Public Review of Proposed 2025 Revisions to AARST CC-1000

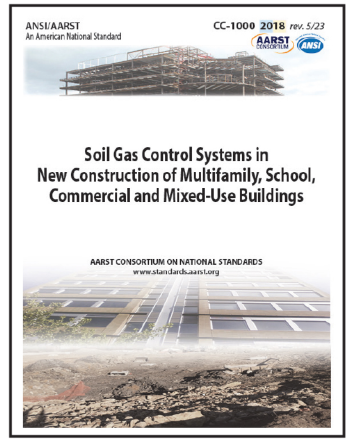
Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings

This a lengthy redline/cross-through version of the many changes for comparing with the current CC-1000 2023 publication. A clean-read version is available.

The provisions in this standard provide prescriptive minimum requirements for the construction of buildings intended for human occupancy in order to reduce occupant exposure to *radon* and other *hazardous soil gases*.

A substantial number of proposed revisions since 2023 include updates and harmonization with recent work on ANSI/AARST CCAH *(Soil Gas Control in New Construction of 1 & 2 Family Dwellings and Townhouses).*

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



Public Review: CC-1000 Revisions 7-2025

COMMENT DEADLINE: **September 1, 2025**

Introduction to CC1000 proposed changes for 2025

Proposed revisions to AARST CC1000 attached represent top-to-bottom review with revisions to CC-1000 in 2023 which was the 2nd revision since first published in 2018.

Proposed revisions for 2025 also include harmonization efforts with a wholly revised AARST CCAH 202x currently out for public review *(Soil Gas Control in New Construction of One & Two Family Dwellings and Townhouses)*.

Significant changes relative to harmonization include:

1. The order of content shifts in places to follow the timeline of actual events in the field.
2. The events relative to aggregates, soil gas pipe inlets and other components of the soil gas collection systems are integrated together rather than left broken out as simply specifications in disjointed sections.
3. Attempts were made in various sections to simplify text. In other sections however, text is expanded to further elaborate on topics, for example, additional terms/definitions and a conversion of a highly condensed table of details into a more definitive OM&M text.

REQUESTED PROCESS AND FORM FOR FORMAL PUBLIC REVIEW COMMENTS

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

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

2) If a new provision is proposed, text of the proposed provision must be submitted in writing. If modification

of a provision is proposed, the proposed text must be submitted utilizing the strikeout/underline format.

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

REQUESTED FORMAT

Public Reviewed Item and Its Date: CC-1000 Revisions 7-2025

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

Repeat the four bullet items above for each comment.

Intellectual rights

AARST Consortium on National Standards

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The Consortium Consensus Process

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

Continuous Maintenance

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

User Tools: User tools are posted online (www.standards.aarst.org/public-review) as they become available (such as templates for field notices, inspection forms, interpretations and approved addenda updates across time).

Notices

Notice of right to appeal: All directly and materially interested parties who have been, or will be, adversely affected by a decision made by a Standards Development Committee (SDC) or the Consortium Executive Stakeholder Committee (ESC) in the implementation of AARST Consortium on National Standards procedures have the right to appeal. Such policies and procedures can be found at www.standards.aarst.org/public-review.

CC-1000

Soil Gas Control Systems in New Construction of Multifamily, School, Commercial and Mixed-Use Buildings

SECTION 1: SCOPE

1.1 General

The provisions in this standard provide prescriptive minimum requirements for the construction of any building intended for human occupancy, except for 1 and 2 family dwellings[4,5] in order to reduce occupant exposure to *radon* and other *hazardous soil gases*.

This standard and informational supplements address construction of buildings that include, among others, the use of a building or structure, or a portion thereof for multifamily or congregate residential occupancies, educational occupancies, and commercial occupancies. This standard also applies when additions to such buildings include new foundations or outside walls that will be in contact with soil.

1.2 Significance of Use

Requirements vary depending upon the structure with focus on reliable capacity for reducing soil gas entry into buildings. The provisions optimize the chances of passive benefits while optimizing energy conservation when operating fans where *active soil depressurization* (ASD) is desired or found needed.

~~This standard of practice stipulates requirements to:~~

~~a) ensure buildings are capable of mitigating soil gas entry;~~

~~b) provide a means for qualified personnel to inspect and evaluate installed mitigation systems; and~~

~~c) provide responsible practices that can be recommended or adopted for use as requirements of a contract or local jurisdiction.~~

~~1.3 Applicability~~

~~This standard can be adopted as requirements for contractual relationships or as recommendations or requirements of an authority or jurisdiction.~~

1.3 Limitations

1.3.1 *1- and 2-family dwellings and townhouses*

While this standard expands into technological specifics associated with any *radon* or other soil gas resistant construction effort, simpler design requirements for dwellings are provided in ANSI/AARST CCAH *(Soil Gas Control in New Construction of 1 & 2 Family Dwellings and Townhouses)*.

~~While this standard expands into technological specifics associated with any *radon* resistant construction effort, more simplistic minimum requirements for dwellings with a footprint of less than 2,500 square feet are provided in other standards[5].~~

~~1.3.2 *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.~~

4 As point of reference, see (as published by the International Code Council) the International Building Code (IBC) for occupancy groups A, B, E. F, H, I, M and R unless regulated by the International Residential Code (IRC).

5 For 1 & 2 Family Dwellings, see ANSI/AARST CCAH "Reducing Radon in New Construction of 1 & 2 Family Dwellings and Townhouses"

1.3.2 *Mitigation methods*

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

1.3.3 *Passive qualities for reducing soil gas entry*

Informative—Building designs intended to optimize passive benefits can require more soil gas vent systems than the minimum requirements herein. ~~In 1994, EPA recommended to rough-in active soil depressurization (ASD) systems during construction of schools and large buildings but did not recommend using passive systems.~~ The U.S. Environmental Protection Agency (EPA) had studied a wide assortment of schools and large buildings by 1992. As a result, it did not recommend relying on passive systems. [6] ASD systems have proven to be a cost-effective and reliable method to reduce the intrusion of radon and harmful soil gases into buildings.

Options for improving system effectiveness that may appeal to some designers and those interested in *zero net energy* construction can include efforts to:

a. Confine gas-permeable aggregates to only soils that immediately adjoin the building foundation, as described in **Section 4.1.1.1**;
b. Ensure that highly permeable materials are within the gas-permeable layer;
c. Enhance soil gas inlet capacity, compared to **Section 5.3**;
d. Enhance thermal optimization, described in **Section 8.9**; and
e. Ensure that building ventilation systems do not create unnecessary negative air pressure in areas that contact the ground, as outlined in **Section 10**.

1.3.4 *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 or temporary conditions.

~~1.4.5 *Hazardous soil gases other than radon*~~

~~While methods and techniques employed in this standard are applicable for most soil gases, this standard does not include all design and safety features that can be required for soil gas or vapors other than *radon*. For additional health and safety considerations when the purpose of soil gas control is chemical vapor intrusion, see ANSI/AARST SGM-SF (Soil Gas Mitigation in Existing Homes).~~

[6] "Radon Prevention in the Design and Construction of Schools and other Large Buildings" EPA/625/R-92/016

~~1.4.6 *Sources other than soil gas*~~

~~This standard does not address mitigation techniques for hazards other than soil gas, such as airborne *radon* that results from *radon* in water, building materials or other less common *radon* sources.~~

~~1.4.7 *Changes to structure*~~

~~Effectiveness witnessed as a result of specifications in this standard cannot be guaranteed or be sustainable where modifications, alterations, structural changes or additions to a building occur.~~

1.3.5 *Prior systems*

This standard shall not apply to systems installed prior to the effective date of this standard.

1.4.9 *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 limitations prior to use. For additional health and safety considerations when the purpose of soil gas control is chemical vapor intrusion, see ANSI/AARST SGM-SF (Soil Gas Mitigation in Existing Homes).

SECTION 2: TERMS AND DEFINITONS

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

2.x 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.

2.1 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.

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

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

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

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

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

2.3 branches, n—Air duct piping that routes air from only one *soil gas* *inlet* ~~or *inlet network*~~.

2.x cfm (m^3/min) — unit of measurement for cubic feet per minute (volumetric airflow rate). Using the conversion factor (0.0283168 m^3/ft^3), converts any volume flow rate from cubic feet per minute to cubic meters per minute.

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

~~2.5 collection wells, n—Pits designed as a soil gas *inlet* or to transition or join multiple *trunks* or *branches* of an *inlet trunk network*.~~

2.x 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.

2.6 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.

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

2.8 equivalent length, n—The resistance of a duct and additional resistance caused by a pipe elbow, valve, damper, orifice, bend, fitting, or other obstruction to flow, expressed in the number of feet of straight duct or pipe of the same diameter that would have the same resistance.

2.9 exhaust, n—A pipe or other piece of apparatus through which soil gases escape or are discharged.

2.10 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 widens as air moves away from the exhaust point. ~~profile grows larger as distance from the point of exhaust increases.~~

2.11 exhaust trajectory, n— The angle of the pipe or elbow at the point of exhaust.

2.12 exhaust vent piping, n—Sometimes referred to as a riser pipe, main stack or vent pipe, these air duct *trunk* or *branch* pipes transfer air between soil gas *inlets* or *inlet* networks within the *soil gas collection plenum* and the outdoor air exhaust location ~~above the roof~~.

2.13 gas permeable layer, n—Void space or ~~permeable~~ aggregate that allows ~~*hydraulic conductivity* for~~ soil gas to move ~~movement into and~~ across a *soil gas collection plenum*.

2.x 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.x gravel, n—A term commonly used to refer to coarser *aggregates*, as defined in Section 2.2. Technically however, the term gravel is used to describe *aggregates* of naturally occurring fragmented stones and pebbles with water worn edges, such as found in riverbeds.

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

~~2.15 hydraulic conductivity, n—The capacity of liquids or gas to pass through permeable materials.~~

~~2.16 inlets, n—See Soil Gas Inlets.~~

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

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

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

2.19 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 "main stack" or "riser pipe."

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

2.x 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.x operable openings, n— The actively operable or constantly open portion of windows, skylights, doors and other ventilation openings that let outdoor air into structures. Portions of a window specifically designed to temporarily open for cleaning are not considered *readily* operable for increasing ventilation with outdoor air.

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

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

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

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

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

2.x post-tension (monolithic) slabs, n—Post-tension concrete slabs are used to create a monolithic (single pour) slab that is stronger than a traditional slab without reinforcement. This is achieved by laying out high-strength steel cables in a crisscrossed grid pattern throughout the foundation prior to pouring the concrete.

2.22 primary trunks, n—*Main trunks* that directly adjoin an ASD fan.

2.23 qualified mitigation professional, n—As determined by jurisdictions having authority who evaluate individuals for specific technical knowledge and skills relative to mitigation of radon or vapor intrusion soil gas hazards, or as defined in Section 13.1.

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

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

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

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

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

2.29 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.

2.30 soil gas retarder, n—Pliable plastic sheeting that establishes a barrier between soil gas and enclosed spaces within a building. Commonly referred to as "vapor barrier."

2.31 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~~.

2.32 subbase, n—A layer of gravel on top of the subgrade.

2.33 subgrade, n—Native soil (or improved soil).

2.x 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.x 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.x 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 exterior or unconditioned space.

~~2.34 system, n—See Soil Gas Vent System~~

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

2.x units, n— Dwellings or non-residential areas.

2.36 vent piping, n—See *exhaust vent piping*

2.x 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: ~~REQUIREMENT SUMMARY~~ DESIGN

3.1 ~~General~~ Building Design

Soil gas control shall be designed and constructed for all portions of foundation systems where there is enclosed space immediately above *crawl spaces* and slab-on-grade or basement slabs. The design and subsequent inspections of work in progress shall be conducted in coordination with an individual who is trained and qualified for design of systems that comply with this standard.

3.1.1 Soil Gas Vent Systems Required

Soil gas vent systems shall be constructed for each ground contact portion of the building. Each soil gas vent system shall include exhaust piping extended from *inlets* within *soil gas collection plenum(s)* to an exhaust location ~~at the roof, in accordance with Sections 4 through 9 and 11~~. as required in this standard.

Exception: Garages attached to a foundation system do not require soil gas vent systems if compliant with ANSI/ASHRAE 62.1, Sections 6.7 and 6.8 for ventilation and pressurization of enclosed spaces surrounding the garage.

3.1.2 *Required Capacity*

Each system shall be sized with no less the capacity needed to allow a fan-driven soil gas depressurization system (ASD) to transport air volumes sufficient to establish a vacuum under each slab or soil gas retarder.

~~3.3 Air Pressure Within the Building~~

~~Building design shall include a review of air pressure relationships expected to result from individual HVAC systems and building features that can naturally induce negative air pressures (e.g., building height, elevator shafts and stairwells). Corrections shall be made, as needed, to control the influences of building air pressure on soil gas entry in accordance with Section 10.~~

~~3.4 Materials and Specifications~~

~~All materials specified for piping and gas permeable aggregates that are different from materials intended for the building design shall be appropriate for similar structures including acceptable tolerances for weight distribution across aggregate and piping below the slab. A qualified structural professional shall be consulted if there are uncertainties in meeting this requirement.~~

~~3.4.1 *Changed designs*~~

~~Where changes to the mitigation design are required due to the needs of structural systems or other building systems, the changed design features shall retain system capacity required in Section 3.2.1.~~

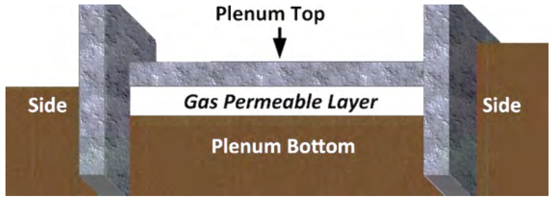
~~SECTION 4: SOIL GAS COLLECTION PLENUMS~~

3.2 ~~General~~ Soil Gas Collection Plenums

~~Each *soil gas collection plenum* shall contain a *gas permeable layer* meeting specifications stipulated in Section 5.5 and be constructed with surrounding surfaces that sustainably restrict airflow between the *gas permeable layer* and spaces outside the enclosing surfaces of the *soil gas collection plenum*.~~

Each *soil gas collection plenum* shall be constructed with surrounding surfaces that sustainably restrict airflow between the *gas-permeable layer* and spaces outside the enclosing surfaces in accordance with **Section 4.** Each *soil gas collection* plenum shall contain a *gas-permeable layer* meeting materials and design specifications stipulated in **Section 5.**

Figure 4.1 Example construction of plenum



~~4.1.1 *Plenum bottom (e.g., subbase or subgrade)*~~

~~The bottom of each plenum shall be constructed to achieve natural closure by way of earthen materials or geosynthetic methods in accordance with Section 5.1.~~

~~4.1.2 *Plenum sides (e.g., foundation walls)*~~

~~Openings in the surrounding sides of each plenum shall be closed in accordance with Section 5.2.~~

~~4.1.3 *Plenum top (surface facing interior spaces)*~~

~~The top of each plenum shall be closed as specified in Section 6 to result in a continuous closed barrier between soil gas and airspaces within the building. Concrete floors that form the plenum top shall be sealed in accordance with Section 6.2. Soil gas retarder membranes over earth that form the plenum top where building design does not include concrete floors shall be installed in accordance with Section 6.3.~~

4.2.1 Plenum Size Calculations

The size of each individual plenum shall first be calculated from the inside perimeter dimensions of the surrounding foundation walls.

3.2.1.1 *Divisions*

Utility piping, ductwork, thickened slabs, grade beams or other obstructions that restricts airflow across a *gas permeable layer* shall be deemed the edge boundary of a plenum and thereby divide the gas permeable expanse into two or more individual plenums.

3.2 1.2 *Foundation drain systems*

Exterior foundation drain systems that connect to *soil gas collection plenums* under the building shall be calculated for size based on the area of wall and foundation surfaces that adjoin permeable materials constructed to enhance groundwater drainage. Portions of exterior foundation wall surfaces not required to be included in calculations are where walls adjoin soils that, due to low permeability, impede the volumetric flow of soil gas and water.

3.3 ~~Soil Gas~~ Vent Systems per Plenum Size

An independent soil gas vent system with an exhaust pipe extended from the *soil gas collection plenum* to the roof shall be installed with exhaust pipe sizing no less than specified in Table 3.3 for each individual plenum and combined set of joined *soil gas collection plenums*.

