

Public Review of Fully Revised CCAH

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

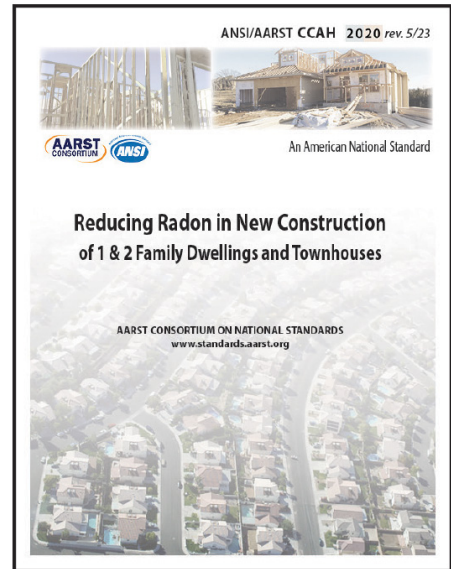
Consistent with ANSI requirements for harmonization of standards where possible, the proposed revisions to CCAH are holistic relative to more recent work on ANSI/AARST CC-1000.

The scope is broadened to include both radon and other soil gas hazards.

The format is step-by-step through design and implementation.

These steps and details vastly increase the chances of passive benefits while optimizing energy conservation when operating fans where active soil depressurization (ASD) is desired or found needed.

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Public Review: CCAH 05-2024

COMMENT DEADLINE: July 1st, 2024

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- 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.
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REQUESTED FORMAT

Public Reviewed Item and Its Date: CCAH 05-2024

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

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Website: www.standards.aarst.org Email: StandardsAssist@gmail.com

527 N Justice Street, Hendersonville, NC 28739

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



Table of Contents

1 SCOPE		7 SOIL GAS EXHAUST VENT PIPE	
1.1 Scope	1	7.1 Prior to Pipe Route Design/Installation	18
1.2 Limitations	1	7.2 Provision for ASD fan(s)	18
2 TERMS AND DEFINITIONS	2	7.3 Exhaust Vent Pipe Materials	19
3 DESIGN		7.4 Duct Size	20
3.1 Building Design	5	7.5 Slope	20
3.2 Soil Gas Collection Plenum Design	5	7.6 Prevention of Air and Water Leakage	20
3.3 Quality Control	6	7.7 Pipe Support	20
4 SOIL GAS COLLECTION PLENUMS		7.8 Required Labels	21
4.1 Before Gas Permeable Materials	7	7.9 Passive Design Optimization	21
4.2 Close the Bottom	7	7.10 Inspect the Soil Gas Exhaust Pipe	21
4.3 Close the Sides	7	8 EXHAUST CONFIGURATION	
4.4 Foundation Drain Systems	8	8.1 Measuring Distances	22
4.5 HVAC Ductwork	8	8.2 Roof	22
4.6 Jobsite Logs	8	8.3 Straight-line Trajectory Restrictions	22
5 GAS PERMEABLE LAYER AIRFLOW		8.4 Directional Spread Restrictions	22
5.1 Before Installing Permeable Materials	9	8.5 Angled Trajectories	22
5.2 Soil Gas Collection Duct Sizing	9	8.6 Elevation Above Grade	23
5.3 Soil Gas Inlet Sizing	9	8.7 Separation from Operable Openings	23
5.3.1 Option 1—Gravel	9	8.8 Separation from People	23
5.3.2 Option 2—Void Airspace	10	8.9 Protection from Debris	23
5.3.3 Option 3—Smaller Gravel	10	8.10 Protection against Obstructed Exhaust	23
5.3.4 Option 4—Small Gravel, Sands, Soils	11	8.11 Inspect the Exhaust Vent Pipe	23
5.3.4 Optimization Options	11	9 SYSTEM COMPLETION	
5.4 Transition from Inlets to Exhaust Pipe	12	9.1 Labeling or Marking	24
5.5 Gas Permeable Layer Installation	12	9.2 Primary Labels	24
5.6 Inspect the Open Plenum	12	9.3 Performance Testing	25
6 CLOSE THE TOP OF THE PLENUM		9.4 Documentation—Owner/Occupied	26
6.1 Continuous Air Barrier	13	9.5 Independent Maintenance	27
6.2 Closure of Concrete Floors	13	10 ADDING ASD FANS	
6.3 Soil Gas Retarder Materials/Installation	13	10.1 Converting to ASD	31
6.4 Closure of Exposed Soil	15	10.2 Allowances When Construction Includes an ASD Fan	32
6.5 Closure of Opening and Gaps	15	NORMATIVE ANNEXES:	
6.6 Gas-tight Barrier Performance Test	17	A Enhancing Passive Effectiveness	34
6.7 Inspect for Closure	17	B Certification/Listing Programs	36
		C Normative References	37
		D Units of Measurement	38
		CONSENSUS BODY MEMBERS	39

CCAH – 202x
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.

1.2 Limitations

1.2.1 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. 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.

1.2.2 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 buildings² or any building where an HVAC system is shared across multiple dwellings or units.

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.

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 "Webster's Collegiate 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/m²) 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 ASD fan, n— A fan that is designed and rated by the manufacturer for continuous duty and for use in an ASD system.
- 2.6 authority having jurisdiction (AHJ), n— Federal, state, province, township, or other jurisdictional body having authority over practices or products.
- 2.7 base (or base course), n— The layer of gas permeable material on top of the subbase and directly under the slab.
- 2.8 branches, n— Air duct piping or geotextile matting that routes air from only one *inlet* or *inlet network*.
- 2.9 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.
- 2.10 collection wells, n— Pits designed as a soil gas *inlet* or to transition or join *trunks* or *branches* of an *inlet trunk network*.
- 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 depressurization, n— A negative pressure induced in one area with respect to another.
- 2.14 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.
- 2.15 duct piping, n— See *exhaust vent piping*
- 2.16 dwelling, n— One or two units within a building that are intended to be occupied for residential living purposes.
- 2.17 exhaust, n— A pipe or other piece of apparatus through which soil gases escape or are discharged.
- 2.18 exhaust spread, n— The exhaust spread extends outward from the point of exhaust in the shape of a circular cone. The tip or apex of the cone is at the geometric center of the exhaust opening and the cone profile grows larger as distance from the point of exhaust increases.
- 2.19 exhaust trajectory, n— The angle of the pipe or elbow at the point of exhaust with a straight-line exhaust spread radius of 11°
- 2.20 exhaust vent piping, n— Air duct *trunk* or *branch* pipes that transfer air between soil gas *inlets* or *inlet networks* within the *soil gas collection plenum* and outside air.
- 2.21 gas permeable layer, n— Void space or permeable aggregate that allows *hydraulic conductivity* for soil gas movement into and across a *soil gas collection plenum*.

