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Radon System Requirements

Radon removal systems are now required in new low rise residential buildings, per the Maine Uniform Building and Energy Code, which is in effect Statewide. (Towns under 4000 population don't have to enforce it, but the Code is in effect in all Maine municipalities.) The radon standard, that contains the installation requirements, is ASTM E 1465- 08. It's available on our website. It's a long, complicated document, that is written more like a textbook than a code, and it's not easy to tell from it what is required for the typical system that is used in most buildings. This handout is a distilled version of the standard, with the requirements for a typical system, and the pertinent sections of the standards [referenced in brackets] that give the material specifications and installation methods, primarily for the people designing buildings and installing the piping.

The typical radon removal system consists of:

1. A 20' long perforated 4" PVC pipe, or a loop if it, underneath the basement slab, in crushed stone, (the "soil gas collector"), with a tee in it that comes up through the floor. [6.4.2] The interior foundation drainage piping can double as the radon collection pipe, if it's run into a sump with a check valve, before leaving the building, as detailed below. [6.4.4.32]

2. A 6 mil polyethylene "soil gas retarder" with 12" overlapped seams over the crushed stone.

3. A 4" or 3" [6.5.3.1 - buildngs with a footprint over 1500 square feet have to be 4"]] non perforated schedule 40 PVC pipe, running up through the building, within the thermal envelope, and through the roof, with space near the roof, or above it, for a fan to be added if needed (The system is to be under negative pressure where it passes through the house. The fan cannot be in the basement.). Near the roof, there has to be space for a 2' diameter x 3' tall cylinder of clear space, in case a fan is needed, with an electrical feed from the panel provided to that space, whether the system has a fan or not.

The foundation drainage has to be such that the radon system can't suck clean air from outdoors through the foundation drainage system. If the building has interior foundation drainage, that has to discharge into a sump in the floor of the basement or crawl space with a checkvalve in the discharge line, and a bolted, gasketed lid [6.2.4.2,and Figures 9 & 10] The check valve will be normally shut, keeping outdoor air out, unless water pushes it open. If the exterior drainage is being piped into an indoor sump to be pumped away (for flat sites where you can't daylight the end of the drain pipe), the same setup is required.

The vent stack must be run inside the thermal envelope of the building, and must terminate above the roof, at least 10' above ground, at least 2' above, or 10' away (horizontally) from any opening into conditioned or occupiable space in the building, or the top of a chimney. The same separation requirements apply to adjacent buildings.

The system can be designed with or without a fan [minimum 75 cfm]. A radon test has to be conducted [6.9.5], and a reading below 4 picocuries is required for occupancy. If a passive system (no fan) yields a reading higher than that, then the fan is added and the test redone.

Table 1, below, gives a list of the installation steps. Figure X 2.1, at the end,is a drawing showing the system components. There is more information in the entire standard about requirements not covered in this handout. This handout contains the basics for designing and installing the system.

There are two versions of this handout. The full, 21 page one, for designers and installers, and a 3 page version, primarily for earthwork contractors, who install the radon and drainiage piping under the floor. If you can't find referenced sections, it's because you have the 3 page version. The full one is on our website, along with the entire standard.

If you have questions or need more information, let us know.

June 2, 2022

TABLE 1 Construction of Radon Systems with Fan-Powered and Passive Pipe Routes Summary of Steps Performed Before Occupancy

Assuming Radon Fan is Installed

Step No.	Summary Step Description	Reference to Practice	Pipe Route Fan-Powered	Pipe Route Passive
Construction References			6.1 through 6.12	
Before Occupancy Steps:			Is step required	
Are the following construction steps required or optional before occupancy?			or optional?	
1	A) Specify Air Handling Equipment Placement	per 6.4.5.4 and 6.7.3	Required	Required
	B) Specify Vent Stack's Pipe Route through House	per 6.5.5	Required	Required
2	Build Foundation	per 6.1, 6.3, and 6.7	Required	Required
3	Install Gas-Permeable Layer Install Soil-Gas Collector(s) Install Connections to Soil-Gas Collector(s)	per 6.4.1 through 6.4.4	Required	Required
4	Install Soil-Gas-Retarder	per 6.2.3	Required	Required
5	Install Concrete Slab or Sealed Membrane Ground Cover, see 6.7.2		Required	Required
	A) Slab-on-Grade with Concrete Floor Slab	per 6.1.1, 6.2, 6.2.1, and 6.4.5	Required	Required
	B) Basement with Concrete Floor Slab	per 6.1.2, 6.2, 6.2.1, and 6.4.5	Required	Required
	C) Crawlspace with Concrete Floor Slab[A]	per 6.1.3, 6.1.3.1, 6.2, 6.2.3, and 6.4.5	Required	Required
	D) Crawlspace with Thin Concrete Floor Slab[A]	per 6.1.3, 6.1.3.2, 6.2, 6.2.3, and 6.4.5	Required	Required
	E) Crawlspace with Sealed Membrane[A]	per 6.1.3, 6.1.3.3, 6.2, 6.2.3, and 6.4.5	Required	Required
	F) Combination Foundations	per 6.1.4	Required	Required
6	Install Radon System Piping through Roof; Install Pipe Insulation and Attach Radon Pipe Labels; Maintain Fire Ratings	per 6.5.1 through 6.5.8 and 6.6	Required	Required
7	Install Electrical Wiring	per 6.8	Required	Required
8	For fan-powered system: Test building with initial test protocol For passive system: Test building with post-mitigation protocol	per 6.10	Required	Required
9	Evaluate radon test results	per 6.11	Required	Required
10	Determine when building is ready for fan installation	per 6.5.9	Required[B]	Required[B]
11	Install fan as required by 6.5.9 and 6.11	per 6.5.10	Required[B]	Required[B]
12	Install Radon System Monitor	per 6.5.11	Required[B]	Required[B]
13	Test building with fan operating with post-mitigation protocol	per 6.10	Required[B]	Required[B]
14	Evaluate radon test results	per 6.11	Required	Required
15	Attach all appropriate labels	per 6.9	Required	Required
16	Assemble and deliver documentation package	per 6.12.4	Required	Required
17	Deliver documented evidence of acceptable radon levels	per 6.12.5	Required	Required
18	Upgrades, Repairs, and Conversions	per 6.11.2 and 6.11.3	—	—

[A] At least one of these three sealed ground covers is required in each crawlspace.
[B] Not required when test results are acceptable in Step #9.

6.1.3.2 *Thin Poured Concrete Slabs in Crawlspaces*—Thin concrete slabs, at least 2 in. (50 mm) thick and finished with either a smooth or rough surface, should be the crawlspace ground cover used for keeping small animals out, and when the intended use of the crawlspace is storage of light weight objects, or when maintenance traffic is expected, or when a sealed polyethylene membrane does not assure, for the life of the building, a durable sealed ground cover.

6.1.3.3 *Sealed Polyethylene Membranes in Crawlspaces*—Sealed polyethylene membrane ground covers are permitted in crawlspaces where there is no traffic or storage and where the membrane can be physically protected and accessible for repair if damaged during the life of the building.

(1) Sealed Polyethylene Membrane Installation—Before the membrane is installed, construction debris shall be removed from the crawlspace. The top surface of the soil or other fill material in the crawlspace shall be graded even and smooth and sloped for drainage, like a flat roof. The sealed polyethylene membrane shall *(1)* have sealed seams that overlap a minimum of 12 in. (300 mm), *(2)* have edges that extend a minimum of 12 in. (300 mm) up the foundation walls and are sealed to the foundation walls, and *(3)* be sealed at all openings for penetrations, like posts and pipes.

(2) Sealed Polyethylene Membrane Protection—When regular traffic over the sealed membrane is possible, its top shall be protected by building: *(1)* barriers that route traffic around it, or *(2)* durable walkways over it, or both. When items can be stored on the sealed membrane it shall be covered with *(1)* more durable plastic or rubber sheeting, or *(2)* storage racks, and so forth, or *(3)* any combination of them that prevent any stored item from resting on the membrane. When racks or other objects are employed to protect the membrane, they shall be constructed and installed in such a way that they do not puncture or abrade the membrane. The sealed polyethylene membrane shall be protected from ultraviolet and sun light by sun shields. The bottom of the sealed polyethylene membrane shall be protected from sharp edged objects in the soil by the previously installed soil-gas-retarder membrane, both membranes being required.

(3) Polyethylene Membrane Material Requirements—The minimum thickness of a polyethylene membrane, when used in crawlspaces for purposes of radon control, shall be 6 mils (0.15 mm). Membranes thicker than 6 mil (0.15-mm) as well as membranes made of equivalent materials, including 3 mil (0.08 mm) cross-laminated polyethylene, shall be permitted.

6.1.4 *Combination Foundations*—Each foundation type (that is, slab-on-grade, basement, or crawlspace) present in a combination foundation shall be given the radon reduction system features appropriate for its type. *Exception*—The suction point pipe(s) for combination foundations shall be permitted to be but not required to be merged into a single vent stack pipe by using manifold piping.

TABLE 5 Methods for Connecting to the Soil-Gas Collector (SGC) Comparing Characteristics of Connection Methods[A]

Connection Description	Method 1 (See 6.4.3.1)	Method 2 (See 6.4.3.2)	Method 3 (See 6.4.3.3)	Method 4 (See 6.4.3.4)	Method 5 (See 6.4.3.5)	Method 6 (See 6.4.3.6)
Suction Point Pipe Orientation	Vertical	Off Set Vertical	Horizontal	Vertical or Horizontal from Manifold	Verticalthrough Membrane	Vertical from Mat
Ground Cover Description	Slab or Membrane	Slab or Membrane	Slab or Membrane	Slab or Membrane	Membrane	Slab
Soil-Gas Collector Types See Table 4	1, 2, or 3	1, 2, or 3	1, 2, or 3	1, 2, or 3	5	4
Number of Gas-Permeable Layers Connected	One	One	One	Two or More	One	One
Connection From:	Soil-Gas Collector Pipe	Soil-Gas Collector Pipe	Soil-Gas Collector Pipe	Two (or More) Soil-Gas Collector Pipes	Soil-Gas Collector Pipe	Proprietary Mat
Connecting To:	Suction Point	Suction Point	Suction Point	Two (or More) Suction Points (and Manifold)	Suction Point	Suction Point
Location of Manifolds Connecting Multiple Gas-Permeable Layers	Above Slab	Above Slab	Above Slab	Below Slab	Above Slab	Above Slab
Location of Suction Point's Penetration	Directly Above SGC Pipe	Anywhere in Slab	Wall at Level of SGC Pipe	[B]	Directly Above SGC Pipe	Directly Above Proprietary Mat Strip
Drawings and Pictures	Fig. 4 and Fig. 6	Fig. 5 and Fig. 7	Fig. 8	Fig. 2	Fig. 4 and Fig. 6	

[A] The parts needed to connect suction point pipe to soil-gas collector are specified in Table 6.
[B] Location of vertical suction point's penetration is directly over sub-slab manifold in slab; horizontal suction point's penetration location is in wall or footing at same level as soil-gas collector.

stone is 100 %. The mat's soil coverage of the sub-slab area using the mat manufacturer's installation instructions is about 18 % of the building foot print.

6.4.2 *Soil-Gas Collectors*—A soil-gas collector shall be built into all gas-permeable layers. Soil-gas collectors shall be one of the types specified by Table 4, and shall be connected according to Table 5 and Table 6. All soil-gas collector piping shall be perforated and selected from Table 7. (See 6.5.1.3.) All non-perforated horizontal piping that is connected to the soil-gas collectors shall be sloped so as to drain into the perforated soil-gas collectors. *Discussion*—Purposes of the gas collectors are: *(1)* to prevent a soil-gas flow restriction where the gas-permeable layer and the suction point pipe join, and *(2)* to enhance negative pressure field extension under the concrete slab or membrane.

