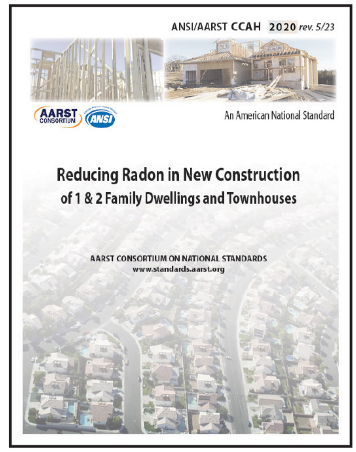
Public Review of Revisions
AARST CCAH 202x (CLEAN READ MOCKUP)

~~Reducing Radon~~ Soil Gas Control in New Construction of One & Two Family Dwellings and Townhouses

The attached proposed revisions are the result of the continuous maintenance program at AARST Consortium on National Standards. The proposed revisions to content publicly reviewed 5/17/24 to 7/1/24 and 10/4/24 to 11/03/24 respond to both public comments received and consensus body work to update and harmonize with ANSI/AARST CC-1000).



Both a redlined mockup of public review content and a clean read mockup of the resulting revised standard are available to download.

Published ANSI/AARST standards are available for review at www.standards.aarst.org. An opt-in link to ensure you receive future public review notices can be found at www.standards.aarst.org/public-review.

Public Review: CCAH Revisions 6-2025
COMMENT DEADLINE: **August 4, 2025**

REQUESTED PROCESS AND FORM FOR FORMAL PUBLIC REVIEW COMMENTS

Submittals (MS Word preferred) may be attached by email to StandardsAssist@gmail.com

1) Do not submit marked-up or highlighted copies of the entire document.

2) If a new provision is proposed, text of the proposed provision must be submitted in writing. If modification of a provision is proposed, the proposed text must be submitted utilizing the strikeout/underline format.

3) For substantiating statements: Be brief. Provide abstract of lengthy substantiation. (If appropriate, full text may be enclosed for project committee reference.)

REQUESTED FORMAT

Public Reviewed Item and Its Date: CCAH Revisions 6-2025

- **Name:** Affiliation:
- **Clause or Subclause**:
- **Comment/Recommendation**:
- **Substantiating Statements**:

Repeat the four bullet items above for each comment.

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The Consortium Consensus Process

The consensus process developed for the AARST Consortium on National Radon Standards and as accredited to meet essential requirements for American National Standards by the American National Standards Institute (ANSI) has been applied throughout the process of approving this document.

Continuous Maintenance

This standard is under continuous maintenance by the AARST Consortium on National Standards for which the Executive Stakeholder Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard.

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CCAH – 202x
Soil Gas Control in New Construction
of 1 & 2 Family Dwellings and Townhouses

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Soil Gas Control in New Construction of 1 & 2 Family Dwellings and Townhouses

SECTION 1: SCOPE

1.1 Scope

The provisions in this standard of practice provide prescriptive minimum requirements for newly constructed one- and two-family *dwellings* and *townhouses* [1] in order to reduce occupant exposure to *radon* and other *hazardous soil gases*. Requirements vary depending upon the structure with focus on reliable capacity for reducing soil gas entry into buildings. The provisions optimize the chances of passive benefits while optimizing energy conservation when operating fans where *active soil depressurization* (ASD) is desired or found needed. This standard also applies when additions to such buildings include new foundations or outside walls that will be in contact with soil.

1.2 Limitations

1.2.1 *More complicated structures*

This standard does not address all additional practices required for soil gas control in construction of more complicated structures that include multifamily, school, commercial and mixed-use buildings[2] or any building where an HVAC system is shared across multiple dwellings or units.

1.2.2 *Mitigation methods*

This standard does not address practices associated with or related to mitigation of *radon,* radon decay products or chemical vapors in outdoor air or that off-gas or volatilize from potable water supplies. This standard does not address all practices needed for *mitigation* of potentially combustible soil gases. Furthermore, this standard does not address practices associated with characterization, possession, handling, encapsulation, generation, removal, extraction, containment, or disposal of radioactive or chemically contaminated materials.

1.2.3 *Action levels and guarantees*

Compliance with provisions herein do not guarantee reduction of soil gas entry to the degree needed to achieve compliance with federal, state, or local jurisdiction action levels for *radon* or soil gas hazards. This limitation extends to:

a) Changes to Structure
Effectiveness resulting by compliance with this standard cannot be guaranteed or considered sustainable where modifications, alterations, structural changes, or additions to a building occur; and

b) Seasonal Changes
Effectiveness witnessed upon completion of construction cannot be assumed to represent effectiveness present during all seasonal conditions.

1.2.4 *Safety*

This standard is not intended to address all safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices. It is the responsibility of the user of this standard to determine the applicability of regulatory and other limitations prior to use.

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[1] As a point of reference, see the International Residential Code (IRC) as published by the International Code Council.

[2] See ANSI/AARST CC-1000 *(Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings)*

SECTION 2: TERMS AND DEFINITIONS

Terms not defined herein have their ordinary meaning as defined in "Merriam-Webster's Dictionary."

2.1 access, ready (readily accessible), adj— That which enables a device, or equipment to be directly reached, without requiring the removal of any door or similar obstruction.

2.2 action level (radon), n— A policy threshold that warrants taking action to protect occupants. The radon action level in the U.S. is 4 pCi/L (150 Bq/m^2) or greater, as published by the United States Environmental Protection Agency (USEPA).

2.3 action level (VI), n— The concentration of any specific *chemical of concern* that warrants taking action to reduce occupant exposure, as published by *authorities having jurisdiction (AHJ).*

2.4 active soil depressurization (ASD), n— A fan-driven system to create a vacuum beneath a structure that is greater in strength than the vacuum applied to the soil by the building above. *ASD* systems include but are not limited to *sub-slab depressurization* and *sub-membrane depressurization*.

2.5 aggregate, n— A mixture of crushed stone or *gravel*, sand, clay and smaller particles. Commercially, aggregates are classified according to the size of the stones and percentages of sand, clay and silt. In the field, aggregate is commonly referred to as *gravel*.

2.6 ASD fan, n— A fan that is designed and rated by the manufacturer for continuous duty and for use in an *ASD* system.

2.7 authority having Jurisdiction (AHJ), n— Federal, state, province, township, or other jurisdictional body having authority over practices or products.

2.8 base (or base course), n— The layer of gas permeable material on top of the subbase and directly under the slab.

2.9 branch, n— Air *duct piping* that routes air from only one *soil gas inlet.*

2.10 chemical of concern (COC), n— Chemicals in vapor, liquids or soil that have been identified at a site location to potentially pose health or safety hazards.

2.11 conditioned space, n— An area, room or space that is enclosed within the building *thermal envelope* and that is directly or indirectly heated or cooled. Spaces are indirectly heated or cooled where they communicate through openings with conditioned spaces, where they are separated from conditioned spaces by uninsulated walls, floors, or ceilings, or where they contain uninsulated ducts, piping or other sources of heating or cooling.

2.12 crawl space, n— A foundation type with an open area beneath livable or enclosed spaces that typically has either a concrete slab or earthen floor and is surrounded by foundation and/or partition components that typically includes flooring above the soil.

2.13 diagnostic tests, n— Procedures, including communication tests and other tests, used to identify or characterize conditions under, beside and within buildings that could contribute to *soil gas entry*, elevated indoor concentrations, or that could provide information regarding the performance of a *mitigation* system.

2.14 duct piping, n— See *exhaust vent piping*

2.15 dwelling, n— One or two units within a building that are intended to be occupied for residential living purposes.

2.16 exhaust, n— A pipe or other piece of apparatus through which soil gases escape or are discharged to the atmosphere.

2.17 exhaust spread, n— The exhaust spread takes the shape of a cone, spreading out from the point of exhaust. The tip of the cone is at the center of the exhaust pipe opening. The cone profile widens as air moves away from the exhaust point. The total directional spread of the exhaust or cone is defined in degrees. It is based on the offset-axis angle of the cone profile compared to the cone's center-line axis.

2.18 exhaust trajectory, n— The path of discharged air created by the angle of the pipe or elbow at the point of exhaust.

2.19 exhaust vent piping, n— Air duct *trunk* or *branch* pipes that transfer air between *soil gas inlets* or *inlet trunk* networks within the *soil gas collection plenum* and outside air.

2.20 gas permeable layer, n— Void space or aggregate that allows soil gas to move across a soil gas collection plenum.

2.21 geotextile matting, n— A product suitable for soil contact, that provides a void space laterally through the material to allow air movement. The void space is created through a matrix of woven mesh, “egg crate” support of a fabric enclosure, or similar means. Also known as drain matting, geotextile vent strip or vapor matting.

2.22 gravel, n— A term commonly used to mean *aggregate*, as defined in Section 2.5. Technically however, the term *gravel* is used to describe *aggregates* of naturally occurring fragmented stones and pebbles with water worn edges, such as found in riverbeds.

2.23 hazardous soil gas, n— Soil gases and vapors regulated by the *jurisdiction having authority* due to toxic, flammable, or explosive hazards.

2.24 inlet piping, n— Air *duct piping* that connects one or more *soil gas inlets* to exhaust vent piping.

2.25 inlet trunk network, n— Air duct pipe configuration that connects one or more *soil gas inlets* to exhaust vent piping.

2.26 jobsite logs, n— Records of actions taken, including verification of compliance with standards or design features, that may be recorded by staff, subcontractor staff, supervisors, or third-party inspectors, to include the *AHJ*.

2.27 main trunks, n— Air *duct piping* that routes the entire system air volume capacity from the *soil gas collection plenum(s)* to the system exhaust or termination point. Above slab main *trunks* are commonly referred to as the “primary trunk“, “main stack” or “riser pipe.”

2.28 mitigation system, n— Any system designed to reduce indoor concentrations of *radon* or other soil gas pollutants.

2.29 openings in structure, n— The openings in structural walls or roofs for mounting windows, skylights, doors, or other assemblies.

2.30 operable openings, n— The portion of windows, skylights, doors, and other openings that can be opened or remain open to allow ventilation with outdoor air. Portions of a window specifically designed to temporarily open for cleaning are not considered readily operable for increasing ventilation with outdoor air.

2.31 outlet, n— A point on the wiring system at which current is taken to supply utilization equipment.

2.32 percolation test, n— A procedure that measures how quickly water drains through soil to evaluate permeability of the soil or aggregate of interest.

2.33 PFE (pressure field extension), n—The distance that the desired pressure change extends outward in a sub-slab gas-permeable layer, under a membrane, behind a solid wall or in a hollow wall.

2.34 PFE (pressure field extension test), n—A diagnostic procedure to evaluate the potential effectiveness and extent of an ASD system by using a shop vacuum or other fan or vacuum device to induce a pressure difference in the space below a slab, membrane or from the cavities inside a block wall relative to indoor air.

2.35 plenum, n— See *Soil Gas Collection Plenum*

2.36 qualified measurement or mitigation professional, n— As determined by authorities having jurisdiction (AHJ) who evaluate individuals for specific technical knowledge and skills relative to mitigation of radon or vapor intrusion soil gas hazards, or as defined in Normative Annex B.

2.37 radon (Rn), n— A colorless, odorless, naturally occurring, radioactive, inert gaseous element formed by radioactive decay of radium-226 (Ra-226). The atomic number is 86. Although other isotopes of radon occur in nature, in this document, radon refers to the gas Rn-222. Rn-222 is measured in picocuries per liter (pCi/L) or in Becquerel per cubic meter (Bq/m^3)

2.38 readily accessible, adj— See *access ready*

2.39 secondary trunks, n—Air *duct piping* that route only a portion of the system air volume capacity from more than one *soil gas inlet*.

2.40 soil gas, n— Air within soil that can contain *radon* or other hazardous gasses or vapors.

2.41 soil gas collection plenum, n— A three-dimensional enclosure, in whatever shape it may be, constructed for collecting *radon* and other soil gases from under slabs, soil gas retarders and from behind walls that surround a void or gas-permeable layer. This description of the cavity under a commonly configured foundation observes that there are at least six sides to this enclosed airspace and that none are perfectly sealed, especially at the side facing soil.

2.42 soil gas collection well, n— A pit designed as a *soil gas inlet* as a means to transition from *soil gas collection plenums* to *soil gas vent pipes* or to join multiple *trunks* or *branches* of a *soil gas inlet trunk*.

2.43 soil gas control, n— Planned control of soil gasses to reduce intrusion of *radon* concentrations or other pollutants into indoor air.

2.44 soil gas inlets, n— Air transfer openings to the face of adjoining granular aggregate or soil sometimes referred to as suction points for *ASD* systems.

2.45 soil gas retarder, n— Pliable sheeting, such as plastic, that is intended to establish a barrier between soil gas and enclosed spaces within a building. Commonly referred to as "vapor barrier."

2.46 soil gas vent system, n— Individual and complete configuration for controlled soil gas venting that includes *exhaust vent piping* extended from gas permeable materials within a *soil gas collection plenum(s)* to the point of system exhaust.

2.47 stretched-string method — A method for measuring distances by a marked string or flexible tape measure that allows measurement of distances that air may travel around intervening obstacles.

2.48 subbase, n— A layer of aggregate on top of the subgrade.

2.49 subgrade, n— In situ soil with or without imported materials used to build a base.