Terms and Definitions

- 2.22 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.
- 2.23 gravel, n— A mixture of crushed rock or naturally occurring pebbles. Commercially, it is classified according to the size of the particles.
- 2.24 hazardous soil gas, n— Soil gasses and vapors regulated by the *jurisdiction having authority* due to toxic, flammable, or explosive hazards.
- 2.25 hydraulic conductivity, n—The capacity of liquids or gas to pass through permeable materials.
- 2.26 inlets, n— See *Soil Gas Inlets*.
- 2.27 inlet piping, n— *Air duct piping* that connects one or more soil gas *inlets* to exhaust piping.
- 2.28 inlet trunk network, n— Air duct pipe configuration that connects one or more soil gas *inlets* to exhaust piping.
- 2.29 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*.
- 2.30 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.”
- 2.31 mitigation system, n— Any system designed to reduce indoor concentrations of *radon* or other soil gas pollutants.
- 2.32 outlet, n— A point on the wiring system at which current is taken to supply utilization equipment.
- 2.33 openings in structure, n— The openings created in structural walls or roofs for the purpose of mounting windows, skylights, doors, or other assemblies that might open to outdoor air.
- 2.34 operable openings, n— The actively operable or constantly open portion of windows, skylights, doors, and other openings designed to increase 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.
- 2.35 plenum, n— See *Soil Gas Collection Plenum*
- 2.36 PFE (pressure field extension test), n—A diagnostic procedure to evaluate the potential effectiveness of an ASD system by using a shop vacuum or other fan or vacuum device to draw air from the space below a slab, membrane or from the cavities inside a block wall.
- 2.37 qualified measurement or mitigation professional, n—As defined in Normative Annex B.
- 2.38 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/m³)
- 2.39 readily accessible, adj— See *access ready*
- 2.40 secondary trunks, n—*Air duct piping* that route only a portion of the system air volume capacity from more than one *inlet*.
- 2.41 soil gas, n— Air within soil that can contain *radon* or other hazardous gasses or vapors.
- 2.42 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.
- 2.43 soil gas collection well, n— A pit designed as a soil gas inlet or to transition or join multiple trunks or branches of an inlet trunk.
- 2.44 soil gas control, n— Planned control of soil gasses to reduce *radon* concentrations or other pollutants in indoor air.

Terms and Definitions

- 2.45 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.
- 2.46 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.
- 2.47 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 system exhaust at the roof.
- 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, roofs, and any other building element or assemblies that enclose conditioned space or provide a boundary between conditioned space and exempt 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 prior to occupancy and the purpose includes protection against *radon* hazards, *radon* testing is conducted in accordance with ANSI/AARST MAH (Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes) and demonstrates results that are below the national *action level*. 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

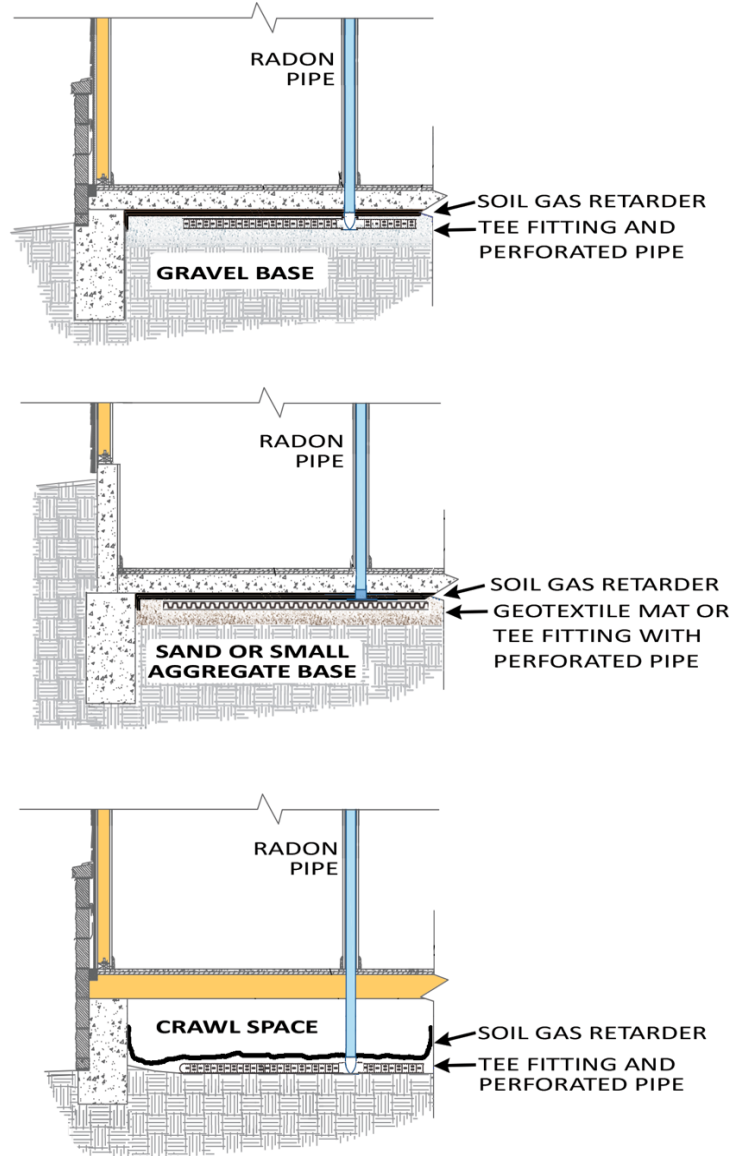
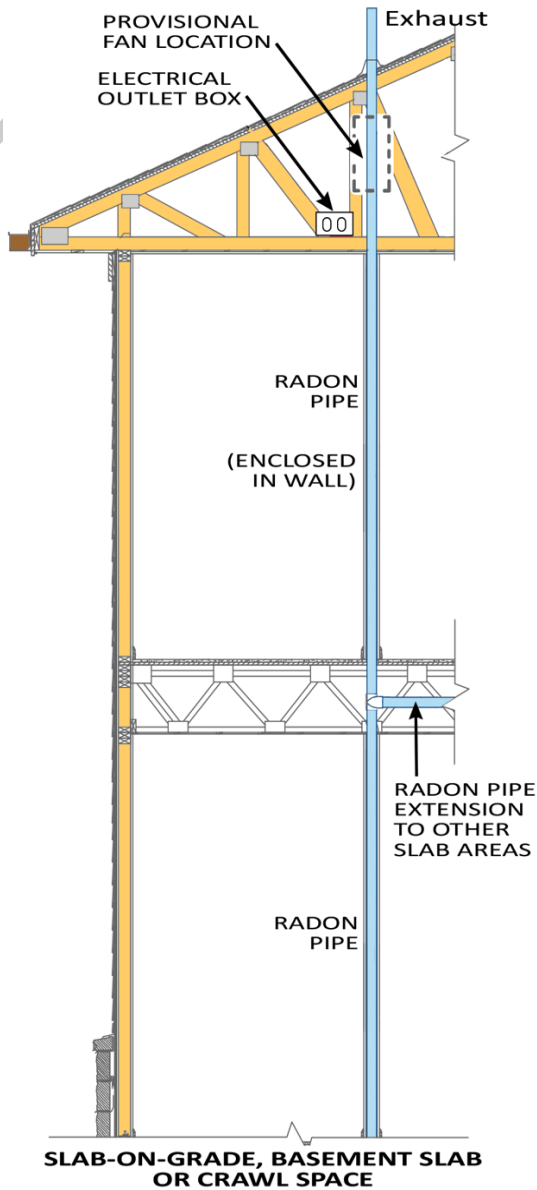
Gas permeable layer material choices shall be determined prior to construction and design of *soil gas vent systems*, as chosen to include conformance with *soil gas inlet* design options required in [Sections 5.3.1](#) through [5.3.5](#).

