon mitigation services.

300.3 Client: Person or persons who has contracted with a mitigation company to have the radon or radon decay product levels in a structure reduced.

300.4 Closed-House Conditions: Those conditions defined in the EPA Radon Measurement Protocols and 1987 Interim Protocols and the EPC-AARST Real Estate

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Testing code for the limiting of structure ventilation.

300.5 Combustion Air: Air that is consumed or passes through a combustion appliance that is drawn from the space around the appliance or is ducted to the outside through a chimney.

300.6 Combustion Make-Up Air: Air that is routed to a combustion appliance, supplying air for combustion.

300.7 Commercial Buildings: Buildings that are occupied a minimum of ten hours a week for the purpose of a business or public or gathering of individuals for whatever purpose that does not fall within the definition of residential structure as defined in this document.

300.8 Communication Test: A diagnostic procedure typically performed upon the concrete slab of the lowest level or levels in a residential structure in an attempt to determine the effectiveness of a radon sub-slab depressurization.

300.9 Detector: Any radon or radon decay product measuring device approved by the EPA and the Pennsylvania Department of Environmental Resources.

300.10 Diagnostic Measurements: Procedures used to help identify radon entry routes, radon flux, radon levels in rooms or conditions of the structure.

300.11 EPA: The United States Environmental Protection Agency

300.12 EPA Measurement Protocols: Those guidelines set forth by the EPA for the purpose of identifying and describing measurement devices, procedures, and their analyses. Refer to Section 201.0.

300.13 EPC-AARST "Guidelines for Radon/Radon Decay Product Testing in Real Estate Transactions of Residential Dwellings: A document that defines guidelines for the testing of radon and radon decay products in dwellings that are involved in real estate transactions.

300.14 Listed: Equipment or material included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials, and whose listing stated either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

300.15 Livable Area: A habitable or potentially habitable space within a structure.

300.16 Long-Term Testing: Any radon or radon decay product measurement that is acknowledged as appropriate in the EPA measurement protocols and has a duration of more than 90 consecutive days.

300.17 Lowest Livable Level: The lowest level of the residential structure that is a livable area (see 300.14) or could be converted into a livable area without major structural changes.

300.18 Mitigation Apprentice: A mitigation system installer who has not yet met the qualifications to be a mitigation mechanic and who is not a mitigation specialist, or

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mitigation consultant. A mitigation apprentice has limited mitigation experience and requires on-site supervision by a mitigation mechanic, mitigation specialist, or mitigation consultant.

300.19 Mitigation Company: A company that employs a mitigation specialist or mitigation consultant and designs and/or installs mitigation systems according to these codes.

The company and its employees, consultants, and sub-contractors shall abide by all state and federal certification required by the state in which the mitigation installation is located. If the company mitigation specialist has not been directly involved in the design and installation of a minimum of fifty mitigation installations, a mitigation consultant shall be retained to supervise each mitigation installation.

This supervision shall require at least one site visit per mitigation installation. The consultant shall provide a written report to the mitigation company for each job inspection, including any discrepancies in the work from these codes. The mitigation consultant shall perform a final inspection and issue a final report for each installation to the Pennsylvania Department of Environmental Resources.

300.20 Mitigation Consultant: A mitigator who designs, consults or supervises mitigation installations for companies other than his own company or the company for which he directly works. He shall have all the qualifications of a mitigation specialist plus he shall have been directly involved in the design and installation of more than one hundred radon jobs.

300.21 Mitigation Installation: The permanent installation of materials, equipment or apparatus specifically designed to reduce radon or radon decay product levels in a structure.

300.22 Mitigation Mechanic: Person who, under the supervision of a mitigation specialist or mitigation consultant, installs or adjusts equipment or materials in a structure in order to reduce the radon levels in that structure. He shall have been directly involved with a minimum of twenty-five radon mitigation installations.

300.23 Mitigation Specialist: A person who designs or supervises the installation or adjustment of equipment or materials in a structure in order to reduce the radon levels in that structure. This person shall have passed the EPA RCP exam and shall comply with any radon certification requirements of Pennsylvania. He or she shall have completed a state or federally approved radon mitigation course that is at least three days long and shall be familiar with the documents listed in Section 200.0.