2.50 sub-membrane depressurization, n— A *radon* mitigation technique designed to maintain lower air pressure in the space under a *soil gas retarder* membrane than above it by use of an *ASD fan* drawing air from beneath the membrane.

2.51 sub-slab depressurization, n— A *soil gas* mitigation technique designed to maintain lower air pressure under a floor slab than above it by use of an *ASD fan* installed in the *soil gas* system piping that draws air from below the floor slab.

2.52 termination bar, n— A mechanical fastening component for securing the edges of *soil gas retarder* membranes. commonly made of rigid stainless steel, aluminum, or plastic. Other methods and products, where suitable for the environment, can be an equivalent method, including wood strips and flexible plastics adequately anchored.

2.53 thermal envelope, n— The basement walls, exterior walls, floors, ceilings, and any other building element or assemblies that enclose conditioned space or provide a boundary between conditioned space and exterior or unconditioned space.

2.54 townhouse, n— A single-family *dwelling* unit constructed in a group of three or more attached units where each unit extends from the foundation to the roof and has a yard or public way on at least two sides.

2.55 trunks, n— Air *duct piping*. See *Main Trunks* and *Secondary Trunks*

2.56 units, n— Dwellings or non-residential areas.

2.57 zero net energy building, n— A building that is optimally efficient, and over the course of a year, generates energy onsite, using clean renewable resources, in a quantity equal to or greater than the total amount of energy consumed onsite.

SECTION 3: DESIGN

3.1 Building Design

Soil gas control features shall include *soil gas vent systems* designed and constructed for all portions of foundation systems having enclosed space above *crawl spaces* and slab-on-grade or basement slabs.

Exceptions:

a) Portions of buildings supported entirely on foundation systems, such as piers, that do not have enclosed areas between the earth and the building floor system.

b) Portions of the foundation reserved for a garage that are outside the *thermal envelope* of the home.

c) Where addressing *radon* hazards is the only purpose for the system and *radon* testing prior to occupancy demonstrates results that are below the national *action level*. The *radon* testing shall be conducted in accordance with ANSI/AARST MAH *(Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes)*. Where required by the code official, testing shall be conducted by an approved third party.

d) Where addressing vapor intrusion hazards would be the only purpose for the system but there is no evidence to indicate such hazards exist for the building or portion of the building. Prior to design, the designer shall request in writing information from the client as to whether there are known concerns for chemical vapor intrusion or other soil gas hazards.

3.1.1 *System coverage area*

Additional *soil gas vent systems* shall be installed where the total building foundation area exceeds the Maximum Coverage Area shown in Table 3.1.1 and each multiple thereof.

Table 3.1.1

Exhaust Pipe Nominal Size	Maximum Foundation Coverage Area Per System
3 inch (75 mm)	2,500 square feet (232 m^2)
4 inch (100 mm)	4,500 square feet (418 m^2)

3.2 Soil Gas Collection Plenum Design

3.2.1 *Plenum Depth*

The building design and construction shall accommodate a layer of *gas permeable* aggregate, 4 inches (10 cm) or more in depth that is ordinarily required below slabs for creation of *soil gas collection plenums*.

3.2.2 *Plenum Sizes*

The lateral dimensions for the edge boundary of each *soil gas collection plenum* shall be calculated based on:

a) the inside perimeter dimensions of the surrounding foundation walls; and

b) as divided into two or more individual plenums where obstructions restrict airflow across gas permeable expanses.

Examples of such obstructions include utility piping, grade beams, thickened slabs, and ductwork.

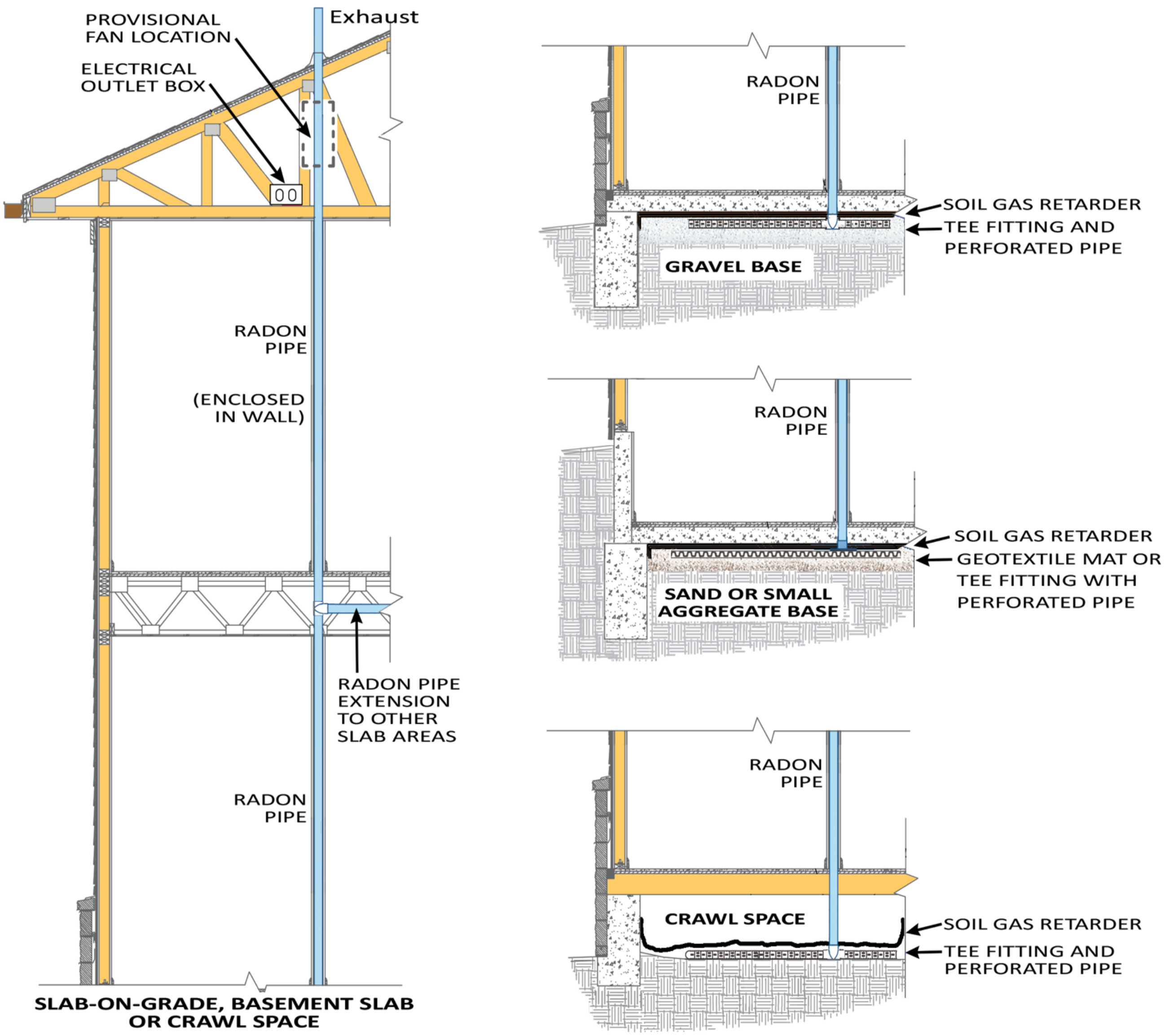
3.2.3 *Gas Permeable Layer Materials*

Gas permeable layer material choices shall be determined prior to construction and design of *soil gas vent systems*, as chosen to include conformance with *soil gas inlet* design options required in Sections 5.3.1 through 5.3.5.

3.2.4 *Vent* configurations

Each individual *soil gas collection plenum* shall be provided a *soil gas vent system* configuration. Alternatively, multiple plenums joined from below or above a slab or membrane to a single soil gas vent system shall be permitted for plenums constructed with the same gas permeable layer specifications. Joining plenums with different *gas permeable layer* specifications to a single *soil gas vent system* is permitted if not less than one air flow-valve is installed where accessible in the future on *trunk* or *branch* vent piping that connects to the more permeable *gas permeable layer(s)*.

EXAMPLES OF SOIL GAS VENT SYSTEM INSTALLATION IN VARIOUS FOUNDATIONS



3.3 Quality Control

A means for retaining *jobsite logs* and inspection reports required for each home in this standard shall exist or be created. *Jobsite logs* and inspection reports intended for internal quality control purposes shall be retained in quality control records.

3.3.1 *Distribution of specifications*

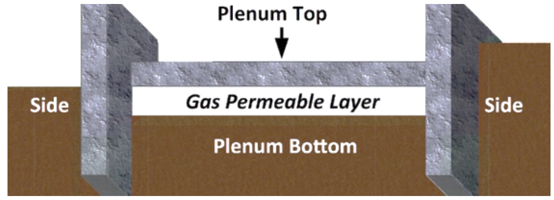
Specifications for the chosen design features, as stated or equivalent to those required in this standard, shall be provided to individuals or parties providing bids, overseeing installation, and for those assigned to implement apportioned tasks.

SECTION 4: PLENUM CONSTRUCTION

4.1 Before Installing Gas Permeable Materials

Prior to installing *gas permeable layer* materials, the *soil gas collection plenum* sides, bottoms, and foundation drain designs shall be reviewed. Openings that do not resist air movement between the *gas permeable layer* and surrounding earth or spaces shall be closed in accordance with this Section 4.

Fig. 4. Example construction of plenum



4.2 Close the Bottom of the Plenum(s)

4.2.1 *Inspect subgrade soil*

If highly permeable subgrade soils or openings to cavities, caves, or crevices between rock layers are known or suspected to adjoin below or to the side of the foundation, closure that resists air movement between the *gas permeable layer* and surrounding subgrade or fill shall be provided.

4.2.1.1 Closure Specifications

For compliance with **Section 4.2.1**, materials below and beside gas permeable layers shall have low permeability to impede soil gas flow into the layer. Materials permitted for this purpose include:

a) Earthen fill aggregates with over 35% clay, silt, rock fragment fines, and sand; and
b) Soil gas retarders that meet specifications in Section 6.3 that are installed to resist air movement while allowing groundwater drainage from the gas permeable layer.

4.2.2 *Optimization Options*

Note—See Annex A for options that can additionally enhance effective soil gas control as may be of interest to home buyers, vapor intrusion professionals and those seeking *zero net energy* construction design.

4.3 Close Side Walls

4.3.1 *Walls and footings*

Openings below grade in foundation walls and footings that surround *soil gas collection plenums* shall be closed with appropriate cementitious or damp proofing products to include all openings around utility penetrations for plumbing or electrical components and any other openings of similar or larger size.

4.3.2 *Damp proofing*

All foundation walls in contact with the soil shall be damp proofed or waterproofed with methods consistent with Section R406 of the International Residential Code.[3] The application shall include closure of all exterior cold joint seams that will be below the ground surface.

4.3.3 *Hollow concrete masonry unit (CMU) walls*

Hollow (CMU) walls shall be designed and constructed as follows:

a) The first course of masonry units bearing on a footing shall be laid with a full mortar bedding and shall be solid units or fully grouted masonry units.
b) Where portions of CMUs are below grade and in contact with earth, a course of CMUs that is at or partially below grade shall be made of solid CMUs or fully grouted masonry units. Such course of masonry units need not change elevation to compensate for differing grade elevations along the building perimeter. Openings in walls, such as for doors, windows and under masonry ledges that are below this course of solid or fully grouted masonry units, shall be closed with solid or fully grouted masonry units.

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[3] The International Residential Code (IRC) as published by the International Code Council.

4.3.4 *Gaps in walls*

All gaps in foundation wall assemblies that will be in contact with soil shall be closed to resist air movement between soil and indoor air, to include where walls adjoin attached garages, parking lots, sidewalks, porches, steps, and other adjoining constructed closures over soil.

4.4 Foundation Drain Systems

4.4.1 *Interior drain systems*

Where groundwater control systems are installed inside foundation areas, the components shall be designed and installed to ensure that maximum groundwater elevations do not prevent airflow within the minimum required thickness of the *gas permeable layer(s).*

4.4.2 *Exterior drain systems*

Where the interior soil gas collection plenum(s) will connect to exterior foundation drain systems, closure to resist airflow between the drain system and outdoor air is required. Methods shall comply with a) and b) of this Section 4.4.2:

a) Water drainage receptors

For grade-level drains, window well drains, and open pipes above grade that collect rainwater from the roof, closure shall be achieved by:

1. surrounding exposed piping and pipe ends with low permeable soil;
2. capping open pipes;
3. using one-way flow valves with access provided for future maintenance; or
4. equivalent methods.

b) For drainage pipes that open to outdoor air or connect to a storm sewer, closure shall be achieved by means of a one-way flow valve with access provided for future maintenance or an equivalent method.

4.5 HVAC Ductwork

HVAC air ducts located below concrete slabs or soil gas retarders shall be affixed in place and sealed to resist air movement between *gas permeable layers* and air within HVAC air ducts, to include:

a) ductwork that is seamless, sealed by spray applied sealants, solvent welded, or equivalent method;
b) branch and plenum connections that are permanently sealed and affixed in place; and
c) ductwork materials that resist deterioration from the surrounding environment.

4.6 Jobsite Logs

Jobsite logs shall be created and retained as part of internal ongoing quality control of operations that confirm compliance with all requirements in Section 4.

