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An American National Standard

# Standard Guide for Radon Control Options for the Design and Construction of New Low Rise Residential Buildings[1]

This standard is issued under the fixed designation E 1465; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide covers design and construction methods for reducing radon entry into new low-rise residential buildings, and methods for facilitating postconstruction radon mitigation.

1.2 These methods are based on radon mitigation procedures that have been used successfully for various foundation types, and include options to accommodate regional construction practices and site conditions.

1.3 These methods should not be considered as the only acceptable methods available to reduce indoor radon levels, and are not intended to preclude or limit the use of other effective options.

1.4 This guide is intended to assist designers, builders, building officials and others involved in the construction of low-rise residential buildings.

## 2. Referenced Documents

2.1 *ASTM Standards:*

E 631 Terminology of Building Constructions[2]

## 3. Terminology

3.1 *Definitions:*

3.1.1 Definitions for standard terminology can be found in Terminology E 631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *channel drain*—an interior basement water drainage system typically consisting of a 1 to 2-in. gap between the interior of a basement wall and the concrete floor slab.

3.2.2 *low-rise residential building*—a structure for permanent human occupancy having three or fewer stories.

3.2.3 *passive stack*—a ventilation system powered by temperature differentials, which typically consists of a vent stack running from the area under a slab up through the conditioned space of the building, and exiting outdoors. When the air inside the stack is warmer than outside air, it can produce a negative pressure differential across the slab that can withdraw soil gas before it can enter the building.

3.2.4 *passive ventilation*—ventilation of a space provided through a stand-pipe, vent or other opening to the outside that permits air flow without mechanical assistance.

3.2.5 *soil-gas retarder*—a continuous membrane material designed and installed to retard or prevent the flow of soil gas into the building. (Materials approved for waterproofing in Sections 1224.4.1.1 and 1224.4.2.2 of the 1990 BOCA National Building Code (**1**)[3] are considered acceptable for this purpose.)

3.2.6 *stem-wall type slab-on-grade*—a concrete slab-on-grade cast independently of and within the boundaries of concrete or masonry stem walls that support the above grade exterior walls of a building.

3.2.7 *subslab depressurization*—the use of a fan-driven system designed to depressurize the subslab area and withdraw soil gas from near the foundation.

3.2.8 *subslab pressurization*—the use of a fan-driven system designed to pressurize the subslab area and direct soil gas away from the foundation.

## 4. Summary of Guide

4.1 Predicting indoor radon levels prior to construction is not feasible at this time. As a result, this guide does not address when or where to use radon-resistant construction. However, it does provide information on radon mitigation methods that will assist the user in selecting appropriate techniques for a given building.

4.2 Methods for constructing radon-resistant buildings according to foundation type are provided in two main sections of this guide. Section 6 describes methods that limit radon entry routes using barrier techniques and methods that facilitate later installation of a supplemental depressurization or pressurization system. Section 7 provides guidance for completing the supplemental systems described in Section 6 and for other systems generally installed after construction.

4.3 Although radon concentrations can sometimes be reduced by sealing entry routes with barrier techniques, results are highly variable. These methods are rarely adequate as a stand-alone mitigation technique. However, if an active or passive subslab mitigation system is needed later, barrier

[1] This guide is under the jurisdiction of ASTM Committee E-6 on Performance of Buildings and is the direct responsibility of Subcommittee E6.41 on Air Leakage and Ventilation.

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[2] *Annual Book of ASTM Standards*, Vol 04.11.

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

techniques improve the effectiveness of the system by avoiding excessive physical openings between the subslab area and the interior of the building.

4.4 For slab-on-grade and basement foundations, subslab depressurization is the primary supplemental system discussed in this guide, since it has been shown to be one of the most cost-effective mitigation techniques. Subslab pressurization is also discussed, although its effectiveness is not as predictable as depressurization.

4.5 There are several options for radon control in homes built on crawl space foundations. Natural ventilation through crawlspace foundation vents is one of the more cost-effective options but may not be effective by itself if a high radon source strength exists. Therefore, additional features for later installation of a submembrane depressurization system are discussed. In colder climates, natural ventilation may not be practical and other options may have better application. In addition to sub-membrane depressurization, other options for crawl spaces include active crawlspace depressurization and mechanical ventilation.

4.6 Other methods suggested in the literature as possibly contributing to reduced indoor radon levels include techniques to reduce depressurization of buildings due to thermal stack effect and the operation of appliances and air handling equipment. Although these methods may be significant under certain circumstances, there is insufficient data to confidently evaluate their performance at this time. General information on these methods is provided in Appendix X1.

## 5. Significance and Use

5.1 This guide is not intended to represent either minimum or maximum acceptable practices and should not be universally applied. Other innovative and effective methods, systems, designs and materials that meet the intent of these practices may be used to control indoor radon levels.

5.2 The methods described here have been shown to have a high probability of success in mitigating radon in residential buildings of typical design and construction. These methods do not guarantee reduction of radon levels below any specific level, since the performance of the methods will vary with site conditions, construction characteristics, and occupant habits.

