Public Review of Proposed 2025 Revisions to AARST CC-1000

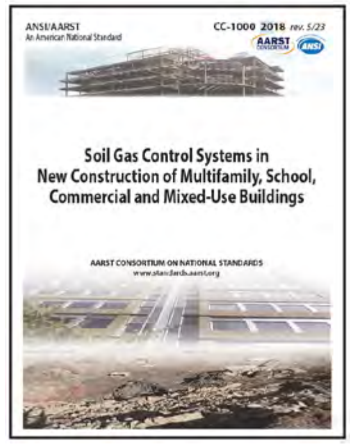
Clean-Read Copy

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

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.

Note that a lengthy redline/cross-through version of the many changes is available for comparing with the current CC-1000 2023 publication

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 Table of Contents

CC-1000 202x

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

SECTION 1: SCOPE

1.1 Scope

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], 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.

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)*.

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 that aim for passive benefits may need more soil gas vent systems than outlined herein. 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.[5] 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 4.2.1.1**;

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

b. Ensure that highly permeable materials are within the gas-permeable layer;
c. Enhance soil gas inlet capacity, compared to **Section 5.4**;
d. Enhance thermal optimization, described in **Section 8.10**; 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**.

Note—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.

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.

1.3.5 *Prior systems*

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

1.3.6 **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 “Merriam-Webster’s Dictionary.”

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

2.2 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.

2.3 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).

2.4 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).*

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

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

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

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

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

2.10 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.

2.11 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.

2.12 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.

2.13 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.

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

2.15 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.

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

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

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

2.19 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 *soil gas inlet trunk networks* within the *soil gas collection plenum* and the outdoor air *exhaust* location.

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

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

2.22 gravel, n—A term commonly used to 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.

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

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

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

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

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

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

2.29 openings in structure, n— The openings created in structural walls or roofs for the purpose of mounting windows, skylights, doors, or other assemblies that might open to outdoor air.

2.30 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.

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

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

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

2.34 PFE (pressure field extension test), n—A diagnostic procedure to evaluate the potential effectiveness and extent of an *ASD* system by using 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.

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

2.36 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.

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

2.38 qualified mitigation professional, n—As determined by *authorities having jurisdiction (AHJ)* who evaluate individuals for specific technical knowledge and skills relative to mitigation of radon or vapor intrusion soil gas hazards, or as defined in **Section 13.1**.

2.39 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)

2.40 readily accessible, adj— See *access ready*

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

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

2.43 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.

2.44 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.

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

2.42 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.

2.43 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.”

2.44 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 point of system *exhaust*.

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

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

2.47 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.

2.48 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.

2.49 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.

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

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

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

SECTION 3: DESIGN

3.1 Building Design

Soil gas control shall be designed and constructed for all portions of foundation systems where there is enclosed space immediately above crawl spaces, slab-on-grade or basement slabs. The system 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 to include each ground contact portion of the building. Each soil gas vent system shall include exhaust piping extended from *soil gas inlets* within *soil gas collection plenum(s)* to an exhaust location as required in this standard.

Exception: Ventilated Garages

Garages attached to a foundation system do not require soil gas vent systems if compliant with **Sections 6.7**, **6.8**, and ANSI/ASHRAE 62.1[6] for separation, ventilation and pressurization of enclosed spaces surrounding the garage.

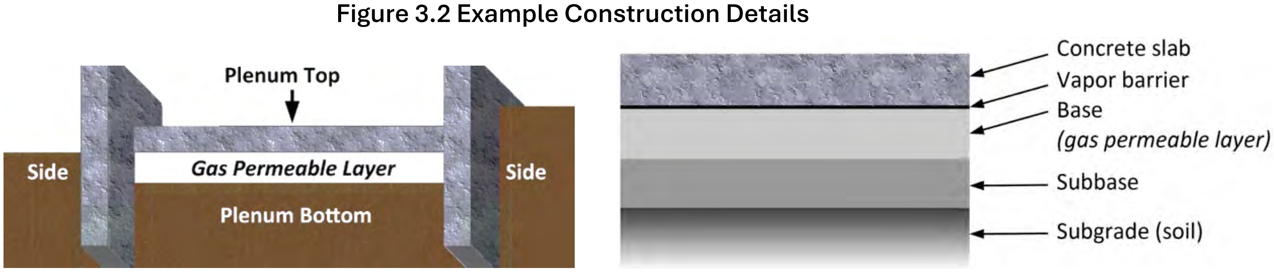
3.1.2 *Required capacity*

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.