~~Table 4.3~~	~~Plenum Size Restrictions~~	
~~Nominal inside pipe diameter~~	~~Maximum size of Soil Gas Collection Plenum(s) per duct size~~	
	~~Where compliant plenum installation is verified by inspection per Section 5.10.2~~	~~Size allowed where gas-tight plenum closure, per Section 6.3.2, is also provided~~
~~3 inch (7.6 cm)~~	~~3,500 square feet (325 m²)~~	~~4,000 square feet (372 m²)~~
~~4 inch (10.2 cm)~~	~~6,200 square feet (575 m²)~~	~~7,100 square feet (660 m²)~~
~~6 inch (15.2 cm)~~	~~14,000 square feet (1,300 m²)~~	~~16,000 square feet (1,486 m²)~~
	~~Where any plenum installation is not verified by inspection per Section 5.10.2~~	~~Penalty for non-compliant gas permeable layer per Section 5.5~~
~~3 inch (7.6 cm)~~	~~2,500 square feet (232 m²)~~	~~1250 square feet (116 m²)~~
~~4 inch (10.2 cm)~~	~~4,500 square feet (418 m²)~~	~~2250 square feet (209 m²)~~
~~6 inch (15.2 cm)~~	~~10,000 square feet (929 m²)~~	~~5,000 square feet (465 m²)~~

4.3.1

Table 3.3	Plenum Size Restrictions	
Nominal inside pipe diameter (primary trunk)	Maximum Size of Soil Gas Collection Plenum(s) per Duct Pipe Size	
	Where compliant plenum installation is verified by inspection per Section 5.6	Enhanced Where gas-tight plenum closure in Section 6.3.2 is included in the design
3 inch (75 mm)	3,500 square feet (325 m²)	4,000 square feet (372 m²)
4 inch (100 mm)	6,200 square feet (575 m²)	7,100 square feet (660 m²)
6 inch (150 mm)	14,000 square feet (1,300 m²)	16,000 square feet (1,486 m²)
8 inch (200 mm)	22,000 square feet (2,043 m²)	25,000 square feet (2,323 m²)
	Where any plenum installation is not verified by inspection per Section 5.6	Penalty Where non-compliant with Section 5 (Soil Gas Collection Design) *
3 inch (75 mm)	2,500 square feet (232 m²)	1,250 square feet (116 m²)
4 inch (100 mm)	4,500 square feet (418 m²)	2,250 square feet (209 m²)
6 inch (150 mm)	10,000 square feet (929 m²)	5,000 square feet (465 m²)
8 inch (200 mm)	15,600 square feet (1,450 m²)	7,800 square feet (725 m²)

* No design is acceptable if gas permeable aggregates do not meet requirements in **Section 5.3.**

~~*Joined soil gas vent systems*~~

~~Multiple soil gas vent systems shall be permitted to join a larger *primary trunk* exhaust pipe for connecting to a single exhaust location. *Primary trunk* exhaust piping that joins multiple soil gas vent systems shall be not less than the combined nominal cross-sectional area for inner diameters of all joined exhaust pipes.~~

~~Exception: Smaller *primary trunk* exhaust piping is permitted if supported by prorated calculations for the cross-sectional equivalencies of duct pipe sizes relative to actual size of each plenum or if supported by diagnostic evaluations in accordance with Section 7.~~

~~4.3.~~2 ~~*Equivalent sizes*~~

~~Cross-sectional equivalent for inside pipe diameter is permitted regardless if achieved by multiple vent pipes.~~

3.4 Collective Expanses

No less than 90% of any 4,500 square foot (418 m^2) slab or membrane expanse shall be vented by *soil gas inlets* that are joined to a soil gas vent system.

3.5 Joined Systems and Plenums

To comply with **Section 3.4**, joined *plenums*, joined soil *gas vent systems*, and multiple smaller vent pipes joined to a larger *trunk* are permitted. The total combined inside diameter area of vent piping shall be not less than that of the designed pipe size listed in **Table 3.3**, as shown in **Table 3.5.2**.

3.5.1 *Joined plenums*

Multiple plenums joined from below or above a slab or membrane to a single soil gas vent system shall be permitted if compliant with a), b) and c) of this Section 3.5.1.~~for plenums constructed with the same *gas permeable layer* specifications. To join multiple plenums:~~

a) The configuration of each plenum shall comply with ~~Table 5.1~~ **Section 5** (Soil Gas Collection Design) ~~(Plenum Size Restrictions)~~ regarding duct pipe sizing in relationship to the individual plenum size;

~~b) The configuration of each plenum shall comply with Sections 5.5 (Gas Permeable Layers) through 5.8.5 in relationship to the connection of *soil gas inlets* for each *gas permeable layer*; and~~

~~c) Exhaust pipe sizing in relationship to the combined size of all plenums joined to each soil gas vent system shall comply with Table 4.3.~~

b) Primary or Main Trunk pipe sizing, in relationship to the combined size of all plenums joined to each soil gas vent system shall comply with **Table 3.3** (Plenum Size Restrictions); and

c) The configuration of each joined plenum shall be nominally the same *gas-permeable layer aggregate* material as specified in options provided in Section 5 (Soil Gas Collection Design).

Exception: Alternatively, airflow valves installed where they will be accessible in the future are permitted to later adjust airflow relative to plenums with very different gas-permeable conditions.

3.5.2 ***Joined soil gas vent systems***

Multiple soil gas vent systems shall be permitted to join a larger *primary trunk* exhaust pipe for connecting to a single exhaust location. *Primary trunk* exhaust piping that joins multiple soil gas vent systems shall be not less than the combined nominal cross-sectional area for inner diameters of all joined exhaust pipes.

Table 3.5.2
Cross-sectional Area Dimensions

Nominal inside pipe diameter	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)
6-inch (150 mm)	28.3 sq. in. (183 cm^2)
8-inch (200 mm)	50.3 sq. in. (325 cm^2)

Note—Table 3.5.2 provides cross-sectional dimensions for equivalent duct piping sizes when joining multiple smaller pipes to larger trunk piping.

3.6 Pipe Length Limits

From connections at soil gas inlets to the point of exhaust, *exhaust vent piping* design shall limit airflow resistance within duct piping to not more than nominally 1 inch water column pressure loss, as required in **Section 5.1.4**

3.7 Provision for ASD Fan

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. in accordance with **Section 8.**

3.8 HVAC Air Pressure Design

The intended mechanical ventilation systems shall be evaluated, in accordance with **Section 10**, for HVAC systems and building features that might induce excessive and unnecessary negative air pressures in ground-contact areas. No later than completion of construction, evaluations and corrections shall be made, as needed, to minimize adverse influences on soil gas entry due to building air pressures.

3.9 Materials and Specifications

All materials specified for piping and gas-permeable aggregates that are different from materials intended for the building design shall be appropriate for similar structures including acceptable tolerances for weight distribution across aggregate and piping below the slab. A qualified structural professional **shall** be consulted if there are uncertainties in meeting this requirement.

3.9.1 *Changed designs*

Where changes to the mitigation design are required due to the needs of structural systems or other building systems, the changed design features shall retain system capacity required in **Section 3.1.1**.

3.10 Quality Control

A means for retaining *jobsite logs* and inspection reports required for each building 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.

3.10.1 *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.

~~4.6 Limiting Plenum and Vent System Size~~

~~Design considerations shall include conditions that can warrant restricting the size of certain plenums. Examples include for limiting unintended transport or distribution of toxic vapors or explosive gas, or to compartmentalize active soil gas control for specific occupied locations.~~

~~4.6.1 *Lines of Evidence and Collective Expanses*~~

~~When lines of evidence indicate that the spatial distribution of a hazardous gas or *chemical of concern* may be limited to only one portion of a building, an evaluation shall be made for the appropriateness of limiting plenum sizes that are joined to each soil gas vent system (e.g., to less than 4,500 square feet [418 m²] expanses). The criteria for determining appropriate limits shall include the likely need of ASD fan control for areas where there is a known soil gas concern.~~

SECTION 4: PLENUM CONSTRUCTION

4.1 Before Installing Gas Permeable Materials

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

4.2.1 *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 this **Section 4.**

4.2 Close the Bottom of the Collection Plenum(s)

4.2.1 *Inspect subgrade soil*

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

~~The designed size of the *soil gas collection plenum* shall be restricted to locations that adjoin the building foundation. Closure that resists air movement between the *gas permeable layer* and surrounding subgrade or fill is required;~~

~~a) where highly permeable aggregates extend nominally 10 ft (3 m) below or horizontally away from the foundation;~~

~~b) where the *gas permeable layer* would be open to sizable cavities, caves, crevices, or outdoor air; and~~

~~c) where soils adjoining foundations are known to pose acute, explosive, or flammable soil gas hazards.~~

4.2.1.1 *Closure specifications*

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

a) Earthen fill aggregates with over 35% clay, silt, rock fragment fines, and sand; and

b) Soil gas retarders that meet specifications in **Section 6.3** that are installed to resist air movement while allowing groundwater drainage from the *gas permeable layer.*

~~Existing or constructed materials that surround the bottom and sides of *gas permeable layers* below and to the side shall be materials that, due to comparatively low permeability, impede the volumetric flow of soil gas into the *gas permeable layer*. Soils or aggregates containing more than 35% clay, silt, rock fragment fines and sand shall be acceptable for meeting this requirement. Where native or fill soils do not meeting this specification, other methods of closure, such as a soil gas retarder, shall be implemented. Soil gas retarders used for this purpose shall:~~

~~a) comply with material specifications in Section 6.3.1; and~~

~~b) be positioned to restrict air movement while not sealed to be impervious to groundwater migration into and out of the *gas permeable layer*.~~

4.2.2 *Grade drainage*

Grading below *gas permeable layer*s shall be level or sloped to prevent collected water from obstructing *gas permeable layers* and portions of *inlet* piping, suction pits, or *inlet trunk networks* within *soil gas collection plenums*.

4.3 Close Side Walls ~~the Sides of the Plenum~~ ~~(before installing gas permeable materials)~~

4.3.1 *Walls and footings*

Openings below grade in walls and footings that surround *soil gas collection plenums* shall be closed with appropriate cementious 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 1805 of the International Building Code.[7] The application shall include closure of all exterior cold joint seams that will be below the ground surface. ~~The methods shall be applied on exterior surfaces of walls from the top of the footing to above ground level, to include closure of all cold joint seams below grade.~~

~~5.2.3 *Gaps and seams on exterior wall surfaces*~~

~~All gaps and seams on the exterior surface of foundation wall assemblies shall be closed, sealed or damp proofed for prevention of soil gas entry to include where walls adjoin footings and attached garages, exterior parking lots, sidewalks, porches, steps, and other adjoining constructed closures over soil.~~

~~5.2.4 *Hollow masonry unit walls*~~

~~In a manner that forms a closed barrier between soil gas within the hollow masonry units and interior spaces, a course of hollow block masonry walls that is not vertically lower in elevation than the adjoining exterior grade shall be made of solid masonry units or shall be fully grouted. Closure is also required for all openings in the wall below this closed course of masonry units using methods that normally include:~~

~~a) fully grouted or solid masonry units that surround openings in the wall such as for doors, windows and under masonry ledges such as is often provided for brick veneer; and~~

~~b) fully grouted joints between blocks on both interior and exterior surfaces.~~

4.3.3 ***Hollow CMU walls***

Hollow *concrete masonry unit* (CMU) walls shall be designed and constructed as follows:

a) The first course of masonry units bearing on a footing be laid in a full mortar bedding and shall be solid units or fully grouted masonry units.

b) Where portions of CMUs will be below grade and in contact with earth, a course of CMUs that is at or partially below grade 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. The openings in CMUs surrounding 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.

4.3.3 ***Foundation walls***

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

4.4 Foundation Drain Systems

~~Requirements for soil gas vent systems shall apply to exterior foundation drain systems if an interior *soil gas collection plenum* is connected to an exterior foundation drain system.~~

[7] The International Building Code (IBC) as published by the International Code Council.

4.4.1 *Interior drain systems*

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

4.4.2 *Exterior drain systems*

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

a) Water drainage receptors

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

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

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

~~5.3.1 *Exterior drain systems*~~

~~The portions of exterior foundation drain systems that are constructed below grade with materials to enhance permeable paths for water drainage (e.g., gravel, perforated pipe, or drainage mats) shall be constructed to include:~~

~~a) Closure to restrict airflow between outside air and the drainage system's water receptors, in accordance with Section 5.3.2;~~

~~b) Closure to restrict airflow between outside air and the drainage system's disposal components in accordance with Section 5.3.3; and~~

~~c) Inclusion in design for soil gas vent systems in accordance with Sections 4.2, 4.3 (Plenum Size Restrictions) and 5.3.4.~~

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;

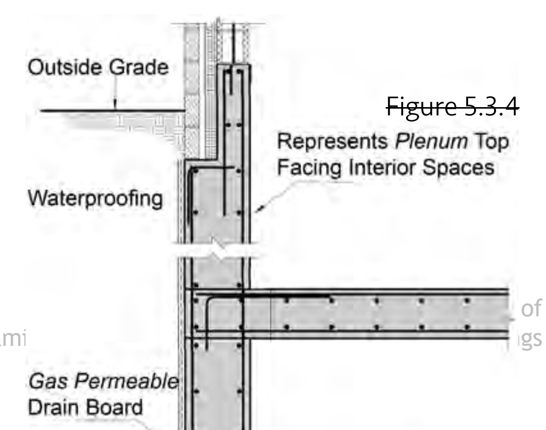
b) branch and plenum connections that are permanently sealed and affixed in place; and

c) ductwork materials that resist deterioration from the surrounding environment.

Moved and modified

5.3.2 ~~*Water receptors (ground or surface water)*~~

~~Closure shall be provided for grade-level drains and open pipes above grade such as roof or window well drains that drain into the exterior foundation drain system. Closure shall be accomplished by surrounding piping and pipe ends with aggregate or soil, capping open pipes, or using one-way flow~~



~~Figure 5.3.4~~

~~valves with access provided for future maintenance or equivalent materials or methods.~~

~~5.3.3 *Water disposal (over ground or storm sewer)*~~

~~Closure for water discharge piping that opens to outside air or connects to a storm sewer shall be provided by means of a one-way flow valve with access provided for future maintenance or an equivalent method.~~

~~5.3.4 *Foundations below the water table*~~

~~Where it is known that foundation walls and floors will frequently be below the water table for extended durations, an evaluation shall be made for the expected vertical elevation of the water table both during floods and during droughts. When the water table is expected to be above the basement floor throughout the year, plenums below the foundation are not required. If the water table is expected to recede below the foundation for extended durations, *soil gas collection plenums* with soil gas vent piping shall be constructed with attention to duct routing design and *soil gas inlets* below the slab.~~

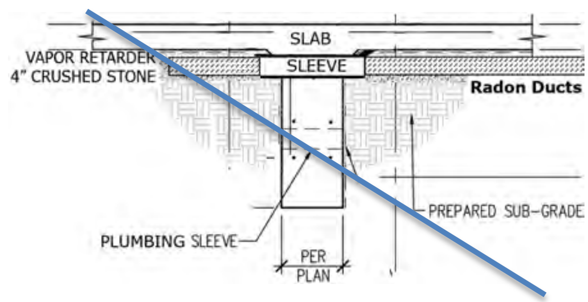
~~Note—Figure 5.3.4 is an example of foundation drain systems that form a *soil gas collection plenum* both below and to the side of foundation walls.~~

~~**5.4 Footings and Joined Plenums**~~

~~A means shall be designed and constructed to prevent obstruction from poured concrete and collected water for openings or ducts that traverse structural supports, such as footings, grade beams and thickened slab areas.~~

~~Figure 5.4~~

~~Example of traversing structural supports~~



~~5.4.1 *Footing openings*~~

~~When air transfer is constructed with an opening in the footing (e.g., under partition doorways) rather than ducted with pipe, the size of the openings shall be no less than required in Section 5.7.1 for open *inlets*. When the opening is filled with gravel, it shall be sized to accommodate the combined area for unobstructed openings between stones as required in Section 5.7.1.~~

SECTION 5: SOIL GAS COLLECTION DESIGN

5.1 Soil Gas Vent Pipe

5.1.1 *Primary - Main trunks*

Main trunk non-perforated duct piping for exhaust vent pipes and within *soil gas collection plenums* that route the entire system air volume from the *soil gas collection plenum(s)* to the system exhaust location **shall** not be smaller than required in **Table** 3.3 (Plenum Size Restrictions).

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

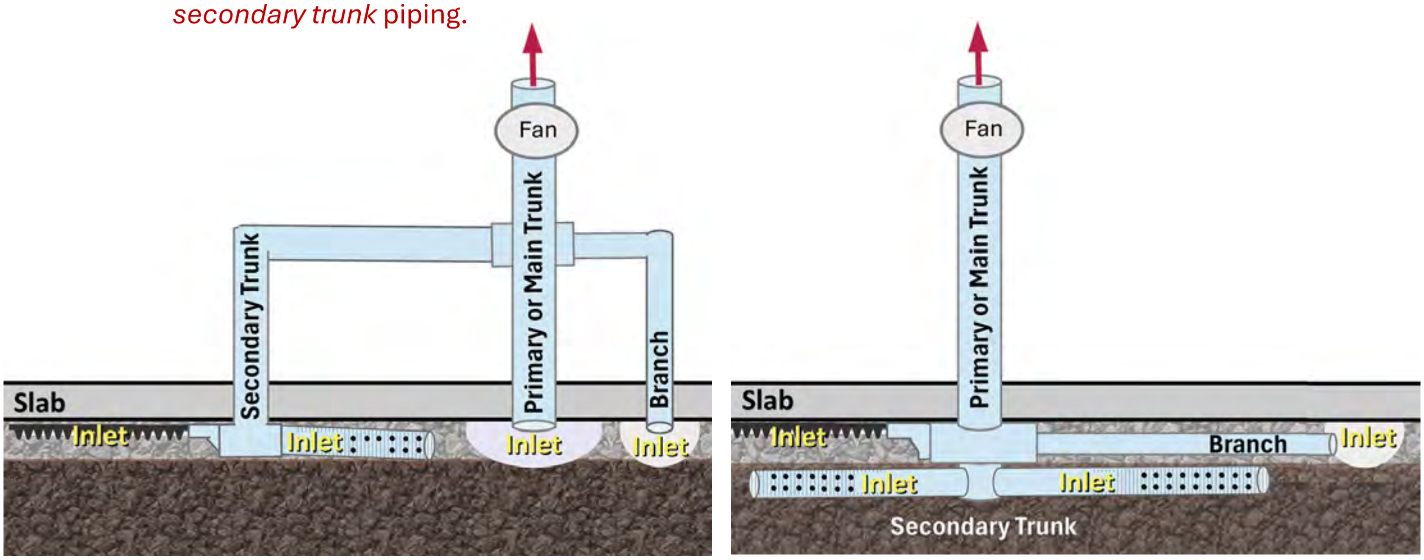
5.1.2 *Secondary trunks and branches*

Where only a portion of system air volume is routed from non-perforated *secondary trunks* or *branches* to a *main trunk, duct piping* shall not be smaller in diameter than 3-inch (7.5 cm) pipe.

Exception: Where expected to be adequate for establishing a vacuum within a smaller targeted area *or soil gas collection plenum,* 2-inch (50 mm) ID *secondary trunk* or *branch duct piping* is permitted:

a) if the targeted area is less than 800 square feet (74 m^2) in size; and

b) if the *equivalent length* is nominally less than 25 feet (7.6 m) between soil gas inlets and *main* or *secondary trunk* piping.