SECTION 5: SOIL GAS COLLECTION DESIGN

5.1 Before Installing Gas Permeable Materials

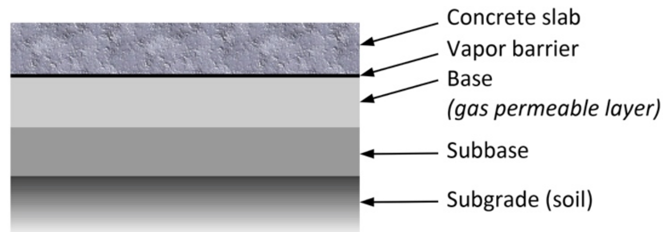
Prior to installing *gas permeable layer* materials, the designed components of soil gas collection ducts, *soil gas inlets* and the transition to above slabs or membranes, shall be installed. The *gas permeable layer* and *soil gas inlet* configurations shall comply with any option identified in Section 5.3.

5.2 Collection Duct Sizing

Within the *gas permeable layer*, non-perforated pipe, perforated pipe, geotextile matting, transition fittings and other products or methods used to convey soil gas to exhaust piping shall retain cross-sectional dimensions for an open airflow pathway that are nominally:

a) not less than 7.1 sq. in. (46 cm^2) for systems designed with 3-inch (75 mm) exhaust piping, and

b) not less than 12.6 sq. in. (81 cm^2) cross-sectional dimensions for systems designed with 4-inch (100 mm) exhaust piping.



Informative Table 5.2 Cross-sectional area dimensions	
Pipe Inner Diameter (ID)	Cross-sectional Area
2-inch (50 mm)	3.1 sq. in. (20 cm^2)
3-inch (75 mm)	7.1 sq. in. (46 cm^2)
4-inch (100 mm)	12.6 sq. in. (81 cm^2)

Exception:

Branches of ducting that connect to *secondary* or *main trunks* are permitted to be smaller where retaining equivalent cross-sectional dimensions for *soil gas inlets* and an open airflow pathway relative to both the whole system and the individual *branch* duct.

5.2.1 *Pipe drainage*

Horizontal pipe located within the soil gas collection plenum shall be configured with no less than the equivalent of a 1/2-inch (1.3 cm) diameter opening for water drainage located near the bottom of every 10 feet (3 m) of duct pipe length.

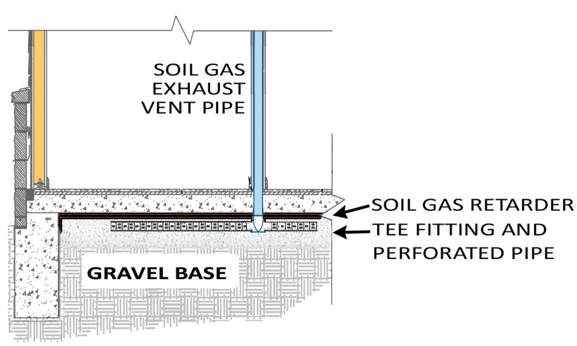
5.3 Inlet Sizing, Distribution and Aggregates

The *soil gas inlet* configuration for soil gas transfer to *exhaust vent piping* shall comply with all requirements in this Section 5.3, as applicable to the chosen *gas permeable layer* aggregate.

Note—The size of gaps between stones, sand and other *aggregate* materials immediately correlate to the distance away from soil gas inlets that soil gas can be ventilated or controlled.

5.3.1 *Option 1—Aggregate (Gravel)*

Where the *gas permeable layer* is to be a 4-inch-thick layer of nominally ≥ 3/4-inch (2 cm) stones with less than 5% fines (as specified in ASTM C33 for gravel sizes 5, 56, 57 or 6), *soil gas inlet* configurations shall comply with designs specified in a), b) or c) of this Section 5.3.1.

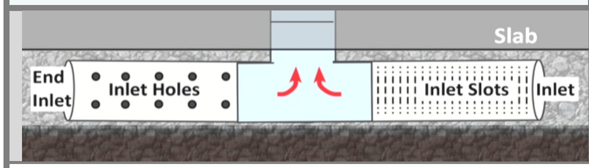


a) Perforated Pipe Option

A "T" pipe fitting, saddle fitting or equivalent device that results in not less than two horizontal openings within the *gas permeable layer* connected to perforated pipe that is:

1. secured to the "T" fitting with a combined length as specified in Table 5.3.1;
2. placed predominantly no closer than 12 inches (30 cm) from sides of the *soil gas collection plenum* such that it can be surrounded on the sides by gravel; and

3. configured with *soil gas inlet* openings on both sides of piping such that not less than 2/3rds of the *soil gas inlet* openings face the gravel while providing drainage openings not less than every 10 feet near the bottom of the piping.

Table 5.3.1* PERFORATED PIPE LENGTH SPECIFICATIONS	Exhaust vent pipe size	Examples of perforation opening size per linear foot		
		1.0 in²/ft (21 cm²/m)	2.0 in²/ft (42 cm²/m)	≥ 3.0 in²/ft (58 cm²/m)
	3" (75 mm)	≥ 15 ft (5 m)	≥ 8 ft (2.5 m)	≥ 5 ft (1.5 m)
	4" (100 mm)	≥ 27 ft (8 m)	≥ 14 ft (4 m)	≥ 9 ft (2.7 m)

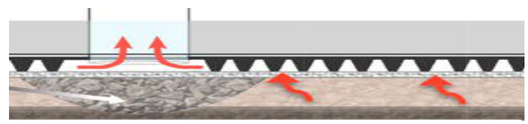
Note—Perforated pipe is commonly configured to minimum specifications of 1 sq. in. per linear foot (19 cm² per linear meter). However, products are available that exceed this minimum specification.

* Additional Perforated Pipe specifications include:

1. Pipe perforations shall not be large enough to allow aggregates to enter and thereby obstruct the duct. Where perforated pipe is to be placed in a layer of sand or small stone, the materials or methods employed shall not allow sand or small stones to obstruct or enter the *soil gas inlet* perforations; and
2. "Where an open end is capped or otherwise closed, the length shall be extended an additional 20%.

b) Geotextile Matting Option

Geotextile matting placed in the *gas permeable layer* shall have an airflow pathway compliant with Section 5.2 and not less than the equivalent *soil gas inlet* opening size of:



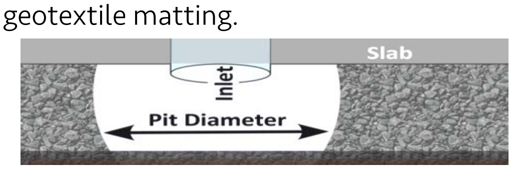
1. 18 sq. in. (116 cm²) of openings to gravel for systems designed with 3-inch (75-mm) exhaust piping, and
2. 32 sq. in. (206 cm²) of openings to gravel for systems designed with 4-inch (100-mm) exhaust piping.

c) Soil Gas Collection Pit Option

Pits with groundwater control sumps shall not be used as *soil gas collection inlets* or *suction points* unless the ground water being controlled is a known source of chemical vapor intrusion.

Soil gas collection pit liners or sump basins made open to the face of gravel shall provide an equivalent soil gas inlet opening size that is not less than specified for geotextile matting.

Where a *gas permeable layer* is gravel, approximately 4 inches (10 cm) in depth, the open void within the pit shall be not less than:



1. 4" x 12" (10 cm x 30 cm) diameter for systems designed with 3-inch (75-mm) exhaust piping; and
2. 4" x 16" (10 cm x 40 cm) diameter for systems designed with 4-inch (100-mm) exhaust piping.

5.3.2 *Option 2—Void airspace*

Where the *gas permeable layer* is to be a void space such as a raised floor, or the gap between exposed soil in a *crawl space* and overlaid *soil gas retarder*, the configuration shall be constructed with:

a) *soil gas inlet* openings no closer than 12 inches (30 cm) away from the sides of the plenum; and
b) perforated pipe meeting specifications in Table 5.3.1, or equivalent sized unobstructed *soil gas* inlet.

5.3.3 *Option 3—Smaller aggregate (gravel)*

Where the *gas permeable* gravel layer inhibits airflow due to ≥ 3/4-inch (2 cm) stones mixed with a high percentage of smaller 3/8-inch (9.5 mm) stones, sand, and fines, such as specified in ASTM C33 for gravel size 67, the *soil gas inlet* sizes shall be double those required in Section 5.3.1. Alternatively, the *soil gas inlet* configuration specified in Section 5.3.4 shall be permitted.

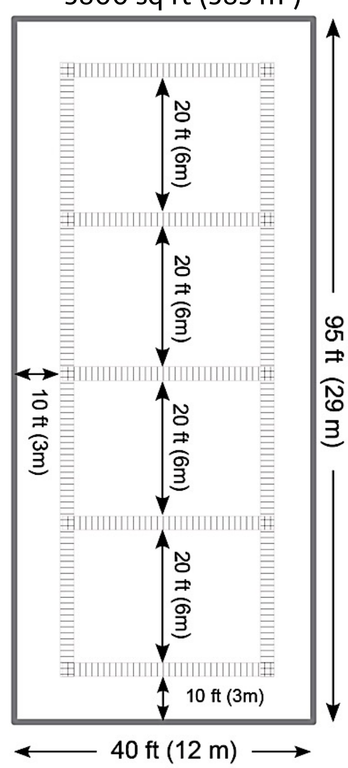
5.3.4 *Option 4—Small gravel, sand, or soil*

Where the *gas permeable layer* is to be aggregate materials or soils described in Table 5.3.4, certain restrictions therein shall apply. These aggregates require *soil gas inlet trunk networks* of perforated pipe within the *gas permeable layer* or *geotextile matting* placed on top of the *gas permeable layer* configured to be:

a) no closer than 12 inches (30 cm) and no further away than 10 feet (3 m) from foundation walls or other surfaces that represent the sides of each *soil gas collection plenum*; and

b) at distances not greater than 20 feet (6 m) apart to achieve a *soil gas* inlet within 10 feet (3 m) for not less than approximately 90% of any part of the *soil gas collection plenum*.

Exception: *Geotextile matting* is permitted to be placed at the bottom of the *gas permeable layer* if ground water will be naturally or mechanically controlled to be below the *gas permeable layer*.

Table 5.3.4	**Gas Permeable Materials and Soil Gas Inlet Trunk Networks**		
Options	**Allowed If Including Required System Design Features**	**Not Permitted ***	**Example Of Required Design Features**
Smaller Stone Option	Aggregate size numbers 67, 7 and 8 as classified by ASTM C33. Note—These aggregates contain a high percentage of nominally 3/8-inch (9.5 mm) stone.	Aggregates containing more than: (1) 10% 0.07-inch (1.8mm) granules as evaluated by a # 16 sieve, and (2) 5% fines as evaluated by a # 50 sieve.	3800 sq ft (383 m^2) 
Sand Option	Aggregate size numbers 8.9 and 9 as classified by ASTM C33. Note—These sands contain high percentage of nominally ≥ 0.19-inch (4.75 mm) granules and less than: (1) 10% 0.07-inch (1.8 mm) granules, and (2) 5% fines.		
Soil Option	Soils with uniform characteristics for fragmental aggregate. The soil **shall** consist of too little fine particles to fill interstices > 0.04 inch (1 mm) between stones, cobbles, gravel, and very coarse sand particles after compaction occurs.	Soils and aggregates containing more than: (1) 35% clay, silt, rock fragment fines and sand; or (2) 10% high plasticity clay or silt, or expansive soils with a liquid limit ≥ 50%.	
* Soil aggregates not permitted for use as a *gas permeable layer* can alternatively be determined by a *percolation test* that indicates a percolation rate slower than approximately 1 minute per inch.			

NOTE FOR PUBLIC REVIEWERS — Further elaboration how to conduct percolation testing is intended to be provided in companion guidance

5.3.5 *Optimization options*

Note—See Annex A for options that can additionally enhance effective soil gas control as may be of interest to home buyers, vapor intrusion professionals and those seeking *zero net energy* construction design.

5.4 Transition from Inlets to Exhaust Vent Piping

5.4.1 *Connection Piping*

Rigid, non-perforated piping or fittings shall be used to connect from *soil gas inlets* or *inlet trunk networks* within *soil gas collection plenums* to above the concrete slab or soil gas retarder membrane. This piping shall:

a) be fixed in place to prevent dislocation during placement of the gas permeable layer, *soil gas retarder* and concrete.
b) extend no less than 2 feet (60 cm) above the slab or membrane.
c) be marked or labeled with the words "radon vent," "soil gas vent" or similar wording, and
d) be temporarily capped or closed during construction to prevent debris from entering.

Alternatively, it shall be permitted to construct *soil gas collection wells* or pits compliant with Section 5.4.2 where the connection to *exhaust vent piping* occurs after slabs and membranes are installed.

5.4.2 *Collection wells or pits*

Soil gas collection wells or pits permitted shall be compliant with Section 5.3.1 c (Soil Gas Collection Pit Option) or serve as a connection point for *soil gas inlet trunks* consisting of perforated pipe or geotextile matting. Where a sump lid is used for transitioning to *exhaust vent piping*, the lid shall be installed in accordance with Section 6.5.5 (Sump Pits) and labeled in accordance with Section 6.5.7 (Label sealed components).

5.5 Inspect the Open Plenum

Prior to placement of a *gas permeable layer* materials, an shall be conducted to verify that:

a) *soil gas inlets* and ducting are secured in place;
b) any sub-slab or sub-membrane HVAC ductwork is sealed in accordance with Section 4.5; and
c) closed surroundings of the plenum in compliance with this standard.