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 inlet 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: SOIL GAS COLLECTION PLENUMS

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 open spaces shall be closed in accordance with this [Section 4](#).

4.2 Close the Bottom of the Plenum

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 exist, closure that resists air movement between the *gas permeable layer* and surrounding subgrade or fill is required;

- a) where, based on visual observations, soil surveys, geotechnical reports, or other sources, *highly permeable* aggregates extend ≥ 10 ft (3 m) away to the side or below the foundation; and
- b) where the *gas permeable layer* would be open to cavities, caves, crevices between rock layers, or outdoor air.

4.2.1.1 Closure Specifications

Where required in [Section 4.2.1](#), existing or constructed materials below and to the side of the *gas permeable layers* shall be materials that, due to comparatively low permeability, impede the volumetric flow of soil gas into the *gas permeable layer*. Impervious soils or aggregates containing more than 35% clay, silt, rock fragment fines and sand shall be acceptable for meeting this requirement. Alternatively, other methods of closure, such as a *soil gas retarder*, shall be implemented. Soil gas retarders used for this purpose shall:

- a) comply with *soil gas retarder* material specifications in [Section 6.3](#); and
- b) be positioned to restrict air movement while retaining the capacity for groundwater to drain out of 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 the Sides of the Plenum

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.

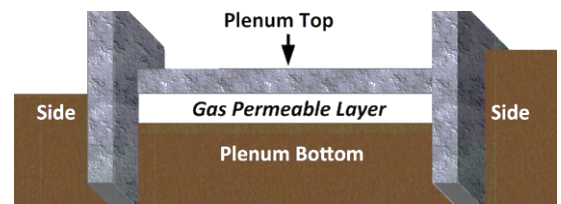
4.3.2 Damp proofing

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.

4.3.4 Hollow concrete masonry unit (CMU) walls

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

Fig. 4. Example construction of plenum



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

- 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.

4.4 Foundation Drain Systems

4.4.1 Interior specifications

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 specifications

Where an interior *soil gas collection plenum* is connected to an exterior foundation drain system, portions of exterior foundation drain systems that are constructed below grade shall be constructed as required in a) and b) of this **Section 4.4.2**.

- a) Closure shall be provided to resist airflow between outside air and water drainage receptors, such as for grade-level drains, window well drains and open pipes above grade that receive rainwater from the roof. Closure shall be accomplished by surrounding piping and pipe ends with low permeability soil, capping open pipes, or using one-way flow valves with access provided for future maintenance or equivalent materials or methods; and
- b) Closure shall be provided to resist airflow between outside air and foundation drain piping that opens to outside air or connects to a storm sewer. Closure shall be accomplished 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: GAS PERMEABLE LAYER AIRFLOW

5.1 Before Installing Gas Permeable Materials

Prior to installing *gas permeable layer* materials, the designed components of soil gas collection ducts, *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](#).

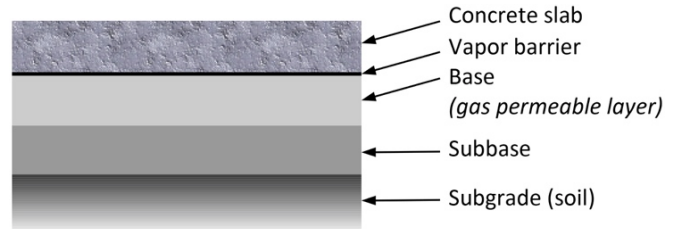
5.2 Soil Gas Collection Duct Sizing

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:

- not less than 7.1 sq. in. (46 cm²) for systems designed with 3-inch (75 mm) exhaust piping, and
- not less than 12.6 sq. in. (81 cm²) cross-sectional dimensions for systems designed with 4-inch (100 mm) exhaust piping.

Exception:

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



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)

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 Soil Gas Inlet Sizing

The *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.

5.3.1 Option 1—Gravel

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

5.3.1. Notes

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:

- secured to the "T" fitting with a combined length as specified in [Table 5.3.1](#);
- 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

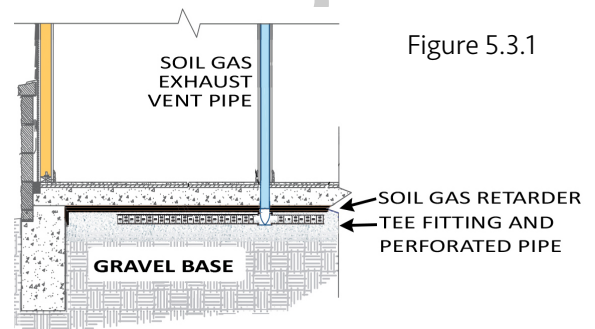
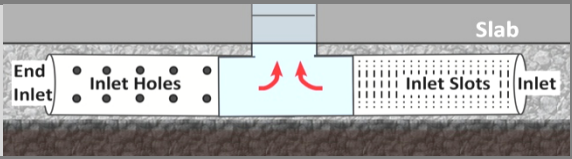


Figure 5.3.1

3. configured with inlet openings on both sides of piping such that not less than 2/3rds of the 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 in ² /ft (21 cm ² /m)	2.0 in ² /ft (42 cm ² /m)	≥ 3.0 in ² /ft (58 cm ² /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.