3.2 Soil Gas Collection Plenums

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 3.2 Example Construction Details



3.2.1 *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 restrict 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

[6] ANSI/ASHRAE 62.1 Ventilation for Acceptable Indoor Air Quality for buildings that are more than three stories tall

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 Vent Systems per Plenum Size

An independent soil gas vent system with an exhaust pipe extended from the *soil gas collection plenum* to the point of exhaust 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 3.3	Plenum Size Restrictions	
Nominal inside pipe diameter (primary trunk)	**Maximum Size of Soil Gas Collection Plenum(s) per Duct Pipe Size**	
	1. Basic Where compliant plenum installation is verified by inspection per Section 5.6	2. 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 m^2)	4,000 square feet (372 m^2)
4 inch (100 mm)	6,200 square feet (575 m^2)	7,100 square feet (660 m^2)
6 inch (150 mm)	14,000 square feet (1,300 m^2)	16,000 square feet (1,486 m^2)
8 inch (200 mm)	22,000 square feet (2,043 m^2)	25,000 square feet (2,323 m^2)
	3. Minimum Where any plenum installation is not verified by inspection per Section 5.6	4. Penalty Where non-compliant with Section 5 (Soil Gas Collection Design) *
3 inch (75 mm)	2,500 square feet (232 m^2)	1,250 square feet (116 m^2)
4 inch (100 mm)	4,500 square feet (418 m^2)	2,250 square feet (209 m^2)
6 inch (150 mm)	10,000 square feet (929 m^2)	5,000 square feet (465 m^2)
8 inch (200 mm)	15,600 square feet (1,450 m^2)	7,800 square feet (725 m^2)

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

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 described in **Table 3.5.2**.

3.5.1 *Joined plenums*

Multiple soil gas inlets and 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**.

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

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 Pressures

The intended mechanical ventilation systems shall be evaluated, in accordance with Section 10, for HVAC systems and building features that might enhance soil gas entry by inducing 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.

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 Plenum(s)

4.2.1 ***Inspect subgrade soil***

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

4.2.1.1 Closure Specifications

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

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

4.2.2 ***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 *soil gas inlet* piping, suction pits, or *soil gas inlet trunk networks* within *soil gas collection plenums*.

4.3 Close Side Walls

4.3.1 ***Walls and footings***

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

4.3.2 ***Damp proofing***

All foundation walls in contact with soil shall be damp proofed or waterproofed with methods consistent with Section 1805 of the International Building Code **(IBC)**. [7] The application shall include closure of all exterior cold joint seams that will be below the ground surface.

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.

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

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

4.4.1 *Interior drain systems*

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

4.4.2 *Exterior drain systems*

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

a) Water drainage receptors

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

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

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

4.5 HVAC Ductwork

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

a) ductwork that is seamless, sealed by spray applied sealants, solvent welded, or equivalent method;

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

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

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.