5.5.1 *Non-compliance*

Where plenum closure, *soil gas* inlets or sizing of ducting are non-compliant, additional steps shall be taken until compliant with this standard prior to placement of *gas permeable layers*.

5.5.2 *Records*

Jobsite logs and inspection reports shall be retained in records in accordance with Section 3.4 (Quality control) as part of internal ongoing quality control of operations.

5.6 Gas Permeable Layer Installation

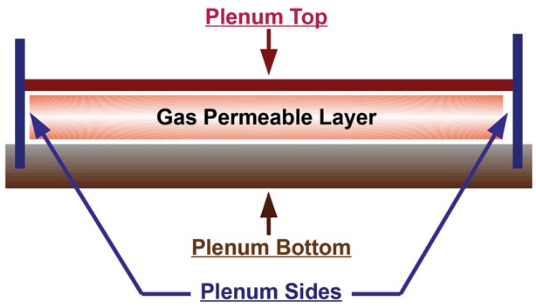
Immediately prior to installation of *gas permeable layer* materials for each home, a person designated with supervision authority shall confirm and record in *jobsite logs* that the gas permeable materials being installed are compatible with the *soil gas inlet* design installed.

5.6.1 *Uniform application*

The installation shall result in a uniform layer of *gas permeable layer* materials that is not less than 4 inches (10 cm) in depth across not less than 90% of each *soil gas collection plenum*.

Exception: A depth of not less than 2 inches (5 cm) is permitted where the *gas permeable layer* is a void air space or where geotextile matting installed to meet requirements in this Section 5 is the primary method for establishing *soil gas inlets*.

SECTION 6: CLOSE THE TOP OF THE PLENUM



Advisory—Any benefits anticipated for reducing soil gas entry with passive soil gas vent systems are negated if a continuous barrier is not established to resist air movement between soil and airspaces within a building.

6.1 Continuous Air Barrier

The entire assembly of foundation components in contact with ground shall, once completed, result in a continuous air barrier that resists air movement between soil and indoor air.

6.1.1 The capacity for the closure of concrete floors and soil gas retarders to degrade over time shall be evaluated when choosing materials and methods for sealing the top of the *soil gas collection plenum(s)*, including for:

a) degradation due to building settlement or movement;

b) shrinking or cracking of building materials; and

c) potential needs to access mechanical systems under floors.

6.2 Closure of Concrete Floors

6.2.1 *Soil gas retarder*

Soil gas retarder material shall completely cover all soil areas under each concrete floor and be placed between the *gas permeable layer* and the concrete slab, except as identified in Section 3.1 (Building design). The soil gas retarder materials and installation shall comply with Section 6.3.

6.2.2 *Immediately below slabs*

The concrete floors shall be cast directly upon a soil gas retarder with the following exceptions:

a) Where insulation is installed under the concrete floor, it is permitted that the soil gas retarder be installed below underslab insulation; and

b) A thin layer of fill material or geotextile fabric for water drainage or protection of the soil gas retarder is permitted between the soil gas retarder and the concrete floor where fill material is no greater in depth than is required for such intended purposes.

Note—Aggregate fills above the soil gas retarder can introduce a new *radon* source.

6.3 Soil Gas Retarder Materials and Installation

6.3.1 *Soil gas retarder materials—radon*

Where the purpose is limited to preventing radon gas from entering the building, *soil gas retarder* materials shall be complaint with the *authority having jurisdiction (AHJ)* and not less than the equivalent of 6 *mil* (0.152 mm) thick polyethylene sheeting.

6.3.2 *Soil gas retarder* materials—*vapor Intrusion*

Where the purpose includes preventing chemical vapors or other hazardous soil gases from entering the building from chemicals of concern (COC), *soil gas retarder* materials shall be compliant with the *AHJ* and not less than required in a) or b) of this Section 6.3.2.

a) Active System Designs

If activating with an *ASD fan* during construction, membrane products shall conform to ASTM E1745 Class A and be a minimum of 10 mil (0.010 inch; 0.25 mm) in thickness.

b) Gas-tight Designs

Where attempting passive mitigation by way of gas-tight closure between soil and indoor air, as specified in **Section 6.6**, the products, and methods for gas-tight closure shall comply with AHJ requirements with a minimum of 60 mil spray-applied vapor barriers or 20 mil soil gas retarder membrane(s).

6.3.3 *Soil gas retarder installation*

The soil gas retarder installation shall comply with provisions in this Section 6.6.3 and result in continuous closure that resists air movement between soil and indoor air:

a) along all outer perimeters and edges of each *soil gas collection plenum*;

b) at membrane seams; and

c) at membrane penetrations.

6.3.3.1 Secure the Membrane

Soil gas retarder membrane configurations shall be secured to withstand anticipated loads that might pull or tear the *soil gas retarder* membrane away from foundation walls or footings. Excess membrane material shall extend beyond foundation walls for a distance, such as four to twelve inches (10 to 30 cm), that is not less than compatible with the designed method for mechanical fastening, sealing and other methods employed to secure the membrane.

6.3.3.2 Mechanically Fastened

The fastening method shall leave no outer edges of the membrane unsecured. *Soil gas retarder* membranes shall be mechanically fastened and sealed to foundation walls, footings, and at structural supports. The mechanical fasteners shall be rated for wet conditions and contact with concrete. Termination bars or equivalent fastening method shall secure the outer edges of the membrane:

a) where membranes are used to cover exposed soil that will not be covered by concrete, and

b) where ≥ 20 mil (0.020 inch; 0.508 mm) membranes are used.

Exception: Where a membrane manufacturer system design secures the membrane to withstand anticipated loads that might pull or tear the soil gas retarder membrane away from foundation walls or footings.

6.3.3.3 Sealing Edges and Seams

All outer perimeters edges of the membrane and all seams between adjacent membrane sheets shall be sealed or closed to resist air movement between soil air and indoor air. All outer membrane edges shall be sealed with caulking products compliant ASTM C920 class 25 or greater, or equivalent method.

Closure of all seams between adjacent membrane sheets shall comply with specifications stated in a) or b) of this Section 6.3.3.3.

a) Seams overlapped not less than 6 inches (15 cm) and sealed by one of the following methods:

   1. A tape recommended by the membrane manufacturer; or
   2. Caulk compliant to ASTM C920 class 25 or greater; or

b) Heat welded seams, spray applied sealants, or equivalent methods for enhancing gas-tight plenum closure."

6.3.3.4 Penetrations (soil gas retarders)

All openings around mechanical or structural penetrations of a soil gas retarder membrane shall be closed to resist air movement between soil air and air above the membrane. Gasket fittings, pipe clamps, sealants or other equivalent methods shall be employed to secure closure where *exhaust vent piping*, foundation supports, plumbing, HVAC ductwork and other utilities penetrate the membrane.

6.3.3.5 Repairs (soil gas retarders)

Tears or punctures in the membrane shall be sealed by one or more of the following methods:

a) A tape recommended by the membrane manufacturer; or
b) An additional sheet of the membrane material that covers and overlaps the tear or puncture not less than nominally 6 inches (15 cm) on all sides and that is sealed with a caulk complying with ASTM C920 class 25 or greater; or
c) An equivalent method.

6.4 Closure of Exposed Soil

A soil gas retarder shall be installed to cover the top of all aggregates or soil not covered by concrete, such as earthen *crawl space* floors, in a manner that conforms to all contours of the grading. The materials and installation shall comply with all provisions of Section 6.3.

6.4.1 *Anticipated loads/degradation*

For membranes over exposed aggregate or soil not covered by concrete, the membrane product shall be capable of withstanding anticipated loads and degradation as required in a) and b) of this Section 6.4.1.

a) Where exposed soil areas are expected to be regularly traversed for storage or other purposes, membranes with tensile strength and puncture resistance to withstand anticipated loads shall be employed.
b) Where a membrane will be exposed to sunlight, such as at window wells in a *crawl space*, the membrane shall be resistant to UV degradation.

Exception:

Where thicker materials, running mats or other protective materials are installed on top of the membrane, to include where trafficked; where heavy items are stored; or where exposed to sunlight. When choosing this option, the protective materials shall be:

a) secured in place, such as by adhesives, and
b) labeled for their purpose with guidance, such as "Do not discard. This component is to protect the soil gas retarder from damage which is a component of a soil gas mitigation system."

6.4.2 *Label the membrane*

Where *soil gas retarder membranes* have been installed over exposed aggregate or soil not covered by concrete, a label or marking shall be located in a conspicuous place or places. Examples include access panels or immediately visible once entering the *crawl space* or room, such as on membrane material near the access location. The label shall include both:

1. A label title that indicates the presence of a *mitigation* system component, and
2. Instructions to help preserve the integrity of the membrane. Examples include, "Do Not Alter. Damage or alteration to plastic membrane sheeting can negatively impact system performance."

6.5 Closure of Openings and Gaps

6.5.1 *Before framing and finishing*

Prior to framing and completion of room finishings, openings and gaps in concrete floors and membranes over open soil shall be sealed or closed to resist air movement between soil and both indoor air and air above membranes over exposed earth.

Exception: Where installing gas-tight designs prior to casting slabs, in accordance with Section 6.5.2.

6.5.1.1 Construction Joints in Interior Concrete Floors

Permanent closure shall be provided for all concrete joints to include around the perimeter of each slab and at all expansion or contraction joints. Caulk meeting ASTM C920 class 25 or higher shall be applied after concrete cures where needed to complete closure of these joints.

6.5.1.2 Openings and Penetrations

Openings and penetrations in the top of all *soil gas collection plenums* shall be sealed against air leakage to include openings around plumbing, exhaust vent pipes, mechanical piping, structural supports, and gaps to the inside of hollow structural posts and electrical conduits that are open to soil.

Sealing of the penetration or opening shall be achieved with caulk that complies with ASTM C920 class 25 or higher or equivalent, closed cell gasket materials or an equivalent method. When caulk is used to seal a crack, joint or opening greater than 1/2 inch (13 mm) in width, foam backer rod or other comparable filler material shall be inserted into the joint to support the caulk as it cures.

6.5.2 *Below slab option*

As an alternative to Section 6.5.1, equivalent closure for resisting air movement between soil and indoor air prior to casting concrete floors shall be permitted.

6.5.2.1 Gas-tight Option

To additionally qualify as a gas-tight design, methods or systems shall be approved, where applicable, by the *AHJ,* compliant with manufacturer requirements, and performance tested as required in accordance with Section 6.6.

6.5.3 *Block-outs and pits*

Openings in the concrete slab that are constructed to facilitate plumbing or other utility needs shall be closed with non-shrink grout, sealed covers, or other appropriate method.″

6.5.4 *Sump pits*

Sumps or other pit openings in interior floors that connect to soil air and require access for maintenance shall have a rigid lid. The lid shall be sealed with gasket material or silicone caulk and mechanically fastened in a manner to that allows easy removal. The lid shall be made of sturdy and durable plastic such as polycarbonate plastic or other rot-resistant material. Durability and installation of the rigid lid material shall be sufficient to support anticipated loads in the area of use.

6.5.4.1 Pump piping and wiring penetrations through the lid shall be sealed. Gaps between the intersection of the sump basin and the floor or membrane shall be sealed with a caulk complying with ASTM C920 class 25 or higher, or an equivalent method. Where attempting the gas-tight option in Section 6.5.2.1, gaps between the membrane and the slab shall also be sealed.

6.5.5 *Surface Water Relief*

Pits that receive water from above concrete or soil gas retarders shall be provided a means to retain water control capabilities of the sump such as an independent floor drain with a one-way flow valve or other mechanical means.

6.5.6 *Floor drains/plumbing*

Floor drains and condensate drains shall not allow soil gas entry. Access openings in the floor provided for drain maintenance shall be provided a method of closure that resists soil gas entry into the building.″

6.5.7 *Label sealed components*

A label or marking shall be provided on sump lids, block-outs, access openings and other closed surfaces that could require access in the future to indicate these are components of a mitigation system. The label title shall state "Component of a Radon (or Soil Gas) Reduction System" or similar wording and include additional text such as "Return to a closed condition if opened, accessed, or damaged.

6.6 Gas-tight Barrier Performance Test

Where designs are intended or are represented to be gas-tight by virtue of sealed closure of all gaps and openings between soil and indoor air, passing performance testing is required for the installation to qualify as a gas-tight air barrier. Performance test where membranes are placed over open soil with no plans for casting slabs shall comply with Section 6.6.1. Performance tests where slabs will be cast over membranes shall comply with both Sections 6.6.1 and 6.6.2.

6.6.1 *Membrane performance test*

After installing soil gas retarder membranes and prior to casting slabs over membranes, a performance test shall be conducted that includes visual indication using smoke or other tracer gas injected beneath the soil gas retarder to evaluate the current extent of gas-tight closure. The procedure shall include:

a) Observing that soil gas retarders are lifted when injecting smoke or other tracer gas below them and cutting small test holes in the retarder to verify smoke (or tracer gas) has reached the full extent of the area being tested; and

b) Sealing all visually identified gaps and openings to soil using sealing and repair methods consistent with manufacturer instructions.