5.1.3 *Duct size changes*

The size of *exhaust vent piping* between the connection to *soil gas inlets* or *soil gas inlet* ducting below the top of the plenum and the point of exhaust discharge shall not be reduced in the direction of airflow toward the exhaust location.

Exception: If a portion of pipe or a fitting is larger than *trunk* or *branch* needs for compliance with **Table 3.3** (Plenum Size Restrictions).

5.1.4 *Duct airflow capacity*

The maximum *equivalent length* of non-perforated soil gas vent pipe *branches* or *trunks* from soil gas inlets to the point of exhaust or a larger *trunk* shall**:**

a) comply with **Table 5.1.4**; and

b) be further reduced by 25% for *piping* that lacks smooth inner surfaces.

Table 5.1.4	Maximum Equivalent Pipe Length
Nominal inside pipe diameter	**Main Trunk, Secondary Trunk and Branch Piping**
2 inch (50 mm)	25 feet (7.6 m)
3 inch (75 mm)	75 feet (23 m)
4 inch (100 mm)	150 feet (50 m)
6 inch (150 mm)	440 feet (146 m)

5.2 Before Installing Gas Permeable Materials

Prior to installing gas permeable layer materials, the designed components of soil gas collection ducts, soil gas inlets and the transition to above slabs or membranes, shall be installed. The gas permeable layer and soil gas inlet configurations shall comply with any option identified in **Section 5.4**.

5.3 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 *main trunk* exhaust piping shall retain the combined equivalent cross-sectional dimensions for an open airflow pathway that are nominally not less than cross-sectional area in **Table 3.5.2** *(Cross-sectional Area Dimensions)*.

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

5.3.1 *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.

5.4 Inlet Sizing, Distribution and Aggregates

The *soil gas inlet* configuration for soil gas transfer to *exhaust vent piping* shall comply with requirements in this Section 5.4, to include:

a) Compliance with applicable requirements of the chosen *gas-permeable layer* aggregate.

b) Compliance with **Section 3.7** where no less than 90% of any 4,500 square foot (418 m^2) slab or membrane expanse **shall** be vented by *soil gas inlets* that are joined to a soil gas vent pipe system.

5.4.1 *Option 1—Aggregate (Gravel)*

Where the *gas-permeable layer* is to be a 4-inch-thick layer of nominally ≥ 3/4-inch (2 cm) stones with less than 5% fines (as specified in ASTM C33 *(Standard Specification for Concrete Aggregates)* for aggregate/gravel sizes 5, 56, 57 or 6), the *soil gas inlet* configurations shall comply with designs options specified in a), b) or c) of this **Section 5.4.1**.

a) **Perforated Pipe Design**

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

1. secured to the "T" fitting with a combined length as specified in **Table 5.4.1 a**;
2. placed predominantly no closer than 12 inches (30 cm) from sides of the *soil gas collection plenum* such that it can be surrounded on the sides by gravel; and
3. configured with *soil gas inlet* openings on both sides of piping such that not less than 2/3rds of the *soil gas inlet* openings face the gravel while providing drainage openings not less than every 10 feet near the bottom of the piping.

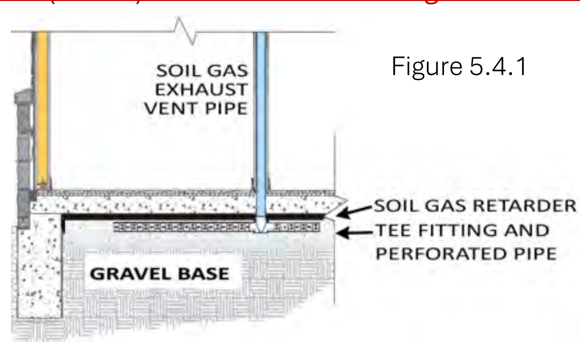
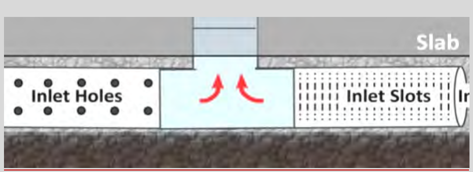


Figure 5.4.1

Table 5.4.1 a* PERFORATED PIPE LENGTH SPECIFICATIONS	Trunk or branch equivalent size	Examples of Perforation Opening Sizes per Linear Foot, Relative to Trunk or Branch Size		
		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) ID	≥ 15 ft (5 m)	≥ 8 ft (2.5 m)	≥ 5 ft (1.5 m)
	4" (100 mm) ID	≥ 27 ft (8 m)	≥ 14 ft (4 m)	≥ 9 ft (3 m)
	6" (150 mm) ID	≥ 57 ft (17 m)	≥ 28ft (9 m)	≥ 19 ft (6m)
	8" (200 mm) ID	≥ 100 ft (30m)	≥ 50ft (15 m)	≥ 33 ft (6m)
Note—Perforated pipe is commonly configured to minimum specifications of 1 sq. in. per linear foot (19 cm^2 per linear meter). However, products are available that exceed this minimum specification.				

* Additional Perforated Pipe Specifications include:

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

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b) **Geotextile Matting Design**

Geotextile matting placed in the *gas-permeable layer* shall have an airflow pathway compliant with **Section 5.2** and not less than the equivalent *soil gas inlet* opening size as specified in **Table 5.3.1 b.**

Table 5.3.1 b	Minimum Soil Gas Inlet Opening
Trunk or branch equivalent size	Equivalent Soil Gas Inlet Opening Size for Geotextile Matting
≤ 3 inch (75 mm) ID	18 sq. in. (116 cm^2) inlet opening
4 inch (100 mm) ID	32 sq. in. (206 cm^2) inlet opening
6 inch (150 mm) ID	71 sq. in. (458 cm^2) inlet opening
8 inch (200 mm) ID	127 sq. in. (819 cm^2) inlet opening

c) **Soil Gas Collection Pit Design**

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

Soil gas collection pit liners made open to the face of gravel shall provide an equivalent *soil gas inlet* opening size that is not less than specified in **Table 5.3.1 b** for geotextile matting.

Where the pit is a void within *gas-permeable layer* aggregate nominally 4 inches (10 cm) in depth, the pit diameter shall be not less than specified in **Table 5.4.1 c**.

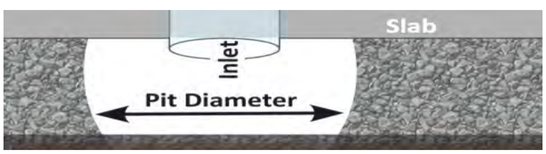


Table 5.4.1 c	**Minimum Soil Gas Inlet Opening**
Trunk or branch equivalent size	**Equivalent Soil Gas Inlet Opening Size For Pits**
≤ 3 inch (75 mm) ID	4" x 12" (100 mm x 300 mm)
4 inch (100 mm) ID	4" x 16" (100 mm x 400 mm)
6 inch (150 mm) ID	4" x 24" (100 mm x 600 mm)
8 inch (200 mm) ID	4" x 32" (100 mm x 800 mm)

5.4.2 *Option 2—Void airspace*

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

a) *Soil gas inlet* openings no closer than 12 inches (30 cm) away from the sides of the plenum; and

b) For the air gap between soil and *soil gas retarders*, perforated pipe not less than 10 feet (3 m) in length meeting specifications in **Table 5.3.1** or equivalent sized unobstructed *soil gas* inlet.

5.4.3 *Option 3—Smaller aggregate (gravel)*

Where less permeable aggregates defined in ASTM C33 for aggregate/gravel sizes 67, 7 and 8 are chosen, the *soil gas inlet* sizes shall either be doubled those required in Section 5.3.1 or configured as required in Section 5.3.4.

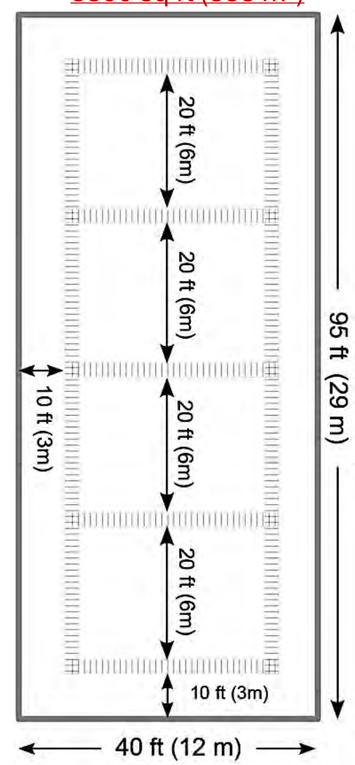
5.4.4 *Option 4—Small gravel, sand, or soil*

Where the *gas-permeable layer* is to be aggregate sands defined in ASTM C33 for aggregate sizes 8.9, 9, or soils described in **Table 5.4.4** , *soil gas inlet trunk networks* consisting of perforated pipe or geotextile matting are required within the *gas-permeable layer*. These *inlet trunk networks* for small gravel, sand, or soil described in **Table 5.4.4** shall be:

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

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

Table 5.4.4 Gas-Permeable Materials and Soil Gas Inlet Trunk Networks

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

* Sands and soils not permitted for use as a *gas-permeable layer* can alternatively be determined by a *percolation test* that indicates a percolation rate slower than about 1 minute per inch.

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

~~5.5 Gas Permeable Layers~~

~~5.5.1 *General*~~

~~A *gas permeable layer* shall be provided under the top of each plenum (e.g., concrete slab or vapor barrier) often described as the location for *base course* aggregate.~~

~~5.5.2 *Gas permeable layer configurations*~~

~~Each *gas permeable layer* shall consist of aggregate or void space that allows *hydraulic conductivity* for air movement across the *gas permeable layer*. To ensure sufficient *hydraulic conductivity*, the *gas permeable layer* configuration shall be one of the following:~~

a) ~~A uniform layer not less than 4 inches (10 cm) in depth of gravel or crushed stone that meets ASTM C33 requirements for size numbers 5, 56, 57 or 6.~~

~~Informative note—These aggregates contain a high percentage of nominally 3/4-inch (19mm) stone with less than 5% fines; or~~

b) ~~A void space that allows unabated air movement across the entire *soil gas collection plenum* such as under plastic membranes placed over open soil in *crawl spaces* or engineered voids under concrete; or~~

c) ~~Sand, fine gravel and soils if permitted and with systems configured in accordance with Section 5.5.3.~~

~~5.5.3 *Sand, fine gravel and soils*~~

~~Materials as specified in Table 5.5.3 shall be permitted when all of the following design features are provided:~~

a) ~~A uniform layer of the aggregate not less than 4 inches (10 cm) in depth is provided or exists;~~

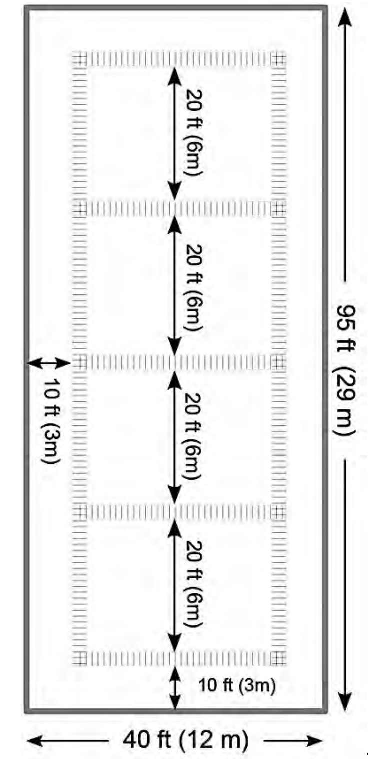
b) ~~*Main trunk*, *secondary trunk*, or *branch ducting*, such as within geotextile drainage matting or perforated pipe are placed within the *gas permeable layer* at distances no greater than 20 feet (6 m) apart. When using perforated piping, the piping shall be placed in a trench backfilled with clean aggregate meeting the criteria of Section 5.5.2a surrounding the pipe on at least 2 sides. The cross-sectional area of the aggregate and pipe soil gas collector shall be at least 50 square inches (323 cm^2);~~

c) ~~*Inlets* into the ducting are to be 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 the *soil gas collection plenum*; and~~

d) ~~The configuration or duct network shall provide no less than 1.0 in^2/ft (21 cm^2/m) of unobstructed *inlet* openings to aggregate in a continuous manner across the length of perforated pipe or face of geotextile drainage matting.~~

~~Table 5.5.3~~
~~Requirements For Alternative Gas Permeable Layers~~

~~Options~~	~~Allowed If Including Required System Design Features~~	~~Restricted Use~~	~~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.~~		
~~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 nominally 0.2 inch (4.75 mm) to 0.1 inch (2 mm) granules.~~	~~Not permitted for fine sands, silt, and clay with more than 10% of the aggregate < 0.05 inch (1 mm).~~	~~Example: 3800 sq ft (383 m^2)~~
~~Soil Option~~	~~This option shall be native soil existing at the building location with uniform characteristics for fragmental aggregate.~~	~~Not permitted when containing more than 35% of sand, rock fragment fines, clay, and silt.~~	

	~~The native soil shall consist of too little fine earth to fill interstices larger than 1 mm between stones, cobbles, gravel, and very coarse sand particles after compaction occurs.~~	~~**Not permitted when containing more than 10% high plasticity clay or silt (e.g., expansive soil with a liquid limit ≥50%)**~~	

~~**5.5.4 *Other gravel or crushed stone options***~~

~~5.5.4.1 Larger Stones~~

~~A uniform layer of gravel or crushed stone not less than 4 inches (10 cm) in depth with size numbers 1, 2, 3, 4 and 367 as classified by ASTM C33 shall be permitted as an alternative to Section 5.5.2a if confirmed to be acceptable for:~~

~~a) structural support requirements of the building or slab; and~~

~~b) sustainable integrity of adjoining soil gas retarders.~~

~~Note—These aggregates contain a high percentage of 3-inch (75 mm) stone; 2-inch (50 mm) stone; 1.5-inch (37.5 mm) stone; or 1-inch (25 mm) stones, respectively.~~

~~5.5.4.2 Smaller Stones~~

~~Gravel or crushed stone size #67 as classified by ASTM C33 shall be permitted as an alternative to Section 5.5.2a when applied as a uniform layer not less than 8 inches [20 cm] in depth and *inlet* size is doubled or augmented to achieve compliance with Section 5.7.1.~~

~~Note—This aggregate contains a high percentage of nominally 3/8-inch (10mm) stone with less than 5% fines.~~

~~**5.5.5 *Depth of gas permeable aggregates***~~

~~5.5.5.1 Exceeding Required 4-inch Depth (encouraged)~~

~~Uniform layers of gas permeable aggregates shall be permitted to exceed 4 inches (10 cm) in depth, as sometimes desired to enhance pressure field extension (PFE) or needed to prevent potential damage to concrete if supported inconsistently as a result of soil adjoining fixed height surfaces (e.g., blocks or rigid piping).~~

~~5.5.5.2 Limits on Less Than 4-inch Depths~~

~~Portions of *gas permeable layers* that are less than 4 inches (10 cm) in depth that can result from limited maneuverability of grading machinery are permitted only to the extent that the *hydraulic conductivity* for air movement across the nominal breadth of *gas permeable layer* is not reduced.~~

5.4.5 *Footings and Joined Plenums*

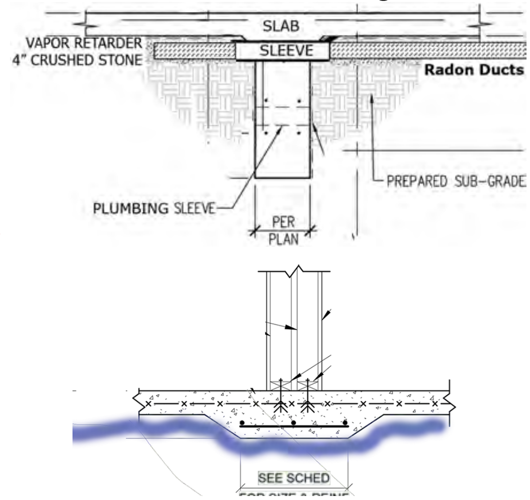
A means shall be designed and constructed to prevent obstruction of soil gas inlets and inlet trunks from poured concrete and collected water, to include inlet trunk networks that traverse structural supports.

If ground water will be naturally below or mechanically controlled to be below the lowest elevation of all *inlet trunk network* components, *geotextile matting*, perforated pipe and non-perforated pipe are permitted:

a) to be placed anywhere within the *gas permeable layer; and*

b) to follow the contour below footings, grade beams and thickened slab locations to traverse structural supports.

Figure 5.3.5



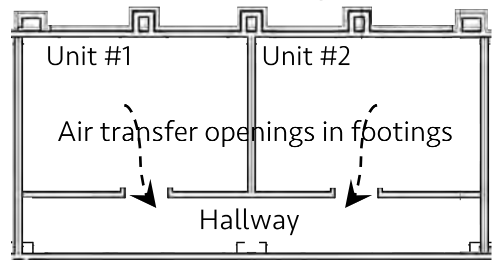
5.4.5.1 Footing Openings

Where air transfer across plenums is to be constructed with an opening in the footing rather than ducted with pipe or geotextile matting:

a) Air transfer openings in the footings shall be sized in accordance with **Table 5.3.1 b** (Minimum Soil Gas Inlet Opening) as per geotextile matting dimensions; and

b) Any aggregates filling the opening or void shall be permeable aggregates identified in **Section 5.4.1**.