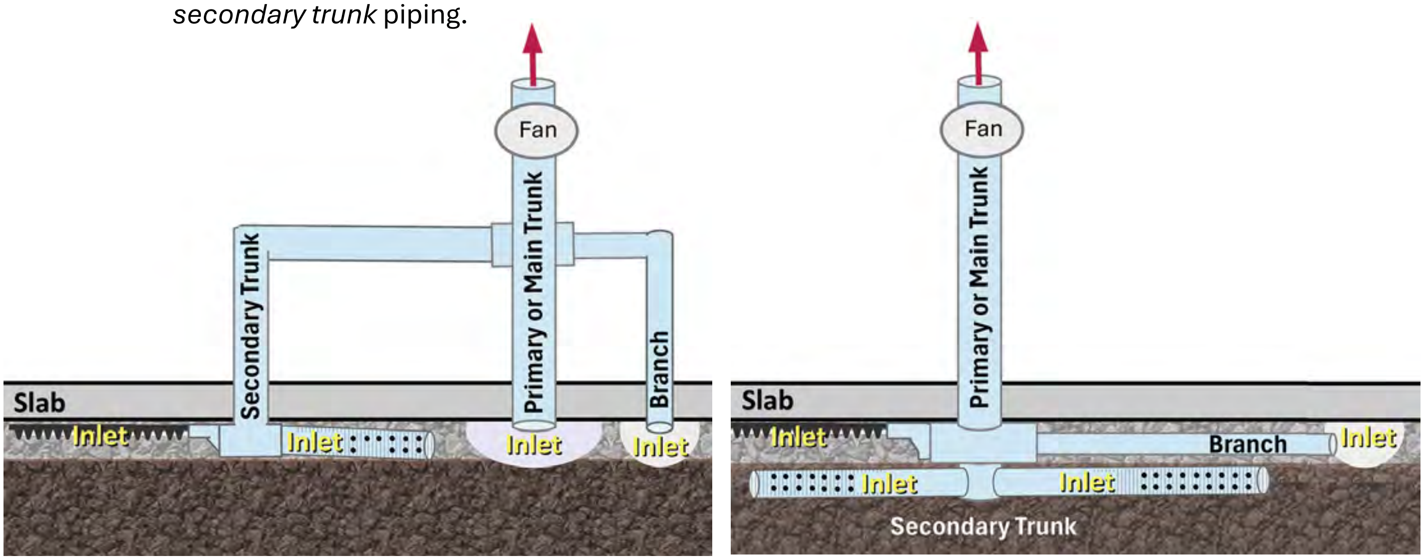
5.1.2 *Secondary trunks and branches*

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.

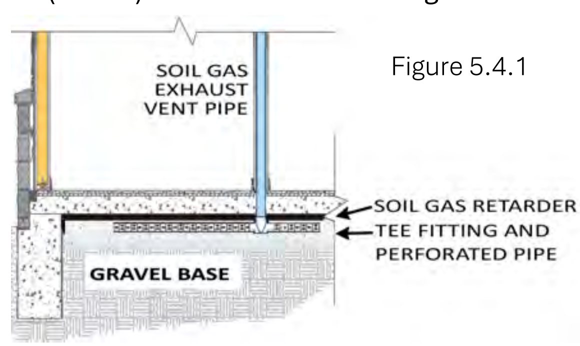


Figure 5.4.1

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.

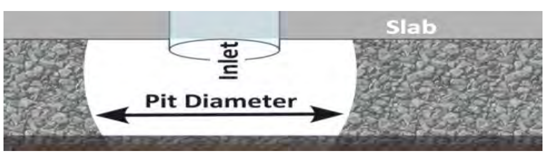


Table 5.4.1 c	**Minimum Soil Gas Inlet Opening**
Trunk or branch equivalent size	**Equivalent Soil Gas Inlet Opening Size For Pits**
≤ 3 inch (75 mm) ID	4" x 12" (100 mm x 300 mm)
4 inch (100 mm) ID	4" x 16" (100 mm x 400 mm)
6 inch (150 mm) ID	4" x 24" (100 mm x 600 mm)
8 inch (200 mm) ID	4" x 32" (100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

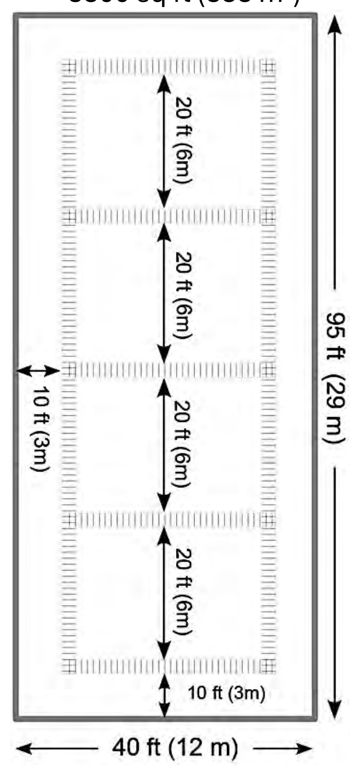
5.4.4 ***Option 4—Small gravel, sand, or soil***

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

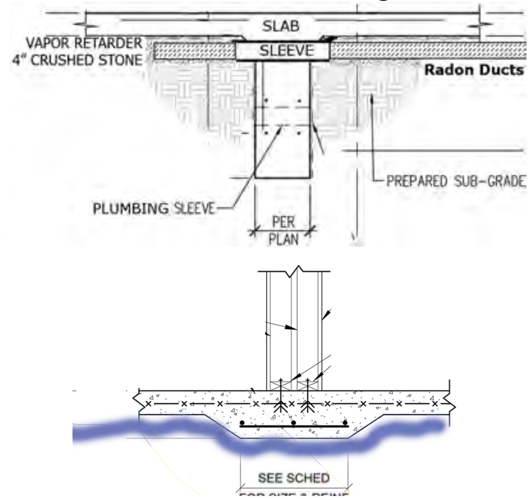
Options	Allowed If Including Required System Design Features	* Not Permitted	Example Of Design 3800 sq ft (383 m^2)
Smaller Stone Option	Aggregate size numbers 67, 7 and 8 as classified by ASTM C33. Note—These aggregates contain a high percentage of nominally 3/8-inch (9.5 mm) stone.	Aggregates containing 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.