6.6.2 *Slab performance test*

After casting slabs but prior to framing and installation of interior finish materials, an additional performance test procedure shall be conducted that includes:

a) Conducting a *PFE* test to verify a downward pressure gradient has been created; and

b) Administering smoke to gaps and openings in the slab to visually identify locations where the smoke is pulled downward, followed by sealing all visually identified gaps and openings to soil.

Where found impractical to close all observed gaps or openings between soil and indoor air, the installation shall not qualify as a gas-tight air barrier.

6.7 Inspect for Closure Prior to Indoor Finishings

Before indoor finishing in any ground-contact areas, an inspection shall be conducted to verify a continuous air barrier has been constructed to resist air movement between soil gas and indoor air for all portions of the building, including both floors and walls, in contact with ground.

6.7.1 *Non-compliance*

Where closure of openings is non-compliant, additional steps shall be taken until compliant with this standard prior to completion of indoor finishings in ground-contact areas.

6.7.2 *Reports*

This inspection shall be retained in records in accordance with Section 3.4.1 (Quality control).

SECTION 7: SOIL GAS EXHAUST VENT PIPE

7.1 Before Vent Pipe Installation

Prior to installation of *exhaust vent piping*, the location for each potential *active soil depressurization* (*ASD*) *fan* and fan monitors shall be integrated into the pipe routing design.

7.2 Provision for ASD Fan(s)

7.2.1 *Fan location*

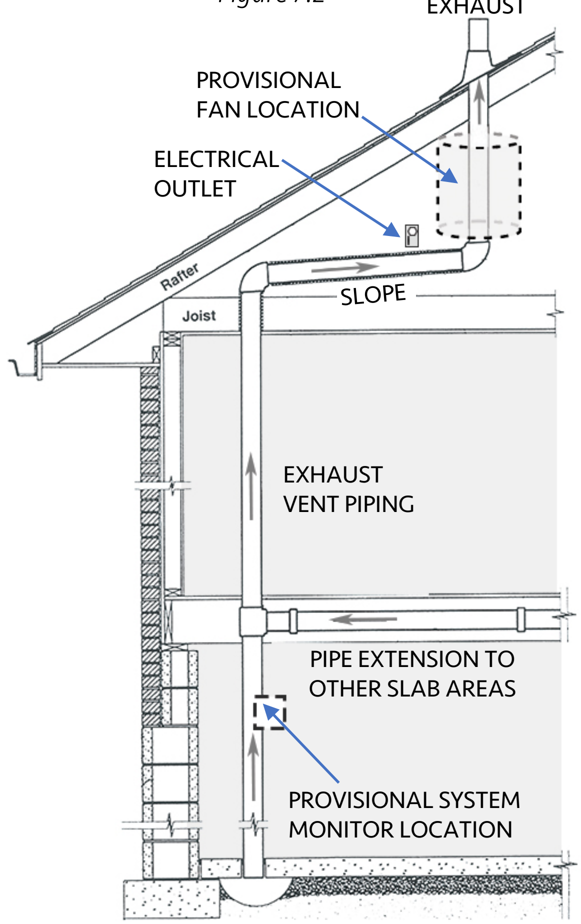
The predetermined location provided for *ASD fans*, shall be in attics, as portrayed in Figure 7.2.

Exception: Where ASD fans are to be activated during the building construction process, additional options are provided in Section 10.2.

7.2.1.1 Available Space for ASD Fan

Clearance space at the location provisionally designated for an *ASD fan* shall be provided. The location for *ASD fans* shall only be on vertical *exhaust vent piping*. The clearance provided shall be a cylindrical space having a diameter of not less than 21 inches (53 cm) and minimum vertical height of not less than 36 inches (91 cm) that is centered on system piping.

Figure 7.2



7.2.1.2 The *exhaust vent pipe* shall be labeled or marked at the location predetermined for mounting an *ASD fan* with words such as "radon fan," or "soil gas fan.

7.2.1.3 Fan Enclosures in Conditioned Attics

Where the designated *ASD fan* location is in an unvented attic space, the fan shall be isolated within an enclosure that does not communicate with the rest of the attic space. The fan enclosure shall be:

a) sealed against air leakage with weatherstripping, caulk or equivalent products to resist air movement between the enclosure and indoor air;
b) constructed to provide access to the fan with a hatch or similar access to be mechanically fastened for maintaining closure;
c) provided with one or more ventilation openings to the outdoors that have a total net free area of not less than 25 square inches (161 cm^2); and
d) meet the requirements of the applicable building and energy codes, to include thermal insulation.

7.2.1.4 Attic Access

Access shall be provided for each predetermined *ASD fan* location to allow installation of *ASD fans* and replacement of same. The service access entry shall be located not greater than 30 feet (9 m) from the *ASD fan* location unless access meeting Section R807.1 of the International Residential Code (IRC) [4] is provided. However, the minimum access does not require walkways, service platforms, level working spaces, receptacle and lighting outlets or clear and unobstructed passageways with

[4] As point of reference for required service access in attics, see the International Residential Code (IRC) as published by the International Code Council.

continuous solid flooring such as are typically required for appliances needing periodic maintenance, servicing, and inspection.

7.2.2 *Electrical Outlet for ASD Fans*

To provide for future fan activation, continuously activated circuit conductors shall supply an electrical *outlet* labeled as to its purpose that is located within 6 feet (1.8 m) of each *ASD fan* location. The over-current device for the branch circuit supplying the *ASD fan* shall be labeled to indicate that it supplies the *radon or soil gas ASD* fan.

7.2.2.1 Collateral Mitigation (electrical)

Where a single mitigation system is intentionally designed to satisfy mitigation needs in more than one unit, dwelling or area within a shared building, power provided to the system shall be from a source that is electrically metered independent from individual units unless the meter is common to all dwellings and units.

7.3 Provision for System Monitors

The location(s) for system monitors shall be Identified and labeled during construction in accordance with Section 7.2.3.2. System monitors that are required in Section 10, Table 10.1.2 in the event the system is activated with a fan, include:

1) A mechanism to indicate if the fan is operating within the established operating range, such as a manometer pressure gauge; and
2) A mechanism to actively alert occupants of fan or other mechanical failure by way of audible, visual light or telemetric notification.

7.3.1 *Accessibility*

System monitor locations shall be provided with ready access to individuals responsible for system maintenance without destruction or significant disassembly of building components or finishes:

a) in a conspicuous location where an individual *soil gas vent system* is designed for only one dwelling; or
b) in no less than two dwellings or units in locations frequently visited by occupants where an individual *soil gas vent system* is designed to address more than one dwelling or unit; or
c) in locations accessible to building staff or all occupants of the building, such as outdoors.

7.3.2 *Labeling required*

The exhaust pipe at the designated location for fan monitors shall be labeled or marked to include the words "This location reserved for a fan monitor should a soil gas fan be installed," or equivalent wording. A *primary label* required in Section 9.2 shall also be provided at this *readily accessible* location.

Exception: Where *ASD fans* are activated during construction, this label shall comply with Section 10.2.

7.3.3 *Remotely located pressure monitors*

Where the designated location for a fan pressure monitor does not immediately adjoin exhaust piping, rigid watertight tubing shall be provided between the exhaust piping and the inlet port of the pressure monitor. Remote monitor tubing visually accessible to occupants shall be labeled or marked to identify its purpose.

7.4 Exhaust Vent Pipe Materials

E*xhaust vent piping* that extends from the *soil gas collection plenum* to the point of exhaust shall be rigid, non-perforated pipe that is suitable for drainage of condensate water. E*xhaust vent piping* shall be Schedule 40 PVC pipe compliant with ASTM D2665, F891 or F1488. Alternatively, rigid, non-perforated pipe products specified in codes[5] as meeting "Above Ground Drainage and Vent" requirements shall be permitted.

[5] As a point of reference, see the International Residential Code (IRC) as published by the International Code Council.

7.4.1 *Joints and transitions*

PVC plastic pipe joints shall be solvent welded in accordance with the pipe manufacturer's instructions with solvent cement conforming to ASTM D 2564, except as allowed in Section 7.3.2 (Flexible couplings). The joint surfaces for PVC plastic pipe and fittings to be solvent welded shall be prepared with:

a) a primer conforming to ASTM F656; or

b) a self-priming product; or

c) as otherwise stipulated in the pipe manufacturer instructions.

7.4.1.1 Joint connections for alternative pipe materials specified in codes[6] as meeting "Above Ground Drainage and Vent" shall comply with the pipe manufacturer's instructions and as required by code.

7.4.2 *Flexible couplings*

For various transitions and where disassembly may be required in the future for maintenance purposes, flexible couplings that comply with ASTM D5926, ASTM C1173 or an equivalent method shall be permitted for joining portions of pipe and equipment, to include:

a) where joining air *duct piping* materials that are incompatible for solvent welding;

b) at locations where physical constraints inhibit the ability to join duct pipe materials by means of a solvent weld; and

c) to minimize noise by breaking the direct transfer of fan vibration energy to *exhaust vent piping*. "

7.5 Duct Size

Exhaust vent pipes shall be sized in compliance with Sections 3.1.1 (System coverage area).

7.6 Slope

Exhaust vent piping shall have a slope that drains water downward toward the soil of not less than 1/8 inch per foot (3.2 mm per 30 cm). The drainage path shall be free of obstructions that might cause water to accumulate in piping. When the required slope or drainage cannot be achieved, other methods for draining collected water shall be provided.

7.7 Prevention from Air and Water Leakage

All *exhaust vent piping*, except the intake and exhaust locations, shall result in a watertight duct system.

7.7.1 *Positively pressured air*

Exhaust vent piping that extends between the location designated for an *ASD fan* and the point of exhaust outside the building shall not be installed in, or pass through or under, the conditioned space of the building.

7.8 Pipe Support

Above ground piping shall be supported by the structure of the building using hangers or strapping designed for piping support. Supports shall be installed at intervals not exceeding 4 feet (1.2 m) for horizontal plastic piping and 10 feet (3 m) for vertical plastic piping.

7.8.1 *Protection Against Physical Damage*

Support locations and pipe routing shall inhibit both lateral and vertical movement of *duct piping* that can result in compromised pipe joint connections, to include locations susceptible to blunt force impact.

7.8.1.1 Where pipes penetrate top or bottom plates of stud walls and the nearest edge of the hole is within 1 ½ inches [3.8 cm] of the face of the member, the pipe shall be protected by steel shield plates. Such shield plates shall have a thickness of not less than 0.0575 inches [1.463 mm] (No. 16 gage). Such plates shall cover the face of the framing member(s) where the plate is bored, shall extend not less than 2 inches above

[6] As point of reference, see the International Residential Code (IRC) as published by the International Code Council.

bottom plates and not less than 2 inches below top plates and shall extend not less than 2 inches beyond each side of the pipe.

7.8.2 *Protect Against Unnecessary Noise*

Duct piping near the determined fan location shall be configured and secured in a manner to minimize transfer of pipe vibration to the structural framing and finishes of the building.

7.9 **Required Labels** (Piping)

Exhaust vent piping shall be labeled or marked prior to closing wall cavities at not less than two locations on each floor level to provide visibility on either side of the wall cavity. The label or marking shall identify that the piping is a component of a *radon* or soil gas vent system.

7.10 Passive Design Optimization

7.10.1 *Thermal optimization*

Systems shall not be described, labeled, or represented as having potential passive mitigation effects where not compliant with this Section 7.9.

7.10.1.1 *Cooler Climates*

For climates zones 3 through 8 (as illustrated in Table 9.5) where heating conditions prevail more that 50% of the year:

a) Interior exhaust vent pipes shall be located within the *thermal envelope* of the building; and

b) Portions of exhaust vent piping that extend through attics or other areas that are outside the heated and cooled envelope of the building shall be insulated with products that have an R-value of no less than 4 or greater.

7.10.1.2 *Warmer Climates*

For climates zones 1, 2 or warmer (as illustrated in Table 9.5) where heating conditions do not prevail more than 50% of the year, a method shall be designed to retain or increase exhaust air temperature within piping to be warmer than indoor air more than 50% of the year.

Note—Examples include:

a) Exhaust vent piping enclosed within a chase where ambient air within the chase is warmer than indoor air much of the year; or

b) Uninsulated vent piping in attics nominally 10 feet (3 m) or longer exposed to attic heat.

7.10.1.3 *Alternatives*

Depending upon the building design and climate, other passive methods that can be proven to be more effective than minimally required for retaining or increasing exhaust air temperature, compare to indoor and outdoor air, more than 50% of the year shall be permitted.

Note—See Annex A-3 for further guidance.

7.10.1.4 *Post-construction testing*

Because passive design may not be effective or the effectiveness may be intermittent across a year, indoor air testing in accordance with Section 9.5.5.2 for at least two indoor test events shall be recommended to occur within the first year after construction.

7.11 Inspect the Exhaust Vent Pipe

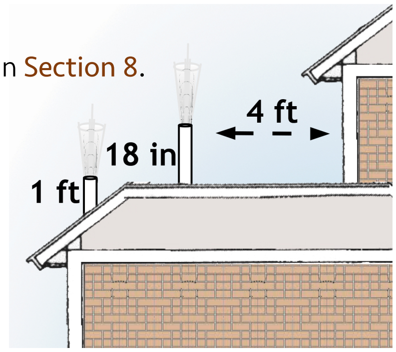
Prior to completion of indoor finishings on each floor level where exhaust piping will be enclosed, piping shall be inspected to verify compliance for soil gas *exhaust vent piping* in accordance with this Section 7. Were non-compliant, additional steps shall be taken until compliant with this standard.