* RELATED ADDITIONAL REQUIREMENTS:

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 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* with an airflow pathway compliant with **Section 5.2** and the equivalent inlet opening size of:

1. not less than a total of 18 sq. in. (116 cm²) of openings to gravel for systems designed with 3-inch (75-mm) exhaust piping, and
2. not less than a total of 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

A *soil gas* collection pit where the sides of the pit are open to the face of gravel to achieve the equivalent inlet opening size prescribed for drain tiles and geotextile matting. Where a *gas permeable layer* is gravel, approximately 4 inches (10 cm) in depth, this equates to a pit that is 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) *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 inlet.

5.3.3 **Option 3—Smaller 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 *inlet* sizes shall be double those required in **Section 5.3.1**. Alternatively, the *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 *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 an 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*.

Options	Allowed If Including Required System Design Features	Not Permitted *	Example Of Required Design Features
Smaller Stone Option	This option shall be in accordance with size numbers 467, 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.		<p>3800 sq ft (383 m²)</p>
Sand Option	This option shall be in accordance with size number 9 as classified by ASTM C33. Note—These aggregates contain a high percentage of 0.2-inch (4.75 mm) to 0.1-inch (2 mm) granules.	Aggregates having > 10% sand fragments and clay or silt particles smaller than 0.05 inch (1 mm), as evaluated by a # 16 sieve.	
Soil Option	This option shall be soil existing at the building location with uniform characteristics for fragmental aggregate. The soil shall consist of too little fine particles to fill interstices >0.05 inch (1 mm) between stones, cobbles, gravel, and very coarse sand particles after compaction occurs.	Soils containing more than 35% of sand, rock fragments, clay, and silt with interstices between stones and sand that are < 0.05 inch (1 mm). Soils containing more than 10% high plasticity clay or silt, or expansive soils with a liquid limit ≥50%.	

* See Companion Guidance. Soil aggregates not permitted for use as a *gas permeable layer* can alternatively be determined by a *percolation test* the indicates a percolation rate slower than approximately 1 minute per inch.

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

5.4.2.1 Not Permitted

Groundwater control sumps shall not be configured for use as *soil gas collection inlets* or *suction points*.

5.4.2.2 Permitted

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). Gaps between the membrane and the slab shall be sealed.

5.5 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.

5.5.1 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.

5.6 Inspect the Open Plenum

Prior to placement of concrete or soil gas retarders over a *gas permeable layer*, an inspection that includes items listed in [Exhibit A-1](#) shall be conducted to verify that:

- a) *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) *gas permeable layer* materials and closed surroundings of the plenum comply with this standard.

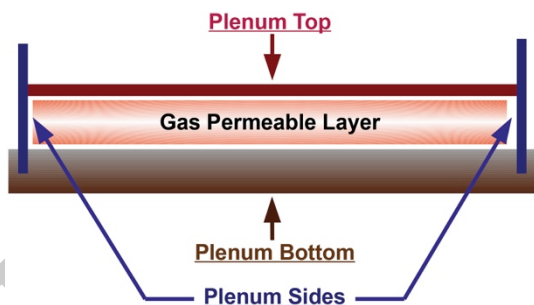
5.6.1 Non-compliance

Where plenum closure, inlet ducting, inlet sizing, or *gas permeable layer* materials are non-compliant, additional steps shall be taken until compliant with this standard prior to placement of concrete or *soil gas retarders* over a *gas permeable layer*.

5.6.2 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.

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 compliant 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, the products, and methods for gas-tight closure, such as spray-applied vapor barriers or geomembranes, shall comply with *AHJ* requirements.

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.

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 no less than 1 inch (2.5 cm) beyond the outer perimeter of the membrane size otherwise minimally required and mechanically fastened locations.

6.3.3.1 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. Where ≥ 20 mil (0.020 inch; 0.508 mm) membranes are used, *termination bars* or equivalent fastening method shall secure the outer edges of the membrane.

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.

6.3.3.2 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.

6.3.3.3 Penetrations

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.

6.3.3.4 Repairs

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 Prior to 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](#), closure equivalent to that required to [Section 6.5.1](#) 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 that is 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, rigid material sufficient to support anticipated loads in the area of use. 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.

6.5.4.1 One-way Flow Valves

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.

6.5.5 *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."

6.5.6 *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 administering smoke 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.

6.6.3 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. Resulting design considerations shall include review of *soil gas vent pipe* design for complying with this standard and converting the design to an ASD system in compliance with requirements in [Section 10](#) (Adding ASD Fans).

6.7 Inspect for Closure Prior to Indoor Finishings

Prior to completion of indoor finishings in 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 Prior to Pipe Route Design/Installation

Prior to installation of *exhaust vent piping*, the location for each potential *active soil depressurization (ASD) fan* and fan monitor 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.

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

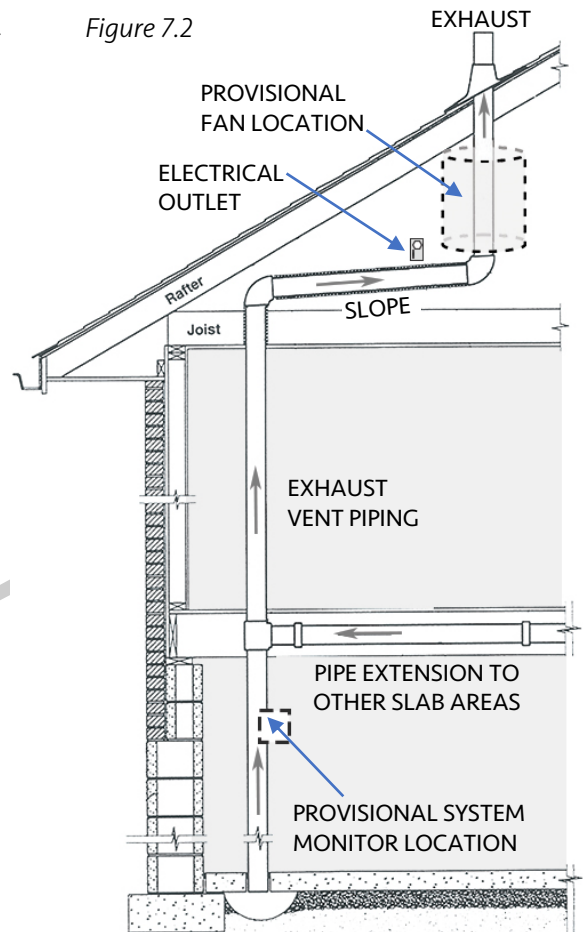
Where the designated *ASD fan* location is in an unvented attic space, the fan shall be isolated within an enclosure that does not communicate with the rest of the attic space. The fan enclosure shall be:

- sealed against air leakage with weatherstripping, caulk or equivalent products to resist air movement between the enclosure and indoor air;
- constructed to provide access to the fan with a hatch or similar access to be mechanically fastened for maintaining closure;
- 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 cm²); and
- 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

Figure 7.2



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 to be Provided*

To provide for future fan activation, 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.