5.4.5 *Footings and Joined Plenums*

Figure 5.3.5



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.

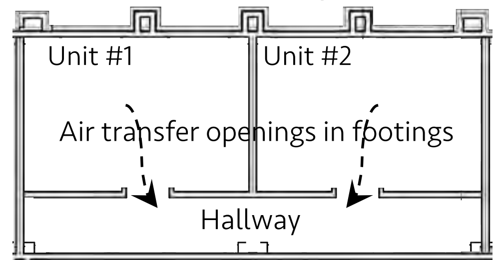
5.4.5.1 Footing Openings

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



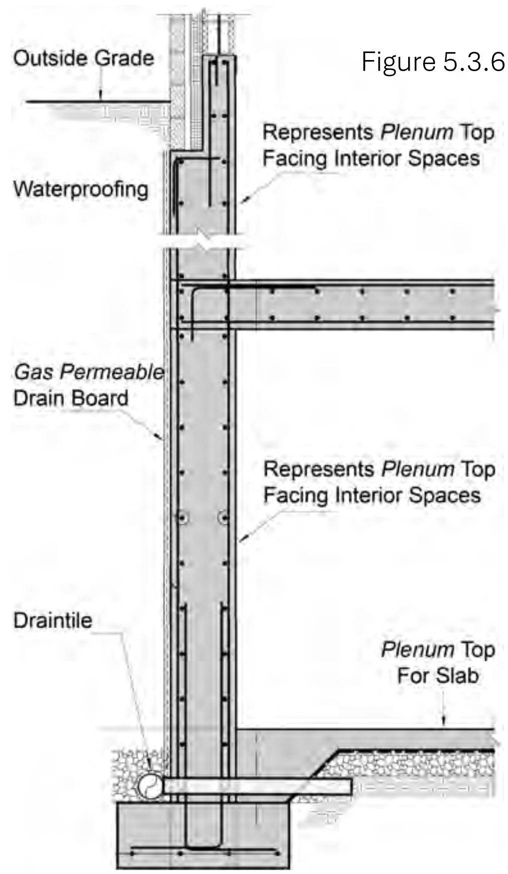
5.4.6 *Foundation walls*

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.

Figure 5.3.6



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.

5.5 Transition from Inlets to Exhaust Vent Piping

5.5.1 *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 pi*pe 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

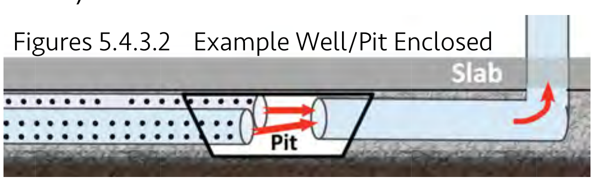
d) be temporarily capped or closed during construction to prevent debris from entering.

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 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.

5.7.1 ***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 *soil gas collection plenum*, 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*.

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.

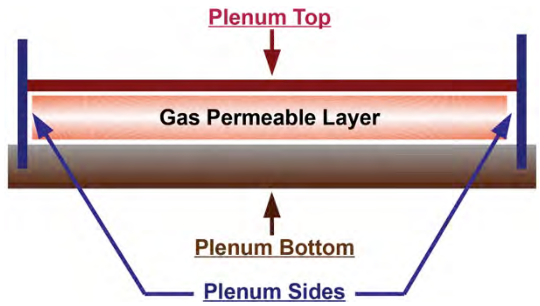


Figure 6.0

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 *Immediately below slabs*

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

a) Where insulation is installed under the concrete floor, it is permitted that the soil gas retarder be installed below sub-slab insulation if ground water will be naturally below or mechanically controlled to be below the soil gas retarder; and

b) A thin layer of geotextile 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 new *radon* source.

6.3 Soil Gas Retarder Materials and Installation

6.3.1 *Soil gas retarder materials—Radon*

Where the purpose is limited to preventing radon gas from entering the building, *soil gas retarder* materials shall be compliant with the *authority having jurisdiction (AHJ)* and 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.

6.3.2 ***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).