7.11.1 *Reports*

This inspection shall be retained in records in accordance with Section 3.4 1 (Quality control).

SECTION 8: EXHAUST DISCHARGE CONFIGURATION

Figure 8.2



8.1 Measuring Distances

The *stretched-string* method shall be used to measure distances specified in Section 8.

8.2 Roof

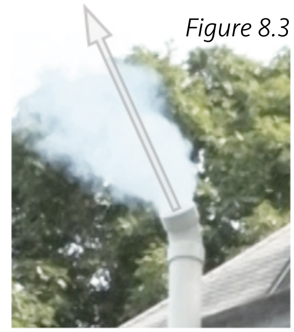
The *point of exhaust* shall be outdoors and:

a) not less than 1 foot (30 cm) above a pitched roof at the point penetrated;

b) not less than 18 inches (46 cm) above a flat roof; and

c) not less than 4 feet (120 cm) horizontally away from a vertical wall that extends above the roof edge.

Figure 8.3

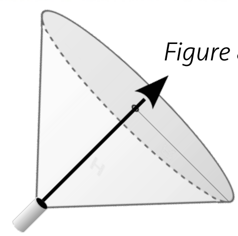


8.3 Straight-line Exhaust Trajectory (Restrictions)

The path of straight-line exhaust air within 20 feet (6 m) of the point of exhaust shall not encounter: openings in structures; building materials; or areas where people walk or gather.

Straight-line exhaust air shall be assumed to spread out from the point of exhaust at an offset-axis angle of 11°.

Figure 8.4



8.4 Directional Exhaust Spread (Restrictions)

Directional *exhaust spread* within 10 feet (3 m) of the point of exhaust shall not encounter: operable openings in structures; building materials (except for roofing materials); or areas where people gather or walk.

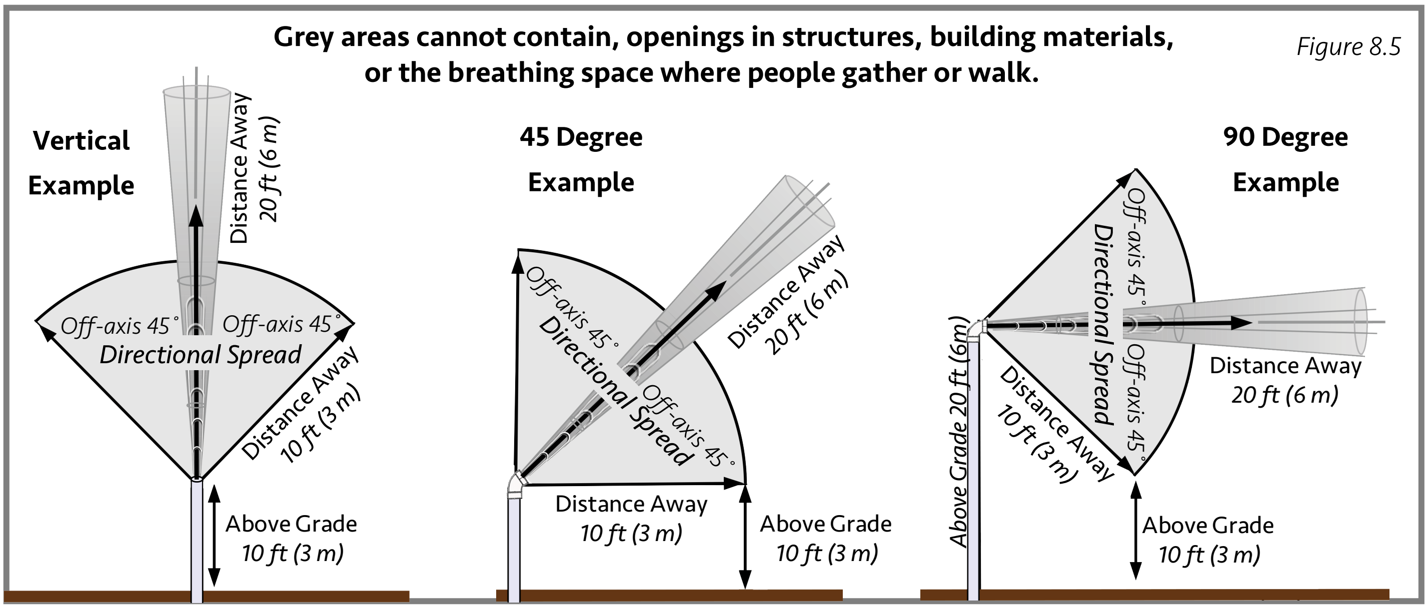
Directional *exhaust spread* shall be assumed to spread out from the point of exhaust at an offset-axis angle of 45˚.

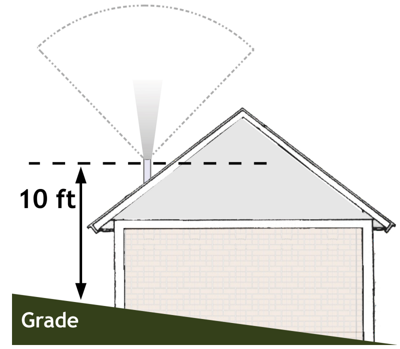
8.5 Angled Trajectories

Exhaust air shall exhaust upward and be kept clear of obstructions. It shall not deviate more than 45 degrees from a vertical exhaust trajectory. Downward exhaust is prohibited.

Exception: 90-degree horizontal *exhaust* shall be permitted where point of exhaust is not less than 20 feet (6 m) above grade to meet requirements in Section 8.4 (Directional spread).

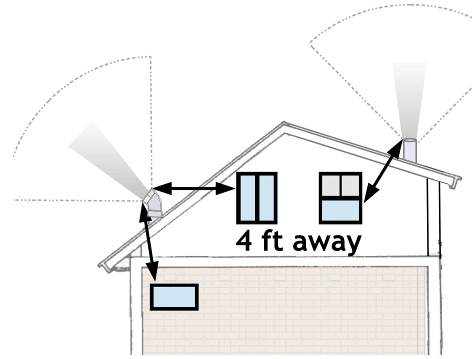
Figure 8.5





8.6 Elevation Above Grade

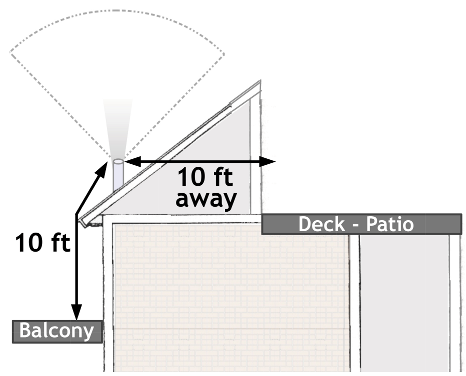
The *point of exhaust* shall be not less than 10 feet (3 m) above the nearest grade and shall be compliant with Section 8.3 (Straight-line trajectory) and Section 8.4 (Directional spread).



8.7 Separation from Openings in Structures

The *point of exhaust* shall be located not less than 4 feet (120 cm) away and pointed away from *operable openings* and other openings that ventilate indoor air with outdoor air. The exhaust air trajectory shall also be compliant with Section 8.3 (Straight-line trajectory) and Section 8.4 (Directional spread).

Note—Active window portions illustrated here are in blue.



8.8 Separation from People

For exterior flooring surfaces like decking, patios, sidewalks, and exterior corridors, the point of exhaust shall be:

a) not less than 10 feet (3 m) above or horizontally to the side of exterior flooring surfaces; and

b) compliant with Section 8.3 (Straight-line trajectory) and Section 8.4 (Directional spread).

8.9 Protection from Debris

Where not installing an *ASD fan*, rodent screen mesh shall be provided at the point of exhaust to stop debris or small animals from entering exhaust piping. Openings in the mesh shall not be smaller than 1/2 inch (13 mm).

8.10 Protection Against Obstructed Exhaust

Obstructions in the path of exhaust air, to include rain caps that can collect ice, shall not be permitted unless:

a) conditions of pervasive torrential rain or pervasive blockage from falling debris can be documented as known to exist, and

b) the configuration complies with all other requirements in this Section 8.

8.11 Inspect the Exhaust Discharge Piping

Upon completion, an inspection shall be conducted to verify compliance for exhaust discharge configuration complies with this Section 8. Where non-compliant, additional steps shall be taken until compliant with this standard.

8.11.1 *Reports*

This inspection shall be retained in records in accordance with Section 3.4 1 (Quality control).

SECTION 9: SYSTEM COMPLETION

9.1 Labeling or Marking Required for All Systems

Final inspections shall confirm that labels or markings are provided in conspicuous places as required in provisions identified in Table 9.1.

9.1.1 *Label specifications*

All labels shall be of durable materials and affixed in place such that they are capable of withstanding ambient conditions where mounted. All label lettering and other annotation on systems shall be of a color in contrast to the color of the background on which the lettering is applied. All label marking titles, as specified within each provision identified in Table 9.1, shall be provided in lettering of a height of not less than 1/4 inch (6.35 mm). Additional information on the labels, where appropriate shall have lettering of a height of not less than 1/8 inch (3.18 mm).

Table 9.1
Labeling or marking required for all systems

5.4.2	Soil gas inlet connection piping / pits
6.4.1	Protective materials on top of membranes
6.4.2	Crawl space membranes / access hatches
6.5.7	Sealed components
7.2.1.2	Designated location for ASD fans
7.2.2	Electrical outlet and respective breaker
7.2.3	Designated fan monitor location
7.8	Exhaust piping
9.2	Primary Label

9.2 Primary Labels

Each *soil gas vent system* shall be labeled with not less than one label at the location predetermined for the locations fan monitors in Section 7.2.3. In addition to messages specified in this Section 9.2, the primary labels shall include contact information for local or federal health and testing guidance.

9.2.1 *Owner-occupied maintenance (Radon)*

Where system maintenance and monitoring for continued effectiveness will be the responsibility of the owner of an individually owned and occupied dwelling, the label shall state the following or equivalent messages:

> "TEST FOR RADON. This soil gas vent piping has NOT been activated with a radon fan. Testing is required to verify if indoor radon concentrations are below the national action level. Testing should be conducted as soon as possible with the goal of achieving a measurement under at least two different seasonal conditions, to include the heating season."

Exception. The words "to include the heating season" need not be included in regions that have no heating season.

Fig. 9.2.1 Example

TEST FOR RADON
This soil gas vent piping has NOT been activated with a radon fan. Testing is required to verify if indoor radon concentrations are below the national action level. Testing should be conducted as soon as possible with the goal of achieving a measurement under at least two different seasonal conditions, to include the heating season.
For Health Guidance: www.epa.gov/radon, or the radon hotline 1-800-SOS-RADON

9.2.2 *Independent maintenance*

Where system maintenance and monitoring are the responsibility of someone other than the occupant, the primary label shall describe the purpose of the system and provide the name and contact information of the party responsible for maintenance and repairs.

Fig. 9.2.2 Example

SOIL GAS VENT PIPE SYSTEM
This system is under the care of: R. Smith, L.L.C 1-800-RN2-2222

9.2.2.1 Where system maintenance and monitoring will be the responsibility of someone other than the occupant, written plans for operation, maintenance, and monitoring (OM&M) shall be created and maintained to include messages consistent with label requirements in this Section 9.2.

9.2.3 *Active systems*

Where *ASD fans* have been activated, labels and documentation shall comply with ANSI/AARST SGM-SF (Soil Gas Mitigation Standards for Existing Homes).

9.2.4 *Incomplete soil gas vent systems*

9.2.4.1 Where not compliant with Section 6 that speaks to closure of openings between soil and indoor air, constructed features shall not be described, labeled, or represented as having potential passive mitigation effects.

9.2.4.2 Where installed components do not comply with Section 7 (Soil Gas Exhaust Vent Pipe), to include Section 7.9 (Passive Design Optimization), systems shall not be described, labeled, or represented as a passive mitigation system.

9.2.4.3 Where the completed installation is subject to requirements in Sections 9.2.4.1 or 9.2.4.2, a primary label shall be placed a conspicuous location that states: "TEST FOR RADON" and includes following or equivalent messages:

> "Not all components required for venting soil gas are installed. Testing should be conducted as soon as possible. If low concentrations are indicated, be certain to test under at least two different seasonal conditions, to include the heating season."

Exception. The words "to include the heating season" need not be included in regions that have no heating season.

Fig. 9.2.4 Example

TEST FOR RADON
Not all components required for venting soil gas are installed. Testing should be conducted as soon as possible. If low concentrations are indicated, be certain to test under at least two different seasonal conditions, to include the heating season.
For Health Guidance: www.epa.gov/radon, or the radon hotline 1-800-SOS-RADON

9.2.4.4 Independent Maintenance

Where maintenance of mitigation efforts is conducted by a party that is not the owner-occupant, written plans for (OM&M) shall be created, maintained, and include messages consistent with this Section 9.2.4. The primary label shall comply with in Section 9.2.2.