6.4.2.1 *Type 1—Buried Length of Perforated Pipe*—shall be a 20 ft (6 m) length of 4 in. (100 mm) perforated pipe buried in a gas-permeable layer of crushed stone 1 to 1½-in. (25 to 38-mm) which is 4 in. (100 mm) in depth. The pipe shall be rigid or flexible and positioned straight, curved, or bent with ¼ or ⅛ bend fittings for easier installation in the gas-permeable layer. The ends of the pipe shall not be capped (or plugged). At a place along the length of the pipe a tee assembly shall be inserted. The tee assembly shall be positioned so that the suction point pipe which attaches to it penetrates the slab in an unobtrusive place and where the suction point can be attached to the vent stack. (See Table 4, Table 5, Table 6, and Fig. 1 for additional specifications.)

6.4.2.2 *Type 2—Buried Loop of Perforated Pipe*—shall be a loop of 4 in. (100 mm) perforated pipe buried in a gas-permeable layer of crushed stone ½ to ¾ in. (13 to 19 mm) which is 4 in. (100 mm) deep. The pipe shall follow the interior perimeter of the foundation. The ends of the pipe shall be joined in a tee assembly to which the suction point shall be attached. The tee assembly shall be located so that the suction point pipe penetrates the slab in an unobtrusive place, and in a place where the vent stack can be attached. (See Table 4, Table 5, Table 6, and Fig. 1 for additional specifications.)

6.4.2.3 *Type 3—Buried Loop of Perforated Pipe in a Trench*—shall be a loop of 4 in. (100 mm) perforated pipe buried in a 4 in. (100 mm) deep gas-permeable layer of crushed stone 1 to 1½-in. (25 to 38-mm). The crushed stone shall be contained in a trench which is about 1 ft (0.3 m) wide. The pipe and trench shall follow the interior perimeter of the foundation. The ends of the pipe shall be joined in a tee assembly to which the suction point shall be attached. The tee assembly shall be located so that the suction point pipe penetrates the slab in an unobtrusive place, and so that the vent stack can be attached. (See Table 4, Table 5, Table 6, and Fig. 1 for additional specifications.)

6.4.2.4 *Type 4—Proprietary Mat Strips on Soil*—Mat strips are suitable for sub-slab depressurization radon control. A proprietary geo-textile mat with a minimum width of about 12 in. (0.3 m) and a thickness of about 1 in. (25 mm) after installation should be used (9). The mat shall be placed on leveled soil. The mat shall follow the interior perimeter of the foundation. The mat is not usually placed under the entire slab. However, in all cases the mat shall be placed according to the manufacturer's instructions. Some building footprints require additional strips of mat inside the strips placed around the foundation's perimeter. Mat strip connections shall be made according to the manufacturer's instructions and secured so that the mat remains in place while the concrete slab is being cast over it. While the slab is being cast, the mat shall be protected so that concrete does enter the mat's void spaces. The suction point pipe shall be attached to the mat according to the manufacturer's instructions using the specified special proprietary fittings. (See also Table 4, Table 5, and Table 6 for additional specifications.) *Discussion*—The construction of gas-permeable mats varies by manufacturer; some mats are strips of dimpled plastic sheet in filter fabric socks and others are matrices of plastic filaments attached on one side to a strip of filter fabric. Other mat constructions are available. Installation procedures for gas-permeable mats vary by mat construction and manufacturer. Manufacturers' installation instructions for strips of matting that have filter fabric socks covering four

TABLE 6 Quantity of Pipe Parts Required for Connecting Suction Point Pipe to the Soil-Gas Collector

Suction Point Pipe Description	Method 1 Vertical through Slab[A]	Method 2 Off-set Vertical through Slab[A]	Method 3 Horizontal through Wall or Footing[B]	Method 4 Horizontal through Wall or Footing from Manifold[B]	Method 5 Vertical through Membrane[C]	Method 6 Vertical through Slab from Mat[A]
Compatible with Soil-Gas Collector (SGC) Types	SGC Types: 1, 2, 3, and 5	SGC Types: 1, 2, 3, and 5	SGC Types: 1, 2, 3, and 5	SGC Types: 1, 2, 3, and 5	SGC Types: 1, 2, 3, and 5	SGC Type: 4
See Picture of Suction Point Assembly	Fig. 6	Fig. 7	Fig. 8	—	Fig. 6	—
See Drawings of Foundation	Fig. 4	Fig. 5	—	Fig. 1 and Fig. 2	—	—
See Sections in this Practice	6.4.3.1	6.4.3.2	6.4.3.3	6.4.3.4	6.4.3.5	6.4.3.6
See All Notes	A	A	B	D,B	C	A
"Above Ground Pipe Type" Connection Components See Table 8 and Table 10	Quantity Required	Quantity Required	Quantity Required	Quantity Required	Quantity Required	Quantity Required
Suction Point Pipe, Diameter 4 in. (100 mm)	1	1	1	1	1	1
Tee (with 3 Hubs), 4 in. (100 mm)	1	—	—	1 (between ends of manifold)	1	E
Street Elbow, (1 Hub and 1 Spigot) 4 in. (100 mm)	—	1	—	—	—	E
Nipples, 4 in. (100 mm)	2	—	—	2	2	E
Rubber Adaptors[F] (to connect above ground pipe to below ground pipe)	2	1	1	2	2	E
"Below Ground Pipe Type"—Non-perforated See Table 7	Quantity Required	Quantity Required	Quantity Required	Quantity Required	Quantity Required	—
Nipple or Length of Non-Perforated Pipe; dia: 4 in. (100 mm)	—	1	1	—	—	—
Tee (with 3 Hubs), 4 in. (100 mm)	—	1	1	—	—	—
Manifold Assembly, 4 in. (100 mm), includes: 2 lengths of non-perforated pipe, each terminating in one compatible pipe tee	—	—	—	1	—	—
"Below Ground Pipe Type"—Perforated See Table 7	Quantity Required	Quantity Required	Quantity Required	Quantity Required	Quantity Required	—
For Soil-Gas Collector Type 1: 10 ft (3 m) lengths of rigid or flexible perforated pipe, dia: 4 in. (100 mm), see Table 4	2	—	—	4	—	—
or For Soil-Gas Collector Type 2, 3, and 5: Loop of flexible or rigid 10 ft (3 m) lengths of rigid or flexible perforated pipe at foundations interior perimeter, dia: 4 in. (100 mm), see Table 4	—	1	1	2	1	—

[A] Openings around radon pipes that penetrate the foundation's slabs shall be sealed with polyurethane caulk or non-shrink grout.
[B] Openings around radon pipes that penetrate the foundation's footings and walls, or both, shall be sealed with polyurethane caulk or non-shrink grout.
[C] The membrane, where it is penetrated by the suction point pipe, shall be sealed to the pipe. Parts, materials and methods for sealing this opening should be provided. Prior to sealing the membrane's pipe penetration, supports for the pipe and the membrane should be installed.
[D] A 20 ft (6 m) straight length of rigid perforated or flexible corrugated perforated pipe or a loop of rigid perforated or flexible corrugated perforated pipe (and necessary fittings) is attached to each end of the manifold. For examples of soil-gas collector to manifold connections see Fig. 1.
[E] Material, methods, and fittings for attaching proprietary mat to the suction point pipe are specific to each mat manufacturer.
[F] *(a)* For connections to rigid PVC pipe (in Table 7) use rubber coupling with designation "4 in (100 mm) PVC Plastic (DWV or S&D) / Cast Iron (XH-SV-NH) to 4 in (100 mm) PVC Plastic (DWV or S&D) / Cast Iron (XH-SV-NH)." *(b)* For connections to flexible polyethylene pipe (in Table 7) use rubber coupling with use designation "4 in (100 mm) PVC Plastic (DWV or S&D) / Cast Iron (XH-SV-NH) to 4 in (100 mm) corrugated polyethylene drainage tubing."

TABLE 7 Below Ground Pipe Types

Short Description	Construction	ASTM No.
PVC Sewer Pipe	Rigid	D 2729
4-in. (100-mm) PVC Sewer Pipe	Rigid with Hole Perforations	D 2729
SDR ABS Sewer Pipe	Rigid	D 2751
PE Corrugated Pipe	Flexible	F 405
PE Corrugated Pipe	Flexible with Hole Perforations	F 405
PE Corrugated Pipe	Flexible with Slit Perforations	F 405
Any Pipe Type in Table 8	Rigid	
Any Pipe Type in Table 8	Rigid With Perforations	

sides suggest casting the concrete slab directly over the mat's filter fabric cover. The instructions for installing strips of filter fabric with matrices of plastic filaments attached to one side direct that the mat strip be placed with the filter fabric side down (against the soil); that the exposed matrices of plastic filaments be covered with polyethylene sheeting; and that the concrete slab be cast over the polyethylene sheets. In all cases the mat manufacturer's installation instructions should be followed. Geo-textile mat has been used as a soil-gas collector in radon systems where aggregate was not available or has been considered by a contractor to be prohibitively expensive. Mat manufacturers produce mat strips in different widths and have different installation instructions and different procedures for attaching the suction-point pipe to the mat. At least one manufacturer reports availability of a mat that is 39 in. (1 m) wide. The different proprietary mats provide differing amounts of void space under slabs (see 6.4.1.3). Normally proprietary mat has not been used in addition to clean aggregate for radon control purposes; however, if a proprietary mat is used in addition to a layer of clean aggregate of uniform thickness, the total void space under the slab may be determined by adding the void space in the mat to the void space in the aggregate, provided that a radon suction point pipe is attached to both the mat and to the aggregate. (See Table 3 for example calculations of void space.)

6.4.2.5 *Type 5—Loop of Perforated Pipe on Soil under Membrane*—A loop of 4 in. (100 mm) perforated pipe placed on level soil and not buried in aggregate, shall be permitted only with membrane ground covers. The pipe shall be placed on leveled soil and shall follow the interior perimeter of the foundation. The ends of the pipe shall be joined in a tee assembly to which the suction point shall be attached. The tee assembly shall be located so that its suction point pipe penetrates the membrane at a place that does not permit the radon system piping to block windows and doorways, or otherwise restrict use of the space over the membrane. (See Table 4, Table 5, Table 6, and Fig. 1 for additional specifications.)

NOTE 14—Noise may be noticeable in fan-powered systems at the connection of the suction point pipe and the Type 5 perforated soil-gas collector pipe, when air leakage into the space under the membrane is large. Sound insulation to muffle the noise at this connection may be necessary.