6.3.3 ***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 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 are used to cover exposed soil that will not be covered by concrete, and
b) where ≥ 20 mil (0.020 inch; 0.508 mm) membranes are used.

Exception 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

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.

6.3.3.4 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

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.

6.5.1.2 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 caulk, 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*

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

6.5.4 *Sump pits*

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

6.5.4.1 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 *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. Openings in the floor that provide access for plumbing maintenance shall be provided a method of closure that resists soil gas entry into the building.

6.5.7 *Label sealed components*

A label or marking shall be provided 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 or located in conspicuous places (such as at access panels).

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**.

6.8 Inspect for Closure Prior to Indoor Finishings

Before indoor finishing in any ground-contact area, an inspection shall be conducted to verify a continuous sealed barrier exists to resist air movement between soil gas and indoor spaces within the thermal envelope of the building. The inspection shall include all floors and walls in contact with ground. The inspection shall be conducted by an individual who is trained and qualified for design of systems that comply with this standard.

6.8.1 *Non-compliance*

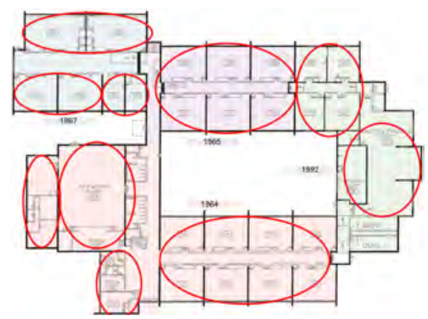
Where closure of openings is non-compliant, additional steps shall be taken until compliant with this standard prior to completion of indoor finishings in ground-contact areas.

6.8.2 *Reports*

This inspection shall be retained in records in accordance with **Section 3.10** (Quality Control).

SECTION 7: 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.[8]

7.2 Pilot Test/Test Port Locations

Strategic locations of test ports shall include all 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

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[8] 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.

c) For larger expanses allowed in Table 3.3 *(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 5.6**, 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 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***

Where preinstalled test ports are required due to concerns noted in **Section 5.6**, each port opening above the slab shall be in an accessible location 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 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 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.

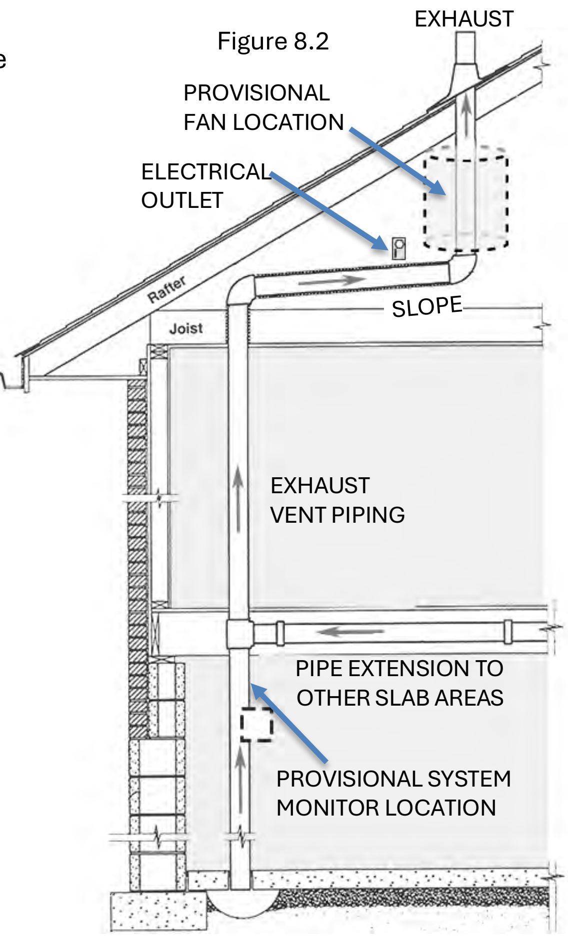
8.2 Provision for ASD Fan(s)

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.

Figure 8.2



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.

8.2.1.2 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

Access shall be provided for each predetermined *ASD fan* location to allow installation of *ASD fans* and replacement of same. The service access entry shall be located not greater than 30 feet (9 m) from the *ASD fan* location unless access meeting Section 306.3 of the International Mechanical Code[9] 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.

8.2.2.1 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

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.

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.

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[9] 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).