9.3 Performance Testing

9.3.1 *Radon*

Where the purpose of the system design includes protecting against exposure to *radon* gas, a short-term *radon* test shall be performed prior to or within 60 days of occupancy and shall be performed by a *qualified measurement professional*. Testing shall be performed in accordance with ANSI/AARST MAH (Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes) or applicable state protocols or requirements. Where testing results are greater than or equal to the national action level, *qualified mitigation professional* shall perform diagnostic tests and mitigation action until *radon* concentrations below the *NAL* are achieved. The final written test report with results less than the national action level shall be provided to the *AHJ*.

9.3.1.1 Radon Test Kit Required.

A minimum of one long-term *radon* test kit from a *certified/licensed* laboratory shall also be provided for the occupants of each *dwelling*.

9.3.2 *Other soil gases of concern*

Where the purpose of the system design includes protection against indoor exposure to chemical vapors or other *hazardous soil gas*, the building shall be evaluated, postconstruction, for soil gas concentrations below slabs or soil gas retarders, or in indoor air. Where test results below slabs or soil gas retarders are greater than the *action level* established by the *AHJ*, indoor air testing shall be conducted, or activation of the mitigation shall be conducted. All testing shall be conducted using methods approved by the *AHJ*. Where testing results do not meet mitigation goals, further action and follow-up testing shall be required until mitigation goals are met.

9.4 Documentation—Owner/Occupied Maintenance

Where maintenance and monitoring for continued effectiveness of a passive *soil gas vent system* is intended to be the responsibility of the owner of an individually owned and occupied dwelling, an information package compliant with this Section 4 shall be provided.

Where ASD fans or other active mitigation components are installed, the information package shall comply with ANSI/AARST SGM-SF (*Soil Gas Mitigation Standards for Existing Homes).*

Where system maintenance and monitoring are the responsibility of someone other than the occupant, a plan for long-term *operation, maintenance, and monitoring* shall be embodied into an OM&M manual in accordance with Section 9.5.

9.4.1 *The information package*

The package shall contain a plan for long-term *operation, maintenance, and monitoring (OM&M)* of the passive *soil gas vent systems.* The package shall include the following essentials:

c) Statements required in Section 9.2 (Primary Labels), or their equivalent, regarding the status of post-construction testing and whether systems are passive, active or not complete.

c) A statement of who is responsible for future maintenance and monitoring;

a) A general description of passive *soil gas vent systems*, components, and basic operating principles;

b) Guidance on maintaining components, to include closure of openings between soil and indoor air;

d) Monitoring guidance in accordance with Section 9.4.2; and

e) Test report documentation from previous testing, if available.

9.4.1.1 The information package shall be:

a) labeled "Radon Vent System" or as otherwise labeled to describe the purpose of the vent system; and

b) attached to the system piping at the location designated for the systems primary label and system monitor, as defined in Section 7.2.3.

9.4.2 *Indoor Air Testing*

The following guidance statements in Sections 9.4.2.1 through 9.4.2.4, or equivalent statements, shall be included in information packages and in OM&M manuals regarding testing for the soil gas of concern and where lines of evidence indicate other hazardous vapors or gases may intrude into the building.

9.4.2.1 *Indoor Radon and COC testing*
• "It is recommended that the indoor air of all new buildings be tested within the first year after construction for the soil gas of concern. • Testing is to be conducted in accordance with standard practices specified in national standards†, and as required by federal or state standards regardless of steps taken during building construction to reduce soil gas entry".
9.4.2.2 *Passive and Non-ASD methods*
• "Passive mitigation methods, including soil gas vent systems that are not activated with fans and those that rely on pressurization or dilution of indoor air, require additional seasonal testing to verify effectiveness. Repeat testing procedures within the first year of occupancy to verify continued effectiveness at times that are representative of:" 1. the building operating condition that lasts the longest each year; and 2. the building operating condition that prevails for the second longest duration each year." *The statements for 1 and 2 shall specify local conditions for heating conditions, cooling conditions or intermittent conditions as described in Table 9.4.*
9.4.2.3 *Elevated Concentrations*
• "If testing at any time indicates concentrations above the action level, conduct evaluations, corrections and further testing until test results indicate concentrations have been mitigated to below the action level. • It is recommended that all buildings where elevated concentrations have been found and mitigated be routinely retested, such as every 2 years, in accordance with standard practices specified in national, federal, or state standards or guidance.

† For *radon* testing, in accordance with ANSI/AARST MAH (Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes)

9.4.2.4 *Low concentrations*
(Where initially testing or testing after fan activation indicates concentrations below the national action level or as required by the *AHJ*.)

- The building should be retested:
  - ✓ at least every 5 years,
  - ✓ In conjunction with any sale of the building,
  - ✓ After a new addition is constructed or building alteration, reconfiguration, or rehabilitation occur, and
  - ✓ when a ground-contact area not previously tested is occupied;
- It is further recommended to test again when any of the following circumstances occur:
  - ✓ Heating or cooling systems are altered with changes to air distribution or pressure relationships;
  - ✓ Ventilation is altered by extensive weatherization, changes to mechanical systems or comparable procedures;
  - ✓ Sizable openings to soil occur due to:
    - — ground water or slab surface water control systems added or altered,
    - — new openings to soil created (e.g., sumps, perimeter drain tile, shower/tub retrofits, etc.); or
    - — natural settlement causing major foundation floor or wall cracks to develop;
  - ✓ Earthquakes, construction blasting or formation of sink holes nearby; or
  - ✓ A mitigation system is altered or modified.

Table 9.4 **Annual Average Building Operating Conditions**

Note—This table provides annual average outdoor temperatures for various climate zones and the building conditions, in terms of heating and cooling system activity, that occur in response to these outdoor temperatures.

	Zone 8 Subarctic	Zone 7 Very Cold	Zone 6 Cold	Zone 5 Cool	Zone 4 Mixed	Zone 3 Warm	Zone 2 Hot	Zone 1 Very Hot	Acutely Hot
Cities	*Fairbanks*	*Caribou ME, Quebec, Marquette MI, Duluth MN, Winnipeg, Grand Forks, Anchorage, Breckenridge, Aspen*	*Portland ME, Buffalo NY, Burlington NH, Milwaukee, Minneapolis, Bismarck ND, Pierre SD, Cheyenne WY, Billings MT, Helena MT*	*Boston, Albany NY, Pittsburgh PA, Cleveland, Indianapolis, Chicago, Omaha, Denver, Albuquerque, Salt Lake, Reno, NV, Boise, ID*	*New York, NY, Philadelphia, Richmond, VA, Baltimore, Louisville, Cincinnati, Nashville, Saint Louis, Kansas City, Amarillo TX, Portland, OR, Seattle*	*Atlanta, Charlotte, SC, Birmingham AL, Jackson, MS, Memphis, Little Rock, Dallas, Austin, Las Vegas, San Francisco, Los Angeles, San Diego*	*Melbourne, FL, Tampa, FL, Mobile, AL, New Orleans, Houston, Brownsville, Phoenix, Tucson*	*Miami, FL, Puerto Rico, Virgin Islands, Honolulu, Guam*	*Certain Asiatic Regions*
Annual Average Outdoor Temperatures	**27 F** (-3 C)	**39 F** (4 C)	**45 F** (7 C)	**49 F** (9 C)	**55 F** (13 C)	**62 F** (17 C)	**69 F** (21 C)	**76 F** (24 C)	**83 F** (28 C)
% of year: Heating	100% (< Freezing)	83%	75%	75%	66%	58%	42%		
% of year: Neither		16%	25%	25%	16%	16%	16%	50%	
% of year: Cooling					16%	25%	42%	50%	100%

Avg Low Winter Outdoor Temps	Zone 8	Zone 7	Zone 6	Zone 5	Zone 4	Zone 3	Zone 2	Zone 1	Acute
	Dec/Jan/Feb	Dec/Jan/Feb	Dec/Jan/Feb	Dec/Jan/Feb	Dec/Jan/Feb	Dec/Jan/Feb	Dec/Jan/Feb	Dec/Jan/Feb	Dec/Jan/Feb
	-21 C	-17 C	-12 C	-8 C	-3 C	2 C	7 C	16 C	24 C
	-6 F	2 F	9 F	17 F	26 F	35 F	45 F	61 F	76 F

Avg Daytime Summer Outdoor Temps	Zone 8	Zone 7	Zone 6	Zone 5	Zone 4	Zone 3	Zone 2	Zone 1	Acute
	Jun/Jul/Aug	Jun/Jul/Aug	Jun/Jul/Aug	Jun/Jul/Aug	Jun/Jul/Aug	Jun/Jul/Aug	Jun/Jul/Aug	Jun/Jul/Aug	Jun/Jul/Aug
	18 C	22 C	24 C	25 C	27 C	28 C	30 C	30 C	32 C
	65 F	72 F	76 F	77 F	80 F	83 F	86 F	86 F	89 F

Climate zone temperatures based 30-year averages published online in 2016 (e.g., the National Centers for Environmental Information-NOAA) for various cities located within each climate zone. Zone classifications reflect ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) standards 90.1 / 90.2. For additional information, visit www.ashrae.org.

9.5 Independent Maintenance (OM&M Manual)

Where system maintenance and monitoring are the responsibility of someone other than the occupant, a plan for long-term *operation, maintenance, and monitoring* shall be embodied into an OM&M manual. An OM&M manual shall be created that is suitable for distribution to maintenance personnel and other appropriate parties to provide tools for operating and maintaining systems.

At a minimum, content in OM&M plans shall include all content required in Section 9.4 *(Owner/Occupied Maintenance)* and Section 9.5.

9.5.1 *A description of systems*

Documentation of installed systems shall also include system components that are also labeled on a floor plan diagram, which may be complemented with photographic documentation.

9.5.2 *Records of inspections and testing*

Documentation shall consist of records that include:

a) Jobsite logs and inspection reports relative to inspections for compliance with this standard.
b) For systems that have been activated, PFE diagnostic results and other diagnostic information; and
c) Testing reports. The OMM manual shall include a recommendation that a copy of all testing reports for *radon* or other soil gas concentrations be added to, and subsequently appended to, the OM&M manual.

9.5.3 *Designated responsibilities*

Documentation shall indicate what party or parties are responsible for maintaining and monitoring the effectiveness of the mitigation system(s).

9.5.4 *Service contact information*

Documentation shall include contact information for design or service inquiries and identification of the persons responsible for adherence to these protocols, to include:

a) Name, address, and phone number;
b) Relevant *radon* mitigation certification and/or licensing number; and
c) Signature (manual, or electronic in conformance with the Electronic Signatures in Global and National Commerce [E-SIGN] Act).

SECTION 10: ADDING ASD FANS

10.1 Converting to ASD

Where adding an *ASD fan* during or after construction to activate the design, the procedure **shall** comply with all provisions of this Section 10.1.

10.1.1 *Verify rough-in completion*

In association with activating an *ASD fan*, the *rough-in* components that are accessible without destructive or significant disassembly of building components or finishes shall be inspected. Conditions not conforming with the a), b), c) and d) of this Section 10.1.1 shall be corrected:

a) Closure of openings in concrete slabs and in membranes over exposed soil to achieve a continuous air barrier that restricts air movement between soil and indoor air;

b) Circuit conductors configured for continuous activation that terminate in an *outlet* located within 6 feet (1.8 m) of the potential *ASD fan* location;

c) Fan locations that are viable for fan installation with the fan and positively pressured system piping not located inside or under conditioned or occupiable space; and

d) System piping that extends from within the gas permeable layer(s) to above the roof and is sloped to drain water to the suction point(s).

Note—Exhibit 1 provides a sample form for "Visual Review for Completion of Essential Components".

10.1.2 *ASD systems and fans*

The resulting installation, to include labeling and documentation, shall comply with ANSI/AARST SGM-SF in addition to requirements of a), b) and c) of this Section 10.1.2.

a) *ASD fans* shall not be mounted to exhaust piping that connects to soil gas unless they can be electrically energized within 3 days.

b) The measurement of vacuum within exhaust trunk piping shall indicate air pressures that are within the range of the fans recommended operating limits.

c) Fan model selection and size shall be approved by *qualified mitigation professional*.

Informative Table 10.1.2 Examples of Active System Requirements

REQUIRED COMPLIANCE WITH SGM-SF TO INCLUDE BUT NOT LIMITED TO	
• Fan locations	*ASD* fans are to be installed in attics, on the exteriors of buildings, or in garages that are not beneath conditioned or otherwise occupiable spaces.
• System Monitors	Each *ASD* system shall be provided with system monitors to monitor fan performance and notify occupants of fan failure, to include both: 1) A mechanism to indicate if the fan is operating within the established operating range, such as manometer pressure gauge; and 2) A mechanism to actively alert occupants of fan or other mechanical failure by way of audible, visual light or telemetric notification.
• Labels	A primary label that describes how to interpret monitors and actions to take if the system monitors indicate system degradation or failure.
• Documentation	A documentation package or manual that provides a plan for operation, maintenance, and monitoring (OM&M).