Figure 5.3.5.1



5.4.6 *Foundation walls*

Soil gas collection plenum design shall be constructed vertically where both:

a) gas-permeable aggregate or a void will exist between foundation walls and adjoining soils; and

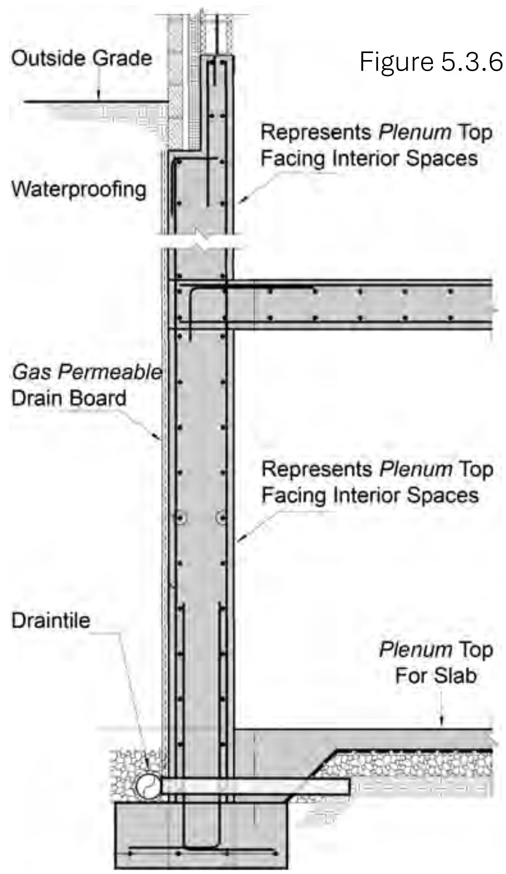
b) foundation walls in contact with ground will be more than one story of the building.

5.4.6.1 Closure of the vertical soil gas collection plenum shall comply with **Section 4** (Plenum Design) and **Section 5** (Soil Gas Collection Design) provisions **5.1** through **5.3.4**.

5.4.6.2 Foundations Below the Water Table

Where it is known that foundation walls and floors will at times be below the water table for extended durations, an evaluation shall be made for the expected vertical elevation of the water table both during floods and during droughts. Where the water table is expected to be above the basement floor throughout the year, plenums below the foundation are not required**.** If the water table is expected to recede below the foundation for extended durations, *soil gas collection plenums with soil gas inlets* connected to a soil gas vent system shall be constructed below the slab.

Figure 5.3.6



5.5 Transition ~~Connection~~ from Inlets to Exhaust Vent Piping

5.5.1 ~~*Transition*~~ ***Air volume and pressure loss***

The portion of non-perforated piping or materials configured to connect between *soil gas inlets* or *soil gas inlet trunk networks* to above the concrete slab or soil gas retarder membrane shall:

a) be sized no less than the *main trunk*, *secondary trunk,* or *branch vent* pipe above the concrete slab or *soil gas retarder* membrane;

b) maintain cross-sectional dimensions of the connected *main trunk*, *secondary trunk*, or *branch vent* pipe regardless of differing connection joint materials or shapes; and

c) be included in calculations for maximum *equivalent* pipe length stipulated in **Section 5.1.4.**

5.5.2 ***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

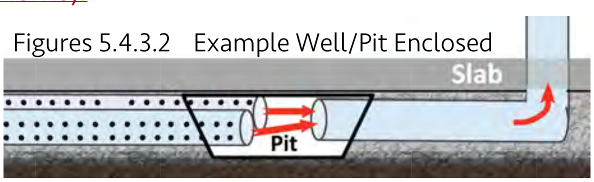
d) be temporarily capped or closed during construction to prevent debris from entering.

Alternatively, it shall be permitted to construct *soil gas collection wells* or pits compliant with Section 5.4.3 where the connection to *exhaust vent piping* occurs after slabs and membranes are installed.

5.5.3 ***Collection wells and pits***

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

Figures 5.4.3.2 Example Well/Pit Enclosed



Example Well/Pit Open to Soil Gas

5.6 Preinstalled Test Ports

Test ports compliant with **Section 7.2** shall be installed prior to placing membranes over soil and casting slabs~~. Locations and design shall comply **Section 7.2**~~ where drilling through a slab presents hazards or could compromise other building systems such as:

a) post-tension slabs with steel tendons,

b) radiant heat systems with heat conveyance components located within or under a slab); and

c) spray-applied vapor barriers and geomembranes intended to form a homogenous closure for chemical containment.

5.7 Inspect the Open Plenum

Prior to placement of concrete or soil gas retarders over a *gas-permeable layer*, an inspection shall be conducted by an individual who is trained and qualified for design of systems that comply with this standard. The inspection shall include verifying that:

a) *soil gas inlets* and ducting are secured in place;

b) any sub-slab or sub-membrane HVAC ductwork is sealed in accordance with **Section 4.5**;

c) closed surroundings of the plenum comply with this standard; and

d) *gas-permeable layer* materials installed are compatible with the *soil gas inlet* design installed.

~~**5.10 Inspection Prior to Membranes/Concrete Closure**~~

~~5.10.1 *Secure the ducting*~~

~~All subslab or submembrane fittings shall be mechanically fastened, taped or secured in a manner to help avoid dislocation that can occur during installation of aggregate, soil gas retarders and concrete.~~

~~5.10.2 *Inspect the open plenum*~~

~~An inspection shall be conducted prior to placement of concrete or soil gas retarders over a *gas permeable layer* to verify that all *inlets* and ducting are secured, and that *gas permeable layer* materials and closed surroundings are compliant with this standard. The inspection shall be conducted by an individual who is trained and qualified for design of systems that comply with this standard. The inspection shall include items listed in Exhibit A-1. A record of the inspection(s) shall be retained in accordance with Section 12 (Documentation).~~

5.7.1 ***Non-compliance***

Where plenum closure, *soil gas* 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*.

5.7.2 ***Records***

Jobsite logs and inspection reports shall be retained in records in accordance with **Section 3.10** (Quality control) as part of internal ongoing quality control of operations.

5.8 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.

5.8.1 *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 Duct Sizes**~~

~~5.6.1 *Primary and main trunk sizing*~~

~~Duct piping for exhaust vent pipes or within *soil gas collection plenums* that route the entire system air volume from the *soil gas collection plenum(s)* to the system exhaust location shall not be smaller than required in Table 4.3 (Plenum Size Restrictions).~~

~~5.6.2 *Secondary trunks and branches*~~

~~Smaller duct piping that routes only a portion of the system air volume shall be sized in accordance with Table 4.3 as applicable for each individual plenum and comply with Section 5.7 for *inlet* capacity.~~

~~5.6.3 *All air duct sizing*~~

~~All duct inner dimensions, including *secondary trunk* and *branches* that route only a portion of the system air volume, shall not be less in size than the nominal cross-sectional inside diameter of 3-inch (7.6 cm) pipe.~~

~~Exceptions: When provided for condensate control or when it is known that a fan-driven air volume less than 40 cfm (1.1 m^3/min) is adequate to establish a vacuum within a *soil gas collection plenum*.~~

~~For these situations, *branch piping* or *secondary trunks* that are not less than 2-inch (50 mm) ID are permitted in lengths to individually not exceed the *equivalent length* of 25 feet (7.6 m). Such pipes shall not be used for soil gas control with plenums that are more than 800 square feet (74 m^2) in size.~~

~~5.6.4 *Duct size changes*~~

~~The size of *exhaust vent piping* between the connection to *inlets* or *inlet* ducting below the top of the plenum and the point of discharge or termination at the roof shall not be reduced in the direction of airflow toward the exhaust location.~~

~~Exception: It shall be permitted to reduce pipe size in the direction of airflow toward the exhaust location when pipes larger than the minimum size for the *main trunk* or *secondary trunks* are employed along the pipe route for a particular purpose, such as to join larger sized *inlets*; minimize pressure loss; facilitate condensate control or to slow airflow velocity in an effort to reduce noise.~~

~~5.6.5 *Transitions*~~

~~Transition connections between different materials or shapes shall maintain cross-sectional dimensions of the connected *main trunk*, *secondary trunk*, or *branch ducting*.~~

~~5.6.6 *Airflow resistance within Inlet trunk networks*~~

~~The design and construction of *Inlet trunk networks* below a slab or membrane shall include evaluation for concerns of excessive airflow resistance at the furthest distances away from the location of the network transition to exhaust piping.~~

~~Informative note - Examples of concern include piping with *equivalent lengths* that exceed:~~

- ~~a) 75 feet (23 m) for 3-inch (7.6 cm) pipe;~~
- ~~b) 150 feet (46 m) for 4-inch (10.2 cm) pipe; and~~
- ~~c) 440 feet (134 m) for 6-inch (15.2 cm) pipe.~~

~~5.7 Soil Gas Inlets and Airflow Capacity~~

~~5.7.1 *Individual inlet minimum capacity (gravel)*~~

~~For gravel or crushed stone classified by ASTM C33 as sizes #1 through #6, the combined total area for unobstructed openings between stones that adjoin an open void within a suction pit or perforations in perforated pipe shall be not less than twice the equivalent cross-sectional diameter of the duct pipe size applicable to the size of the plenum as specified in Section 4.3 (Plenum Size Restrictions).~~

~~See Table 5.7.1 (Inlet Air Transfer Capacity - Gravel) in the CC-1000 Companion Guidance for examples and calculations for meeting *inlet* requirements.~~

~~5.7.2 *Inlets under soil gas retarders in crawl spaces*~~

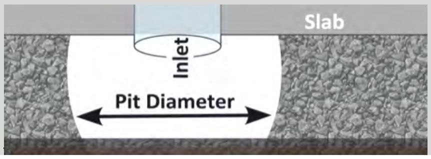
~~The configuration shall be constructed to ensure the air transfer openings extend under all portions of the soil gas retarder(s). In addition:~~

- ~~a) *Inlet* openings shall be no less than 12 inches (30 cm) away from the sides of the plenum;~~
- ~~b) The combined total area of *inlet* openings for perforations and open ends of pipe shall be not less than twice the equivalent cross-sectional diameter of the duct pipe size applicable to the size of the plenum as specified in Table 4.3 (Plenum Size Restrictions); and~~
- ~~c) At a minimum, perforated pipe, or equivalent material not less than 10 feet (3 m) in length and 3 inch (7.6 cm) nominal diameter shall be provided for each connection to *trunk* or *branch piping*.~~

~~5.7.3 *Whole system minimum inlet capacity*~~

~~The combined total area of all unobstructed *inlet* air transfer openings on the face of aggregate or soil shall be not less than twice the equivalent cross-sectional pipe diameter required in Section 4.3 (Soil gas vent systems per plenum size).~~

~~Exceptions: *Inlets* adjoining layers of sand, fine gravel and soils shall be in accordance with Section 5.5.3. Void space constructed without obstruction under concrete shall have *inlet* openings not less than the equivalent size required in Table 4.3 (Plenum Size Restrictions).~~

~~**Table 5.7.1 Examples of Minimum Inlet Air Transfer Capacity**~~				
~~**Minimum surface-face for gravel size numbers 5, 56, 57 or 6 to achieve required air transfer openings between stones.**~~		~~Common Examples~~		
				
			~~**Equivalent openings per length of perforated pipe**~~	
~~Duct pipe size~~	~~Minimum surface face of the gravel~~	~~Open face of gravel for pits with a 4" (10 cm) layer gravel.~~	~~Minimum for ASTM F705, F758, D2729, AASHTO 252:~~ ~~1.0 in^2/ft (21 cm^2/m)~~	~~Other product examples~~
~~3" (7.6 cm)~~	~~214 sq in (1,383 cm^2)~~	~~= 4" x 12" diameter pit (10 cm x 30 cm)~~	~~3" x 18 ft (5.4 m)~~	
~~4" (10.2 cm)~~	~~381 sq in (2,458 cm^2)~~	~~= 4" x 16" diameter pit (10 cm x 33 cm)~~	~~4" x 32 ft (10 m)~~	~~4" x 7 ft (2.3 m) 2.0 in^2/ft (42 cm^2/m)~~
~~6" (15.2 cm)~~	~~857 sq in (5,531 cm^2)~~	~~= 4" x 24" diameter pit (10 cm x 61 cm)~~	~~6" x 71 ft (22 m)~~	~~6" x 40 ft (12 m) 2.0 in^2/ft (42 cm^2/m)~~
Example Geotextile Mat Configuration				

~~5.7.4 *Perforated pipe—Inlet obstructions*~~

~~5.7.4.1 Perforated Pipe~~

~~Perforated pipe shall be oriented or augmented to provide unobstructed *inlet* openings to soil gas while also providing water drainage from the bottom portion of the piping. The calculation for openings to soil gas in perforated pipe as specified in Section 5.7.1 shall not include openings that are effectively closed by adjoining surfaces of soil gas retarders, concrete, or packed soil. Drainage of these air ducts shall include no less than 1/2 inch (1.3 cm) diameter opening or equivalent with multiple openings located near the bottom of piping for every 10 feet of duct pipe length.~~

~~5.7.4.2 Pipe Perforations~~

~~Pipe perforations shall not be large enough to allow gravel to enter and obstruct the duct. Where perforated pipe is placed in a layer of sand or small stone, materials or methods shall be employed to not allow sand or small stone to enter perforations and thereby obstruct the duct.~~

~~5.7.5 *Geotextile mats and woven fabric products*~~

~~5.7.5.1 Duct Opening~~

~~The void space within the mat that represents air duct piping shall comply with Section 5.6 including retention of nominally equivalent cross-sectional dimensions for *main trunk*, *secondary trunk* or *branch ducting* and transitions. *Soil gas inlet* surfaces or openings shall comply with Section 5.7.~~

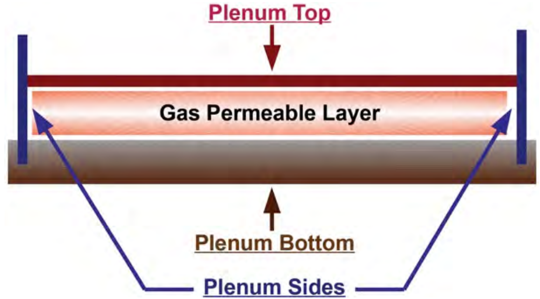
~~5.7.5.2 Woven Products~~

~~Woven geotextile products such as those intended to retain integrity for the size of the void space that represents an air duct shall not be used as a standalone *inlet*, duct, or *gas permeable layer*.~~

SECTION 6: CLOSE THE TOP OF THE PLENUM

Informative 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.

Figure 6.1



~~**6.1 General.**~~

~~A continuous sealed barrier that resists air movement between soil and indoor air is required. 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:~~

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:

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. The soil gas retarder materials and installation shall comply with Section 6.3.

6.2.2 ~~*Above the soil gas retarder*~~ *Immediately below slabs*

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

a) Where sheet foam board insulation or woven geotextile matting is installed under the concrete floor, it is permitted that the soil gas retarder be installed below the foam board insulation or woven matting; and

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

Note—Aggregate fills above the soil gas retarder can introduce a *radon* source not previously present. ~~Identification as a primary source and mitigation methods of such a source are not addressed herein.~~

~~6.2.3 *Construction joints in interior concrete floors*~~ **Moved below**

~~6.2.4 *Molded or saw-cut control joints*~~

~~In any situation where a soil gas retarder is not placed between the slab and the *gas permeable layer*, all molded or saw-cut control joints shall be sealed with caulk complying with ASTM C920 class 25 or higher or an equivalent method.~~

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 be not less than 10-mil (0.010 inch; 0.254 mm) in thickness with products that conform to ASTM E1745 Class A, B or C.

~~6.3.1 Soil gas retarder materials~~

~~Soil gas retarder materials placed below adjoining concrete slabs shall comply with specifications in a), b) or c) of this Section 6.3.1.~~

~~a) Soil gas retarder membranes that are a minimum of 10-mil (0.010 inch; 0.254 mm) in thickness with products that conform to ASTM E1745;~~

~~b) Products designed to form a permanent homogenous closure for chemical containments, such as spray-applied vapor barriers and geomembranes; or~~

~~c) As required in Section 6.3.1.1.~~

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 suitable for preventing vapor intrusion, compliant with the *AHJ* and not less than required in a) or b) of this **Section 6.3.2.**

a) Active system designs

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

b) Gas-tight designs

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

~~6.3.1.1 Vapor Intrusion~~

~~Where the purpose of the system includes vapor intrusion from known chemicals of concern (COC), compliance with a) and b) of this Section 6.3.1.1 is required.~~

~~a) An evaluation shall be made prior to installation to help ensure degradation of the soil gas retarder material will not occur over time due to exposure to chemicals known to be present.~~

~~b) Based on manufacturer testing and documentation, soil gas retarder materials installed shall be capable of retaining permeance that inhibits diffusion of the chemicals of concern through the membrane, regardless of expected potential for membrane degradation over time.~~

~~6.3.2 *Soil gas retarder installation*~~

~~The soil gas retarder installation shall 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.~~

~~Exception: Monolithic/Post-tension Foundation. Where the floors and footings are monolithic, the soil gas retarder shall extend under the footings.~~

6.3.3 ***Soil gas retarder installation***

The soil gas retarder installation shall comply with provisions in this **Section 6.3.3** and result in continuous closure that resists air movement between soil and indoor air:

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

b) at membrane seams; and

c) at membrane penetrations.

6.3.3.1 Secure the Membrane

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

6.3.3.2 Mechanically Fastened

Soil gas retarder membranes shall be mechanically fastened and sealed ~~in accordance with Section 6.3.3~~, to foundation walls or footings and at structural supports. The fastening method shall leave no outer edges of the membrane unsecured. Mechanical fastening materials shall be rated for damp and wet conditions and contact with concrete. *Termination bars* or equivalent fastening method shall secure the outer edges of the membrane:

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

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

~~b) where lines of evidence suggest that vapors from chemicals of concern (COC) or other *hazardous soil gases* could pose a health concern to building occupants.~~

Exception 1: 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.

Exception 2: Monolithic/Post-tension Foundations. Where the floors and footings are monolithic, the soil gas retarder shall be permitted to extend under designed locations for thickened slabs and footings.

6.3.3.3 Sealing Edges and Seams ~~*Membrane edges, seams, penetrations, and repairs*~~

All outer perimeter 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 with 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.