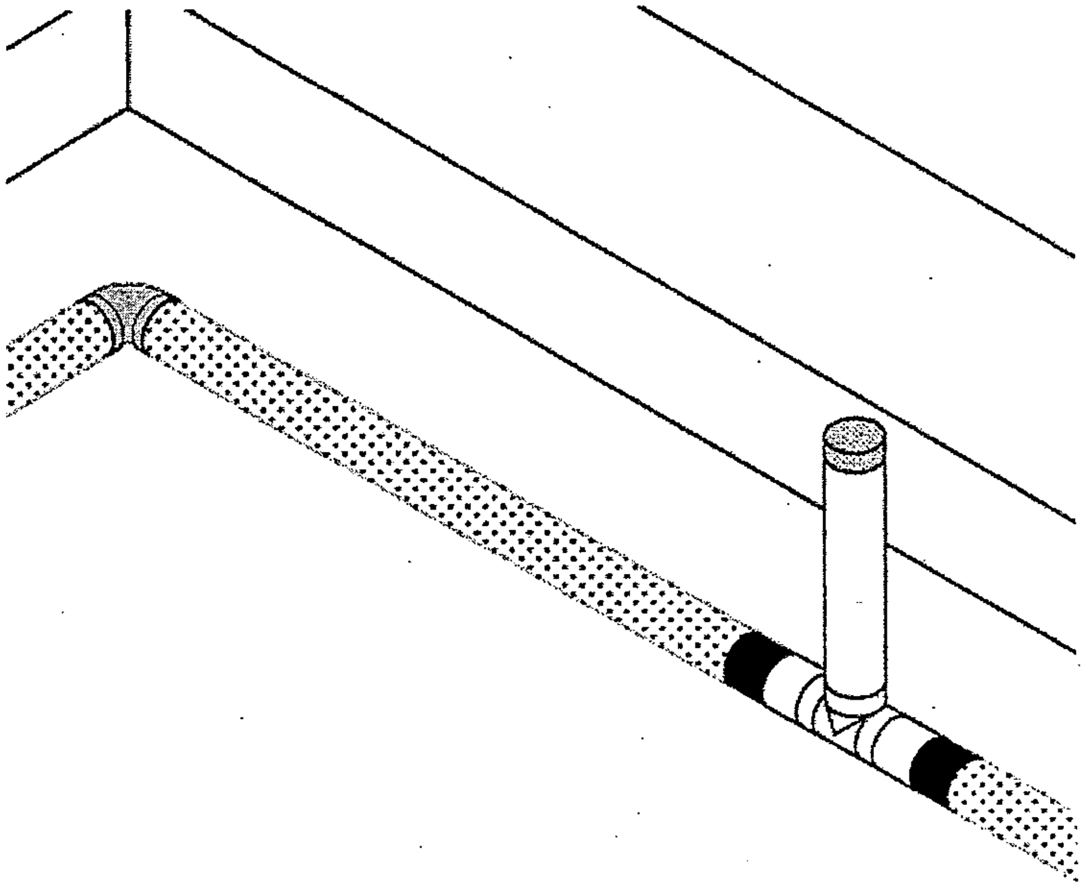
6.4.2.6 *Soil-gas Collector in Each Gas-Permeable Layer*—A soil-gas collector shall be installed in every sub-slab gas-permeable layer. Each compartment within the concrete footing's footprint shall be constructed to enable soil depressurization. To keep construction debris out, a temporary cap shall be installed on the suction point pipe where the vent stack pipe or manifold pipe is to be attached. Fig. 1 shows a perimeter footing and a strip footing. For purposes of illustration, two soil-gas collectors have been installed in Fig. 1; on the left is a Type 1 soil-gas collector pipe and on the right is a Type 2 soil-gas collector pipe (see Table 4). A manifold made of non-perforated below-ground-type pipe connects the two soil-gas collectors to the suction point pipe. When the aggregate is installed it will cover the soil-gas collector piping and the manifold. When the slab is cast there will be two sealed chambers filled with aggregate each connected by a sub-slab manifold to the suction point pipe which extends up through the slab.

6.4.3 *Pipe Connections to Soil-Gas Collectors*—Six methods for connecting soil-gas collectors to the radon system piping are compared in Table 5. Gas-permeable layers, mats, and soil-gas collectors shall be connected to suction points and manifold pipes using the methods in Table 6. Manifold designs, for sub-slab/membrane use, shall prevent soil-gas of one gas-permeable layer from being drawn through the soil-gas collector of another gas-permeable layer. All radon system piping, including suction point and manifold piping shall be of a pipe type intended for above ground use and specified in Table 8 and 6.5.1.2. All soil-gas collector piping shall be of a pipe type intended for below ground use and specified in Table 7 and 6.5.1.3. *Discussion*—Soil-gas flows from the gas-permeable layer/soil-gas collector into the suction point pipe. There are six methods for connecting suction point pipes to soil-gas collectors. When it is not practical to connect each suction point pipe directly to a vent stack above the sealed ground cover (see 3.2.4), suction point and manifold piping shall be placed under that ground cover. The suction point pipe shall be routed vertically and upward from the soil-gas collector, or offset horizontally from the soil-gas collector to one side or the other. (See Fig. 5.) (**Warning**—While attaching suction point and other pipes, care should be exercised to assure that wet concrete or other material does not plug or obstruct the void space in the gas-permeable layer or plug the sub-slab or sub-membrane piping. Until the suction point pipe is connected to the rest of the radon system piping, the open end of the suction point pipe should be temporarily capped (or plugged) to keep out debris.)

6.4.3.1 *Method 1: Vertical Suction Point Pipe Directly Over Soil-Gas Collector Pipe*—When the intended position of a suction point pipe is directly over the gas-collector pipe, the suction point pipe connection shall be made according to Method 1 in Tables 5 and 6. (See Fig. 1.)

6.4.3.2 *Method 2: Vertical Suction Point Pipe Offset from Soil-Gas Collector Pipe*—When the intended position of a vertical suction point pipe is not directly over the soil-gas collector pipe, the suction point connection shall be made according to Method 2 in Tables 5 and 6. (See Fig. 1.)

6.4.3.3 *Method 3: Horizontal Suction Point Pipe Beside Soil-Gas Collector Pipe*—When the intended position of the suction point pipe is horizontal and in the same plane as the soil-gas collector pipe, the suction point pipe connection shall be made according to Procedure 3 in Tables 5 and 6. (See Fig. 1.)



NOTE 1—Suction point rises from loop of perforated pipe. (See Types 1 and 5 in Table 4; see Methods 1, 4, and 5 in Tables 5 and 6.)

FIG. 4 Vertical Suction Point Pipe

TABLE 8 Above Ground Pipe Types

Short Description	Construction	ASTM No.
Schedule 40 PVC	Pressure Rated	D 1785
Schedule 40 PVC	Pressure Rated	D 2466
Schedule 40 PVC DWV	DWV	D 2665
Schedule 40 PVC DWV	DWV with Cellular Core	F 891
Schedule 40 ABS	Pressure Rated	D 2282
Schedule 40 ABS DWV	DWV	D 2661
Schedule 40 ABS DWV	DWV with Cellular Core	F 628
SDR PVC (see Table 10)	Pressure Rated	D 2241

Exception—Exterior perimeter drains that *(1)* are not connected in any way to an interior perimeter drain, *(2)* share no component(s) with interior perimeter drain(s), and *(3)* are located entirely outside the building's footprint shall be permitted in addition to those specified in Table 9.

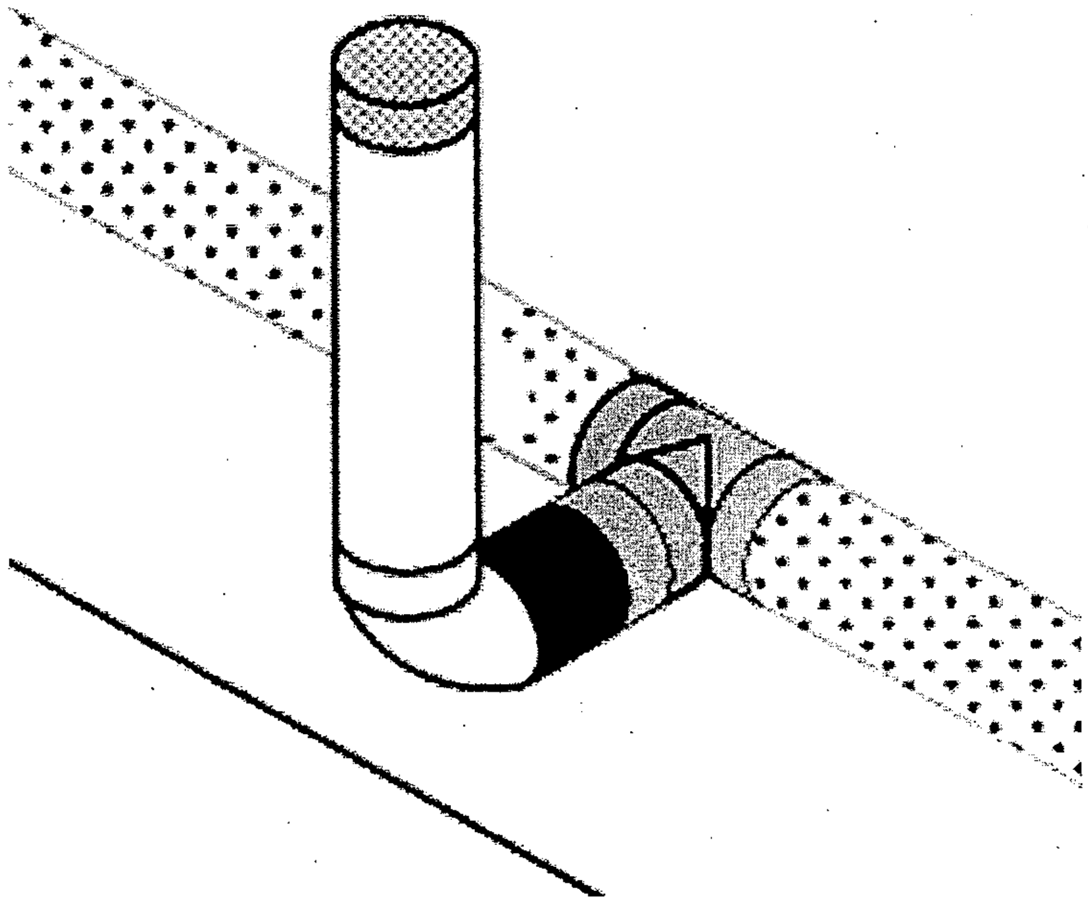
(3) Installing Soil-gas Collectors and Interior Perimeter Drains—Soil-gas collectors Types 2, 3, and 5 (see Table 4) also serve as interior perimeter drains. These loops of flexible perforated drain pipe shall be laid down so that the loop's ends terminate in an appropriately located sump tub that has been fitted with a sealing cover. The loop shall be installed so that water, sufficient to inhibit air flow, does not accumulate in it. Seals are not required at the places on a tub's side walls where the perforated pipe, serving as the interior perimeter drain, penetrate it.

(4) Piping for Radon and Ground Water Control Systems—including soil-gas collectors/interior perimeter drains, sump tubs, and other radon and drainage system piping should be installed and inspected for compliance with 6.4.4 before the gas-permeable layer is placed.

(5) Joining Gravity operated Interior and Exterior Perimeter Drains—Gravity operated exterior and interior perimeter drains are permitted to share a run-off (non-perforated gravity drain pipe) provided that such joining is accomplished using Table 9's Configuration 7 or 9a; dedicated run-offs for the interior and exterior drains covered by Configurations 7 and 9a are also permitted.

(6) Backwater Check Valve Service—Backwater check valves shall be easily accessible for service and replacement.

Discussion—The backwater check valve permits water to flow out of the interior perimeter drain's sump tub without allowing soil-gas from the interior perimeter drain's run-off pipe or from an exterior perimeter drain pipe to leak into the interior perimeter drain and its surrounding gas-permeable layer. For maintenance of the backwater valve and the gravity



NOTE 1—Suction point pipe is offset horizontally from the soil-gas collector (or manifold) to locate its slab penetration for unobtrusive connection to the radon vent stack; see Method 2 in Tables 5 and 6.

FIG. 5 Off-set Vertical Suction Point Pipe

operated run-off pipes down stream from it, the backwater check valve's cover should be removed.

(7) When Both Interior and Exterior Perimeter Drains are Desired—When the ground water conditions at the building site indicate that interior and exterior perimeter drains are required and that both drains must be dewatered by pumping, two sump tubs shall be installed according to Table 9's Configurations 8a and 8b (for pump operated dewatering) or Configurations 9a and 9b (for pump and gravity dewatering.)