300.24 Outside Air Supply: An air duct or air intake that routes outside air to introduce air into the livable area of the structure.

300.25 Perimeter Openings: A small canal around the perimeter of a basement or gap between the wall and the slab that is typically the depth of the slab and 3/4" to 2 1/2" wide. It is also referred to as a french drain, perimeter drain, or floating slab construction.

300.26 Permeability: A measure of the ease with which soil gas can flow through a medium.

300.27 Pressure Field Extension: The strength and distance that a pressure change is induced in the sub-floor from single or multiple points of the sub-floor pressure or depressurization.

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300.28 Radon: When used in this code without modification, the terms "radon" or "radon measurement" refer to the radioactive elements radon (Rn-222) and/or its short-lived decay products.

300.298 Radon Barrier: A gas-resistant material that prevents or substantially limits the flow of radon gas.

300.30 Radon Decay Products: If this document states "radon decay products", the term refers only to the four radioactive elements which immediately follow Rn-222 in the decay chain and are measured in units of working levels (WL).

300.31 Radon Gas: If this document states "radon gas", the term refers only to Rn-222, a naturally occurring radioactive element which is a gas and is measured in units of picoCuries per liter (pCi/L).

300.32 Radon Test: The exposure of Pennsylvania Department of Environmental Resources-approved detectors in a structure using EPA protocols to measure the radon or radon decay product concentration of that area.

300.33 Re-entrainment: Radon-laden air entering into the livable areas of the structure from a radon system or its exhaust.

300.34 Residential Structure: A single family structure or a one family structural unit, containing not more than four separate residential structural units, each such unit used or occupied, or intended to be used or occupied, wholly or partly, as the home or residence of one or more persons.

300.35 Shall: Indicates a requirement that is necessary to fully adhere to the provisions of this standard.

300.36 Short-Term Testing: Any radon measurement that has a duration of 90 consecutive days or less.

300.37 Should: indicates an advisory recommendation that is to be applied whenever practical.

300.38 Soil Gas Entry Route: An opening in the dwelling envelope that allows radon gas to enter the structure from the soil.

300.39 Sub-Barrier Depressurization: An installed system that exhausts air to the outside from below an air-tight barrier that causes the air pressure under the barrier to be lower than the air directly above it.

300.40 Sub-slab: The space directly below a concrete slab floor that may be a gravel base or dirt with a varying amount of permeability.

300.41 Sub-Slab Depressurization: An installed system that exhausts air to the outside from below the slab of a structure that causes the air pressure under the slab to be lower than the air directly above the slab.

300.42 Suction Point: A penetration through a concrete slab or block wall cavity, the excavation of material out from under the slab, and the sealing of a pipe into the hole with the pipe connected to an exhaust fan that draws air from the hole to the outside in order to

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create a sub-slab depressurization.

300.43 Temporary Mitigation: Mitigation systems that are installed to lower the radon concentration but would not be acceptable as a permanent installation, such as (but not limited to) the following examples: the installation of sealants or barriers that could easily fail or be removed; the forced or passive introduction of unconditioned air into the structure (other than make-up air) that would cause significant occupant discomfort or harm to the structure and furnishings

300.44 Whole House Fan: A large exhaust fan used to ventilate the whole house. Typically the fan is installed in the ceiling or attic of the structure and draws air out of the structure from the ceiling of the highest floor.

300.45 Working Level Month (WLM): A unit of measure that is used to determine the accumulated exposure from breathing radon decay products. It is calculated by multiplying the average working level that the worker was exposed to by the amount of hours he was exposed for and dividing that number by 170.

400.0 GENERAL PRACTICES:

401.0 CONTRACT: All estimates or contracts for mitigation installations shall be in writing. The estimate or bid shall clearly define the scope of the work, the set price or any hourly rates, the length of time for which the price is valid, the owner's responsibilities, all extras, and the conditions of the warranty or guarantee, if any. If no warranty is included, it must be stated in writing on the contract.

402.0 PERMITS: Mitigators shall obtain permits in those municipalities which require them.

403.0 WORKMANSHIP: All work performed on each mitigation installation shall be in a good and workman-like manner.

404.0 SUB-CONTRACTORS: Sub-contractors shall not be used for the portions of the mitigation installation that require specialized knowledge of mitigation or mitigation training, unless the sub-contractor meets the requirement of the mitigation mechanic as defined in this code or is under direct supervision by a mitigation mechanic or specialist. Sub-contractors shall carry all insurance required by governmental authorities.