5.3 Foundations constructed on expansive soils should not be built using the methods in this guide unless approved by a qualified foundation design engineer.

## 6. Construction Methods

6.1 *Slab-on-Grade Foundations*—This section provides guidance for providing buildings constructed on slab-on-grade foundations with certain basic features that limit radon entry routes, and that could ultimately become part of a fully functional subslab depressurization or pressurization system. Figs. 1 and 2 illustrate these construction methods.

6.1.1 *Subslab Preparation*—Properly prepare the subslab area to minimize cracks in the concrete slab that could permit radon entry and to facilitate later installation of a passive or active mitigation system. Minimize cracking by providing a uniform subgrade of compacted or undisturbed soil under ground-supported concrete floor slabs. Provide a gas-permeable layer over the subgrade for a future subslab depressurization or pressurization system. This layer can consist of a nominal 4 in. of ⅜ to 1½-in. diameter aggregate. Use geotextile drainage matting with smaller aggregate or where aggregate is not available.

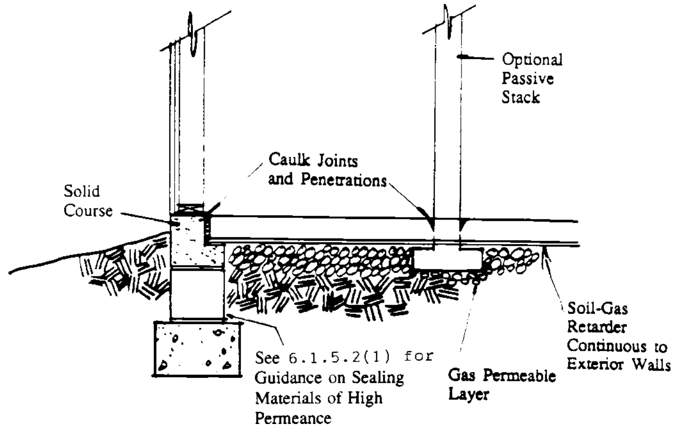


**FIG. 1 Stem-Wall Slab-on-Grade**

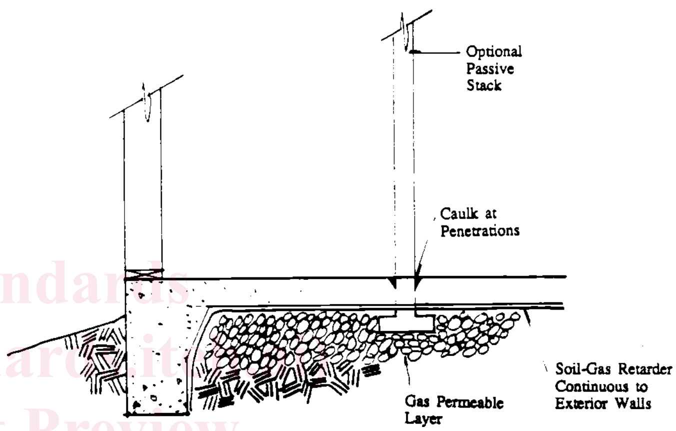


**FIG. 2 Monolithic Slab-on-Grade**

6.1.2 *Access to the Gas-Permeable Layer*—In order to facilitate installation of a subslab depressurization or pressurization system if needed later, a 3 or 4-in. vent stack may be installed. The top of the vent stack should be located away from any fresh air intakes or operable windows and doors. In split-level construction, connect each separate foundation area to the vent stack.

6.1.2.1 Vent stacks may operate as passive mitigation systems by relying on temperature differentials to induce a low pressure field across the gas-permeable layer beneath the slab. To increase the temperature differential across the stack, locate passive vents within the thermal envelope of the building and terminate the vents above the roof in a manner similar to a plumbing vent stack.

6.1.2.2 Connect the stack to the gas-permeable layer directly through the slab into the top of the layer; through a sealed sump cover; or through an interior or exterior loop of drain-tile or perforated pipe that connects to the subslab gas permeable layer, provided the drain is not open to outside air at its termination. If inserted directly into the gas-permeable layer, install a plumbing "T" as shown in Figs. 1 and 2 on the bottom of the stack prior to casting the slab to prevent the pipe from bottoming out on the subgrade.

6.1.3 *Subslab Ground Cover*—Place a soil-gas retarder on top of the gas-permeable layer prior to casting the concrete slab to retard pressure-driven flow of soil gas through cracks that may develop in the slab, and to prevent concrete from infiltrating the gas-permeable layer as the slab is cast. The retarder should be continuous over the entire floor area and lapped a minimum of 12 in. at joints. Remove grade stakes and other accessories used during the casting of the slab and repair penetrations in the soil-gas retarder.

6.1.3.1 Although other steps are sometimes recommended for sealing the retarder, results from such measures will have a minimal effect on radon entry. These steps include taping or otherwise sealing the retarder at all pipes, penetrations and other openings in the slab with durable, compatible caulking, tape, or sealant material.

6.1.4 *Concrete Placement*—Recommended practices to minimize cracking of concrete floors are provided in ACI 332R (**2**). Effectively seal control joints if using them to resist cracking.