~~6.3.3.1 Edges and Seams (soil gas retarders)~~

~~All seams between adjacent membrane sheets and outer perimeters edges of the membrane shall be sealed or closed to resist air movement between soil air and indoor air, as required in a) and b) of this Section 6.3.3.1.~~

~~a) Perimeters Edges~~

~~Caulk meeting requirements of ASTM C920 class 25 or equivalent closure sealants or methods shall be applied to all outer membrane edges.~~

~~b) Seams~~

~~Seams between adjacent membrane sheets shall be 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~~

~~3. An equivalent method, such as heat welded or spray applied sealing of seams as an alternative to overlapped seams or a system that meets manufacturer design specifications.~~

6.3.3.4 Penetrations (soil gas retarders)

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

6.3.3.5 Repairs (soil gas retarders)

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

a) A tape recommended by the membrane manufacturer; or

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

c) An equivalent method.

6.4 Closure of Exposed Soil ~~*Over exposed soil*~~

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

6.4.1 *Plenum closure*

Prior to installing soil gas retarders over otherwise exposed soil, compliance with Section 4 (Plenum Construction) shall be confirmed and as needed, established for closure of surrounding foundation surfaces and any HVAC ductwork within the void that will be below the soil gas retarder.

6.4.2 *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** 6.4.2.

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.”

6.4.3 *Label the membrane*

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

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

6.5 Closure of Openings and Gaps

6.5.1 *Before framing and finishing*

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

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

6.5.1.1 Construction Joints in Interior Concrete Floors

Permanent closure shall be provided for all concrete joints to include around the perimeter of each slab and at all expansion or contraction joints. Closure shall be achieved by means of gasket materials made of closed cell polyethylene or equivalent products that retain closure of joints after concrete shrinkage. Caulk meeting ASTM C920 class 25 or higher shall be applied after concrete cures where needed to complete closure of these joints.

~~6.2.3 *Construction joints in interior concrete floors*~~

~~**Exception:** Such caulk applied to joints shall be permitted as an equivalent method where applied 28 days or more after the slab is cast, unless a qualified concrete or structural professional has verified concrete mixtures allow a shorter curing period.~~

~~6.2.4 *Molded or saw-cut control joints*~~

~~In any situation where a soil gas retarder is not placed between the slab and the *gas permeable layer*, all molded or saw-cut control joints shall be sealed with caulk complying with ASTM C920 class 25 or higher or an equivalent method.~~

6.5.1.2 *Openings and penetrations*

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

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

6.5.2 ***Below slab option***

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

6.5.2.1 ***Gas-tight option***

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

6.5.3 *Block-outs and pits*

Prior to completion of room finishings, 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~~ The lid shall be sealed with gasket material or silicone caulk and mechanically fastened in a manner to facilitate 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.

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

6.5.5 ~~One-way Flow Valves~~ ***Surface water relief***

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

6.5.6 *Floor drains/plumbing*

Floor drains and condensate drains shall not allow soil gas entry. Access openings in the floor provided for drain maintenance shall not allow soil gas entry.

~~6.2.9 *Air ducts for HVAC systems*~~

~~Air ducts located below concrete slabs or soil gas retarders shall be sealed to prevent *radon* entry and constructed in accordance with the International Mechanical Code (IMC)[8].~~

6.5.7 *Label sealed components*

A label or marking shall be provided for 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 Reduction System" or similar wording and include additional text such as "Return to a closed condition if opened, accessed or damaged."

The labels or markings shall be placed on the component and/or located in a conspicuous place or places (such as at access panels).

[8] ~~The International Mechanical Code (IMC) as published by the International Code Council.~~

Close the Top of the Plenum

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, performance testing is required for the installation to qualify as a gas-tight air barrier. Performance testing where membranes are placed over open soil with no plans for casting slabs shall comply with **Section 6.6.1**. Performance testing 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 to evaluate the current extent of gas-tight closure. The procedure shall include:

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

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

6.6.2 *Slab performance test*

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

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

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

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

6.7 Untreated Areas

All gaps, openings and egress pathways in walls, floors and ceilings shall be closed, except for momentary entry and exit, to resist air movement between enclosed areas not provided with *soil gas vent systems* and other portions of the building, such as where walls that adjoin attached enclosed parking lot garages allowed in **Section 3.1.1**.

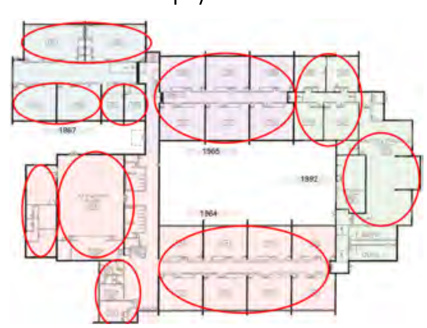
6.4 Inspect for Closure Prior to Indoor Finishings

~~Prior to completion of~~ Before indoor finishings in any ground-contact area, ~~and upper floor areas~~, an inspection shall be conducted to verify ~~compliance with this standard and ensure~~ a continuous sealed barrier exists to resist air movement between soil gas and indoor spaces within the thermal envelope of the building. ~~has been constructed between soil gas and airspaces within the building.~~ The inspection shall include all floors and walls in contact with ground. ~~the items listed in Exhibit A-2. A record of the inspection(s) shall be retained in accordance with Section 12 (Documentation).~~ The inspection shall be conducted by an individual who is trained and qualified for design of systems that comply with this standard.

SECTION 7: ~~PRESSURE FIELD EVALUATION~~ PFE PERFORMANCE TEST

7.1 Pressure Field Extension (PFE) Test

Shortly after slabs are cast, a performance test shall be conducted for the distance a vacuum can extend across each soil gas collection plenum.



This test requires connecting a fan to *exhaust vent trunks* or *branches* and measuring vacuum at points specified in Section 7.2. It shall be conducted after efforts to close openings to soil, as required in Section 6. The measurements shall be conducted and evaluated by persons who are qualified for this task.[9]

~~7.1 General~~

~~After slabs have been cast or soil gas retarders in *crawl spaces* have been installed, an evaluation of air communication across newly constructed *soil gas collection plenums* shall be conducted by a *qualified mitigation professional*. This evaluation is to verify that no changes are needed for the design of exhaust vent pipe assemblies that will soon be constructed. The evaluation shall include connecting a fan to the *primary trunk* of the exhaust vent pipe and measuring the resulting vacuum within the *gas permeable layer(s)* at strategic locations.~~

7.2 Pilot Test/Test Port Locations

Strategic locations of test ports shall include all of the following locations:

a) Test port locations remotely distant from the exhaust vent pipe transition to below the slab or soil gas retarder that are sufficient in number to:

   1. evaluate effectiveness of soil gas transport across the major expanse of the slab or membrane; and
   2. evaluate consistency of soil gas transport across *soil gas collection plenums* that are joined to a shared exhaust vent pipe.

b) Not less than one test port for each outer quadrant area of the building while also achieving one test port for each soil gas vent system and each *soil gas collection plenum* joined to a single soil gas vent system; and

c) For larger expanses allowed in Table 4.3 (Plenum Size Restrictions), not less than one test port for each outer quadrant area of *soil gas collection plenums* that are 8,000 sq. ft. (744 m^2) or larger while also achieving one test port for each additional 8,000 sq. ft. (744 m^2) area;

Exception: Where there are no openings or utility penetrations through the slab or soil gas retarder, test ports are not required for plenum areas that are less than 64 square feet (6 m^2), or collectively represent less than 10% of any 4,500 square foot (418 m^2) area.

7.2.1 *Preinstalled test port locations*

Where test ports are installed prior to casting slabs as required in Section 5.9, additional test port locations shall include:

a) ground contact rooms designed to be under significant negative pressure (e.g., industrial use kitchens, clean-rooms or similar); and

b) additional locations, as required, for measuring concentrations of *hazardous soil gas* or vapors.

~~7.3 The PFE Evaluation~~

~~The pressure measurements shall be recorded and compared for evidence of:~~

~~a) Poor effectiveness (i.e., unexpectedly low vacuum at all test ports associated with the same exhaust vent pipe); and~~

[9] The National Radon Proficiency Program (NRPP) and the National Radon Safety Board (NRSB) are two programs nationally recognized in the United States by the U.S. Environmental Protection Agency (EPA) that certify or list individuals who are qualified mitigation professionals trained in this task. Note—Identification of these private sector organizations is not an endorsement of either program.

b) ~~Inconsistencies (i.e., unexpected differences between vacuum at one test port compared to another test port that is associated with the same exhaust vent pipe.)~~

~~If poor effectiveness or inconsistency is indicated, a *qualified mitigation professional* shall conduct an investigation to identify unclosed openings in the *soil gas collection plenum(s)* and any changes that may be needed for number and locations of *soil gas inlets* and exhaust vent pipes.~~

7.3 The PFE Evaluation

The evaluation **shall** be conducted by connecting an *ASD fan*, shop vacuum device or other device to each *primary or main trunk* and measuring vacuum at all test ports associated with the same exhaust vent pipe. Test port vacuum measurements shall be made using a micromanometer or equivalent differential pressure gauge that is capable of reading to 1/1000-inch water column (0.25 Pa). All pressure measurements shall be recorded in jobsite logs for comparison of effectiveness.

7.3.1 *Test results*

Where less than 0.004 WC Inch (1 Pa) vacuum is witnessed at any test port when applying up to 4 Inch WC vacuum at the *primary or main trunk*, an investigation is required to include :

a) Identification of any unclosed openings in the *soil gas collection plenum(s)*;

b) The viability of stronger fans to achieve ≥ 0.004 WC Inch (1 Pa) vacuum at the test port(s); and

c) If there is a need to augment the design to increase the number or locations for *soil gas inlets* and exhaust vent pipes or systems.

Alternatively, regardless of the vacuum pressure applied at *primary or main trunk*, if not meeting benchmarks required at the test ports by the *AHJ* pressure requirements the investigation shall be conducted.

7.4 Test Port Design

Test ports required for evaluating PFE and/or soil gas concentrations are most commonly created by drilling 1/4- to 1-inch (6 mm to 2.5 cm) diameter holes through the slab with care to vacuum debris from each hole to achieve unobstructed air transfer of soil gas. The test ports shall be:

a) closed at the top during and after construction but reasonably accessible for future measurements without destructive or significant disassembly of building components or finishes;

b) installed in a safe manner so as not to present hazards to future occupants; and

c) prominently documented in as-built diagrams.

7.4.1 *Preinstalled test port design*

Each port opening above the slab shall be in an accessible location in accordance with Section 5.9 and either:

a) replicate a vertically drilled 1/4- to 1-inch (6 mm to 2.5 cm) diameter hole through the slab; or

b) connect with tubing that is 1/4- to 1-inch (6 mm to 2.5 cm) inner diameter (ID) to a remotely located port opening within the *gas permeable layer(s)*.

7.4.2 *Remote port access*

It is permitted to design and install monitoring locations within the building that are remote from the location where air and air pressures would be tested, as required in a) and b) of this **Section 7.4.2.**

a) Open ends of the port tubing within the *gas-permeable layer(s)* shall be inserted into a constructed void space in a manner that achieves an unobstructed *soil gas inlet* for air transfer that will not be compromised during construction. For example, 1/2-inch (1.3 cm) ID tubing should be inserted into a constructed void space not less than 1 pint (0.5 L) in size or into perforated pipe not less than 1 foot (30 cm) in length for equivalent air transfer capacity; and

b) Port tubing shall extend above a slab or membrane at desired locations in ~~accordance with Section 5.8.3~~ and result in being unobstructed with durable qualities associated with tubing in conduit. The tubing shall be resistant to rust degradation and if chemical contaminates are known to be in the soil, an environmental engineer shall be consulted for choosing products that are resistant to chemical degradation.

SECTION 8: SOIL GAS EXHAUST VENT PIPE

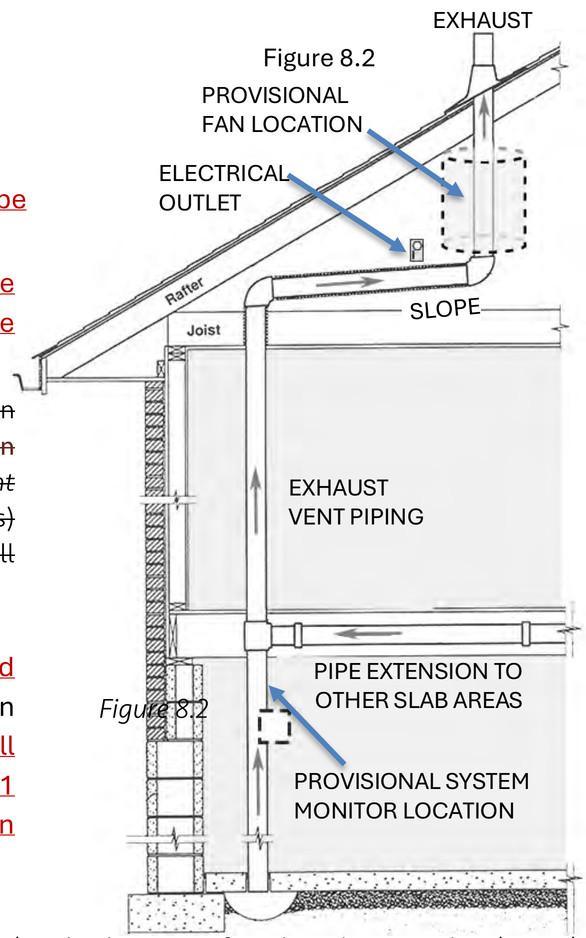
~~**8.1 General**~~

~~Exhaust vent pipes (i.e., *vent pipe*, riser pipe, *primary trunk* or *main trunk*) shall be sized and configured to comply with Sections 4.2 (Plenum Size Calculations)., 4.3 (Plenum Size Restrictions), 5.6 (Duct Sizes), and 5.8 (Transition Connection to Exhaust Vent Piping).~~

8.1 Before Pipe Route Design/Installation

Prior to installation of exhaust vent piping, the location for each potential active soil depressurization (ASD) fan and fan monitors shall be integrated into the pipe routing design. Jobsite logs shall be created and retained as part of internal ongoing quality control of operations that confirm compliance with all requirements in **Section 8.**

Figure 8.2



~~A location for each ASD fan shall be identified.~~

8.2 Provision for ASD Fan(s)

8.2.1 ***Fan location***

The predetermined location provided for *ASD fans*, shall be in attics, as portrayed in Figure 8.2.

Exception: Where *ASD fans* are to be activated during the building construction process, additional options are provided in **Section 11.4.**

~~The location designated for ASD fans shall be only outdoors, in attics or in garages that meet ventilation requirements of Section 4.8. The location for ASD fans shall only be on vertical *exhaust vent piping*. *Exhaust vent piping* from the designated ASD fan location(s) to the termination point of exhaust pipe outside the building shall not be located inside or below conditioned or occupiable space.~~

8.2.1.1 Available Space for ASD Fan

Clearance space at the location provisionally designated for *ASD fans* shall be provided. The location 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.

~~8.9.2 *Fan service access (attics)*~~

~~A space having a vertical height of not less than **48 inches** (122 cm) and a diameter of not less than 21 inches (53 cm) shall be provided where the ASD fan will be installed if required. The ASD pipe shall be centered in this space. The exhaust pipe at this location shall be labeled or marked with the words such as "radon fan location," or "soil gas fan location."~~

8.2.1.2 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.

8.2.1.3 Fan Enclosures in Conditioned Attics

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

a) sealed against air leakage with weatherstripping, caulk or equivalent products to resist air movement between the enclosure and indoor air;

b) constructed to provide access to the fan with a hatch or similar access to be mechanically fastened for maintaining closure;

c) provided with one or more ventilation openings to the outdoors that have a total net free area of not less than 25 square inches (161 cm^2); and

d) meet the requirements of the applicable building and energy codes, to include thermal insulation.

8.2.1.4 Attic Access

~~Service~~ Access shall be provided for each ~~attic~~ 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 306.3 of the International Mechanical Code [10] is provided.

8.2.2 *Electrical outlets for ASD fans*

To provide for future fan activation, a dedicated over-current device 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 (breaker) device shall provide continuous service to *ASD fans* when activated and shall not be joined to systems that could deactivate the breaker. 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.

~~8.9.4 *Electrical*~~

~~Conductors from a dedicated breaker shall be provided within 6 feet (1.8 m) of ASD fan locations to supply a boxed outlet. The boxed outlet shall be labeled or marked with the words "radon fan," "soil gas fan" or similar wording. The breaker shall provide continuous service when activated and shall not be joined to mechanical or automated systems that could deactivate the breaker.~~

~~8.9.4.2 Label the Breaker~~

~~The receptacle and the over-current device for the branch circuit that would supply the ASD fan shall be labeled or marked with the words "radon fan," "soil gas fan" or similar wording.~~

8.2.2.1 Collateral Mitigation (electrical)

When a single mitigation system is 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 units, dwellings, or areas.

8.3 Provision for System Monitors

The location(s) for system monitors shall be Identified and labeled during construction in accordance with **Section 8.2.3.5**. Monitors required in **Section 11.4** if a system is activated with an *ASD fan*, include:

1) A mechanism to indicate if the fan is operating within the established operating range, such as a manometer pressure gauge; and

2) A mechanism to actively alert occupants of fan or other mechanical failure by way of audible, visual light or telemetric notification.

8.3.1 *Ready access*

System monitors location(s) shall be provided with *ready access* to individuals responsible for system maintenance without destruction or disassembly of building components or finishes:

a) in a conspicuous location where *soil gas vent systems* are designed for only one dwelling; or

[10] As point of reference for required service access in attics, see the International Mechanical Code (IMC) Section 306.3 (as published by the International Code Council).

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.