(8) When Multiple Submersible Sump Pumps are required in a Sump Tub—When a back-up sump pump and other additional sump pump(s), or both, are deemed desirable or necessary in a particular sump tub, such installation shall be

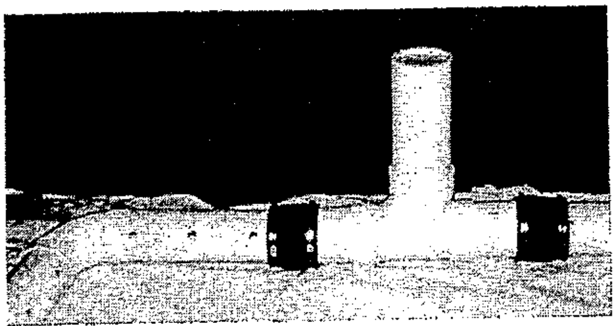


FIG. 6 Vertical Suction Point Pipe Assembly

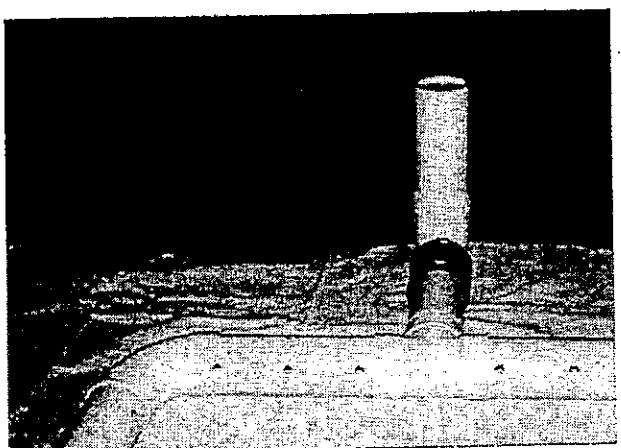


FIG. 7 Off-set Vertical Suction Point Pipe Assembly

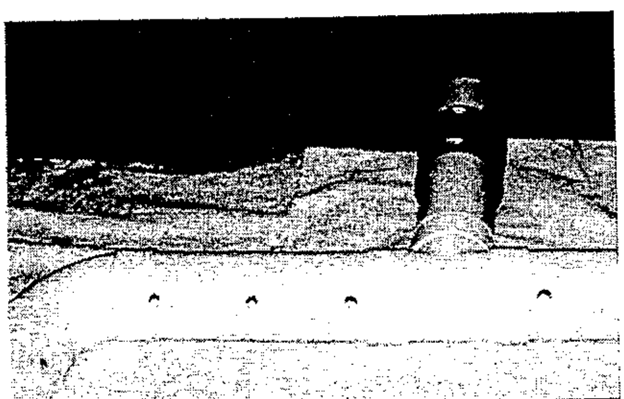


FIG. 8 Horizontal Suction Point Pipe Assembly

permitted, provided that the sump tub's diameter is appropriate for the additional pump(s) and the sump tub's required sealing can be achieved.

(9) Gravity Drain Pipe Clean-out—Gravity drain clean-outs are recommended for run-off drain pipes that are: (a) outside the building's footprint and (b) down stream from the drain pipe's connection to the perforated exterior perimeter drain pipe, especially when Configuration 4b is installed.

(10) Drain Pipes that Penetrate Footings and Sump Tubs—Rigid pipe with cemented joints shall be used for pipes that pass through footings. Note that to obtain proper fit, the pipe used to penetrate the footing, the sump tub side seals and the output hub of the backwater check valve must have compatible diameters where they attach; all are commercially available in sizes compatible with Schedule 40 pipe.

(11) Openings in Footing around Drain Pipe Penetrations—Drain pipe penetrations in foundation footings shall be made for rigid non-perforated drain pipe; the openings around the pipe shall be sealed with low shrink mortar or grout unless the drain pipe is cast in place or is positioned in the footing's form prior to casting the concrete footing. After the gravity drain pipe extends outside the building's footprint, it is permitted to be either rigid or flexible drain pipe or as specified by applicable code.

Exception—When applicable building codes require sleeves for foundation wall or footing penetrations, the opening between the sleeve and the rigid non-perforated drain pipe shall be filled with a flexible caulk such as urethane.

(12) Sump Tubs shall have Removable Covers with Seals and shall have Sealed Joints where they meet the Floor Slab (or Other Ground Cover)—Sump tubs specified in Table 9 shall be sealed to the concrete slab or membrane that they penetrate. Sump tubs shall have removable bolt-on covers that have a gasket for the cover's seal. The tub's cover shall have rubber bushing type seals at its penetrations, including sump pump discharge pipe, submersible sump pump's power cord, sump view port, and so forth. If a sump pump is not installed in a sump tub, any unused openings in the cover shall be closed with durable but removable air-tight plugs. Sump tubs for the single submersible sump pump configurations found in Table 9 should have diameters that are about 18 in. (0.5 m); the tub's diameter shall be larger when multiple submersible pumps are required in a single tub.

(13) Water Control System Drainage—Dewatering of water control systems and their components, like sump tubs and perimeter drains, are permitted by means of gravity flow, sump pump or both, depending on the owners preference and the drainage requirements and topography of the site. Gravity operated run-offs are permitted to terminate at daylight, at a dry well, or in a storm sewer depending on customer preference and applicable codes. In all cases, water control methods that prevent air leakage into the gas-permeable layer shall be used (see 6.4.4).

(14) Greater Footing Height—Contractors should consider thickened footings under the place where horizontal drain pipes pass through them.

(15) Sump Tubs or Sump Pits—Sealing is required on both. Sump tubs and sump pits can be used interchangeably, however the sump tub and its factory manufactured seals are recommended.

6.4.4.2 *Interior Perimeter Drain Requirements*—The following requirements apply to interior perimeter drains; the general requirements in 6.4.4.1 also apply:

(1) Permitted Interior Perimeter Drain Configurations—are defined in Table 9; Configurations 1, 2, and 3 are exclusively for interior perimeter drains. Fig. 9 corresponds to Configuration 3, which is an interior perimeter drain dewatered by both gravity flow and sump pump. Configuration 1 is dewatered by gravity only; Configuration 2 is dewatered by

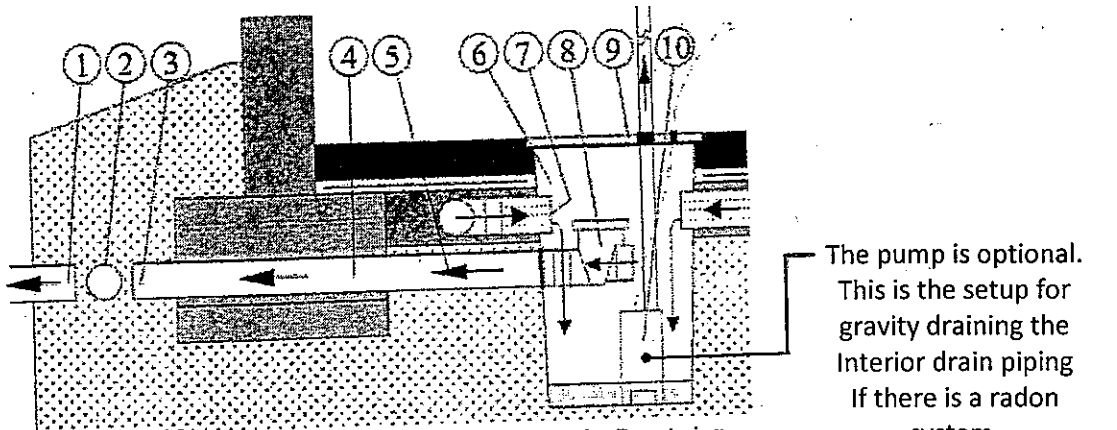


FIG. 9 Interior Perimeter Drain with Sump Pump and Gravity Dewatering

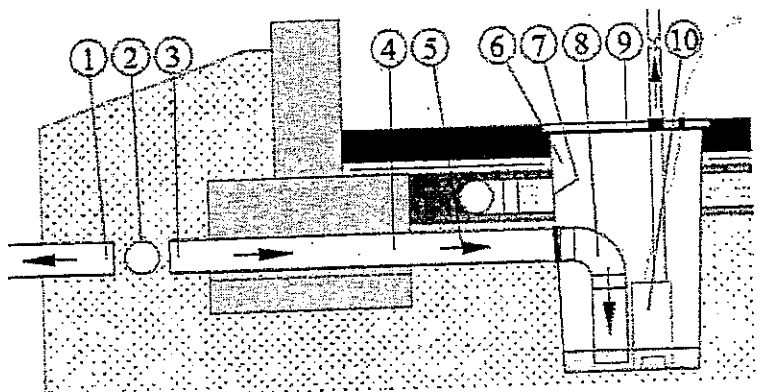


FIG. 10 Exterior Perimeter Drain with Sump Pump and Gravity Dewatering

sump pump only. Configurations 7, 8a, 8b, 9a, and 9b also have interior perimeter drains, but in combination with exterior perimeter drains.

(2) Ten Features/Components/Items of Interior Perimeter Drains—vary from one interior drain configuration to the next; the ten items are shown in Fig. 9 and listed in Table 9. The arrowheads shown in Fig. 9, (item 5 being an example,) indicate normal direction of flow for drain's water.

(3) Interior Perimeter Drain's Perforated Pipe (item 7 in Figure 9)—Soil-gas collector perforated pipe loops, Types 2, 3, and 5, are the only pipes that are permitted for use as interior perimeter drain pipes (see Table 4). The ends of the soil-gas collector shall be routed to an appropriately located sump tub. This loop of perforated pipe shall be installed level so that air flow in it is not restricted by accumulated water along the pipe route.

(4) The Exterior Perimeter Drain (Item 2 in Figure 9)—when present is a common source of unwanted air leakage into the gas-permeable layer of radon reduction systems. The exterior perimeter drain shall not be directly connected to the interior perimeter drain in buildings where radon reduction by soil-depressurization is specified.

(5) The Backwater (Check) Valve (Item 8 in Figure 9)—prevents unwanted air leakage into the gas-permeable layer from gravity drain run-offs (item 1 in Fig. 9) and from exterior perimeter drains (item 2 in Fig. 9.) The backwater valve is required in four of the eight interior perimeter drain configurations, specifically Configurations 1, 3, 7, and 9a.

(6) The "Thru the Footing" Pipe (Item 4 in Figure 9)—When used with an interior perimeter drain the "thru the footing" pipe connects the gas-permeable layer/soil-gas collector/interior perimeter drain (item 7 in Fig. 9) to a gravity run-off (item 1 in Fig. 9.) The end of the "thru the footing" pipe (item 3 in Fig. 9) connects to a dedicated interior gravity run-off for Configurations 1 and 3. However, for Configurations 7 and 9a the end of the "thru the footing" pipe connects to either a dedicated interior drain run-off or to a combined run-off that also takes water from the exterior perimeter drain. The "thru the footing" pipe is prohibited in Configurations 2, 4b, and 8a.

(7) Submersible Sump Pump (item 10 in Figure 9)—When interior perimeter drain Configurations 2, 3, 8a, and 9a are required, the sump pump, its discharge piping, its check valve and the drilled sump cover (item 9 in Fig. 9) with bushing seals for electric cord and discharge pipe shall be installed.

Exception—Configurations 2, 3, 8a and 9a are permitted without a submersible sump pump installed, provided that their sump tub cover is either not drilled (that is, left blank) or is sealed with removable plugs at penetrations for pump discharge and electric power cord, and so forth.