7.2.3 *Provision for ASD fan monitor(s)*

The predetermined location(s) for fan monitors (e.g., pressure gauge) shall be labeled during construction in accordance with [Section 7.8.3.2](#). Fan monitor locations shall be *readily accessible* to individuals responsible for system maintenance without destructive 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.

7.2.3.1 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](#).

7.2.3.2 Remotely Located 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.

7.3 **Exhaust Vent Pipe Materials**

Exhaust 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. *Exhaust vent piping* shall be Schedule 40 PVC pipe compliant with ASTM D2665, F891 or F1488. Alternatively, rigid, non-perforated pipe products specified in codes⁵ as meeting "Above Ground Drainage and Vent" requirements shall be permitted.

7.3.1 *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:

1. a primer conforming to ASTM F656; or
2. a self-priming product; or
3. as otherwise stipulated in the pipe manufacturer instructions.

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

7.3.1.1 Joint connections for alternative pipe materials specified in codes⁶ as meeting “Above Ground Drainage and Vent” shall comply with the pipe manufacturer’s instructions and as required by code.

7.3.2 **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*. “

7.4 **Duct Size**

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

7.5 **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.

7.6 **Prevention from Air and Water Leakage**

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

7.6.1 **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.

7.7 **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.

7.7.1 **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.

7.7.1.1 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 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.

7.7.2 **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.

Note—A means to achieve isolation from pipe vibration is also recommended where pipes entering attics are to penetrate top or bottom plates of stud walls.

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

7.8 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.

7.9 Passive Design Optimization**7.9.1 Thermal optimization**

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

7.9.1.1 Cooler Climates

For climates zones 3 through 8 (as illustrated in [Table 9.5](#)) where heating conditions prevail more than 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.

7.9.1.2 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.

7.9.1.3 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.

7.9.1.4 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.

7.10 Inspect the Soil Gas Exhaust Vent Pipe

Prior to completion of indoor finishings that enclose exhaust piping, an inspection shall be conducted 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.

7.10.1 Reports

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

SECTION 8: EXHAUST DISCHARGE CONFIGURATION

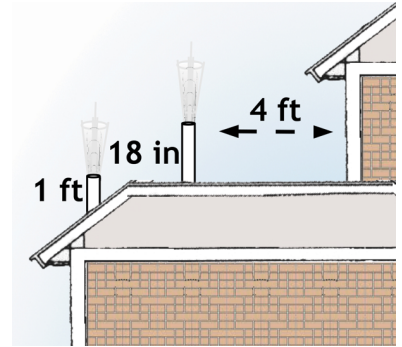
8.1 Measuring distances

The *stretched-string method* shall apply when measuring distances between the point of exhaust and all objects and distances specified in [Section 8](#).

8.2 Roof

The *point of exhaust* shall be outdoors and:

- not less than 1 foot (30 cm) above a pitched roof at the point penetrated;
- not less than 18 inches (46 cm) above a flat roof; and
- not less than 4 feet (120 cm) horizontally away from a vertical wall that extends above the roof edge.



8.3 Straight-line Trajectory (restrictions)

The *straight-line trajectory* for air exhausted shall be pointed away from openings in structures, building materials and the breathing space where individuals congregate or traverse that are within 20 feet (6 m) from the point of exhaust.

8.4 Directional Spread (restrictions)

The trajectory for the *exhaust spread* radius of 45° shall not encounter openings in any structures, building materials other than roofing materials, or the breathing space where individuals congregate or traverse within 10 feet (3 m) from the point of exhaust.

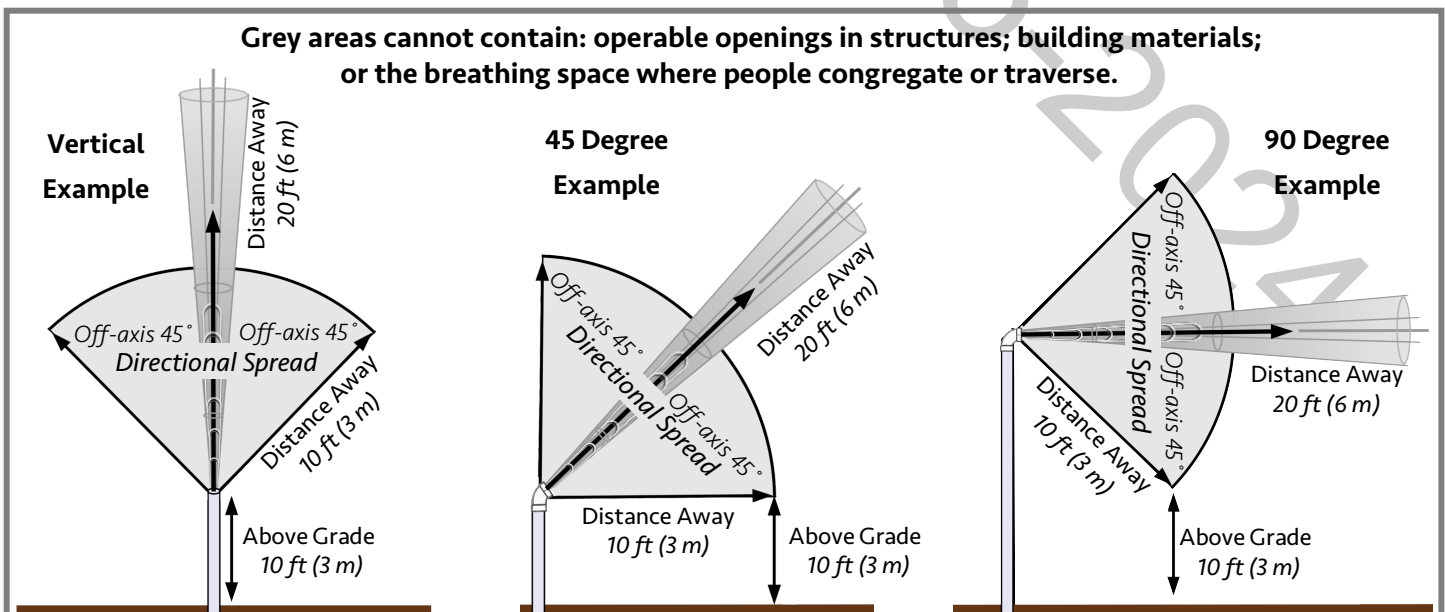
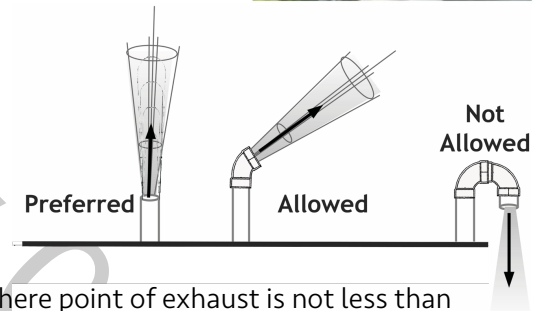