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 s*ystem 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

E*xhaust vent piping* that extends from the *soil gas collection plenum* to the point of exhaust shall be rigid, non-perforated pipe that is suitable for drainage of condensate water. E*xhaust vent piping* shall be Schedule 40 PVC pipe compliant with ASTM D2665, F891 or F1488. Alternatively, pipe products specified in codes[10] as meeting "Above Ground Drainage and Vent" requirements shall be permitted.

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
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*.

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). 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.

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

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 ***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 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 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.

SECTION 9: EXHAUST DISCHARGE CONFIGURATION

9.1 Measuring Distances

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

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 9.2

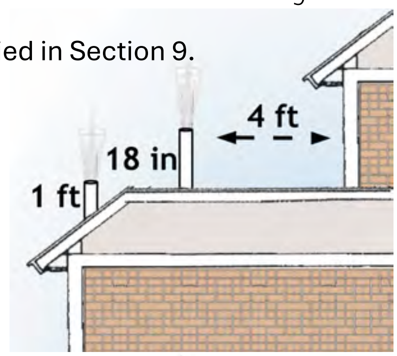
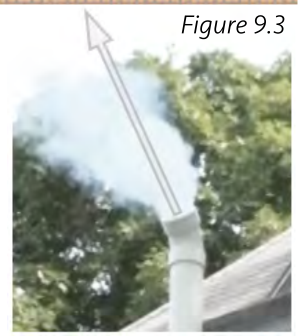


Figure 9.3



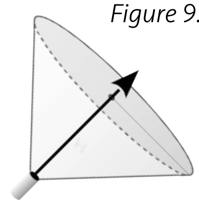
9.3 Straight-line Exhaust Trajectory (Restrictions)

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°.

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˚.

Figure 9.4

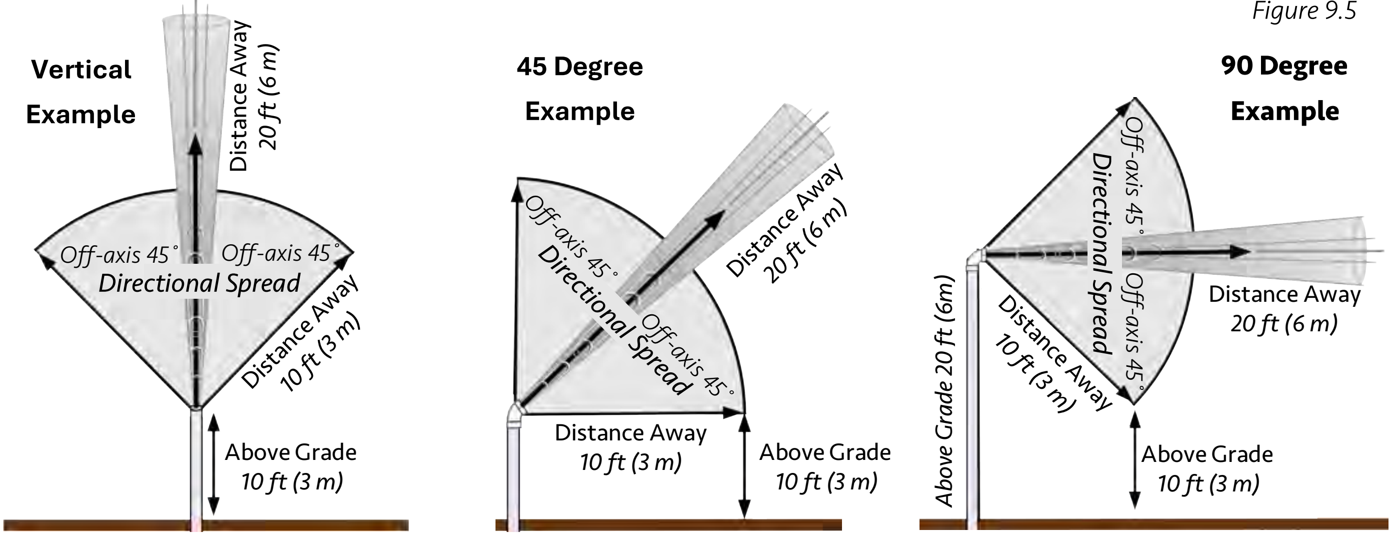


9.5 Angled Trajectories

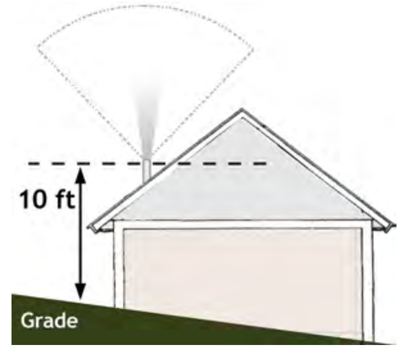
Exhaust air shall exhaust upward and be kept clear of obstructions. It shall not deviate more than 45 degrees from a vertical *exhaust trajectory*. Downward exhaust is prohibited.