TABLE 9 Permitted Perimeter Drain Configurations

Configuration Number:	1	2	3	4a w/sump	4b w/o sump	5	6	7	8a sump 1	8b sump 2	9a sump 1	9b sump 2
Perimeter Drain Type:	Interior	Interior	Interior	Exterior		Exterior	Exterior	Interior and Exterior	Interior and Exterior		Interior and Exterior	
Dewatering Method:	gravity	pump	gravity and pump	gravity		pump	gravity and pump	gravity	pump for interior	pump for exterior	gravity for int. and ext.; pump for interior	pump for exterior
Reference Figure:	Fig. 9	Fig. 9	Fig. 9	Fig. 10	Fig. 10 [A]	Fig. 10	Fig. 10	Fig. 9 [B]	Fig. 9	Fig. 10	Fig. 9 [B]	Fig. 10
Item 1 Type of run-off pipe (Item 1)—run-off pipe runs by gravity to dry well, daylight, storm sewer, and so forth. A) Dedicated interior drain, B) Dedicated exterior drain, C) Merged exterior and interior drain, D) None	A	none	A	B	B	none	B	(A and B) or (C)	none	none	(A and B) or (C)	none
Item 2 Exterior perimeter drain (Item 2) is connected to: A) Item 1 gravity run-off (see Item 1 for type), B) Item 3 "outside end" of "thru-footing" pipe, C) Nothing, D)n/a (ext. per. drain is not present)	n/a	n/a	n/a	A and B	A	B	A and B	A and B	nothing	B	A and B	B
Item 3 "Outside end" of "thru-footing" pipe (see Item 3) is connected to: A) Item 1 run-off (see Item 1 for type), B) Item 2 exterior perimeter drain pipe, C) n/a ("thru-footing" drain pipe is not present)	A	n/a	A	B	n/a	B	B	A	n/a	B	A	B
Item 4 "Thru-footing" pipe A) Required or B) Prohibited	required	prohibited	required	required	prohibited	required	required	required	prohibited	required	required	required
Item 5 Gravity Drain Pipe Flow Direction: A) Out of building (out), B) Into building (in), C) n/a ("thru-footing" drain pipe is not present)	out	n/a	out	in	n/a	in	in	out	n/a	in	out	in
Item 6 Sump tub: A) Required or B) None	required	required	required	required	none	required	required	required	required	required	required	required
Item 7 Interior perimeter Drain connection: soil-gas collector shall penetrate sides of sump tub. A) Required, B) Prohibited, or C) n/a	required	required	required	prohibited	n/a	prohibited	prohibited	required	n/a	prohibited	required	prohibited
Item 8 "Inside end" of "thru-footing" drain pipe is connected to: A) Backwater valve (BV)—required, B) Water Trap (WT)—Recommended, C) n/a ("thru-footing dral pipe is not present)	BV	n/a	BV	WT	n/a	WT	WT	BV	n/a	WT	BV	WT
Item 9 Sump tub cover style: A) Blank, B) Drilled (for sump pump connections) or, C) n/a (no sump tub is present)	blank	drilled	drilled	blank	n/a	drilled	drilled	blank	drilled	drilled	drilled	drilled
Item 10 Submersible sump pump A) Required or, B) None	none	required	required	none	none	required	required	none	required	required	required	required

[A] Configuration 4b is a tee fitting in the exterior perimeter drain that directs water by gravity to a run-off drain pipe.

[B] Configurations 7 and 9a permit joining of interior and exterior perimeter drains to use a common run-off drain, but only outside the building's footprint. Configurations 7 and 9a also permit the interior and exterior drains to have separate dedicated run-off pipes.

(8) The Sump Tub with Bolt on Sealed Cover (item 6 in Figure 9)—is required by all Configurations except Configuration 4a. Where the "thru the footing" pipe (item 4 in Fig. 9) penetrates the sump tub wall an air and water tight seal is required. When a sump pump is not installed in the sump tub, the bolt on cover shall be blank, (that is, be without drilled holes,) except for those holes used to fasten the cover to the tub.

6.4.4.3 *Exterior Perimeter Drain Requirements*—The following requirements apply to exterior perimeter drains; the general requirements in 6.4.4.1 also apply:

(1) Permitted Exterior Perimeter Drain Configurations—are defined in Table 9 (see Configurations 4a, 4b, 5, and 6). Figure 10 corresponds to Configuration 6, which is an exterior perimeter drain dewatered by both gravity flow and sump pump. Configurations 4a and 4b are dewatered by gravity only. Configuration 4a allows maintenance of exterior perimeter drain's gravity run-off pipe from within the building's footprint. Configuration 4b is an exterior perimeter drain installed entirely outside the building's footprint; maintenance work for Configuration 4b must be performed outside the building's footprint using an outside clean-out or a manhole. Configuration 5 is dewatered by sump pump only. Configurations 7, 8a, 8b, 9a, and 9b also have exterior perimeter drains, but in combination with interior perimeter drains.

(2) Ten Features/Components/Items of Exterior Perimeter Drains—vary from one exterior drain configuration to the next; these ten items are shown in Fig. 10 and are listed in Table 9. The arrowheads shown in Fig. 10 (item 5 being an example) show the water's normal direction of flow.

(3) Soil-gas Collector Perforated Pipe (item 7 in Figure 10)—shall not be connected to exterior perimeter drains or to sump tubs used in Configurations 4a, 4b, 5, 6, 8b, or 9b. All soil-gas collectors, including Types 2, 3, and 5, all interior perimeter drains, and all gas-permeable layers shall be isolated from the spaces used by exterior drains and their components, including sump tubs (item 6 in Fig. 10.)

(4) The Exterior Perimeter Drain (Item 2 in Figure 10)—when present is a common source of unwanted air leakage into the gas-permeable layer of radon reduction systems. The exterior perimeter drain shall not be directly connected to the interior perimeter drain in buildings where radon reduction by soil-depressurization is specified. The perforated drain pipe of an exterior perimeter drain shall always be routed entirely outside the building's footprint. Other components of an exterior perimeter drain shall be kept outside the building's footprint. *Exception*—If it is intended that a sump pump as well as (or instead of) gravity flow be used to drain the exterior perimeter drain, it is permitted to connect the exterior drain to a sealed sump tub located within the building's footprint with a sealed "thru the footing" rigid non-perforated drain pipe (see item 4 in Fig. 10).

(5) The Water Trap (Item 8 in Figure 10)—prevents unwanted soil-gas and radon from leaking into the sump tub from the exterior perimeter drain while sump pump and other maintenance is being performed. The water trap also prevents unwanted soil-gas and radon from entering occupiable space when the sump cover is off or when its seal is imperfect. The water trap consisting of a quarter turn pipe elbow and a length of pipe that extends at least 2 in. (50 mm) into standing water at the bottom of the sump tub. The water trap assembly should be secured to its supporting pipe with a stainless steel screw fastener, to facilitate removal if maintenance and inspection of the exterior perimeter's run-off is required. The water trap is recommended, but not required, for Configurations 4a, 5, 6, 8b, and 9b

(6) The "Thru the Footing" Pipe (Item 4 in Figure 10)—connects the exterior perimeter drain (item 2 in Fig. 10) to the sump tub (item 6 in Fig. 10); this connection makes it possible to dewater the exterior perimeter drain with a pump located within the building's footprint. The "thru the footing" pipe (item 4 in Fig. 10) shall be non-perforated and rigid; it shall have cemented air-tight joints. One end of this connecting pipe shall be attached to the exterior perimeter drain at a location outside the building's footprint; the other end shall be attached to sump tub wall using hubs, seals, or other sump tub accessories specifically designed to provide water-tight attachment and seal between a sump tub and pipe. The use of "thru the footing" pipe is prohibited in Configurations 2, 4b, and 8a.

Discussion—Commercially available seals bushings and hubs (sump tub accessories) are compatible with Schedule 40 pipe sizes.

(7) Required Exterior Perimeter Drain Connections—*(1)* Configurations 4a and 6 require that Fig. 9's item 1, 2, and 3 be connected; specifically the exterior perimeter drain (item 2) must be connected to both the "thru the footing" pipe (item 3) and its dedicated run-off (item 1); *(2)* Configuration 4b requires that Fig. 9's items 1 and 2 be connected; specifically the exterior perimeter drain (item 2) musts be connected only to its dedicated run-off (item 1); and *(3)* Configurations 5, 8b, and 9b require that Fig. 10's items 2 and 3 be connected; specifically the exterior perimeter drain (item 2) must be connected to the "thru the footing" pipe (item 3).

(8) Submersible Sump Pump (item 10 in Figure 10)—When exterior perimeter drain Configurations 5, 6, 8b and 9b are required, the sump pump, its discharge piping, its check valve and the drilled sump cover (item 9 in Fig. 9) with bushing seals for electric cord, and discharge pipe shall be installed.

Exception—Configurations 5, 6, 8b, and 9b, installed as part of a water control contingency plan during construction or for other reasons, are permitted without a sump pump installed, provided that their sump tub cover is either not drilled (that is, left blank) or is sealed with removable plugs at penetrations for pump discharge and electric power cord, and so forth.

(9) Sump Tubs with Bolt on Sealed Covers (item 6 in Figure 10)—are required by all Configurations except Configuration 4a. Where the "thru the footing" pipe (item 4 in Fig. 10) penetrates the sump tub wall an air and water tight seal is required.

6.4.5 *Sealing Gas-Permeable Layer*—The gas-permeable layer shall be sealed at the top, sides, and bottom. Heating ducts that pass through the gas-permeable layer or the soil below, or both, shall be avoided. *Discussion*—Heating, Ventilation, and Air Conditioning (HVAC) ducts are serious potential radon entry pathways when they are installed in or below the gas-permeable layer. Because return air ducts run at negative pressure and are not completely airtight, soil-gas leaks into them. Supply air ducts which are not completely sealed and which are buried in or below the gas-permeable layer are radon entry pathways when the HVAC system is not operating and they are no longer pressurized.

6.4.5.1 *Sealing Top of Gas-Permeable Layer*—Slabs and membranes are the top seals of the gas-permeable layer. Slab penetrations and openings around pipes, conduits, and other objects shall be sealed. The slab should be poured tight to the foundation walls and the objects that penetrate the slab. When the slab is not poured tight to foundation walls and tight to penetrating objects, all joints and openings shall be sealed with polyurethane caulk. The floor wall cold joint shall be sealed with polyurethane caulk when expansion joints, which are intended to cushion the slab's motion, are used (see 6.2.5). Sump pits and tubs shall have sealed covers. Floor or condensate drains, or both, terminating in the soil shall be eliminated or trapped (see 6.2.4.1). When membranes are used as crawlspace ground covers, they shall be sealed to foundation walls, at their seams, and at all penetrations (see 6.1.3.3).

6.4.5.2 *Sealing Sides of Gas-Permeable Layer*—Foundation walls and footings (or curtain walls) seal the gas-permeable layer on the sides. Openings around utility pipes and conduits and other penetrations under the slab or membrane shall be sealed. Pipes and conduits shall be air and water tight. Open ends of conduits shall not terminate in the gas-permeable layer or in the soil below.

6.4.5.3 *Sealing Bottom of Gas-Permeable Layer*—When building on permeable soils, a membrane or a concrete slab can be placed between the footings and under the gas-permeable aggregate to seal the bottom of the gas-permeable layer. A geo-technical engineer and a structural engineer should be consulted when building on ground where blasting has occurred or where the material on which the footings are to be located is known to be highly permeable to gas, like certain karst. The engineers should be asked to design a foundation with sealed bottom and sides for the gas-permeable layer. When a membrane or a slab is placed on the soil under the gas-permeable layer, water drainage from the slab or membrane shall be provided. *Discussion*—Undisturbed soil under buildings usually seals the bottom of the gas-permeable layer. Footings resting on undisturbed soil usually seal the foundation walls to the soil. Generally the undisturbed soil under a building is assumed to be non-permeable or only slightly permeable. When soil is highly permeable or has been disturbed, which increases its permeability, greater soil-gas leakage into the gas-permeable layer should be expected. Such leakage can cause soil depressurization radon reduction systems to have degraded performance.