8.5 Angled Trajectories

The *point of exhaust* shall be directed upward without obstruction at an angle that does not deviate more than 45 degrees from a vertical *exhaust trajectory*. The exhaust discharge shall not exhaust downward.

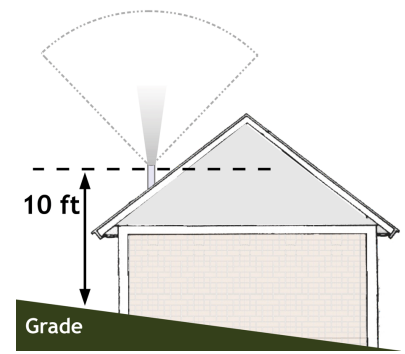
Exception: 90-degree horizontal discharges.

90-degree horizontal *exhaust trajectories* shall be permitted where point of exhaust is not less than 20 feet (6 m) above grade for meeting requirements in [Section 8.4](#) (Directional spread).



8.6 Elevation Above Grade

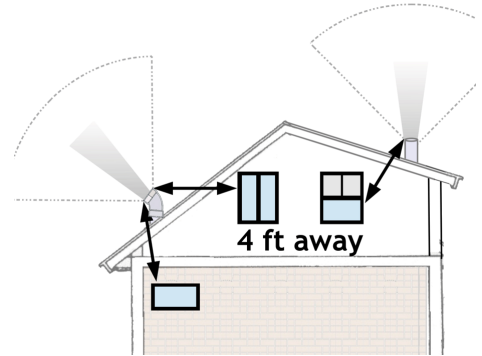
The *point of exhaust* shall be not less than 10 feet (3 m) above grade nearest to the *point of exhaust* and shall be compliant with **Section 8.3** (Straight-line trajectory) and **Section 8.4** (Directional spread).



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* in structures and other openings allowing outdoor air into structures. The exhaust air trajectory shall also be compliant with **Section 8.3** (Straight-line trajectory) and **Section 8.4** (Directional spread).

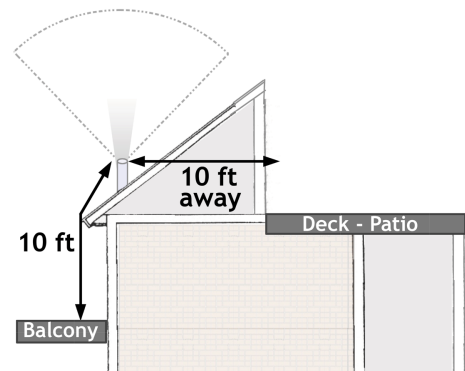
Note—Active window portions illustrated here are in blue.



8.8 Separation from People

In relationship to exterior flooring surfaces such as decking, patios, sidewalks, and exterior corridors where individuals may congregate or traverse, 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*, wire mesh or equivalent rodent screen mesh not smaller than 1/2 inch (13 mm) shall be provided at the point of exhaust to prevent debris or small animals from entering exhaust piping.

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 Soil Gas Exhaust Vent Pipe

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 made of durable materials that 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	Inlet connection piping / pits
6.4.1	Protective materials on top of membranes
6.4.2	Crawl space membranes / access hatches
6.5.6	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.

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.

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**.

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

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

9.2.3 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.

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

Fig. 9.2.4 Example



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 Radon

Where system maintenance and monitoring for continued effectiveness is intended to be the responsibility of the owner of an individually owned and occupied dwelling, an information package shall be provided. 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:

- 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;
- c) A statement of who is responsible for future maintenance and monitoring;
- d) Monitoring guidance in accordance with **Section 9.4.1**; and
- e) Test report documentation from previous testing, if available.

9.4.1 Monitoring guidance

The following guidance statements or equivalent statements shall be included in the information package.

“It is recommended that the indoor air of all new buildings be tested within 90 days after construction for radon gas. Passive soil vent mitigation methods require seasonal testing to verify effectiveness. It is recommended to repeat testing procedures within the first year until verifying effectiveness during both:

1. the predominant annual average operating condition for the building; and
2. the building operating condition that prevails for the second longest duration each year.

Note—For much of North America, heating season conditions are predominant for more than half of the year. In some Southern regions of North America, cooling seasons mixed with intermittent use of cooling and heating systems may comprise the two predominant seasons.

It is recommended to retest the building(s) at least every 5 years and in conjunction with any sale of a building; and

It is recommended to test again when any of the following circumstances occur:

- ✓ A new addition is constructed or alterations for building reconfiguration or rehabilitation occur;
- ✓ A ground-contact area not previously tested is occupied;
- ✓ Heating or cooling systems are altered with changes to air distribution or pressure relationships;
- ✓ Ventilation is altered by 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 or new openings to soil created (e.g., sumps, perimeter drain tile, shower/tub retrofits, etc.); or
 - natural settlement causing major cracks to develop;
- ✓ Earthquakes, construction blasting or formation of sink holes nearby; or
- ✓ A mitigation system is altered or modified.”

9.4.2 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**.

9.5 OM&M Manual—Independent Maintenance

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. The plan shall include stipulations required in [Section 9.5.1](#) through [Section 9.5.5](#).

9.5.1 *A description of systems*

Documentation of installed systems shall include narrative that describes:

- a) A general description of passive *soil gas vent systems* and basic operating principles;
- b) guidance on maintaining components, to include closure of openings between soil and indoor air; and
- c) 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).