405.0 PRODUCT DISCLOSURE: The mitigation company shall give a written and oral advisory about products that are currently known to be hazardous to the homeowner's health during installation and curing time.

406.0 WORKER PROTECTION: All governmental laws and requirements for worker safety and protection shall be met. The following are in addition to such requirements.

406.1 Company Program: The mitigation company shall have on record a company worker protection program that is available to all employees and is approved by any state or federal regulating agencies that require such a plan.

406.2 Eye Protection: The mitigation company shall provide the necessary

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eye protection during cutting, drilling, grinding, polishing, demolishing, or any other work activity that may cause injury to the eyes.

406.3 Ear Protection: The mitigation company shall provide the necessary ear protection required during cutting, drilling, grinding, polishing, demolishing, or any other work activity that may cause injury to the ears or cause hearing loss.

406.4 Electrical Protection: Whenever electrical work is being performed, necessary measures shall be taken to ensure that all such equipment is properly grounded and electrically safe to avoid electrical shocks. Where electrical lines may be encountered, non-conductive equipment should be used. Ground-fault circuit-interrupters shall be provided on all work sites.

406.5 Physical Protection: Whenever it is required to work in an area where objects could fall or strike a worker, the mitigation company shall provide the necessary safety equipment, such as hard hats, face shields, steel toe boots, or heavy gloves. Whenever it is required to work at elevations above the ground or floor, the mitigation company shall ensure that the necessary equipment, such as ladders or scaffolding, is safely installed and operated.

406.6 Workplace Air Quality: Whenever there is a need to reduce ambient radon levels, dust, or other airborne pollutants, the mitigation company shall ventilate the work area as required to reduce the risks to acceptable levels. It is strongly recommended that employees and others do not smoke on the job site.

406.7 Fire Safety: Whenever a potential for fire or ignition of combustible materials exists, the mitigation company shall provide the necessary fire prevention, protection and fire fighting equipment at each work site. All job sites shall have fire extinguishers suitable for extinguishing type A, B, and C fires. Where open flame is being used, ABC fire extinguishers shall be in the immediate work area.

406.8 Monitoring Worker Radon Exposure: Mitigation company employees who are exposed to potentially elevated levels of radon and radon decay products on the worksite shall monitor their exposure with a personal radon dosimeter. The radon levels accumulated by the employee shall be converted into working levels using a 50% equilibrium and then into working level months. No employee shall knowingly be exposed to two WLM or more in any year of continuous exposure.

406.9 Respirators: Whenever it is required to use respiratory protection equipment, the mitigation contractor shall ensure that the personnel wearing such respirator equipment are properly trained and medically qualified to wear a respirator which satisfies minimum OSHA standards. All companies shall have a written respiratory protection program and policy.

406.10 Material Safety Data Sheets: Whenever it is required to use sealants, compounds, adhesives, paints, glue, etc., the mitigation company shall provide the applicable Material Safety Data Sheets and shall explain the required safety procedures to the work force. All mitigation companies shall also have a written Material Data Safety Sheet program. Material Safety Data Sheets are required to be available on the worksite.

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407.0 COMPANY RECORDS

407.1 Job Records

Each mitigation company shall keep records of all mitigation installations. Records will be maintained for 2 years. All record keeping and bookkeeping required by any state or federal regulations shall be recorded and maintained.

407.2 Health and Safety Records

All records of health and safety required by this code or state or federal regulations shall be kept and maintained for a minimum of 2 years.

408.0 LABELING: All mitigation systems that use an active system shall have the control switch or disconnect labeled to indicate its function and a company name, certification number, telephone number to call if service is needed, and an advisory to test the home annually for radon. Any required system checks, maintenance, or service shall be in a written homeowners' manual and supplied to the homeowner with the installation. Passive systems require labeling as set forth in Section 514.0.

409.0 POST MITIGATION TESTING

409.1 Delay Time Before Testing: Post mitigation testing after installation of a radon system shall not begin until at least 48 hours after the installation is activated and closed house conditions have been maintained for at least 12 hours preceding the test. Any state requirements shall supersede this minimum time requirement.