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

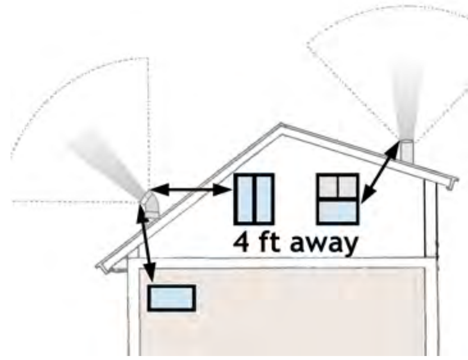


9.6 Elevation Above Grade



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**.

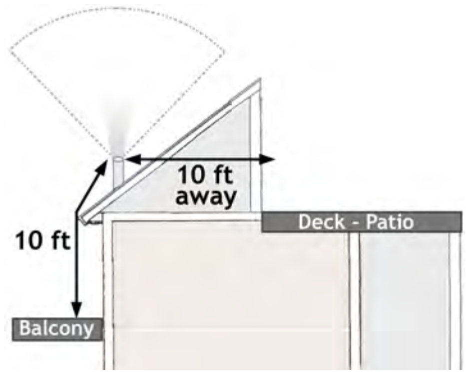
9.7 Separation from Operable Openings in Structures



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

Note—Active window portions illustrated here are in blue.

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

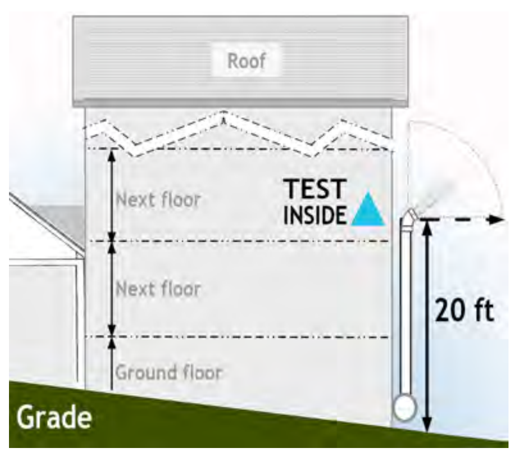
b) compliant with **Section 9.3** and **9.4**.

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:

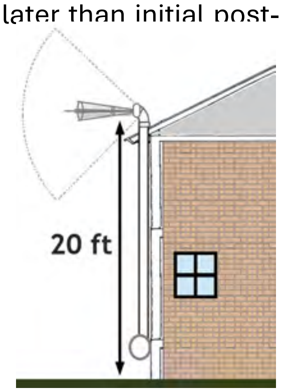
1. compliant with **Section 9.4** (Directional Exhaust Spread);
2. not less than 20 feet (6m) above the nearest grade; and

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

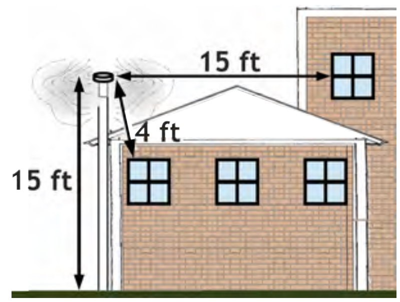
9.11.1 *Horizontal discharge*



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.

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.