~~a) in locations frequently visited by building staff; or~~

~~b) in locations frequently visited by occupants when an individual soil gas vent system is designed to satisfy the mitigation needs of only one unit, dwelling or area within a shared building; or~~

~~c) in locations that are accessible and visible or audible for all occupants of the building; or~~

8.3.2 ***Physical access to monitors***

Where the predetermined location(s) for system monitors is on exhaust vent piping that is to be enclosed, access panels shall be provided to allow physical access to the monitor. The access panels shall meet applicable fire-rating requirements.

8.3.3 ***Remotely located pressure monitors***

When the designated location for a fan pressure monitor does not immediately adjoin exhaust piping, rigid tubing shall be provided between the exhaust piping and the *soil gas inlet* hose of the pressure monitor.

8.3.4 ***Electrical outlets for system monitors***

Circuit conductors shall supply an electrical *outlet* labeled as to its purpose that is located within 6 feet (1.8 m) of each *system monitor* location. The over-current breaker device for the branch circuit supplying the *system monitor* location shall be independent of the *ASD fan* over-current device and labeled to indicate that it supplies the *radon or soil gas system* monitor.

8.3.5 ***Labeling system monitor locations***

The exhaust pipe at the designated location for each fan monitor 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. Electrical outlets and related components, such as access panels and exposed remote monitor tubing, shall be labeled or marked to identify as components of a *radon* or soil gas vent system.

8.4 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, pipe products specified in codes[11] as meeting "Above Ground Drainage and Vent" requirements shall be permitted.

~~8.7.2 *Alternative materials*~~

~~Alternative materials specified in codes for "Subslab Soil Exhaust Systems" shall be permitted including ABS plastic pipe and iron, steel, copper, or other materials permissible by code. Alternative pipe materials that do not meet durability specifications in ASTM D1785 for Schedule 40 shall be permitted as an alternative material for use only when within enclosed wall cavities. Support for above ground alternative duct pipe materials shall be in accordance with code[12] and manufacturer specifications.~~

8.4.1 ***Joints and transitions***

PVC plastic pipe joints shall be solvent welded in accordance with the pipe manufacturer's instructions with solvent cement conforming to ASTM D 2564, except as allowed in **Section 8.4.2** (Flexible couplings). The joint surfaces for PVC plastic pipe and fittings to be solvent welded shall be prepared with:

a) a primer conforming to ASTM F656; or

[11] As a point of reference for alternative piping support, see the International Mechanical Code (IMC) Section 305 (as published by the International Code Council).

b) a self-priming product; or

c) as otherwise stipulated in the pipe manufacturer instructions.

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

8.4.2 *Flexible couplings*

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

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

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

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

~~c) at locations allowed by code to provide temporary access to areas requiring maintenance or inspection, such as access to mechanical equipment by removal and airtight replacement of duct pipe sections; and~~

8.5 Duct Pipe Size

Exhaust vent pipes shall be sized in compliance with **Sections 5.1** (Soil Gas Vent Duct Sizing).

8.6 Slope

Exhaust vent piping shall have a slope that drains water downward toward the soil of not less than 1/8 inch per foot (3.2 mm per 30 cm). ~~Sloped sections of horizontal pipe more than nominally 15 feet (5 m) shall be avoided to the extent practicable.~~ 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.

8.7 Prevention from Air and Water Leakage

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

8.7.1 ~~*Conditioned Space*~~ ***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.

8.8 Duct 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.

8.8.1 ***Protection against physical damage***

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

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

8.8.2 ***Protect against unnecessary noise***

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

8.9 ~~Labels Required for Exhaust Vent Piping~~ 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.

~~8.10.1 *Piping*~~

~~*Exhaust vent piping* shall be labeled or marked on each floor level of the building and within each room or accessible service area that exhaust piping traverses.~~

~~8.10.2 *Label/Marking*~~

~~The label or marking shall identify that the item is a component of a *radon* or soil gas vent system.~~

~~8.10.3 *Pipe length*~~

~~The labels or marking shall be at intervals not greater than 20 feet [6 m] along the developed length of exhaust piping.~~

~~8.10.4 *Exposed and not exposed*~~

~~Label or marking locations on exhaust piping that are exposed and not enclosed behind walls shall be plainly visible to approaching service personnel.~~

8.10 ~~Pipe Routing and Thermal Optimization~~ Thermal Optimization (for passive designs)

8.10.1 *Cooler climates*

For climates zones 3 through 8 (as illustrated in **Table 12.3**) where heating conditions prevail more than 50% of the year:

a) Interior *primary or main trunk* duct pipes shall be located within the *thermal envelope* of the building and not traverse other locations, except attics, where the piping is exposed to temperatures that can be colder than indoor air; and

b) Portions of *primary or main trunk* duct pipes piping that extend through attics or other areas that are outside the *thermal envelope* of the building shall be insulated with products that have an R-value of no less than 4.

8.10.2 *Warmer climates*

For climates zones warmer than zone 3 (as illustrated in **Table 12.3**) 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. 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.

8.10.3 *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.

~~8.4.2.1 Cold Climates~~

~~Where it is likely on a regular basis (e.g., annually or every few years) that freezing temperatures will result in ice buildup within duct piping that would adversely affect long term system performance, duct piping shall be provided with insulation that is protected from the elements and has an R-value of no less than 4 or greater depending upon climate extremes.~~

~~8.4.2.2 Hot and Humid Climates~~

~~Where it is likely that condensation will occur on the exterior surface of duct piping to the extent damage would occur to adjacent building materials, duct piping shall be provided with insulation having an external vapor barrier and an R-value of not less than 1.8.~~

~~**8.6 Equivalent Length—Vent Pipe Pressure Loss**~~

~~**8.10 Labels Required for Exhaust Vent Piping**~~

~~8.10.1 *Piping*~~

~~*Exhaust vent piping* shall be labeled or marked on each floor level of the building and within each room or accessible service area that exhaust piping traverses.~~

~~8.10.2 *Label/Marking*~~

~~The label or marking shall identify that the item is a component of a *radon* or soil gas vent system.~~

~~8.10.3 *Pipe length*~~

~~The labels or marking shall be at intervals not greater than 20 feet [6 m] along the developed length of exhaust piping.~~

~~8.10.4 *Exposed and not exposed*~~

~~Label or marking locations on exhaust piping that are exposed and not enclosed behind walls shall be plainly visible to approaching service personnel.~~

SECTION 9: EXHAUST DISCHARGE CONFIGURATION

9.1 ~~General~~ Measuring distances

The *stretched-string method* shall be used to measure distances specified in Section 9.

~~9.1.1 *Measuring distances*~~

~~Distances shall be measured between the closest point of the exhaust opening to the closest point of all location requirements specified in Section 9.1 using the shortest distance, as if a string were stretched between them.~~

~~9.1.2 *Related definitions*~~ *Moved to terms and definitions*

~~Definitions a), b), c) and d) of this Section 9.1.2 shall apply to all exhaust requirements in Section 9:~~

~~a) Openings in structure — 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;~~

~~b) Operable openings — The operable or constantly open portion of windows, skylights, doors and other openings designed to readily operate for increasing 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;~~

~~c) Exhaust trajectory — The angle of the pipe or elbow at the point of exhaust.~~

~~The angle of the *exhaust trajectory* from the open end of the pipe or elbow is geometrically defined as the straight- or center-line axis that extends outward from the geometric center of the exhaust opening and is perpendicular to the plane of the exhaust opening; and~~

~~d) Exhaust spread — 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.~~

~~Note—The total directional spread of the exhaust or cone is defined in degrees by the offset-axis angle of the cone profile compared to the cone's center-line axis. Expanding outward from the point of exhaust:~~

~~An *exhaust spread* radius of 45˚ equals an *exhaust spread* diameter of 90˚.~~

~~An *exhaust spread* radius of 11˚ equals an *exhaust spread* diameter of 22˚.~~

9.2 Roof

The *point of exhaust* shall be outdoors and:

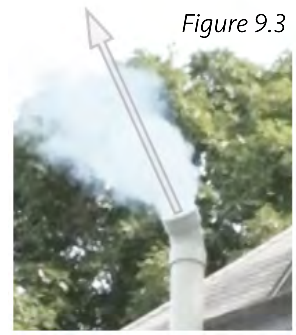
a) not less than 1 foot (30 cm) above a pitched roof at the point penetrated;

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

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

Exception: Exhausts below the roof if compliant with **Section 9.10**.

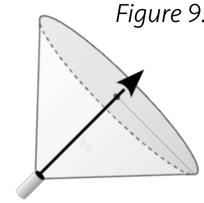
Figure 9.3



9.3 Straight-line Exhaust Trajectory (Restrictions)

The path of straight-line exhaust air within 20 feet (6 m) of the point of exhaust shall not encounter: openings in structures; building materials; or areas where people walk or gather. Straight-line exhaust air shall be assumed to spread out from the point of exhaust at an offset-axis of 11°.

Figure 9.4



9.4 Directional Exhaust Spread (Restrictions)

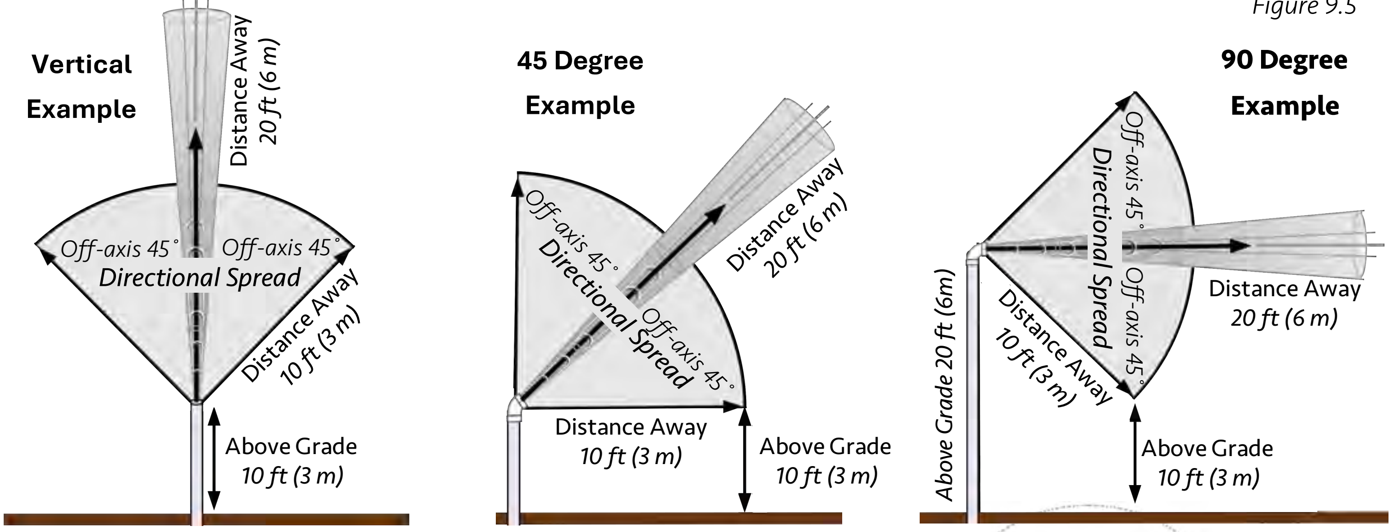
Directional *exhaust spread* within 10 feet (3 m) of the point of exhaust shall not encounter: operable openings in structures; building materials (except roofing materials); or areas where people gather or walk. Directional *exhaust spread* shall be assumed to spread out from the point of exhaust at an offset-axis angle of 45˚.

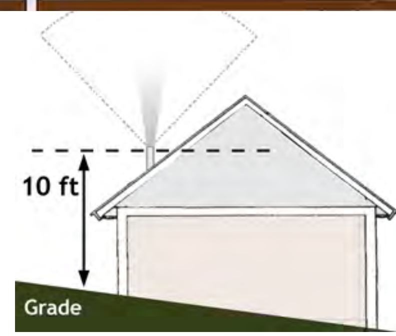
9.5 Angled Trajectories

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

Exception: 90-degree horizontal *exhaust* shall be permitted where point of exhaust is not less than 20 feet (6 m) above grade to meet requirements in **Section 9.4** (Directional spread).

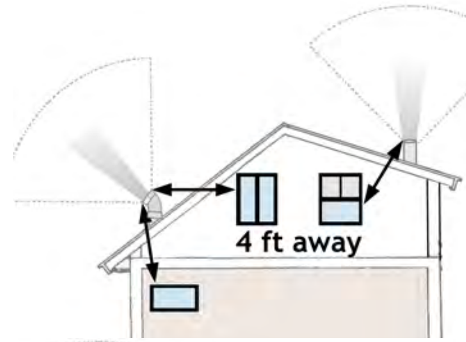
Figure 9.5





9.6 Elevation Above Grade

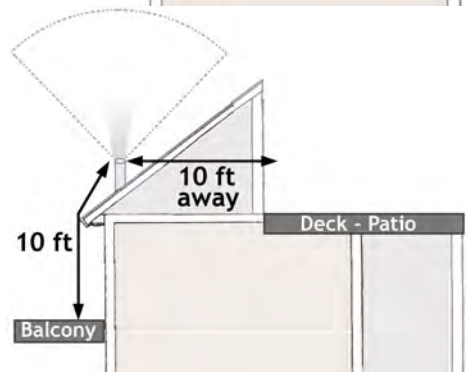
The *point of exhaust* shall be not less than 10 feet (3 m) above the nearest grade and compliant with **Sections 9.3** and **9.4**.



9.7 Separation from Operable Openings in Structures

The *point of exhaust* shall be located not less than 4 feet (120 cm) away and pointed away from *operable openings* and other ventilation openings that let outdoor air into structures. The exhaust air trajectory shall also comply with **Sections 9.3** and 9.4.

~~a) not less than 10 feet (3 m) horizontally to the side operable openings in structures; and~~



9.8 Separation from People

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

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

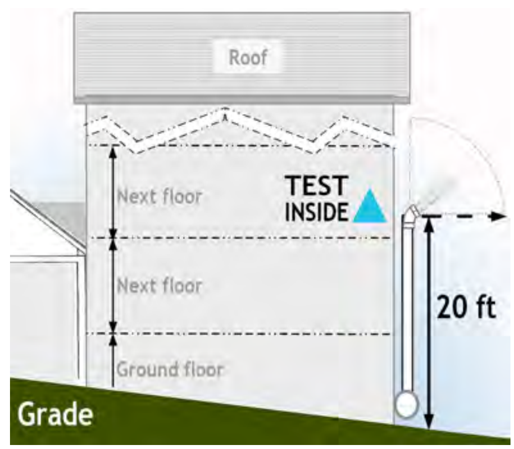
b) compliant with **Section 9.3** and **9.4**.

9.9 Equipment wells and parapet roofs

The point of exhaust relative to open equipment well airspaces or parapet roof construction, where areas are enclosed by more than two walls, shall comply with Section 9.4 *(Directional Exhaust Spread)* to include the breathing space where individuals conduct maintenance.

9.10 Below the Roof

The point of exhaust shall be permitted to be located below the edge of the roof if compliant with all requirements in **Section 9** and in a), b), and c) of this **Section 9.10**.



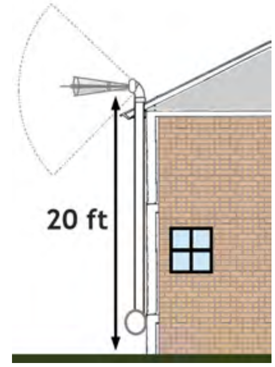
a) The reason for placing the exhaust below the roof edge shall be noted in the operations and maintenance plan. The reason shall be based on either:

1. the inability to comply with other requirements of **Section 9** if the point of exhaust were located above the roof, or
2. the edge of the roof exceeds 20 feet (6 m) above the nearest grade.

b) The point of exhaust shall be:

1. compliant with **Section 9.4** (Directional Exhaust Spread);
2. not less than 20 feet (6m) above the nearest grade; and
3. not less than 4 feet (120 cm) away and pointed away from operable openings that are above the point of exhaust.

c) If activated with an *ASD fan*, testing shall be conducted within the building where any occupiable area immediately adjoins the point of exhaust. This testing is required no later than initial post-mitigation testing and shall be recommended for all future testing.

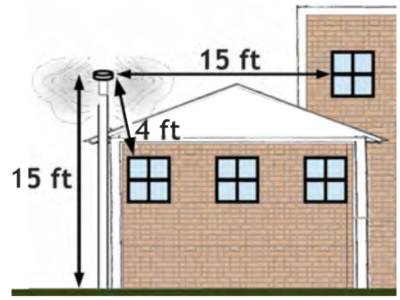


9.11 Horizontal Trajectory

9.11.1 *Horizontal discharge*

90-Degree horizontal discharges shall not be less than 20 feet (7.5 m) above the nearest grade and compliant with Section 9.3 and 9.4.

For "T" style rain caps that direct 90-degree horizontal discharge in two directions, both discharge paths shall meet these requirements.



9.11.2 *Diffused horizontal discharges*

Where allowed, the point of exhaust for diffused horizontal discharges, (such as rain caps) shall not be less than 15 feet (4.6 m) above the nearest grade. It shall also be not less than 4 feet (120 cm) above or 15 feet (4.6 m) away from operable openings in structures, such as windows, skylights and doors.

9.12 Protection from Debris

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

9.13 Protection Against Obstructed Exhaust

Obstructions in the exhaust air path, such as 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 9.

9.14 Increased Distances for Large Capacity Systems

When the ASD system is designed for larger airflow capacities with duct piping larger than 4-inch (100-mm), distances shall be increased beyond what is required in Section 9 to comply with Table 9.14.