409.2 Test Conditions: If feasible, a post mitigation test should be conducted under similar conditions to the pre-mitigation measurement in order to help assess the system effectiveness. It is important, however, to test the mitigation installation under the conditions that will most effectively determine the performance of the system. The mitigator shall recommend to the client that 2 an additional acceptable short-term post-mitigation tests be performed during the heating season, followed by a long-term test having at least half of the exposure period in the heating season..

409.3 Testing Company: A testing company certified to offer testing services in the state of Pennsylvania should be used for all post mitigation testing of real estate transfer dwellings.

409.4 System Failure: If any future re-testing by the homeowner during the warranty period indicates elevated radon levels above the guaranteed levels, the mitigation contractor shall promptly provide, at his expense, services to correct the system failure. The mitigation contractor shall also provide within 30 days, at his expense, a retest to EPA protocols at the conclusion of his repairs. The retest shall be similar to the original retest offered in the proposal.

500.0 MITIGATION METHODS:

501.0 BUILDING INVESTIGATION

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501.1 Client Interview: Mitigation companies shall interview the client and/or his agents to obtain background information about the structure and the previous radon measurements.

501.2 Previous Measurements: The mitigation company shall review and assess the quality of any previous radon measurements made by the client to determine whether these measurements were made in accordance with EPA Measurement Protocols and state regulations. If the pre-mitigation measurements were not performed by the homeowner, the mitigation company shall record the type of test and testing company that performed the test, if available. If the homeowner performed the test, the mitigation company shall obtain the laboratory name of the test kit, if available. This information shall be included in the post-mitigation report form to the state. Should a determination be made that the measurements did not follow protocols or state regulations and that these discrepancies could result in potentially erroneous measurements, the client shall be advised of the discrepancies and advised of the appropriateness of retesting according to the protocols or state regulations.

501.3 Walk Through: To determine the potential radon entry routes and establish the appropriate mitigation strategy, an on-site building investigation shall be performed by a mitigation specialist prior to submission of a mitigation proposal. Further diagnostic testing may be necessary if previous testing and building investigations do not provide adequate information to ascertain radon entry routes and provide enough information to properly design a mitigation installation.

501.4 Communication Tests: If a sub-slab depressurization system is considered as a possible choice of systems then a communications test should be performed if sub-slab soil conditions are unknown. The owner shall be informed about the procedures of the test and his/her permission requested to perform the test prior to any drilling. All vacuum discharge likely to contain sub-slab gases shall be vented to the exterior of the structure. Ideally, the entire vacuum unit should be located outside the structure, with only an extended suction tube inside the structure. This test is performed to determine the most appropriate fan type and size, number of suction points, suction point locations, and pipe size.

501.5 Diagnostic Radon Measurements: If diagnostic radon measurements are required, they shall be performed by or supervised by a certified testing or mitigation specialist to help define radon sources and their strength. These measurements can be performed with a number of different passive or active radon or radon decay product detectors. The mitigation specialist shall consider the effect of pressure differentials, ventilation rates of the sampled area and other significant factors when using this information or reporting this information to a client. The mitigation company shall inform the client of the limitations of such measurements.

501.6 Ventilation Measurements: If ventilation pressure or building leakage rear measurements are required to design a mitigation system or analyze an existing mitigation system, they shall be performed by or supervised by a mitigation specialist. If the HVAC measurements are outside the expertise of the mitigation specialist, the mitigation specialist should retain the services of a qualified HVAC contractor or consultant.

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502.0 SYSTEM DESIGN

502.1 System Goals: A radon reduction system shall be designed as an integral part of a dwelling. It shall be designed so that it does not create additional environmental, health, or safety hazards to the occupants or compromise the integrity and comfort of the dwelling environment. The system shall be designed to minimize noise (as set forth in Section 506.0) and aesthetic impact on the structure.

502.2 Temporary Mitigation Systems: Mitigation companies shall not install temporary systems in lieu of a permanent installation, unless it is contracted with the client specifically as a temporary system. If a temporary system is installed, the mitigation company shall inform the owner that the installation is temporary, and put in writing in the contract and warranty or guarantee, if any.