9.15.1 *Reports*

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

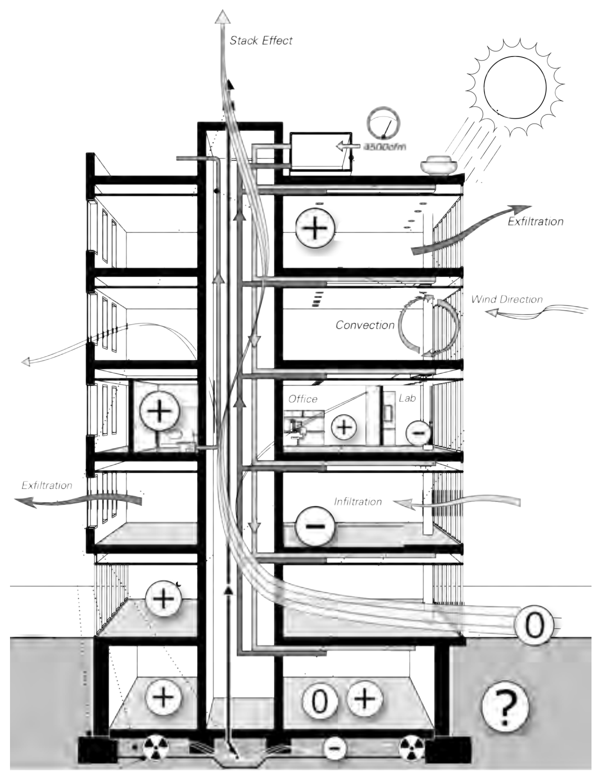
SECTION 10: HVAC EVALUATIONS REQUIRED [11]

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 lot garages that are not constructed with soil gas vent systems.



10.1.1 *The evaluation*

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

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.

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

Note—Specific locations of concern include enclosed spaces that immediately adjoin *crawl spaces*, slab-on-grade or basement slabs and rooms with walls that adjoin soil and other earthen aggregates and attached garages.

[11] 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

10.3 Appropriate Designs

HVAC designs for mitigating negative pressure shall be reviewed for: compliance with ASHRAE ventilation standards[12]; unnecessary energy consumption[13]; and design capabilities to accommodate degradation to the system's functionality that often occurs over time.

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 and affixed in place such that they are capable of withstanding ambient conditions where mounted. All label lettering and other annotation on systems shall be of a color in contrast to the color of the background on which the lettering is applied. All label 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

5.4.3	Pits
6.4.3	Crawl membranes / access hatches
6.5.7	Sealed components
8.2.1.2	Designated location for ASD fans
8.2.2	Electrical conductor boxes/breakers
8.2.3	Designated fan monitor location
8.8	Exhaust vent piping
11.2	Primary Label
10.5	HVAC components used for mitigation

[12] 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).

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

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

11.3 Systems with No Active Fan

System completion includes the documentation required in **Section 12** (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 for *radon* after construction 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 after construction 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 *authority having jurisdiction (AHJ)*, indoor air testing shall be conducted to evaluate if further action is needed. All testing shall be conducted using methods approved by the authority having jurisdiction (AHJ). 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** (OM&M Manual) shall include results of evaluations that indicate system effectiveness.

11.5 Adding ASD Fans

11.5.1 *Converting to ASD*

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

EXHIBIT 1 Sample Form

Visual Review for Completion of Essential Components

✓ Where required components are complete, check the box to indicate each statement is true.

Where a component is deficient, action must be taken to correct deficiencies.

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

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

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**.

11.5.2 ***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.

SECTION 12: 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."

12.3 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, NC, 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*
Zone	Zone 8		Zone 7		Zone 6		Zone 5		Zone 4		Zone 3		Zone 2		Zone 1		Acutely Hot	
°F	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
°C	-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	100 % (< Freezing)	92 % (< Freezing)	83 %	75 %	75 %	66 %	75 %	66 %	66 %	58 %	58 %	42 %	42 %	25 %				
% per year: Neither		8%	16 %	25 %	25 %	16 %	25 %	16 %	16 %	16 %	16 %	25 %	16 %	33 %	50 %	25 %		
% per year: Cooling						16 %		16 %	16 %	25 %	25 %	33 %	42 %	42 %	50 %	75 %	100 %	100 %

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 in 2016 (e.g., the National Centers for Environmental Information-NOAA) for various cities 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 any of the following events 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:
  - ✓ Heating or cooling systems are altered with changes to air distribution or pressure relationships;
  - ✓ Ventilation is altered by extensive weatherization efforts;
  - ✓ Sizable openings to soil occur due to:
    - — groundwater or slab surface water control systems or sewer lines are added or altered (for example: sumps, drain tiles, shower/tub retrofits) or
    - — natural settlement causing major cracks to develop;
  - ✓ Earthquakes, blasting, or formation of sink holes nearby; or
  - ✓ An installed *mitigation* system is altered.

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

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 [14].; 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 required standards.

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

c) Programs that include educational prerequisites as follow:
   1. Qualified Mitigation Professionals—Homes
      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.

[14] 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.

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)
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)

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)

Acknowledgement

Deep appreciation is both expressed and deserved for contributions in time and wisdom provided by the following consensus body members and staff.

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