9.5.5 OM&M Manual – Indoor Air Testing

The following guidance statements in [Sections 9.5.5.1](#) through [9.5.5.4](#), or equivalent statements, shall be included in the OM&M manual regarding testing for the soil gas of concern and where lines of evidence indicate other hazardous vapors or gases may intrude into the building.

9.5.5.1 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”;

9.5.5.2 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 no less than under:”
 1. The predominant normal occupied building operating condition for the building, or unique sector within a building, along with the annual average outdoor temperature for the climate zone; 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 9.5](#).

9.5.5.3 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 MA-MAH](#) (Protocol for Conducting Measurements of Radon and Radon Decay Products in Homes)

9.5.5.4 *Low concentrations*

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

- It is recommended to retest the building(s) at least every 5 years and with any sale of the building.
- In addition, it is recommended to test again when any of the following circumstances occur:
 - ✓ A new addition is constructed or building alteration, reconfiguration, or rehabilitation occur;
 - ✓ A ground-contact area not previously tested is occupied;
 - ✓ 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 cracks to develop;
 - ✓ Earthquakes, construction blasting or formation of sink holes nearby; or
 - ✓ A mitigation system is altered or modified.

Table 9.5 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.

	<i>Fairbanks</i>	<i>Caribou ME</i> <i>Quebec</i> <i>Marquette MI</i> <i>Duluth MN</i> <i>Winnipeg</i> <i>Grand Forks</i> <i>Anchorage</i> <i>Breckenridge</i> <i>Aspen</i>	<i>Portland ME</i> <i>Buffalo NY</i> <i>Burlington NH</i> <i>Milwaukee</i> <i>Minneapolis</i> <i>Bismarck ND</i> <i>Pierre SD</i> <i>Cheyenne WY</i> <i>Billings MT</i> <i>Helena MT</i>	<i>Boston</i> <i>Albany NY</i> <i>Pittsburgh PA</i> <i>Cleveland</i> <i>Indianapolis</i> <i>Chicago</i> <i>Omaha</i> <i>Denver</i> <i>Albuquerque</i> <i>Salt Lake</i> <i>Reno, NV</i> <i>Boise, ID</i>	<i>New York, NY</i> <i>Philadelphia</i> <i>Richmond, VA</i> <i>Baltimore</i> <i>Louisville</i> <i>Cincinnati</i> <i>Nashville</i> <i>Saint Louis</i> <i>Kansas City</i> <i>Amarillo TX</i> <i>Portland, OR</i> <i>Seattle</i>	<i>Atlanta</i> <i>Charlotte, SC</i> <i>Birmingham AL</i> <i>Jackson, MS</i> <i>Memphis</i> <i>Little Rock</i> <i>Dallas</i> <i>Austin</i> <i>Las Vegas</i> <i>San Francisco</i> <i>Los Angeles</i> <i>San Diego</i>	<i>Melbourne, FL</i> <i>Tampa, FL</i> <i>Mobile, AL</i> <i>New Orleans</i> <i>Houston</i> <i>Brownsville</i> <i>Phoenix</i> <i>Tucson</i>	<i>Miami, FL</i> <i>Puerto Rico</i> <i>Virgin Islands</i> <i>Honolulu</i> <i>Guam</i>	<i>Certain</i> <i>Asiatic</i> <i>Regions</i>
	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
	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	100%	83%	75%	75%	66%	58%	42%	50%	100%
	< Freezing								
Avg Low Winter Outdoor Temps	Zone 8	Zone 7	Zone 6	Zone 5	Zone 4	Zone 3	Zone 2	Zone 1	Acute
	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>	<i>Dec/Jan/Feb</i>
	-21 C -6 F	-17 C 2 F	-12 C 9 F	-8 C 17 F	-3 C 26 F	2 C 35 F	7 C 45 F	16 C 61 F	24 C 76 F
Avg Daytime Summer Outdoor Temps	Zone 8	Zone 7	Zone 6	Zone 5	Zone 4	Zone 3	Zone 2	Zone 1	Acute
	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>	<i>Jun/Jul/Aug</i>
	18 C 65 F	22 C 72 F	24 C 76 F	25 C 77 F	27 C 80 F	28 C 83 F	30 C 86 F	30 C 86 F	32 C 89 F

Climate zone temperatures based 30-year averages published online (e.g., the National Centers for Environmental Information-NOAA) for a major city 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.

SECTION 10: ADDING ASD FANS

10.1 Converting to ASD

Where not originally planned but it is later decided during or after construction to activate the design by adding an *ASD fan*, 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 Converting to ASD

The resulting installation, to include labeling and documentation, shall comply with **ANSI/AARST SGM-SF** (Soil Gas Mitigation Standards for Existing Homes) 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	<i>ASD fans</i> 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 <i>ASD system</i> shall be provided with system monitors to monitor fan performance and notify occupants of fan failure, to include both: <ol style="list-style-type: none"> 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 compliant with this standard, resulting installations, to include labeling and documentation, shall comply with [Section 10.1.2](#).

10.2 Allowances When Construction Includes an ASD Fan

Where fans are activated during construction, the installation shall comply with all provisions in this standard ([ANSI/AARST CCAH](#)), including [Section 10.1.2](#), with the following exceptions:

- Fans are permitted to be located in garages or outdoors where pipe configurations, labeling and documentation are compliant with [ANSI/AARST SGM-SF](#) (Soil Gas Mitigation Standards for Existing Homes);
- Provisions in [Section 7.9.1](#) (Passive Design Optimization) are not required;
- 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
- 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
<input type="checkbox"/>	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	
	<input type="checkbox"/> The tops and sides of the soil gas retarder(s) are sealed	
	<input type="checkbox"/> Penetrations through the membrane(s) are sealed	
	Sub-Slab Depressurization	
	<input type="checkbox"/> Penetrations through the slab(s) are sealed	
	<input type="checkbox"/> Block-outs or openings cast or constructed in the concrete slab, such as for under plumbing fixtures, are sealed	
	<input type="checkbox"/> Accessible floor to wall joints are sealed	
	General	
	<input type="checkbox"/> Sumps are closed with a rigid lid and the lid is sealed	
	<input type="checkbox"/> Openings and penetrations in hollow block masonry walls are sealed	
<input type="checkbox"/>	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	
<input type="checkbox"/>	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	
<input type="checkbox"/>	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 inlets to exhaust piping where 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.