502.3 Informing the Client: As a minimum, the client shall be informed of the following aspects of the installation proposed by the mitigator. These aspects include: equipment to be used and its placement, operating costs, effect on heating costs, system noise, necessary time for caulk to fully cure before traffic is allowed on it, and required maintenance by the homeowner.

503.0 SEALING

503.1 Cracks and Non-Functional Openings to Soil Gas: Cracks and non-functional openings that emanate soil gas or allow room air to be drawn into depressurization systems shall be sealed with a urethane caulk or equivalent sealant. Surfaces to be sealed shall be brushed or vacuumed clean. Gun grade urethane sealant or equivalent shall be mechanically tooled and forced into the crack to be sealed. Maximum joint size and depth without a backer rod is 1/2". Openings wider than 1/2" shall have a backer rod material installed prior to the application of the sealant. Care shall be used to ensure that air is not trapped between the sealant and the surface to which it is bonded. Larger openings can be sealed with masonry products, but the materials selected shall limit poor bonding and shrinkage. Masonry patches larger than a few inches wide shall have the edges troweled with a groove around the perimeter so that a urethane sealant or equivalent can be installed to span the shrinkage crack.

503.2 Open Block Cores and Voids: Open cinder and concrete blocks that emanate soil gas or allow room air to be drawn into depressurization systems should be sealed. If foam plastics are used, the foam shall be separated from the interior of the building by 1/2 gypsum wallboard or equivalent thermal barrier, as set forth by BOCA National Building Code, Section 2002.2.

503.3 Sump Holes: Sump holes that emanate soil gas or allow room air to be drawn into depressurization systems shall be covered and sealed with materials that are permanent and resistant to rotting and breakage. No sump holes shall be covered with wood. In cases where there is any chance of future water problems, the cover shall be installed in a manner that allows it to be easily removed. The top of the sump cover shall be flushed or recessed below the concrete floor. All covers that are installed over an existing mechanical pump shall have a method for inspecting the operation of the pump without removing the cover. Sealed sump pits that previously provided protection or relief from surface water collection on basement floor shall be fitted with trapped drains.

503.4 Floor Drains: Floor drains which are sealed shall be provided with mechanically trapped drain fittings. All mechanically trapped floor drains shall be accessible for cleaning and shall be mounted below or flush with floor level. Floor drains that allow a significant amount of soil gas to enter the structure or that significantly reduce the sub-slab depressurization due to leakage shall be replaced or fitted with a gas-resistant drain. Replacement drains or drain fittings shall contain provisions to allow the drain to be easily cleaned. Sealed drains that previously provided protection or relief from surface water collection on basement floor shall be fitted with trapped drains.

503.5 Condensate Removal: All condensate lines leading or draining in shall be fitted with traps, stand-alone condensate pumps, or be indirectly drained to a trapped floor drain. Traps shall provide a 6" standing water seal depth.

503.6 Perimeter (Canal) Openings: Openings around the perimeter of a foundation shall be sealed. Perimeter opening sealant systems shall be designed so that the sealant system will not interfere with the effectiveness of the existing water control system.

One approved method for sealing the perimeter opening is to install a backer rod in the opening first and pour a flowable urethane sealant on top of the backer rod, leaving an air space below the backer rod and the top of the sealant 1/4" recessed below the level of the floor to contain a small amount of condensation. This method is appropriate for dry basements.

Another approved method of sealing the perimeter opening is to use a baseboard waterproofing channel on top of the perimeter opening.

A third method is to seal water-resistant sheet metal that is bent in the shape of an L.

If the perimeter opening is located behind a finished wall, the required portion of paneling should be removed and the opening sealed appropriately.

If there is no threat of moisture infiltration into the basement, one or two part foam may be injected through 3/8" holes drilled through the lowest part of the wall on 8" centers. Foam sealants shall be used only behind wall areas finished with 1/2" drywall or its thermal equivalent.

504.0 SOIL DEPRESSURIZATION

504.1 Piping: PVC or ABS piping shall be used. The fittings shall be manufactured from the same material as the pipe. Only adhesives compatible with the pipe and fittings shall be used. Schedule 20 gauge pipe and fittings may be used for mitigation installations. Integral bell couplings shall be at least 2 1/2 inches deep. Pipe straps shall be fastened at a minimum of every 6 feet on center for all horizontal pipe runs. Schedule 40 shall be used in garages, through firewall penetrations, and in locations subject to physical damage. The above protocols do not apply to sub-barrier piping.