6.4.5.4 *Sealing Penetrations of the Gas-permeable Layer*:

(1) Ducts—Heating ducts or other ducts shall not contact the gas-permeable layer or soil, and shall not be installed under ground covering slabs or membranes.

(2) Pipes—Pipes and conduits passing into or through the gas-permeable layer or soil below a dwelling shall be airtight after installation. *Examples*—An exterior perimeter drain connected to an interior sealed sump tub shall not be connected with perforated pipe. An electrical conduit carrying wires for an outdoor light shall be air and water tight and shall not terminate with an unsealed end in the gas-permeable layer or in soil.

TABLE 10 SDR (Standard Dimension Ratio) Pipe Series

When nominal pipe diameter range is:	The SDR Series Number shall be equal to or less than:[A]
1 to 1.5-in. (25.4 to 38.1-mm)	13.5
2 to 3.5-in. (50.8 to 88.9-mm)	17
4 to 6-in. (101.6 to 152.4-mm)	21
8-in. (203.2-mm)	26

[A] The wall thickness for SDR series pipe is determined by dividing the average outside diameter dimension by the SDR series number. (See Specifications D 2241 and D 2282.)

6.5 *Radon System Piping*:

6.5.1 *Physical Requirements of Pipe*:

6.5.1.1 *Pipe Wall Thickness*—For radon system piping described with a Schedule number, the minimum wall thickness shall be equal to or greater than that of Schedule 40. Dimensions for the schedules of steel and certain plastic pipes are specified in ASME B36.10M (see 2.2). For radon system piping described by a standard dimension ratio (SDR) series number, the pipe series shall be selected from SDR series specified in Table 10.

6.5.1.2 *Above Ground Piping*—All radon system piping shall be of a type selected from Table 8; for pipe size see 6.5.2. Certain SDR series pipes are acceptable as "Above Ground Pipe Types."

6.5.1.3 *Below Ground Piping*—All soil-gas collector piping shall be of a type selected from the Table 7. Below ground pipes types designated Specification D 2729, Specification D 2751, and Specification F 405 shall not be used in radon systems above slabs or membranes. The use of any piping with an ASTM designation listed in Table 8 shall be permitted for below ground radon system use. For pipe size see 6.5.2.

6.5.2 *Pipe Size*:

6.5.2.1 *Above Ground Pipe Size*—Four-inch (100-mm) inside diameter (ID) is the nominal radon system pipe size for use above ground. Three-inch (75-mm) ID pipe shall be the minimum radon system piping size permitted for use above ground; it shall be permitted only when air leakage into the gas-permeable layer is expected to be low for the life of the building. Four-inch (100-mm) minimum ID or larger pipe shall be used when using construction features with the potential to allow additional air leakage into the gas-permeable layer including: *(1)* when a building has a membrane for a ground cover that could be used in conjunction with a sub-membrane depressurization system, *(2)* when a building has a 1500 ft^2 (140 m^2) or greater foot print, *(3)* when the site has high soil permeability, *(4)* when fibrous expansion joint material is used at the floor wall joint or in slabs, *(5)* when there has been blasting at the construction site, *(6)* when footings are placed over boulders or crushed stone, and *(7)* when any other construction feature that could cause air leakage into the gas-permeable layer is present.

6.5.2.2 *Below Ground Pipe Size*—For below ground use, the minimum pipe size shall be 4-in. (100-mm) ID.

6.5.3 *Connection to Gas-Permeable Layer*—The gas-permeable layer shall be connected to the suction point pipe through one of the soil-gas collectors which are defined in Table 4. When the gas-permeable layer under a building is not continuous (that is, split level buildings with their multiple slabs or in buildings with strip footings that divide the gas-permeable layer into isolated compartments), a soil-gas collector shall be installed in each individual gas-permeable layer. The soil-gas collectors shall be connected to the radon piping system. When a suction point cannot share a vent stack pipe by connecting to a manifold, it shall be connected to its own vent stack pipe (see 6.4.3).

NOTE 16—The location of suction point pipes should be decided before the gas-permeable layer or the ground cover is installed. A suction point pipe in the wrong place can be an unsightly obstruction in living space.

6.5.4 *Discharge from Vent Stack Pipes*—To reduce the risk of vent stack blockage due to heavy snow, to reduce the potential for re-entrainment of radon into the living spaces of a building, and to prevent direct exposure of individuals outside of buildings to high concentrations of radon, certain minimum requirements for the discharge from vent stack pipes of soil depressurization systems have been established. The minimum requirements for the vent stack pipes and their discharge are all of the following:

(1) The vent stack pipe shall be vertical and its discharge upward, unobstructed, outside the structure, at least 10 ft (3 m) above the ground level, above the edge of the roof, and shall also meet the separation requirements of *(2)* and *(3)* below. Whenever practicable, vent stack pipes shall terminate above the highest roof of the building and above the highest ridge.

(2) The end of the vent stack pipe shall be 10 ft (3 m) or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure, if the radon discharge point is not at least 2 ft (0.6 m) above the top of such openings. Chimney flues shall be considered openings into conditioned or otherwise occupiable space.

(3) The end of the vent stack pipe shall be 10 ft (3 m) or more away from any opening into the conditioned or other occupiable spaces of an adjacent building. Chimney flues of adjacent buildings shall be considered openings into conditioned or otherwise occupiable space.

(4) For vent stack pipes which penetrate the roof, the point of discharge shall be at least 12 in. (0.3 m) above the surface of the roof. For vent stack pipes attached to or penetrating the sides of buildings, the point of discharge shall be vertical and a minimum of 12 in. (0.3 m) above the edge of the roof and in such a position that it can neither be covered with snow, or other materials nor be filled with water from the roof or an overflowing gutter.

(5) When a horizontal run of vent stack pipe penetrates the gable end walls, the piping outside the structure shall be routed to a vertical position so that the discharge point meets the requirements of sections *(1)*, *(2)*, *(3)*. and *(4)* above.

(6) Points of discharge that are not in a direct line of sight from openings into conditioned or otherwise occupiable space because of intervening objects, such as dormers, chimneys, windows around the corner, and so forth shall meet the separation requirements of sections *(1)*, *(2)*, *(3)*, *(4)*, and *(5)* above.

NOTE 17—Measurements from the point of discharge to openings into the conditioned or otherwise occupiable spaces of the structure shall be made from the point of discharge to the closest part of any opening into such space. For example, to determine compliance with section *(2)* above, when the location of a planned vent stack discharge can not be seen from a dormer window, the contractor would determine whether the required separation existed by routing a flexible measuring tape between the planned discharge point location and the part of the dormer window that is the shortest distance away. The measuring tape must follow the shortest possible path, and be allowed to bend where it passes intervening part(s) of the dormer.

NOTE 18—The discharge separation requirements of 6.5.4 apply whether the vent stack is capped, plugged, or open.

6.5.5 *Pipe Routes*—The specific pipe route that connects the suction point pipe(s) to the above roof discharge depends on the characteristics of the specific site and on whether the route is intended for a passive or a fan-powered operation. The radon system's pipe route, fan location, and monitor location can impact the use of interior space and should be specified before construction begins (see 6.5.7). All pipe routes, including those optimized for passive system operation, shall be capable of fan-powered operation. All passive system pipe routes shall provide space for installing a radon fan and a radon system monitor.

6.5.5.1 *Fan-Powered System Pipe Route*—The fan-powered system permits horizontal pipe runs and a reasonable number of fittings. The fan-powered system's pipes can be installed in outside walls without losing significant performance. The pipes of the fan-powered system should be insulated inside the thermal envelope to prevent water vapor in the air from condensing on them. Also, in very cold climates where the fan is subject to freezing the fan-powered system's pipes and fan located in unconditioned spaces shall be insulated to help prevent frost and ice buildup inside the vent stack piping and inside the fan. (See 6.5.7). *Discussion*—fan-powered radon reduction systems can apply 50 times more suction pressure at the suction points than passive systems. The chief advantage of a fan-powered radon system is that it always achieves a greater and more reliable radon reduction than passive systems. Also, fan-powered systems offer more flexibility in pipe location because their piping can use more fittings and can be placed in exterior walls which are outside the building's thermal envelope.

6.5.5.2 *Passive System Pipe Route*—Radon system piping used with a passive radon control system that relies on temperature differentials shall be routed within the thermal envelope of the building. Passive radon system piping shall not be routed within the outside walls of a building since these spaces are outside the thermal envelope. Pipe diameter used in passive radon systems shall be larger, fittings used (other than couplings) shall be fewer, and horizontal and nearly horizontal pipe runs shall be avoided. Radon system piping that is routed through unconditioned spaces shall be insulated to reduce heat loss from the piping. Piping routed within the building's thermal envelope, where the vent stack pipe can be warmed, shall not be insulated. The vent stack pipe discharge shall meet the requirements of 6.5.4. *Discussion*—The advantage of passive radon reduction systems is their low operating cost.

6.5.6 *Radon System Piping Drainage*—All components of radon system piping shall drain their condensed water vapor and collected rain completely to the ground beneath the slab or membrane. Horizontal pipe runs shall be sloped to accomplish the necessary drainage. Three-inch (75-mm) pipes operating with high air velocities can require pitches as much as 1½ in. per foot (115 mm per metre) depending on the air velocity. Drainage pitch for 4-in. (100-mm) pipes should be about ⅜ in. per foot (30 mm per metre).

6.5.7 *Radon System Fan Mounting Space and Piping Accessibility*—Radon vent stacks shall be accessible for subsequent installation of fans and system monitors. The accessible space reserved for the radon fan shall occupy an imaginary cylinder, standing on end, which is 24 in. (60 cm) or more in diameter, shall be centered about the axis of the vent stack pipe, and shall extend for a minimum vertical distance of 3 ft (90 cm).

6.5.7.1 *Accessibility for Fan Installation*—Radon vent stacks shall be routed to ensure accessibility to suitable space for future fan installation and servicing. Suitable spaces for fans located within the main building shell are outside the thermal envelope of the building in unconditioned areas and above occupiable space. Fan installation is permitted in a garage attic provided that the garage attic is unconditioned space, that it contains no occupiable space, and the garage attic has a full fire rated ceiling immediately under it. *Exception*—Access to the radon vent stack for mounting the radon fan shall not be required in interior space when an approved rooftop electrical supply is provided for future use and it is possible to mount the fan above the roof and still have the discharge point positioned according to 6.5.4.

6.5.7.2 *Accessibility for Radon System Monitor*—Access to a visual or audible radon system status indicator shall be provided at a location where radon system status can easily be obtained on a daily basis. Also the location of the radon system monitor shall be suitable for installing and servicing a plastic tube connecting the monitor to the vent stack.

6.5.8 *Radon System Piping Supports, Marking, Labeling and Insulation*:

6.5.8.1 *Radon System Piping Supports*—All above ground radon system piping shall be selected from the pipe types listed in Table 8. Pipe support hardware that is manufactured to support drain waste vent (DWV) piping above ground shall be used to support radon system piping. Horizontal and vertical runs of radon system piping shall be supported in accordance with applicable building codes for DWV pipe of the same type and size. The vent stack pipe shall be braced above and below the place where the fan should be installed and at the roof penetration. *Discussion*—The pipe supports should not interfere with installed pipe insulation. A radon fan should be supported by the vent stack pipe; the radon fan housing should not support the vent stack. Installing and replacing a radon fan without moving/removing the vent stack pipe by which it should be supported reduces the chances of creating water leaks around the vent stack's roof flashing. For additional guidance see Appendix X1 of Specification D 2665 and the support manufacturer's directions.