9.2

Table 9.14	Increased Distances for Large Capacity Systems		
Pipe ID As in Section 4.3 ≤ 4" (100 mm) Pipe	**Distance Away** Directional spread As in Section 9.4 10 ft (3 m)	**Distance Away** Straight-line As in Section 9.3 20 ft (6 m)	**Distance Above, Below or To Side** Grade, Operable Openings and People compared to Sections 9.6, 9.7, 9.8, 9.9, 9.10 and 9.11
For Larger Pipe ID	Increase to	Increase to	Increase distances by another:
6" (150 mm)	12 ft (3.6 m)	25 ft (7.6 m)	2 ft (1.8 m)
8" (200 mm)	18 ft (5.5 m)	30 ft (9 m)	4 ft (2.4 m)
10" (250 mm)	20 ft (6 m)	40 ft (12 m)	6 ft (1.8 m)
For pipe larger than 10" (250 mm)	Shall be increased to meet or exceed ASHRAE 62.1, Appendix B (Separation of Exhaust Outlets and Outdoor Air Intakes)		

9.15 Inspect the **Soil Gas Exhaust Vent Pipe**

After completion, an inspection to verify that soil gas vent piping complies with **Section 8** and that the exhaust discharge configuration meets this **Section 9** shall be conducted. If not compliant, further steps shall be taken until it meets this standard.

~~Prior to completion of indoor finishings that enclose exhaust piping, an inspection shall be conducted by an individual who is trained and qualified for design of systems that comply with this standard to verify compliance for soil gas *exhaust vent piping* in accordance with Sections 8 through 9. The inspection shall include items listed in Exhibit A-3 and be retained in records in accordance with Section 12 (Documentation).~~

9.15.1 ***Reports***

This inspection report shall be kept on file as per **Section 3.10** (Quality control).

SECTION 10: HVAC EVALUATIONS REQUIRED [13]

10.1 General

The intended building design and mechanical ventilation systems shall be evaluated by a heating and cooling design specialist for natural and mechanically induced negative pressure in enclosed spaces with respect to:

a) locations below and to the side of the exterior foundation surfaces that adjoin soil and other earthen aggregates; and

b) adjoining parking garages that are not constructed with soil gas vent systems.

10.1.1 *The evaluation*

The evaluation shall include the building design and mechanical system response to changing diurnal and seasonal outdoor temperatures that alter both:

a) pressures induced by mechanical system operation; and

b) natural negative pressure commonly observed in taller buildings due to unobstructed vertical air passageways such as stairwells, elevator shafts and other thermal bypasses between floors.

10.2 Controlled Negative Pressure

The combination of HVAC design (e.g., duct balancing and air handler capacity) and compartmentalized isolation of interior airspaces shall be designed to avoid excessive negative pressure with a design goal to result in nominally neutral or positive air pressure within the enclosed spaces. Specific locations of concern include enclosed spaces that immediately adjoin *crawl spaces*, slab-on-grade or basement slabs, rooms with walls that adjoin soil and other earthen aggregates, and attached garages.

Exception: Enclosed spaces that are intentionally designed to be under negative pressure (e.g., bathrooms).

10.3 Appropriate Designs

HVAC designs for mitigating negative pressure shall be reviewed for: compliance with ASHRAE ventilation standards[14]; unnecessary energy consumption[15]; and design capabilities to accommodate degradation to the system's functionality that often occurs over time.

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[13] For general applicability of these methods and impact on other indoor air quality issues, see "Indoor Air Quality Guide – Best Practices for Design Construction and Commissioning" published by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). www.ashrae.org

[14] For further information, see ANSI/ASHRAE Standard 62.1 (Ventilation for Acceptable Indoor Air Quality) for buildings that are more than three stories tall or ANSI/ASHRAE Standard 62.2 (Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings).

[15] For further information, see ANSI/ASHRAE/ USGBC/IES 189.1, "Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings"

10.4 Controls

Controls for mechanical equipment shall be configured and verified after building construction to consistently meet design goals across normal fluctuations in diurnal and seasonal outdoor temperatures.

10.5 Label Monitors, Controls, and Startup

Control settings and fan monitors shall have a label on or in close proximity to the mechanism that describes the purpose of the control and general instructions for operation. System control settings for any mechanical equipment shall be clearly marked to indicate the settings that existed at the time design goals were achieved and verified.

10.6 Documentation of Evaluations and Actions

A written evaluation and related actions shall be provided by the heating and cooling design specialist and included in the operation, maintenance, and monitoring (OM&M) manual.

10.7 HVAC Use for Supplemental Mitigation

The design and installation of HVAC systems shall comply with ANSI/AARST SGM-MFLB (Soil Gas Mitigation in Multifamily, School, Commercial and Mixed-Use Buildings) for Non-ASD Mitigation Methods.

SECTION 11: COMPLETION OF SYSTEMS

11.1 Labeling or Marking Required for All Systems

Labels or markings shall be provided within eyesight or in conspicuous places in accordance with the sections listed in Table 11.1.

11.1.1 *Label specifications*

All labels shall be made of durable materials. 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 titles as specified within each provision identified in Table 11.1 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 11.1
Labeling or marking required for all systems

6.2.9	Sealed components
6.3.5	Crawl space membranes / access hatches
8.9.2	Designated location for ASD fans
8.9.4	Electrical conductor boxes
8.9.4.2	Electrical breakers
8.9.5.3	Designated fan monitor location
8.10	Exhaust piping
9.6 c	Roof
10.5	HVAC components used for mitigation

11.2 Primary Label

Each *soil gas vent system* shall be labeled with not less than one label at the location predetermined for the locations fan for monitors in **Section 8.2.3.1**. The primary label shall describe the system and provide the name and contact information of the party responsible for maintenance and repairs. In addition, the location shall include label content required in either **Section 8.2.3.5**, or ANSI/AARST SGM-MFLB if the system includes an *ASD fan* or other non-ASD active components.

Fig. 11.2 Example

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

~~11.4.1. *Fan monitor label*~~

~~A label shall be provided at each designated location for fan monitor(s) identified for the system in Section 8.9.5.3. The label's title shall state, "Soil Gas Vent System," "Radon Vent System" or similar description and the label shall include the following information:~~

~~a) A description of the fan monitor(s) to include:~~

- ~~How to interpret the monitor;~~
- ~~A list of actions to take if the fan monitor indicates system degradation or failure; and~~
- ~~A routine inspection advisory to check the monitor(s) at least quarterly or as otherwise specified in an operational and maintenance plan;~~

~~b) An advisory statement that the building should be tested for *radon* at least every 2 years or as required or recommended by state, local or federal agencies;~~

~~c) Additional information resources, such as *radon* resources at www.epa.gov/radon and the *radon* hotline 1-800-SOS-RADON (767-7236); and~~

~~d) The words "For information, contact: ____."~~

~~*(Insert name and phone number of the installer or designated party responsible for operation, maintenance, monitoring and management of the system(s).*~~

11.2 Systems with No Active Fan

System completion includes the documentation required in Section 12 (~~Documentation~~ OM&M Manuals).

11.4 Performance Testing

11.4.1 *Radon*

Where the purpose of the system design includes protecting against exposure to *radon* gas, the building shall be tested, postconstruction, for *radon* in accordance with ANSI/AARST MA-MFLB. Where *radon* testing indicates that the indoor *radon* concentration equals or exceeds the national action level, the system shall be activated and the building shall be retested to verify if the *radon* concentration is below the national action level. Where testing indicates mitigation goals have not been met after system activation, additional diagnostics and mitigation shall be conducted by a *qualified mitigation professional*, in accordance with ANSI/AARST SGM-MFLB.

11.4.2 *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 jurisdiction having authority, indoor air testing shall be conducted to evaluate if further action is needed. All testing shall be conducted using methods approved by the jurisdiction having authority. Where testing results do not meet mitigation goals, further action and follow-up testing shall be required until mitigation goals are met.

11.4.3 *Performance test reports*

Reports to be provided in the OM&M manual described in Section 12.~~2~~ (OM&M Manual) shall include results of evaluations that indicate effectiveness.

11.5 ~~Activation with ASD Fan~~ *Converting to ASD*

Where adding an *ASD fan* during or after construction to activate the design, the procedure shall comply with all provisions of this **Section 11.5.**

11.5.1.1 Verify Rough-in Completion

In association with activating an *ASD fan*, the *rough-in* components that are accessible without destructive or disassembly of building components or finishes shall be inspected. Conditions not conforming with the a), b), c) and d) of this **Section 11.5.1.1** 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 the point of exhaust and is sloped to drain water to the suction point(s).

11.5.1.2 ASD Systems and Fans

The resulting *ASD* system installation, to include labeling and documentation, shall comply with ANSI/AARST SGM-MFLB in addition to requirements of a), b) and c) of this **Section 11.5.1.2.**

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 a *qualified mitigation professional*.

Informative Table 11.5.1.2 **Examples of Active System Requirements**

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

11.5.1.3 Incomplete Ducting

Where, due to intentional choices or mishaps in completing pipe exhaust duct designs that can be made complaint with this standard, resulting installations, to include labeling and documentation, shall comply with **Section 11.5.1.2.**

11.4.2 ***Allowances when designing for active systems***

Where adding an *ASD fan* during or after construction to activate the design, the installation shall comply with all provisions in this standard (ANSI/AARST CC-1000), including **11.5.1.2**, with the following exceptions:

a) *ASD Fans* are permitted to be located outdoors and other locations with exhaust vent piping and exhaust discharge configurations that are compliant with ANSI/AARST SGM-MFLB *(Soil Gas Mitigation Standards for Multifamily, School, Commercial and Mixed-Use Buildings)*. Related labeling and documentation shall also comply with ANSI/AARST SGM-MFLB;

b) Provisions in **Section 8.9** (Passive Design Optimization) are not required;

c) The wire mesh or equivalent rodent/insect screen mesh required in **Section 9.12** to prevent debris or small animals from entering exhaust piping is not required if activating with ASD fans; and

d) Where the purpose of the system is for reducing occupant exposure to radon, the soil gas retarder required under all portions of slabs in **Section 6.3** 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.

~~11.4.3 *Flexible coupling connectors required*~~

~~ASD fans shall be connected to the ASD piping using flexible unshielded couplings complying with ASTM D5926 or ASTM C1173 or an equivalent method. Connections shall be air- and water-tight.~~

~~11.4.4 *Fan start-up*~~

~~ASD fans shall be electrically energized upon installation in the ASD system piping.~~

~~11.4.5 *Disconnect required*~~

~~Where the fan is not cord and plug connected, a means of electrical disconnect shall be provided for, and within eyesight of the ASD fan.~~

~~11.4.6 *ASD fan monitors required*~~

~~Each ASD system shall be provided with system monitors to monitor fan performance and notify occupants or maintenance personnel of fan failure. The system monitors shall be connected to the fan piping and located in an area where the monitor status is readily observable by the occupants or maintenance personnel. Each ASD system shall include both:~~

~~1) Negative pressure meter, such as manometer type pressure gauge; and~~

~~2) Fan failure notification by audible or visual fan alarm or remote telemetry.~~

~~11.4.6.1 Electrical Power~~

~~System monitors that require electricity for indication of fan failure shall be on non-switched circuits separate from the circuit powering the *radon* fan unless loss of power triggers the alarm. Battery operated monitors shall be equipped with a low battery-power warning feature. Electrical ASD system monitors, whether visual or audible, shall be designed to reset automatically when power is restored after power outage.~~

~~11.4.6.2 Startup marking~~

~~ASD system negative pressure monitors shall be clearly marked to indicate the pressure that existed when the system was initially activated. The monitor device shall have a durable label on or in close proximity to it that describes how to interpret the monitor and what to do if the monitor indicates that system performance has changed.~~

SECTION 12: ~~DOCUMENTATION~~ OM&M MANUALS

12.1 Stewardship Obligations

Ownership and property management shall retain/produce, implement, maintain, and update, as applicable and as determined by the qualified professional, a plan for OM&M and a written OM&M manual in accordance with **Sections 12.1** through **12.3**:

a) The OM&M plan and manual shall be produced and implemented within 90 days of ownership for radon and within 6 months of ownership for other Soil Gas Hazards;

b) The OM&M manual and all associated records shall be transferred to the new entity within 30 days whenever the party responsible for system maintenance and monitoring changes to another party who is not the owner/occupant of the property; and

c) The OM&M manual shall be stored in a format (paper, electronic, other) that the manual and all details and records are readily and equally accessible to property ownership, management, and maintenance personnel.

12.2 Essential Content for All OM&M Manuals

The OM&M manual is to provide stewardship guidance and instruction that include:

a) Statement of Stewardship Obligations included in **12.1** of this **Section 12**;

b) A general statement regarding ownership and property management stewardship obligations for assessment, re-assessment, mitigation, and development and implementation of an OM&M Plan and Manual; as well as engagement of a qualified professional regarding these obligations and OM&M content;

c) A summary of historical testing and mitigation activities. Copies of available previous reports shall be maintained with the OM&M manual;

d) Instruction to update contact information within the OM&M Manual and on system labels when there is a change in ownership or change in the party/person(s) responsible for maintaining low hazard conditions in the facility;

e) The OM&M Manual is a living document for the life of the subject facility. Protocols and records are to be updated in the OM&M Manual unless or until the potential indoor environment hazard no-longer exists; as determined by the testing consultant(s), mitigation contractor(s), and/or qualified professional.

f) Designating a person responsible for OM&M plan implementation and management;

g) Awareness requirements and procedures for employees, tenants, visitors, and contractors;

h) Employee training requirements;

i) One property-specific checklist and schedule of ownership and property management ongoing OM&M Plan action items, as extracted from **12.1** through **12.4.3** of **Section 12**;

j) Record keeping requirements; and

k) Guidance to the property owner for decommissioning soil gas mitigation system(s). Included shall be a written recommendation: “Prior to decommissioning soil gas mitigation system(s), it is recommended to engage a Certified Radon Professional to evaluate and report on indoor radon conditions and render recommendations regarding decommission (with consideration of occupant exposure to radon). Continued use and maintenance of the mitigation system(s) may be valuable for maintaining improved indoor air and protection from other soil gas hazards, such as radon gas.”

~~12.1 Operation and Maintenance Plan~~

~~A written operations and maintenance plan for the mitigation system(s) 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 in Section 12.1.1 through Section 12.1.3.~~

~~12.1.1 *A description of systems*~~

~~Documentation of installed systems shall include narrative that describes:~~

~~a) basic operating principles; and~~

b) ~~system components that are also labeled on a floor plan diagram, which may be complemented with photographic documentation.~~

~~12.1.2 *Designated responsibilities*~~

~~Documentation shall include a statement that indicates what party or parties are responsible for maintaining and monitoring the effectiveness of the mitigation system(s).~~

~~12.1.3 *Active systems (ASD and/or non-ASD)*~~

~~If active systems are installed, the plan shall include all applicable details stipulated in Table 12.1.3 and information regarding fan monitors shall be prominently displayed to include:~~

a) ~~A description of the fan monitor(s);~~

b) ~~A routine inspection advisory to check the monitor(s) at least quarterly or as otherwise specified in an operational and maintenance plan;~~

c) ~~Documented startup parameters such as pressure gauge readings that existed at the time successful mitigation was initially achieved; and~~

d) ~~A list of actions to take if the fan monitor indicates system degradation or failure.~~

~~12.2 OM&M Manual~~

~~To provide essential tools for future efforts in long-term risk management, a written operations, maintenance, and monitoring (OM&M) manual for the mitigation system(s) shall be created and distributed to appropriate parties upon completion of the project. The OM&M manual shall include all of the following components:~~

~~12.2.1 The operation and maintenance plan as required in Section 12.1.~~

~~12.2.2 *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).~~

~~12.2.3 Records of inspections, as required, for compliance verification. Examples are provided in Exhibits 1, 2 and 3.~~

~~12.2.4 Records of PFE diagnostics conducted in accordance with Section 7 and other diagnostic information.~~

~~12.2.5 A written evaluation and related actions regarding natural and mechanically induced negative pressure in enclosed spaces that adjoin soil and garages in accordance with Section 11.~~

~~12.2.6 *Any adverse conditions observed*~~

~~Documentation shall include a description of any important observations that might adversely affect the mitigation system(s) or other building systems and any deviations from this standard or state requirements.~~

~~12.2.7 *Other essential information*~~

~~Other essential information for future reference and operation or repair considerations shall be provided either in an information package that contains the OM&M plan or independently distributed, to include:~~

a) ~~Pre- and post-mitigation test data if available;~~

b) ~~Copies of contracts and warranties;~~

c) ~~Copies of building permits when required and available; and~~

d) ~~An estimate of the annual operating costs.~~

~~12.2.8 *Testing reports*~~

~~A recommendation that a copy of all testing reports for *radon* and other soil gases be kept with the OM&M manual should be included to facilitate long-term risk management and future operation and maintenance of the system(s).~~

~~**Table 12.2 OM&M Manual Required Content for active ASD and Non-ASD systems**~~ ~~(These steps can be integrated into an overall indoor air quality plan)~~		
~~Controls and Mechanical System Monitors~~	~~Maintenance Inspections of Controls and Monitors~~	~~Frequency of Inspection~~
~~Document Startup Details:~~ ~~A description shall be provided for the fan monitors, control settings and other operating parameters that existed at the time successful mitigation was initially achieved. The description should include explicit detail for comparison during inspections and repair, including:~~ ~~a) descriptions of equipment labeling and annotations for fan monitors, control settings and other operating parameters;~~ ~~b) exact locations of fan monitors, electronic telemetry/monitoring equipment, permanent test ports,, electrical disconnects and other components;~~ ~~c) instructions for equipment sufficient to interpret labels, annotations, and the designed operating parameters for the equipment. When applicable, include manufacturer instructions;~~ ~~d) a list of appropriate actions for the Client(s) to take if fan monitor devices or other inspection procedures indicate the system(s) are not operating as designed; and~~ ~~e) documented measurements for balance of airflow in and airflow out of HVAC system(s) when HVAC is a component of a mitigation system.~~	~~The operations, maintenance and monitoring (OM&M) manual provided shall note that routine inspections of controls and monitors are a minimum obligation and required component of a long term risk management plan. The following inspections shall be written into the OM&M plan as required actions:~~ ~~a) inspection of fan monitors, control settings and other operating parameters to ensure the system(s) are operating as designed;~~ ~~b) investigation and correction of any conditions that indicate component failure or inconsistencies with designed operating parameters for the system(s);~~ ~~c) maintenance of records assimilated into the overall building OM&M documentation; and~~ ~~The plan shall stipulate that a qualified professional should perform these inspections and if performed by in house maintenance staff such staff shall be trained in system operations.~~	~~The plan shall stipulate recommendations and any requirements for the frequency of inspections of controls and monitors, as deemed appropriate to the situation.~~ ~~It is recommended that the plan stipulate inspections be conducted at least quarterly of all fan monitors, controls and, as applicable, filters and vent openings.~~ ~~The plan should also recommend inspections of mechanical equipment in addition to controls and monitors subsequent to a motor replacement or any catastrophic event that could damage system components.~~
~~Mechanical Equipment~~	~~Mechanical Equipment Inspections~~	~~Frequency of Inspection~~
~~Include Equipment Details and Instructions:~~ ~~a) Include manufacturer instructions and instructions specific to design configurations, as appropriate;~~ ~~b) Documentation should include exact locations of fans, electrical disconnects and other components; and~~ ~~c) Include a list of appropriate actions for the Client(s) to take if the fan monitor warning device indicates system degradation or failure. A list of potential repair items for ASD systems should include:~~ ~~i. fan monitor repair or replacement (e.g., reconnect or replace oil in U-tube);~~ ~~ii. electrical repair;~~ ~~iii. fan or boot replacement; and~~ ~~iv. sealing of foundation openings to soil or piping connections.~~	~~The OM&M plan provided shall observe that mechanical equipment inspections should include all seals, straps, fasteners, electrical system (including switch operation), boots, performance indicators, labels, pipe condition, filters, inlet grills and fan operation.~~ ~~If applicable, airflow in and airflow out of HVAC system(s) and duct balance should be checked to ensure that no significant changes have occurred. Examples of HVAC inspection items:~~ ~~i. functionality of HVAC filters;~~ ~~ii. room differential pressure test;~~ ~~iii. fresh-air damper settings; and~~ ~~iv. verification for supply air into rooms of interest.~~	~~It is often customary that recommendations include inspection of mechanical equipment by a qualified professional no less than every 2 years.~~

12.3 ~~OM&M Manual —~~ Indoor Air Testing

The following guidance statements in Sections 12.3.1 through 12.3.4, or equivalent statements, shall be included in the OM&M manual regarding *radon* testing and where lines of evidence indicate other hazardous vapors or gases may intrude into the building.