Informative Table 10.1.2.c **Examples of Fan Sizing**

PIPE SIZE Nominal (I.D.)	TOTAL FOUNDATION AREA		
	Less Than 1600 sq. ft. (149 m^2)	**1600 to 2500 sq. ft.** (149 to 232 m^2)	**2500 to 4500 sq. ft.** (232 to 418 m^2)
(3 inch) [7.6 cm]	Use Radon Fan Type: RF1 RF1 Minimum rating: 50 cfm @ 0.5 in. WC [85m^3/hr @ 125 Pa]	Use Radon Fan Type: RF2 RF2 Minimum rating: 75 cfm @ 1.0 in. WC [127m^3/hr @ 250 Pa]	N/A
(4 inch) [10 cm]	Use Radon Fan Type: RF1 RF1 Minimum rating: 50 cfm @ 0.5 in. WC [85m^3/hr @ 125 Pa]	Use Radon Fan Type: RF2 RF2 Minimum rating: 75 cfm @ 1.0 in. WC [127m^3/hr @ 250 Pa]	Use Radon Fan Type: RF2 RF2 Minimum rating: 75 cfm @ 1.0 in. WC [127m^3/hr @ 250 Pa]

Note—Radon Fan Types RF1 & RF2 minimum flow and pressure ratings are specifications reflecting those published by multiple fan manufacturers.

10.1.3 *Incomplete ducting*

Where, due to intentional choices or mishaps in completing pipe exhaust duct designs that can be made complaint with this standard, resulting installations, to include labeling and documentation, shall comply with Section 10.1.2.

10.2 Allowances When Design is ASD

Where decisions are made during building design to activate systems rather than rely on passive mitigation, the installation shall comply with all provisions in this standard (ANSI/AARST CCAH), including Section 10.1.2, with the following exceptions:

a) *ASD fans* are permitted to be located outdoors and other locations with exhaust vent piping and exhaust discharge configurations that are compliant with ANSI/AARST SGM-SF (Soil Gas Mitigation Standards for Existing Homes). Related labeling and documentation shall also comply with ANSI/AARST SGM-SF;

b) Provisions in Section 7.9.1 (Passive Design Optimization) are not required;

c) The wire mesh or equivalent rodent/insect screen mesh required in Section 8.9 to prevent debris or small animals from entering exhaust piping is not required; and

d) Where the purpose of the system is for reducing occupant exposure to radon, the soil gas retarder required under all portions of slabs in Section 6.4 is not required. However, in any situation where a soil gas retarder is not placed between the slab and the *gas permeable layer*, all molded and saw-cut control joints shall be sealed with caulk complying with ASTM C920 class 25 or higher or an equivalent method.

EXHIBIT 1 Sample Form

Visual Review for Completion of Essential Components

✓ Where required components are complete, check the box to indicate each statement is true.
Where a component is deficient, action must be taken to correct deficiencies.

Verification of component completion prior to, or during fan activation		
Reviewed	**Component**	**Corrected**
☐ 1)	All openings to soil in concrete slabs and membranes are closed to achieve a continuous air barrier that restricts air movement between soil gas and indoor air.	
	Sub-membrane Depressurization	
	☐ The tops and sides of the soil gas retarder(s) are sealed	
	☐ Penetrations through the membrane(s) are sealed	
	Sub-Slab Depressurization	
	☐ Penetrations through the slab(s) are sealed	
	☐ Block-outs or openings cast or constructed in the concrete slab, such as for under plumbing fixtures, are sealed	
	☐ Accessible floor to wall joints are sealed	
	General	
	☐ Sumps are closed with a rigid lid and the lid is sealed	
	☐ Openings and penetrations in hollow block masonry walls are sealed	
☐ 2)	Circuit conductors are configured for continuous activation that terminate in a receptacle outlet located within 6 feet [1.8 m] of the potential ASD fan location	
☐ 3)	Potential fan location exists that is viable for fan installation with the fan and positively pressured system piping not located inside or directly beneath conditioned or occupiable space	
☐ 4)	System piping extends from within the gas permeable layer(s) to above the roof and is sloped to drain water to the suction point(s)	

NOTE: Exhibit 1 may be reprinted without license from AARST.

NORMATIVE ANNEX A

Enhancing Passive Effectiveness

A-1 Minimizing Permeable Boundaries

Note—Relative to Section 4.2 (Close the Bottom of the Plenum) and Section 4.3 (Close the Sides of the Plenum), advisories and requirements in this Section A-1 address foundation design and installation options if implemented early in design and installation.

A-1.1 *Informative*—To optimize passive effectiveness, it may be recommended to install features that confine the size of *soil gas collection plenums* to only soils that immediately adjoin the building foundation. This serves to reduce fan or passive energy needed to depressurize a soil gas collection plenum.

This can be achieved with low permeable soils or materials described in Section 4.2 (Close the Bottom of the Plenum) if available and viable.

Using the example of soil gas retarder membrane materials, place soil gas retarder membrane materials directly on base soils after excavating exterior footing locations.

a. From the bottom of the footing, extend the length of the membrane to achieve closure to the top of all outer foundation walls below grade, and

b. For additional optimization, extend the membrane from the bottom of the footing across the top of interior foundation base soils. Note that the initial membrane over interior foundation base soils should extend at least 3-feet (1 m) horizontally away from the footings to provide for completion of a continuous soil gas barrier.

   Requirement—This membrane is in addition to the membrane required above the gas permeable layer. Where choosing such layered option to reduce the volume of soil gas that would otherwise enter the gas permeable layer, a means of ground water drainage shall be provided to drain accumulated water from the *gas permeable layer*.

A-2 Optimizing Soil Gas Flow

Note—Relative to Section 5 (Gas Permeable Airflow), advisories and requirements in this Section A-2 address design and installation options if implemented early in design and installation.

A-2.1 *Enhanced soil gas Inlets (smaller gravel, sands, and soils)*

Informative—Where concerns exist that more dense aggregates will restrict airflow across the *soil gas collection plenum*, it may be recommended to install enhanced *soil gas inlet* capacity. Examples of enhanced *soil gas inlet* configurations include grid networks of drain tile or geotextile matting that are positioned ~~much~~ closer to each other than minimally required herein.

A-2.2 *Source targeting*

Informative—Where soil gas assessments indicate high contaminant concentrations in soil only under specific portions of a building, it may be recommended to locate the transition from drain tile or geotextile matting *soil gas* inlets to exhaust piping where *soil gas* inlet trunk networks provide the least resistance for airflow relative to a targeted source.

A-3 Passive Design Optimization

Note—Relative to Section 7 (Soil Gas Exhaust Vent Pipe) and Section 7.9, (Passive Design Optimization), advisories and requirements in this Section A-3 address design and installation options for enhancing passive system effectiveness.

A-3.1 *Thermal optimization alternatives*

Informative—Dependent upon building design and local climate, there may be a variety of ways to use passive heat sources to more consistently drive soil gas upward and out of the exhaust pipe.

Each of the following conditions are usually temporary in nature.

a) Where attics are colder than indoor air more than 50% of the year, insulated exhaust pipe in an attic helps to retain exhaust air heat accumulated where uninsulated pipe passed through heated portions of a building.
b) Where attics are warmer than outside air more than 50% of the year, uninsulated exhaust piping nominally 10 feet (3 m) or longer exposed to attic heat can enhance passive effectiveness.

Configurations that optimize upward airflow within piping under both conditions are likely to be more effective than minimally required herein.

A-3.2 *Passive mechanical alternatives*

Informative—Wind turbines are an example of mechanical devices that can function passively to help drive soil gas out of the exhaust pipe. As with other passive methods, effectiveness is often intermittent across a year due to weather changes or inadequate for concentrations naturally present.

Requirements. Because exhaust soil gas is commonly humid, the designed use of turbines where permitted shall account for turbine failure due to corrosion or temporary ice buildup in cold seasons.

A-4 Minimizing Stack Effect

Informative—The option provided in this Section A-3 addresses design and installation options relative to Section 7.9 (Passive Design Optimization). This effort to optimize passive system effectiveness can be conducted at any time.

It may be recommended to implement closure to resist air movement between all openings between attics and the heated and cooled envelope, to include thermal bypasses such as open chases between ground contact rooms and attics.

Note—Reducing the volume of air escaping upper portions of a building reduces the magnitude of stack effect force.

A-5 Zero Net Energy Buildings

Informative—Where designing to optimize passive effectiveness relative to the goals intended for *zero net energy buildings*, it is recommended that installations include *gas permeable layer* materials that are highly permeable, and most design features provided in this Annex A.

A-6 High-risk Industrial Contaminants

Informative advisory—For sites that pose high-risk exposures to industrial site contamination, building designs should include multiple mitigation methods. These include optimizing barriers between soil and indoor air, optimized soil gas collection features, and HVAC designs that are capable of consistently pressurizing and/or diluting indoor air.

NORMATIVE ANNEX B NATIONAL CERTIFICATION/LISTING PROGRAMS

As referenced in this standard in Sections 9.3.1 and 10.1.2.c), the terms *qualified measurement professional* and *qualified mitigation professional* are defined as individuals who have demonstrated a minimum degree of appropriate technical knowledge and skills specific to either radon measurement or design and installation of systems that mitigate occupant exposure to radon gas or other hazardous soil gas in existing homes, as established in certification requirements of:

a) a national program that is compliant with requirements in this Annex B; or

b) as required by local statute, state or provincial licensure or certification programs that evaluate individuals for radon-specific technical knowledge and skills.

For private sector certifications and listings, this standard requires a national program that evaluates and lists qualified individuals, training courses and other products or services, such as laboratory services, integral to achieving public health goals intended by this standard[7]. Programs meeting the purpose, need and requirements of this standard are those with policies as established in a), b) and c) of this Annex B.

a) Programs with published policies that:
   1. require persons to undergo education and an impartial examination process prior to granting personal certification or certificates of educational achievement; and
   2. require surveillance of continued competence, not less than as demonstrated by continuing education on standards updates, compliance and other related technical knowledge and skills, prior to granting recertification or renewed certificates or listings; and
   3. require, for the certification of radon measurement laboratories, initial demonstration and scheduled ongoing surveillance of compliance with required standards.

b) Programs that:
   1. have a written policy and means for receiving and adjudicating complaints against individuals or companies who have been granted a credential; and
   2. have publicly published educational and examination requirements for each credential or listing available online where readily accessible for consumers of credentialed services.

c) Programs that include educational prerequisites as follow:
   1. Qualified Radon Measurement Professional—Homes
      Certifications granted that qualify individuals as proficient in conducting radon measurements in existing homes are to include:
      a. no less than 16 hours education prior to granting certification that focuses on tasks required in ANSI/AARST MAH (Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes); and
      b. biennial recertifications after completing continuing education requirements and any other program surveillance activities.

[7] The National Radon Proficiency Program (NRPP) and the National Radon Safety Board (NRSB) are two programs nationally recognized in the United States by the U.S. Environmental Protection Agency (EPA) and other public and private sector stakeholders to meet requirements in Annex B for evaluation of individuals and listing those who have demonstrated technical knowledge and skills sufficient to be certified as qualified mitigation professionals.

Note—Identification of these private sector organizations is not an endorsement of either program.

2. Qualified Mitigation Professionals—Homes

   Certifications granted that qualify individuals as proficient in designing radon or soil gas *mitigation* systems in existing homes are to include:

   a. no less than 32 hours education prior to granting certification that focuses on tasks required in this standard, ANSI/AARST SGM-SF (Soil Gas Mitigation Standards for Existing Homes); and
   b. biennial recertifications after completing continuing education requirements and any other program surveillance activities.

NORMATIVE ANNEX C Normative References

The following ANSI/AARST standards are available for review and purchase at https://standards.aarst.org

MAH *Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes*

The following ASTM standards are referenced herein and are available at www.astm.org for a fee.

C33/C33M *Standard Specification for Concrete Aggregates*

C920 *Standard Specification for Elastomeric Joint Sealants*

C1173 Standard Specification for Flexible Transition Couplings for Underground Piping Systems

D2235 *Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings*

D2564 *Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems*

D2661 *Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe and Fittings*

D2665 *Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings*

D2949 *Standard Specification for 3.25-in. Outside Diameter Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings*

D5926 *Standard Specification for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems*

E 1643 *Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs*

E1745 *Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs*

F628 *Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) Schedule 40 Plastic Drain, Waste, and Vent Pipe With a Cellular Core*

F656 *Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings*

F891 *Standard Specification for Coextruded Poly(Vinyl Chloride) (PVC) Plastic Pipe With a Cellular Core*

F1488 *Standard Specification for Coextruded Composite Pipe*

NORMATIVE ANNEX D Units of Measurement

Terms not defined herein have their ordinary meaning as defined in "Webster's Collegiate Dictionary."

2.7 becquerels per cubic meter (Bq/m^3), unit of measurement— A unit of measurement for the amount of radioactivity in one cubic meter of air. CONVERSION: 1.0 Bq/m^3 = 0.027 *pCi/L*.

2.14 cubic feet per minute (cfm), unit of measurement— A measure of the flow rate of a fluid, such as air. CONVERSION: 1.0 cfm = 1.7 m^3/hr.

2.15 cubic meters per hour (m^3/hr), unit of measurement— A measure of the flow rate of a fluid, such as air. CONVERSION: 1.0 m^3/hr = 0.6 *cfm*.

2.31 Inches of water column (in. WC), unit of measurement— A measure of pressure. CONVERSION: 1 in. WC = 249 *Pascals*.

2.37 mil, unit of measurement— 1 mil=1/1000 of an inch = 0.0254 millimeters.

2.43 pascal (Pa), unit of measurement— A measure of pressure. CONVERSION: 1 Pa = 0.004 Inches of Water (in. WC).

2.45 picocuries per liter (pCi/L), unit of measurement— A unit of measure for the amount of radioactivity in a liter of air. CONVERSION: 1.0 *pCi/L = 37* Bq/m^3.

Acknowledgments

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