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 standard⁷. 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), the National Radon Safety Board (NRSB), or equivalent programs that also meet requirements of a), b) and c) of this **Annex B** meet the requirements of this standard. Note that identification of existing certification bodies is not an endorsement of their programs. The purpose of requirements in this **Normative Annex B** is to ensure contractors have an appropriate degree of technical, engineering, and scientific knowledge to protect occupants by successfully reducing hazards associated with *radon gas*, chemical vapors or other soil gases that are present in indoor air.

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/m³), unit of measurement— A unit of measurement for the amount of radioactivity in one cubic meter of air. CONVERSION: $1.0 \text{ Bq/m}^3 = 0.027 \text{ pCi/L}$.
- 2.14 cubic feet per minute (cfm), unit of measurement— A measure of the flow rate of a fluid, such as air. CONVERSION: $1.0 \text{ cfm} = 1.7 \text{ m}^3/\text{hr}$.
- 2.15 cubic meters per hour (m³/hr), unit of measurement— A measure of the flow rate of a fluid, such as air. CONVERSION: $1.0 \text{ m}^3/\text{hr} = 0.6 \text{ cfm}$.
- 2.31 Inches of water column (in. WC), unit of measurement— A measure of pressure. CONVERSION: $1 \text{ in. WC} = 249 \text{ Pascals}$.
- 2.37 mil, unit of measurement— $1 \text{ mil} = 1/1000 \text{ of an inch} = 0.0254 \text{ millimeters}$.
- 2.43 pascal (Pa), unit of measurement— A measure of pressure. CONVERSION: $1 \text{ Pa} = 0.004 \text{ Inches of Water (in. WC)}$.
- 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: $1.0 \text{ pCi/L} = 37 \text{ Bq/m}^3$.

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NCSG (New Construction—Soil Gas Committee)

Consensus Body Members 2021-2024

Chair: Bill Angell (MN)		Assistance Team: Gary Hodgden (KS)
Stakeholder Group	Delegate	Affiliation
(Educators)	Chad Robinson (KS)	Midwest University Radon Consortium (MURC)
(Regulated States Rn)	Josh Kerber (MN)	Minnesota Department of Health
(Regulated States VI)	Jennifer Borski (WI)	Wisconsin Dept. of Natural Resources
(Federal EPA Rn)	Tommy Bowles (DC)	U.S. Environmental Protection Agency (EPA)
(Federal EPA VI)	Alana Lee (CA)	U.S. Environmental Protection Agency (EPA)
(Federal HUD)	John Schneider (IL)	HUD Office of Healthy Homes
(Public Health NGO)	Kevin Stewart (PA)	American Lung Association
(Public Health NGO) (alt)	Jonathan Wilson (MD)	National Center for Healthy Housing
(Rn Measurement Prof.)	David Metzger (OH)	Professional Service Provider
(Radon Mitigation Prof.)	Leo Moorman (CO)	Professional Service Provider
(VI Mitigation Prof.)	Rachel Saari (MI)	Professional Service Provider
(Construction Installers)	Tony McDonald (OH)	Professional Service Provider
(Building Remodelers)	Duane West (OR)	Professional Service Provider
(Quality Control)	Chris Heckle (KY)	Professional Service Provider
(Design Professionals)	Keith Hoylman (KY)	Professional Service Provider
(Design Professionals) (alt)	Ted Waldron (VA)	Professional Service Provider
(Home Builders)	Dan Buuk (DC)	National Association of Home Builders
(Home Builders) (alt)	Gary Ehrlich (DC)	National Association of Home Builders
(Commercial Builders)	Naomi Marx (MN)	Professional Service Provider
(Commercial Builders) (alt)	Mark Quimby (MI)	Professional Service Provider
(Passive Products) (alt)	Tom Marks (NC)	Stego Industries
(Fan Products)	Dave Kapturowski (MA)	Spruce Environmental
<i>Prior to 2024:</i>		
(VI Measurement Prof.)	Chris Bonniwell (OH)	Professional Service Provider

CCAH/RRNC — Consensus Body 2017-2020

Non-voting Chair:	Dave Kapturowski	PA
Non-voting Assist Team:	Gary Hodgden	KS
Stakeholder Group	Delegate	
Educators	Bill Angell	MN
Educators Alternate	Chad Robinson	KS
Non-regulated States	Chrys Kelly	CO
Federal EPA	Jani Stolarova	DC
Federal EPA Alternate	Nick Hurst	DC
Federal HUD	John Schneider	IL
Proficiency Program	Bruce Snead	KS
Proficiency Program Alternate	Kyle Hoylman	KY
Public Health NGO (ALA)	Kevin Stewart	PA

Acknowledgments

Mitigation prof.	Dan West	OH
Mitigation prof. Alternate	Tom Thies	NM
Measurement prof.	Matt Koch	AL
Measurement prof. Alternate	David Metzger	OH
Code Officials	Gregg Gress	IL
Home Builders	Steve Tucker	OR
NAHB Association	Dan Buuck	DC
NAHB Alternate	Gary Ehrlich	DC
Architects	Ted Waldron	VA
Architects Alternate	Tim Pitman	SC
System Designer	Keith Hoylman	KY
Scientist	David Wilson	TN

CCAH — Consensus Body 2009-2013

Non-voting Chair:	Dave Kapturowski	MA
Non-voting Assist Team:	Gary Hodgden	KS
<u>Stakeholder Group</u>	<u>Delegate</u>	
Educators	Bill Angell	MN
Educators <i>Alternate</i>	Jack Hughes	GA
Non-regulated States	Josh Miller	MN
Regulated States	Matt Shields	PA
Regulated States <i>Alternate</i>	Patrick Daniels	IL
Federal	Phil Jalbert (EPA)	DC
Federal <i>Alternate</i>	David Wilson (DOE)	TN
Proficiency Program	Bruce Snead	KS
Proficiency Program <i>Alternate</i>	Shawn Price	NC
Public Health NGO	Kevin Stewart (ALA)	PA
Public Health NGO <i>Alternate</i>	Bill Field (UIOWA)	IA
Consumer Advocates	Jane Malone (NCHH)	MD
Mitigation prof.	Dan West	OH
Mitigation prof. <i>Alternate</i>	Tom Thies	NM
Measurement prof.	Julie Somis	MD
Measurement prof. <i>Alternate</i>	Tom Getchman	MO
Home inspectors	Kurt Saloman	UT
Home inspectors	John Cundiff	OH
Code Officials	Gregg Gress (ICC)	IL
Code Officials <i>Alternate</i>	Matt Koch	IL
Home Builders	Andrew E Harris	CO
Home Builders <i>Alternate</i>	Steve Tucker	OR
Architects	Jacques Sirvain	MD
Architects <i>Alternate</i>	Tim Pitman	SC