6.5.8.2 *Pipe and Fan Insulation*—The parts of the passive system vent stack pipe subjected to freezing temperatures shall be insulated; the parts of a passive system's piping that is routed inside the building's thermal envelope shall not be insulated. (See 6.5.5.2.) In places with very cold winters where the fan is subject to freezing, extra attention should be paid to pipe and fan insulation. The pipe insulation should be designed or selected to fit the radon system piping used. The fan should be located in an insulated enclosure located in unconditioned space. The enclosure should be built to permit fan replacement, without destroying its insulation. *Discussion*—Insulation improves four conditions. First, in cold climates passive system performance is improved by insulating passive vent stack pipes installed outside the building's thermal envelope. Second, water vapor condensation on the exterior of the piping is reduced for operating fan-powered systems. In warm moist climates, water vapor in the air is less likely to condense and drip from the outside of the pipe being chilled by cool soil-gas; however, passive systems should not be insulated within the building's thermal envelope. Third, pipe freezing is reduced. In colder climates, water vapor that condenses on the inside of the pipe is less likely to freeze. Fourth, noise from fan-powered system operation is reduced because less air flow noise emanates from piping covered by insulation.

6.5.8.3 *Pipe Identification Labeling and Marking*—Radon system piping that is located inside the building, and that extends above the building's ground covering slabs or membranes, shall be labeled or marked to identify it as radon system piping, according to 6.9.1.

6.5.9 *When to Install the Radon Fan*—Radon fans shall be installed before occupancy when the new residential building's required radon tests produce test results indicating unacceptable radon concentrations in occupiable spaces. When radon test results are acceptable, it is not necessary to install a radon fan (see 6.5.10.5).

NOTE 19—When radon test result is 10 % or less below the maximum acceptable radon concentration (without the fan installed or operating), at a time of year when radon concentrations are usually lower, the owner should consider having the fan installed and turned on.

NOTE 20—Once a radon fan has been installed it should be turned on and run continuously. Installed radon fans that are not operating can be damaged by moisture in the vent stack (that comes from rain and from the soil below the building).

6.5.9.1 *Fans for the Fan-Powered Pipe Routes*—The radon fans for fan-powered pipe routes shall be installed *(1)* after closed-house conditions can be maintained in the building for its initial radon test, and *(2)* after the building's radon test results are determined to be unacceptable (see 6.11). To prevent soil-gas and possibly radon from leaking into the occupiable spaces of the building, the vent stack shall not be cut for fan installation until the fan is on hand and prepared for installation. Further, the radon fan should not be installed until it can operate continuously; moisture from vent stacks can damage installed radon fans that are not operating. *Discussion*—Fan-powered pipe routes should have their vent stacks routed up through the dwelling and extended through the roof. The fan-powered pipe route is permitted in space outside the building's thermal envelope (see 6.5.5.1). The vent stack pipe should not have any gaps, plugs, or caps; and it should be extended through the roof during the system's initial installation.

6.5.9.2 *Fans for Passive Systems*—Passive radon systems shall be equipped with radon fans when they do not reduce radon concentrations to acceptable levels while operating without the fan. The radon fan shall be installed in the passive system's vent stack after *(1)* closed-house conditions can be maintained in the building for its post-mitigation radon test, and *(2)* after the building's post-mitigation test results are determined to be unacceptable (see 6.11.3). To prevent soil-gas and possibly radon from leaking into the occupiable spaces of the building, the vent stack shall not be cut for fan installation until the fan is on hand and prepared for installation. Further, the radon fan should not be installed until it can operate continuously; moisture from vent stacks can damage installed radon fans that are not operating. *Discussion*—Passive systems should have their vent stacks routed up through the dwelling and extended through the roof. The passive system's pipe route should be routed through the building's thermal envelope, see 6.5.5.2. The passive vent stack should not have any gaps, plugs, or caps. The passive system, unlike the fan-powered system, operates from the time that its vent stack pipe is completed.

6.5.10 *Radon Fan Installation*—The fan-powered radon system shall not be operating when the building's construction phase is completed. The system shall have an open vent stack. The radon fan should not be installed until initial radon test results are available. Further, the radon fan should not be installed until it can operate continuously; moisture from vent stacks can damage installed radon fans that are not operating. The initial radon test protocol is appropriate for testing houses with fan-powered pipe routes before the radon fan is installed and operating.

6.5.10.1 *Visual Inspections before Installing Radon Fan*—Check the ground cover (that is, slab(s) or membrane(s), or both) the radon system piping and the access space for the radon fan and the radon system monitor. The defects and omissions observed shall be corrected before the radon fan is installed.

(1) Slab or Membrane—The ground cover shall be complete and sealed. Check for exposed soil, holes, or openings in slabs; openings or tears in membranes; missing sump covers; and so forth. Check the visible seals of the gas-permeable layer, like the floor-wall joint seal, for integrity.

(2) Radon System Piping—The system's piping shall be complete from the suction point to the discharge point above the roof. The discharge point shall meet the location and separation requirements of 6.5.4.

(3) Vent Stack Access for Installing Fan and Monitor—Space around the vent stack pipe, and access to that space, shall be available for installing the radon fan in a vertical run of vent stack located in unconditioned space above all occupiable space or above the roof. Access to the vent stack for connecting a plastic tube for the radon system monitor shall be available. Accessible space at a location frequently passed by and appropriate for the radon system monitor's attachment to the building shall be provided.

NOTE 21—To keep water out of the monitor, when attaching it to horizontal runs of vent stack, the tubing connection should be tapped into the top or side of the vent stack pipe and be 1 ft (0.3 m) below the monitor. To keep water out of the monitor, when attaching to vertical runs of vent stack, the pipe's tubing connection should located at least 1 ft (0.3 m) below the monitor or if the monitor must be located below the pipe's connection, the tubing should be routed vertically and upward at least 1 ft (0.3 m) before it turns downward and attaches to the monitor.

6.5.10.2 *Radon Fan and Couplings*—The radon fan type that is usually selected for soil depressurization systems are tubular in-line centrifugal fans capable of continuous operation for 5 or more years. Radon fans shall be resistant to temperature extremes and soil-gas moisture fluctuation. The fan shall be able to move at least 75 cfm (2120 L/min) of air at a static pressure of 0.75 in. WC (190 Pa). The fan shall be connected to the vent stack pipe with two rubber couplings. The coupling's size depends on the fan's intake and exhaust openings (which vary by fan model number) and the vent stack pipe's nominal diameter. *Exception*—Radon fans rated at less than 75 cfm (2120 L/min) at a static pressure of 0.75 in. WC (190 Pa) are permitted provided that the fan maintains a negative pressure of at least 0.020 in. WC (5 Pa) in all parts of the gas-permeable layer (3).

6.5.10.3 *Radon Fan Location*—The fan and all positively pressured portions of the suction pipe shall be located in unconditioned space above all occupiable space or outside the building, see 6.5.7.1. *Discussion*—The vent stack piping located below the fan is depressurized; pipe punctures in the depressurized portion of the vent stack fail safe because air is sucked into the pipe through the puncture, preventing radon gas from escaping into occupiable space.

6.5.10.4 *Installing Radon Fan*—The radon fan shall be installed in a vertical section of the vent stack pipe and in a vertical orientation, to prevent condensed water and precipitation from accumulating in the fan (see 6.5.7). After the radon fan is installed the top of the vent stack pipe shall meet the requirements of 6.5.4. In places with very cold winters where the fan is subject to freezing, the radon fan and the radon system piping outside a thermal envelope shall be insulated (see 6.5.8.2).

(a) Interior Fan Installation—For interior installations, the vent stack pipe shall be supported above and below the place where the fan will be installed. A straight length of vent stack pipe, at least ten pipe diameters long, should be directly below the fan. The vent stack pipe shall support the fan, not vice versa. The radon fan shall be above occupiable space, see 6.5.10.3. *Discussion*—The straight pipe below the fan reduces turbulence in the pipe's air stream which allows the radon fan to operate more efficiently.

(b) Above Roof Fan Installation—For exterior installations with shingled and pitched roofs, the fan shall be securely attached to the top of the vent stack by its bottom coupling. An 8 to 24 in. (20 to 60 cm) length of pipe shall be inserted into the fan's top coupling and firmly secured. The pipe extending above the top coupling shall be firmly attached to the roof's support structure for lateral support with two horizontal weather proofed rigid rods or equivalent supporting hardware. For exterior installations with flat roofs covered with sheets of rubber, plastic, or metal, the vent stack pipe shall be supported by a weather proof structure that is firmly attached to the building's structure. The vent stack shall be located in such a way that the discharge separation requirements of 6.5.4 are maintained.

conjunction with a sub-slab or sub-membrane radon depressurization system. Sub-slab or sub-membrane depressurization systems are appropriate for use in vented and un-vented basements and enclosed crawlspaces. Sub-slab and sub-membrane depressurization systems are not prohibited by code and can coexist with any natural ventilation that is required by code for moisture control. Installation of passive or fan-powered soil depressurization systems in basement or enclosed crawlspace foundations does not interfere with the operation of natural draft combustion appliances. Sub-slab or sub-membrane depressurization is the superior radon reduction strategy for enclosed crawlspaces in new construction.

NOTE 23—The prohibition of natural ventilation as a radon control strategy does not apply to buildings supported by stilts or pilings, provided that any connections between the soil and the building, like walled enclosures, utility chases, and so forth, are specifically designed and constructed to prevent soil-gas from entering the building through them.

6.7.3 *Air Handling Equipment in Crawlspaces*—When air handling equipment is installed in crawlspaces that are protected form the weather by foundation or other walls, the radon concentration in the these enclosed crawlspaces shall be maintained as if they were occupiable space. *Discussion*—There is no airtight sealing method available to building contractors that can prevent radon from entering off-the-shelf air handling equipment and ductwork installed according to good commercial practice. Normal operation of HVAC equipment is intermittent, preventing the supply ductwork from being continuously pressurized. When the HVAC equipment is operating it creates a negative pressure in the return air ducts that causes air from the crawlspace to be drawn into those ducts. When the HVAC equipment is at rest, air from the crawlspace enters conditioned space because the supply duct work has a positive pressure with respect to the occupiable space above. The radon concentrations in a crawlspace can be controlled by a sub-slab depressurization system, which is compatible with virtually all residential air handling equipment and combustion appliances.

6.8 *Radon System's Electrical Installation*:

6.8.1 *Electrical Junction Box for Radon Fan to be Installed Under the Roof*—An electrical junction box, with a receptacle shall be installed so that the radon fan's 6 ft (1.8 m) plugged cord can reach the receptacle. The wires for a dedicated non-switched electric circuit shall be present in the fan's junction box. *Discussion*—Generally, residential radon fans are rated up to about 150 watts. In most jurisdictions, the maximum cord length allowed for a radon fan is 6 ft (1.8 m). Electrical junction box shall be installed for fan-powered and passive radon system pipe routes.

6.8.2 *Electrical Junction Box for Radon Fan to be Installed Above the Roof*—An electrical junction box, located under the roof, shall be installed. The wires from a non-switched electric circuit shall be present in the fan's junction box. The fan, when installed above the roof, shall be hard wired to this junction box to avoid the unpredictable operation of ground fault interrupt devices required for rooftop receptacles. A disconnecting means shall be installed above the roof and near the fan according to 6.8.6.