504.1.1 Removal of Sub-slab Material: A minimum of one half cubic foot of sub-slab material shall be excavated at each suction point.

504.1.2 Pipe Size: The sizing of the pipe shall take into consideration the fan performance and the calculated pressure drop of the piping and system to ensure that no portions of the piping system are significantly restricting the air flow or the required pressure to operate the system.

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effectively.

504.1.3 Pipe Routing: Pipe routing shall be designed to ensure that condensation will not accumulate in any portions of the pipe. Pipes shall be completely sealed to reduce pressure loss from leakage as well as radon re-entrainment from positive portions of the pipe routing. Any portions of the pipe routing that penetrate a firewall shall maintain the firewall according to local code requirements with an approved fire stop system. The alternative to the installation of a fire stop system is to protect the pipe with an approved fire stop material in the fire area.

504.1.5 Number of Suction Points: The number of suction points shall be determined by the communication available throughout the sub-soil, the number of separate slabs that are significant radon sources and do not communicate with other slabs and the amount of leakage through or around the slab or radon barrier. The suction points should be located to avoid obstruction of dwelling or storage space. If multiple suction points are installed and there is significant difference in flow and pressure requirements between different suction points, then dampers should be installed in the pipes leading to the high flow suction points and adjusted to balance the amount of vacuum and flow to the individual suction points. When flow and pressure differences vary greatly from slab to slab in the same structure, two separate systems may be required.

504.2 Fans: Fans shall be designed specifically for radon removal applications and shall be capable of providing a seal against leakage. Fans shall be sized to provide adequate vacuum and air flow characteristics for each mitigation installation. Fans shall also be installed only in locations for which they are listed. The fan shall be designed and installed to handle the amount of water typically produced by condensation from the operation of the system. The fan shall meet acceptable standards for noise and power consumption. The fan shall be installed so that it can be easily serviced.

504.2.1 Fan Location: Soil depressurization fans shall be located outside the heated or cooled envelope. Outdoor, attic, or garage attic installations are allowable locations. The decision of fan location shall include considerations for fan noise to the occupants. No fans shall be buried underground.

504.2.2 Fan Installation: Fans shall be installed so that condensation will not be trapped inside the unit. They shall be installed in such a manner that they do not transfer significant vibration to the framing. The fan shall be installed in such a manner as to allow simple replacement if the fan becomes defective in the future. The fan shall be securely fastened. The fan shall be sealed so as to eliminate exfiltration of soil gas from itself or its components into the structure. All fans should be mounted with rubber couplings.

504.3 Framing Cutouts: Removal of framing material shall be performed in accordance with local code allowance for removal of framing material as required to install plumbing pipes. If no codes are enforced, mitigators shall adhere to BOCA National Building Code, Section 1702.2.1.

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504.4 System Insulation: Portions of the system that are installed in unconditioned spaces in climates that are colder than 7500 degree days per year should be insulated to reduce condensation and system freeze up. Systems shall also be insulated for noise reduction where necessary.

504.5 Drain Tile Suction: Interior drain tile suction shall be designed to minimize or eliminate the air leakage effect of any drains to grade or openings in the system. If the foundation is a block wall and the block wall is connected to the drain tile with individual drilled holes that are drilled into the open block cores, the block wall shall be sealed to reduce air leakage from the structure and enhance the pressure field extension of the system. Foam sealant application shall conform to BOCA National Building Code, Section 2002.0.

504.6 Exhaust Location: The exhaust location shall be at least 12" above the roof line and at least ten feet from any vent, windows, skylight, doors, or openings that are less than 2 feet below the exhaust point.. The exhaust through a roof shall be sealed with a plumbing flashing or equivalent and installed in accordance with manufacturers' recommendations. Caulk or collar sealing methods shall not be used for roof penetrations. Gable or sidewall exhaust should not be used because of the possibility of radon re-entrainment into the living envelope. Exhaust shall not be terminated at ground level. Roof caps for roof exhaust are not required; if installed, roof caps shall have a minimum of 6" of clearance between the roof penetration and the lower edge of the rain shield.