6.1.5 *Entry Routes in Slabs*—Reduce potential radon entry routes into buildings by sealing concrete joints, pipe openings, cracks, floor penetrations, and other below-grade openings. Cast up concrete to exterior stem walls or to resilient expansion joint materials. Seal perimeter joints by tooling the slab to accept a bead of caulk, or by cutting or holding back the top ⅜ to ½ in. of expansion material and filling the resultant space with a sealant. Where feasible, use a monolithic slab to eliminate the perimeter joint. Apply a sealant around plumbing pipes and other penetrations in floor slabs.

6.1.5.1 An above-grade course in concrete masonry stem-walls should be fully-grouted, FHA termite block, or of 100 % solid concrete masonry, or open cores may be used provided the cores are filled solid at the time the floor slab is cast.

6.1.5.2 Avoid heating and cooling supply ducts in or under slabs. If unavoidable, install supply ducts to maintain an airtight system in accordance with Ref. (**3**). Return ducts in or under slabs are not recommended, since they operate under a negative pressure that can draw in radon and distribute it throughout the building.

(*1*) *High Permeance Stem-Walls*—When materials with high permeance are used, parge, or otherwise seal the inside face of the stem-wall that extends below the slab to reduce movement of soil gas through the materials and into the building (See Appendix X2 for discussion of permeance).

6.1.6 *Floor Drains and Other Openings*—Do not install drains and other openings that provide direct communication between the interior of a building and the surrounding soil or aggregate. Install floor drains that discharge to daylight using non-perforated pipe with welded, glued or otherwise air-tight joints. Seal all other floor drains and condensate drains to prevent the upward flow of soil gas without preventing the downward flow of liquid. The seal should include a water trap with either a trap seal primer or a check valve to provide protection if the trap should dry out.

6.1.6.1 Wherever possible, completely install traps for showers, tubs and other plumbing fixtures above the slab to preclude the need for a large opening. Where it is necessary to provide a larger opening to accommodate plumbing rough-ins, the opening should be subsequently filled with a non-shrink grout or equivalent sealant.

6.2 *Full and Partial Basement Construction*—This section provides guidance for providing buildings constructed on basement foundations with certain basic features that limit radon entry routes, and that could ultimately become part of a fully functional subslab depressurization or pressurization system. Radon-resistant construction practices for basement foundations are similar to those for slab-on grade foundations. Follow guidance in 6.1 to reduce radon entry routes in the basement floor slab and to prepare the building for later installation of a subslab mitigation system. The additional recommendations in this section provide guidance for limiting soil gas entry routes in below-grade walls and drainage systems. Figs. 3 and 4 illustrate these methods.

6.2.1 *Cast-in-Place Concrete Walls*—Concrete foundation walls should be designed, constructed and finished to minimize cracking. Recommended practices for placement of concrete walls in residential construction are provided in ACI-332R (**2**).

6.2.2 *Concrete Masonry (Block) Walls*—Recommended practices for the design and construction of concrete masonry walls are provided in UBC Chapter 24 (**4**) or ACI 530/ASCE 5-88 (**5**), and in *TEK Notes* (**6**).

6.2.3 *Entry Routes in Below-Grade Walls*—Penetrations that permit soil gas entry through below-grade walls, including but not limited to form-tie holes, water and sewer piping, natural gas lines, electrical wire or conduit, and other utility openings, should be sealed effectively with compatible materials in accordance with manufacturer's recommendations. For hollow walls, seal both interior and exterior penetrations to reduce entry of soil gas into the void space of the wall. At least one above grade course should be fully grouted, FHA termite blocks, or 100 % solid masonry to prevent soil gas flow up through the void space.

6.2.3.1 Foundation wall damp-proofing or waterproofing can retard convective flow of soil gas through concrete

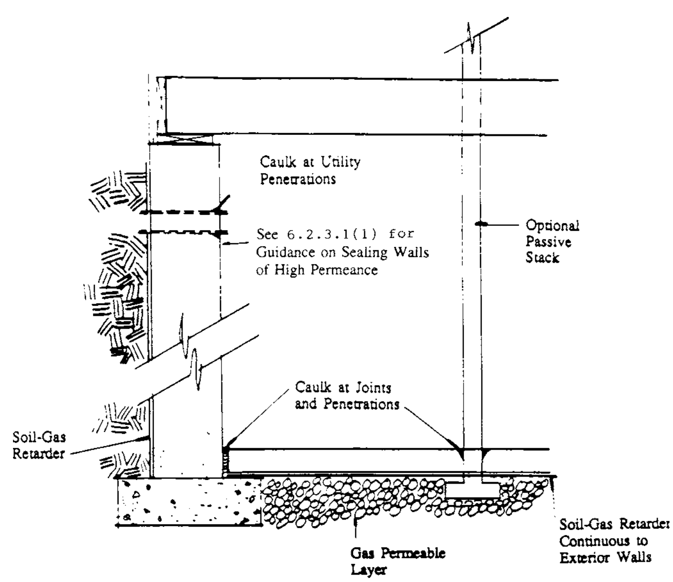


**FIG. 3 Basement with Cast Concrete Walls**