12.3.1 *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 radon gas and where lines of evidence indicate testing is warranted for other soil gas hazards. • 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";
12.3.2 *Passive and non-ASD methods*
• "Passive mitigation methods, including soil 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 to verify effectiveness is retained no less than under: 1. Provide, in accordance with Table 12.3, 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. Provide, in accordance with Table 12.3, the building operating condition that prevails for the second longest duration each year.
12.3.3 *Elevated concentrations*
• "If testing at any time indicates concentrations above the action level, conduct evaluations, corrections and further testing until testing indicates 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-MFLB (Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily, School, Commercial and Mixed-Use Buildings).

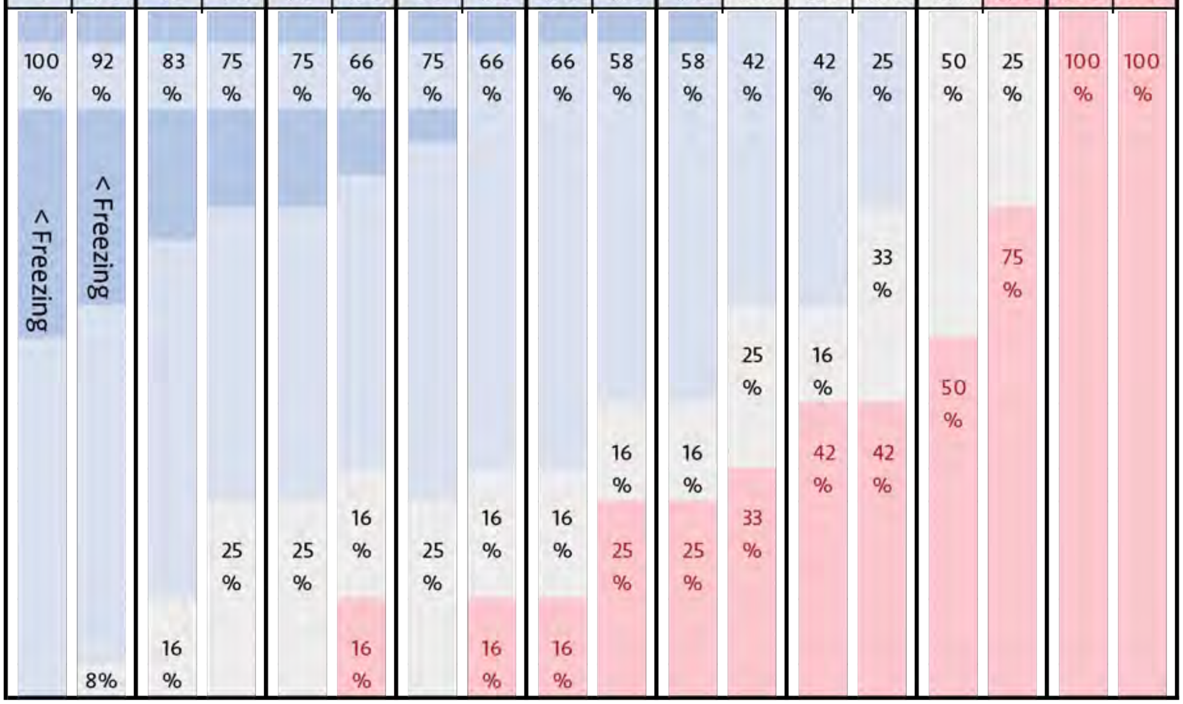
Table 12.3 Annual Average Building Operating Conditions

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

	Zone 8 Subarctic		Zone 7 Very Cold		Zone 6 Cold		Zone 5 Cool		Zone 4 Mixed		Zone 3 Warm		Zone 2 Hot		Zone 1 Very Hot		Acutely Hot	
	Fairbanks		*Caribou ME, Quebec, Marquette MI, Duluth MN, Winnipeg, Grand Forks, Anchorage, Breckenridge, Aspen*		*Portland ME, Buffalo NY, Burlington NH, Milwaukee, Minneapolis, Bismarck ND, Pierre SD, Cheyenne WY, Billings MT, Helena MT*		*Boston, Albany NY, Pittsburgh PA, Cleveland, Indianapolis, Chicago, Omaha, Denver, Albuquerque, Salt Lake, Reno, NV, Boise, ID*		*New York, NY, Philadelphia, Richmond, VA, Baltimore, Louisville, Cincinnati, Nashville, Saint Louis, Kansas City, Amarillo TX, Portland, OR, Seattle*		*Atlanta, Charlotte, SC, Birmingham AL, Jackson, MS, Memphis, Little Rock, Dallas, Austin, Las Vegas, San Francisco, Los Angeles, San Diego*		*Melbourne, FL, Tampa, FL, Mobile, AL, New Orleans, Houston, Brownsville, Phoenix, Tucson*		*Miami, FL, Puerto Rico, Virgin Islands, Honolulu, Guam*		*Certain Asiatic Regions*	
					Annual Average Outdoor Temperatures													
*Home & Work**	Hm	Wk	Hm	Wk	Hm	Wk	Hm	Wk	Hm	Wk	Hm	Wk	Hm	Wk	Hm	Wk	Hm	Wk
	27 F	**32 F**	**39 F**	**45 F**	**45 F**	**50 F**	**49 F**	**54 F**	**55 F**	**59 F**	**62 F**	**67 F**	**69 F**	**73 F**	**76 F**	**80 F**	**83 F**	**86 F**
	-3	0 C	4 C	7 C	7 C	10 C	9 C	12 C	13 C	15 C	17 C	19 C	21 C	23 C	24 C	27 C	28 C	30 C

% per year

Heating
Cooling
Neither



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

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 standards 90.1 / 90.2 (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) https://www.ashrae.org.

Note—Recommending a testing event at a time when the average temperature during the test is within 10˚ F (6˚ C) of the average low outdoor temperature across December, January and February may be prudent where lines of evidence indicate soil gas hazards could represent an acute or sub-chronic risk.

12.3.4 *Low concentrations*
(Where testing indicates concentrations below the national action level initially or after fan activation.)

- Retest the building(s) at least every 5 years and in conjunction with any sale of a building and after ~~In addition, be certain to test again when~~ any of the following circumstances occur:
  - ✓ New adjoining additions, structures, or parking lots;
  - ✓ Building reconfiguration or rehabilitation; or
  - ✓ A ground contact area not previously tested is occupied or a building is newly occupied.
- Note—Where the following changes to the structure are observed and substantial, procedures to verify continued low hazard conditions should be conducted:

~~✓ 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 extensive weatherization, ~~changes to mechanical systems or comparable procedures;~~

✓ Sizable openings to soil occur due to:

- groundwater or slab surface water control systems added or altered (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.~~

-

12.4 Other Essential Testing Content

Where no assessment has been performed or assessment has identified low hazard conditions that do not require mitigation, the OM&M shall contain the following:

a) Identify soil gas concerns and guidance.

1. Should no radon testing reports be available for inclusion in historical information, the following or equivalent guidance shall be provided:

> *"We have no recent test reports or otherwise reliable evidence that radon testing has been conducted. Note—Any building on any parcel of land can have a radon problem. Radon concentrations cannot be predicted based on state, local or neighborhood radon measurements. Testing indoor air for radon is the only way to know."*

2. Should no testing reports relative to COCs be available for inclusion in historical information, the following or equivalent guidance shall be provided:

> *"We have no recent test reports or otherwise reliable evidence that chemical vapor testing has been conducted. Note—Should there be reason for concern, contact your state health department for further information."*

b) The dates of initial assessment and re-assessments;

c) Schedule for on-going re-assessments to assure low hazard conditions;

d) Required procedures to verify continued low hazard conditions; and

e) List of conditions/timing/events that necessitate procedures to verify continued low hazard conditions per **Section 12.3.4**.

12.5 Essential Mitigation Content

12.5.1 *Maintenance inspection checklists*

The OM&M manual is to provide instructions regarding maintenance inspections, in accordance with requirements in a) and b) of this **Section 12.5.1**.

a) Closure Between Soil Air and Indoor Air
Because it is part of virtually all mitigation methods, the OM&M manual is to define a list of items that are to be visually inspected annually to verify that openings between soil and indoor air remain closed, to include:
   1. Sump pits and similarly large openings to soil, such as for plumbing access;
   2. The observance of sizable new cracks or gaps in foundation floors or walls that often occur due natural settlement of a building; and
   3. The integrity of soil gas retarder membranes placed over open soil,

b) Where mechanical mitigation systems have been installed, information compliant with ANSI/AARST SGM-MFLB shall be provided to include a visual operational inspection checklist and, as applicable:
   1. An ASD mechanical inspection checklist; or
   2. A non-ASD mechanical inspection checklist

Where assessment has identified the need for mitigation system installation, the OM&M shall contain the following:

a) The Date of installation;

b) A list of conditions that indicate component failure or inconsistencies in operating parameters.

c) Maintenance and monitoring instructions, to include:
   1. A description of system monitors and actions to take if system monitors indicate system degradation or failure; and
   2. A recommendation to verify continued system effectiveness at regular intervals that comply with this standard;

d) Records of completed and updated maintenance logs, records of repairs and measurement reports;

e) Resources for credible health guidance at state, provincial, federal, or other authority; and

f) Contact information for service inquiries.

12.5.2 *Mitigation system description*

The OM&M manual is to include information regarding mitigation systems and methods as specified in items a) through e) of this **Section 12.5.2**:

a) System components and sealed components labeled on a floor plan sketch or portrayed in narrative that describes system components and locations.

b) Basic operating principles;

c) Fan equipment model(s) and startup parameters, including system monitor pressure gauge readings and any control settings that existed at the time mitigation goals were achieved.

d) Adverse or extenuating circumstances

A description of important observations that have potential to adversely affect the mitigation system(s) or other building systems; and

e) Warranty/Guarantees

Information regarding warranties, guarantees and related conditions or limitations.

12.5.3 ***Mitigation system components***

The *OM&M* manual is to provide detailed operating instructions and information to maintain *mitigation* equipment and components, to include:

a) Manufacturer model numbers for fans and essential equipment;

b) Instructions on equipment and manufacturer instructions where applicable to operation and maintenance;

c) Locations of fans, fan monitors, electronic telemetry/monitoring equipment, permanent test ports, electrical disconnects and other components unique to the system;

d) Descriptions on how to interpret labels and annotations relative to control settings and other designed operating parameters for the equipment; and

e) A list of common maintenance and repair tasks associated with the system, such as:

1. Fan and fan monitor replacement or repair;
2. Duct pipe connections; and
3. Sealing and closure of openings between soil and indoor air.

12.5.4 ***Passive component inspection checklists***

OM&M manuals are to provide instructions regarding maintenance inspections, in accordance with requirements in a), b), c), and d) of this **Section 12.5.4**.

a) Closure Between Soil Air and Indoor Air

Because it is part of virtually all mitigation methods, the OM&M manual is to define a list of items that are to be visually inspected to verify that openings between soil and indoor air remain closed, to include:

1. Sump pits and similarly large openings to soil, such as for plumbing access;
2. The observance of sizable new cracks or gaps in foundation floors or walls that often occur due to natural settlement of a building; and
3. The integrity of soil gas retarder membranes placed over open soil and below slabs if there evidence of building reconfiguration or rehabilitation that may have damaged soil gas retarder.

12.5.5 ***Active component inspection checklists***

OM&M manuals are to provide instructions regarding maintenance inspections, in accordance with requirements in a) and b) of this **Section 12.5.5**.

a) Visual Operational Inspection Checklist

The OM&M manual is to define a list of items that are to be visually inspected on a frequent basis to verify continued operation of fans and other mechanical components, such as system monitors, controls, labels, vents, and filters.

b) Mechanical Inspection Checklist

The *OM&M* manual is to define a list of equipment to inspect when conducting mechanical performance inspections that include:

1. Performance indicators, labels, and fan operation;

2. Seals, straps, fasteners, fan boots, pipe connections, and any permanent, riser pipe and PFE test ports;
3. Electrical components (including switch, GFCI or disconnect operation); and
4. Other related building systems, as applicable, such as sump pumps and combustion appliances.

SECTION 13: NORMATIVE APPENDICES AND REFERENCES

13.1 National Certification/Listing Programs

13.1 National Certification/Listing Programs

As referenced in this standard in **Sections 7.1, 7.3,** and **11.3.1**, the term *qualified mitigation professional* is defined as individuals who have demonstrated a minimum degree of appropriate technical knowledge and skills specific to 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 **Section 13.1** [16].; or

b) as required by licensure or certification programs operating under an authority having jurisdiction (AHJ) that evaluates individuals for radon-specific technical knowledge and skills.

For private sector certifications or listings, this standard requires a national program that evaluates and lists qualified individuals, training courses and other products or services, such as laboratory services, integral to achieving public health goals intended by this standard Programs meeting the purpose, need and requirements of this standard are those with policies as established in a), b) and c) of this **Section 13.1.**

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 ANSI/AARST MS-QA (Radon Measurement Systems Quality Assurance).

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 Mitigation Professionals—Homes

[16] The National Radon Proficiency Program (NRPP) and the National Radon Safety Board (NRSB) are two programs nationally recognized in the United States by the U.S. Environmental Protection Agency (EPA) and other public and private sector stakeholders to meet requirements in Normative Section 13.1 for evaluation of individuals and listing those who have demonstrated technical knowledge and skills sufficient to be certified as qualified mitigation professionals. Note—Identification of these private sector organizations is not an endorsement of either program.

Certifications granted by equivalent national programs that qualify individuals as proficient in designing radon or soil gas (vapor intrusion) *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 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.

~~Informative Note 1—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 Section 13.1 meet the requirements of this standard.~~

~~Note that identification of existing certification bodies is not an endorsement of their programs.~~

~~Informative Note 2—The purpose of requirements in this Section 13.1 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.~~

13.2 Normative References

Published by the AARST Consortium on National Standards
For the latest versions of AARST/ANSI documents, see: www.standards.aarst.org

ANSI/AARST MA-MFLB (Protocol for Conducting Measurements of Radon and Radon Decay Products in Multifamily, School, Commercial and Mixed-Use Buildings)

Note—Previously published as ANSI/AARST MAMF and MALB and now harmonized and consolidated into a single standard.

ANSI/AARST SGM-SF (Soil Gas Mitigation in Existing Homes)

ANSI/AARST SGM-MFLB (Soil Gas Mitigation in Existing Multifamily, School, Commercial and Mixed-Use Buildings)

Note—Previously published as ANSI/AARST RMS-MF and RMS-LB and now harmonized and consolidated into a single standard.

Published by the International Code Council, Inc.
For the latest versions of ICC documents see: www.iccsafe.org

- The International Building Code® (IBC)
- The International Mechanical Code® (IMC)
- The International Residential Code® (IRC)

Published by the ASHREA
For the latest versions of ASHRAE documents see: www.ashrae.org

- Indoor Air Quality Guide – Best Practices for Design Construction and Commissioning
- 62.1 Ventilation for Acceptable Indoor Air Quality for buildings that are more than three stories tall
- 62.2 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings

Published by ASTM International
For the latest versions of ASTM documents see: www.astm.org

- C33 Standard Specification for Concrete Aggregates
- C920 Elastomeric Joint Sealants
- C1173 Flexible Transition Couplings for Underground Piping Systems
- D1785 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
- D2564 Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
- D2665 Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
- D5926 Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems
- E1745 Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs
- F656 Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings
- F891 Coextruded Poly(Vinyl Chloride) (PVC) Plastic Pipe With a Cellular Core
- F1488 Coextruded Composite Pipe
- D2787 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)