505.0 ELECTRICAL CONNECTIONS

505.1 Fans: Only fans that are Underwriters Laboratory or equivalently listed for the application for which they are being used shall be installed. Fan shall meet acceptable standards for power consumption and noise. Fans shall be installed so they can be easily serviced. Fans shall be sized to provide adequate performance for their required use. Fans shall not be oversized so as to impose an unnecessary operating cost for the occupants of the structure.

505.2 Wiring: All wiring shall be performed according to the National Electric Code and any applicable regulations. All wiring installed in the structure shall be sized to handle the rated load of any circuit upon which it is installed. Wiring may not be located in or chased through the mitigation installation ductwork or any other heating or cooling ductwork. All exposed outside wires shall be installed in liquid-tight conduit. The maximum length of any plugged cord used in a mitigation installation shall be 6 feet. A plug shall not be installed in the last available outlet in an existing outlet location. No plugged cord may penetrate a wall or be concealed.

505.3 Circuits: If the fan capacity exceeds 50% of the circuit capacity, then the fan shall be wired with a dedicated circuit. The fan shall not be wired to a circuit that has a total connected load of 80% of the circuit (including the fan). The fan shall not be wired to the bathroom or kitchen circuit. The fan shall be treated as any other continuous appliance.

505.4 Electrical Disconnect: There shall be an electrical disconnect for the fan for homeowner and service use. There shall be an electrical disconnect within sight. Plugged fans shall not be used outdoors.

505.5 Electrical Labeling: The circuit breaker containing the radon system

fan shall be labeled "Radon System".

506.0 NOISE CONSIDERATION: Radon mitigation systems shall be designed and installed to minimize system noise. It shall be the goal of the mitigator that the installed and operating system will not interfere with the enjoyment of the home, nor shall it interfere with sleep or other activities which require a quiet setting.

506.1 Design Standard: Radon mitigation systems shall be designed to minimize noise. The following design details are recommended to minimize noise in the home:

506.1.1 Mounting: It is recommended that motor-driven fans be mounted in rubber. The most common mounting system is to use rubber couplings to mount the fan to the plastic pipe. If it is necessary to provide additional support, rubber noise isolation shall be incorporated. Fans shall not be rigidly mounted to the structure of the house.

506.1.2 Exhaust: Noise from the system exhaust normally is not a problem due to the rooftop exhaust location. Placing the exhaust away from windows and doors will normally prevent noise from becoming a problem.

506.1.3 Additional Noise Control: If an especially noisy fan, such as a regenerative blower, is used in the system, additional noise control may be necessary

506.2 Performance Standard: The absolute noise level shall be below that which most people consider objectionable.

506.2.1 Noise Measurements: The absolute noise level which is objectionable will vary depending on the background noise level and may depend to some extent on which room the noise is affecting. For the purpose of this standard, the allowable noise level shall depend solely on the background noise level, since the background level will determine the audibility of the noise.

The noise limit shall be determined using a sound level meter using the "A" weighting, which corresponds to the sensitivity of the human ear. The noise limit shall be a 3 decibel increase above the background noise measured with the radon mitigation fan turned off. This background measurement shall be made at the time when background is lowest. In most cases, this will be in a bedroom at night. The 3 decibels increase corresponds roughly to a doubling of the noise power level in the room. This is the approximate point where an added noise is readily noticeable. Noise increases below this amount are perceptible but generally not noticeable.

506.2.2 Purpose: It is the intent of this standard that sound level measurements will not be a routine procedure for radon mitigation system installation. Sound level measurements would normally be used only in the case of a disagreement over system noise. Incorporation of the noise control Design Standard described above should normally provide sufficient noise protection.

507.0 MATERIAL PROTECTION

507.1 Protecting System Components: The portions of the installation that are susceptible to significant damage from the environment shall be protected. This includes such items as protecting the PVC pipe from UV degradation due to direct sunlight. The mitigation system shall be installed in a manner to minimize the risk of damage by occupant traffic or moisture.

507.2 Fan Protection: The fan shall be protected from damage or failure. This would include installing the system so that rain water, ground water, or condensation within the system does not accumulate in the fan or in the piping. Exterior mounted fans shall be rated for outdoor installation or be installed in a weatherproof housing.

507.3 Firedampers: Any penetration of an existing firewall with the mitigation installation ductwork that requires the installation of a firedamper to meet code requirements shall have the necessary components installed according to the manufacture recommendations. If allowed by code, the radon duct vent may be boxed in with 5/8" drywall to meet code requirements for penetrating a firewall.

508.0 SYSTEM MONITORS: Each depressurization system shall include a vacuum indicator. All other active systems shall include an appropriate indicator of system performance. All indicators shall be labeled and located for easy monitoring by the occupant of the structure.

509.0 CRAWL SPACE BARRIER AND SUB BARRIER SUCTION

509.1 Barriers: All barriers shall provide the required degree of durability based on the possible use and traffic. All accessible dirt crawl spaces should be sealed with a barrier.

509.1.1 Concrete: Concrete may be used as a barrier in areas used as storage only. Concrete is the recommended for floors, although wood may be used. Concrete shall be used in areas that are designated as floor space. When concrete is used, provisions for sub barrier suction should be employed.

509.1.2 Wood: Wood may be used for floor barriers, but concrete is recommended. Wood (or EPDM, see 509.1.3) may be used for crawl areas designated as storage areas. If wood is used, it shall be pressure treated plywood, with a minimum thickness of 3/4". All subfloor supports shall be pressure treated as well. Galvanized fasteners shall be used in the wood floor and sub-barrier supports. Unless the plywood is tongue and groove, the joints between floor pieces shall have support members or cleats for support. All edges shall be prior to installation. The perimeter of the wood floor shall have a 4" ribbon of mortar where the floor meets the wall. Where the concrete meets the wall and the wood shall be tooled and sealed.

509.1.3 Rubber and Plastic Barriers: EPDM shall be used in areas designated as storage. Ultra-violet light protected 6 mil polyethylene or thicker shall be used in crawl areas with limited required access. Combinations of barriers may be used in continuous crawl spaces with

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more than one designated use area. Two-part urethane spray foam shall not be used in crawl areas that are continuous with any living space, as defined in the BOCA National Building Code, Section 2002.3.5.

509.2 Barrier Sealants: All barriers shall be secured and sealed at the perimeter so as to minimize conditioned air loss into the system and maximize the sub-barrier pressure field extension.

509.3 Number of Suction Points: The number of suction points should be determined by sub-barrier communication testing. All barrier systems should have communication enhancements installed with the barrier.

510.0 DEPRESSURIZING CRAWL SPACE: Crawl space depressurization should be limited to areas where crawl space barrier and/or crawl space sub-barrier depressurization are not feasible due to inaccessibility. The present home owner and any future home owner during warranty period shall be advised in writing of possible heat loss due to crawl space depressurization.

510.1 Sealing Crawl Space Area: When crawl space depressurization is employed, air leaks from the conditioned and unconditioned areas shall be identified and sealed. Areas that are determined beyond the ability of the contractor to seal shall be disclosed to the client in writing on all contracts and warranties. The disclosure shall include a heat loss impact statement.

511.0 BLOCK WALL VENTILATION

511.1 Sealing Walls: All openings into the block wall voids shall be sealed for any wall being depressurized. All openings that may allow conditioned or unconditioned air to enter the depressurized area shall be identified and sealed. Areas that are determined beyond the ability of the contractor to seal shall be disclosed to the client in writing on all contracts and warranties. The disclosure shall include a heat loss impact statement.

511.2 Number & Location of Wall Suctions: The number and location of wall suction points should be determined by communication diagnostics.

511.3 Baseboard Suction: When using baseboard suction, all seams and joints in the baseboard system shall be sealed so as to prevent the entry of room air into the system.

512.0 SOIL PRESSURIZATION

512.1 System Considerations: Soil pressurization shall be employed only after sub-slab diagnostics indicate very loose or fractured subsoil which allows free air movement and inhibits depressurization, as well as the existence of (or the ability to develop) a leak free barrier under which the pressure will be applied.

512.2 Fan Location:

Fan location considerations shall include possible noise impact. Fan intake should be located in the heated envelope if unconditioned air may result in frosted or cold floors, or an excessive amount of condensation on or about the system. However, if the fan is located in the heated envelope of the home, HVAC measurement shall be taken to measure for house depressurization, and compensated for, if necessary.