TABLE 11 Radon System Label Selection Guide

Pipe Route Type	Status	Label No.	Radon System Label Required (see subsection)
Fan-powered	Operating	1	6.9.3.1
Fan-powered	Not Operating	2	6.9.3.2
Passive	Operating	3	6.9.3.3

6.8.3 *Electrical Junction Box for Electrically Operated Radon System Monitor*—An electrical junction box, located near the radon system monitor, shall be installed if that monitor is to operate on electric power. When a radon system monitor requires electric power, it shall be connected to a non-switched circuit not used by the radon fan.

6.8.4 *The Circuit Lists*—When a junction box for a radon fan or radon system monitor, or both, is installed and wired, the circuit list posted on the circuit breaker enclosure shall be updated to include the fan and monitor.

6.8.5 *Disconnecting Means*—A disconnecting means is a switch, a plugged cord, or a circuit's over current device. A disconnecting means shall be present in the electric circuit powering radon fans. The disconnecting means shall be in sight of the fan, except when the fan motor develops ⅛th horsepower or less. *Discussion*—The primary purpose of the fan's disconnecting means is to temporarily disconnect the fan's electric power while fan maintenance is being performed. Operation of the fan's disconnecting means should not interrupt the power to the radon system monitor if it is connected to electrical power or to other electrical devices in the dwelling.

6.8.6 *Electrical Code*—All wiring, connections, and electrical equipment shall comply with applicable electric codes.

6.9 *Radon Labels*—There are five types of radon labels: pipe labels, membrane inspection labels, radon system labels, sump cover inspection labels, and radon maintenance provider identification labels. The radon pipe labels (6.9.1) are the same for all radon reduction systems. The membrane inspection label (6.9.2) applies only to residential buildings with ground covering sealed membranes. Three different radon system identification labels are used (6.9.3). Sump cover inspection label applies only to residential buildings with sumps (6.9.4). The Radon Maintenance and Information Label, which identifies the radon maintenance service provider and the state radon contact, applies to all types of radon system (6.9.5).

6.9.1 *Pipe Labels*—A permanent label or distinctive marking that can be read at a distance of 6 ft (2 m) shall be applied to the radon system piping (or its insulation) on each floor of the building, at locations such that at least one label is visible from any accessible location along the piping, whether or not it is to be visible following completion of the building. The label should read: "Radon Pipe," "Radon System," or have other wording that identifies the pipe as part of a radon reduction system.

6.9.2 *Membrane Inspection Label*—A permanent label that can be read from a distance of 3 ft (1 m) shall be securely attached in a prominent location, close to or in sight of each membrane. The membrane inspection label shall show all information between the quotation marks.

Call your state radon contact for additional radon information, including the names and phone numbers of certified or licensed radon contractors. The state radon contact should be visible on a label near this one; if not, the state radon contact's phone number is available from the U.S. EPA website (http://www.epa.gov/radon) or U.S. EPA Regional Offices.

Practice E 1465 Label No. 1"

6.9.3.2 *Radon System Label No. 2*—Label No. 2 shall be displayed in dwelling units of residential buildings with a fan-powered pipe route (but without a fan installed) constructed according to this practice. Label No. 2 shall show all information between the quotation marks.

"Radon Reduction System

Radon system specification: Practice E 1465

Type: Soil Depressurization – Fan-Powered Pipe Route

Status: Fan not Installed – Not Operating

Upgrade Option: Install radon fan.

Description:

A soil depressurization radon reduction system is installed in this building; it is not operating or complete because the radon fan and system monitor are not installed.

Radon Testing:

This building was tested for radon while unoccupied. Because radon test results were acceptable then the radon fan was not installed in order to conserve electrical energy.

Test the dwelling units in this building for radon soon after occupancy.

Also retest the dwelling units for radon whenever there has been a change of ownership; occupants; heating, ventilating, or air conditioning equipment; or when the building's structure has been changed by renovations like additions or finishing rooms in basements or attics; and so forth.

Radon Test Result Interpretation:

When radon test results are 4 pCi/L (150 Bq/m^3) or more, promptly have the radon fan installed; and the building retested with the radon fan operating.

When radon test results are 2.0 pCi/L (75 Bq/m^3) or more (but less than 4 pCi/L (150 Bq/m^3)), consider having the radon system evaluated to determine if its performance can be improved to further reduce both indoor radon concentrations and the risk from radon.

Additional Radon Information:

Call your state radon contact for additional radon information, including the names and phone numbers of certified or licensed radon contractors. The state radon contact should be visible on a label near this one; if not, the state radon contact's phone number is available from the U.S. EPA website (http://www.epa.gov/radon) or U.S. EPA Regional Offices.

Note that if the installed radon system now has a radon fan operating, its label should have been changed to Practice E 1465 Label No. 1.

Practice E 1465 Label No. 2"

6.9.3.3 *Radon System Label No. 3*—Label No. 3 shall be displayed in dwelling units of residential buildings with operating passive radon reduction systems constructed according to this practice. Label No. 3 shall show all information between the quotation marks.

"Radon Reduction System

Radon system specification: Practice E 1465

Type: Soil Depressurization – Passive

Status: Operating

Upgrade Option: Convert to an operable complete Fan-Powered system.

Description:

A soil depressurization radon reduction system designed for passive operation is installed and operating in this building.

Radon Testing:

Test the dwelling units in this building for radon soon after occupancy.

At least once every two years, this dwelling unit should be retested for radon during the colder months of the year. Additional testing in each season is recommended for operating passive radon systems.

Also retest the dwelling units for radon whenever there has been a change of ownership; occupants; heating, ventilating, or air conditioning equipment; or when the building's structure has been changed by renovations like additions or finishing rooms in basements or attics; and so forth.

Radon Test Result Interpretation:

When radon test results are 4 pCi/L (150 Bq/m^3) or more, either have the passive system promptly repaired and the building retested, or, for greater health benefit and greater radon reduction, promptly have this system converted to a fan-powered system, and retested.

When radon test results are 2.0 pCi/L (75 Bq/m^3) or more (but less than 4 pCi/L (150 Bq/m^3)), consider having the radon system evaluated to determine if its performance can be improved to further reduce both indoor radon concentrations and the risk from radon.

Additional Radon Information:

Call your state radon contact for additional radon information, including the names and phone numbers of certified or licensed radon contractors. The state radon contact should be visible on a label near this one; if not, the state radon contact's phone number is available from the U.S. EPA website (http://www.epa.gov/radon) or U.S. EPA Regional Offices.

Note that if the installed radon system is now a fan-powered system (that is, the original passive system has been converted to a fan-powered system), its label should have been changed to Practice E 1465 Label No. 1.

Practice E 1465 Label No. 3"

6.9.4 *Sump Cover Inspection Label*—A permanent label that can be read from a distance of 3 ft (1 m) shall be securely attached in a prominent location, close to or in sight of each sump cover. The sump cover inspection label shall show all information between the quotation marks:

"Sump Cover Inspection Required

The sump cover seal is an important part of the radon system installed in this dwelling. Air leakage past the cover's edges or under it can reduce the performance of the installed radon reduction system. Periodically inspect the sump cover's condition and the integrity of its seals. The sump cover should be removable so that equipment in the sump can be serviced. A removable type caulk should be used to seal the cover to the concrete slab. Gaskets used to form seals between sump covers and sump tubs should be in good condition. Mechanical fasteners should be installed to hold the cover in its intended position.

Call your state radon contact for additional radon information, including the names and phone numbers of certified or licensed radon contractors. The state radon contact phone number is available from the U.S. EPA website (http://www.epa.gov/radon) or U.S. EPA Regional Offices."

NOTE 25—The sump cover inspection label applies only to residential buildings with sumps installed.

6.9.5 *Radon System Maintenance and Information Label*—A label that identifies the radon system maintenance provider, identifies the state radon contact, and shows the system's installation/activation date(s) shall be applied near the radon system label. The following information shall appear on the Radon System Maintenance and Information Label: *(1)* the name, address, and phone number of the radon system's maintenance provider; *(2)* the state radon contact's agency name, address and phone number; *(3)* the date on which the radon system's installation was completed; *(4)* the date on which the radon fan was installed or turned on, or both; and *(5)* a sentence about floor drains and water traps that states "Floor drains, if any, should be fitted with water traps or other device for controlling sewer/soil-gas entry. When water traps are installed, they should be refilled periodically to replace the water that slowly evaporates from them."

6.10 *Radon Testing for New Residential Buildings with Fan-Powered and Passive Systems*—For a perspective of radon testing in residential buildings, see Table 12. Also, see 6.9.3, which describes labels that are intended to inform owner/occupants about post occupancy matters including radon testing.

6.10.1 *Radon Test Devices and Protocols*—All radon test devices and test protocols utilized in conjunction with this practice shall be short term. The initial radon test protocol shall be used to determine whether or not the new residential building has unacceptable indoor radon concentrations. The post-mitigation test shall be used to determine whether or not a residential building, has acceptable radon concentrations after its mitigation system is operating. Fan-powered and passive radon systems shall have operated for a minimum of 24 hours immediately prior to starting a short-term radon test and shall continue to operate for the duration of the test. Closed-house conditions shall be established at least 12 hours immediately prior to starting a short-term radon test and shall be maintained for the duration of that radon test. All testing shall be done with devices that meet U.S. EPA requirements and are listed by a recognized proficiency program. Testing shall be done in accordance with applicable U.S. EPA or state protocols (5, 6). *Discussion*—Before occupancy use of short-term (48 to 72 hours) radon test devices is appropriate for real estate transactions and likewise their use is appropriate for new construction. Testing with the initial and post-mitigation test protocols is relatively fast, reliable, and inexpensive way to determine whether or not a new residential building has acceptable radon concentrations. *Exception*—short-term radon tests for buildings in certain karst areas and for buildings with passive systems should be supplemented by long term (that is, up to a year in length) radon tests, because the performance of radon systems in such buildings are intermittent and variable due to season, wind, and other weather conditions and the geology at and around the site where the dwelling is located. State radon testing protocols may require long-term testing and other test procedures that are different than U.S. EPA protocols. Applicable state radon testing protocol(s) shall supersede the U.S. EPA protocol(s).

6.10.2 *Required Radon Testing for Buildings with Fan-Powered Pipe Routes*—All new residential buildings with fan-powered pipe routes constructed according to this practice shall be tested, without the fan operating, for acceptable radon concentrations before occupancy, using the initial radon test protocol. The initial radon test is required to determine whether or not the building requires radon mitigation. When a new building with a fan-powered pipe route has unacceptable initial test results, a radon fan should be promptly installed and the building tested again using the post-mitigation test protocol. The post-mitigation testing of fan-powered radon systems requires that the radon system and its fan have been operating for at least 24 hours before the test is started; the radon system shall continue to operate during the test. If the building's post-mitigation test results show acceptable radon concentrations, and the radon system is completely installed, no additional post-mitigation testing is required before occupancy. If the test results show unacceptable radon concentrations or if the radon system is not completely installed, or both, the system shall be fixed (repaired, upgraded, or completed) and the building shall be tested again, using the post-mitigation test protocol. This test-and-fix cycle shall continue, before occupancy, until acceptable radon concentrations have been achieved.

NOTE 26—For the meaning of acceptable radon concentrations see 3.2.1.

6.10.3 *Required Radon Testing for Buildings with Passive Radon Systems*—All new residential buildings with passive radon systems constructed according to this practice shall have an open vent stack that is not capped or plugged and shall be tested for acceptable radon concentrations before occupancy, using the post-mitigation test protocol. The post-mitigation test protocol is appropriate because the passive radon system is operating as soon as it is completed and the building is being tested to determine whether or not the radon system is providing acceptable radon concentrations.

NOTE 27—For the meaning of acceptable radon concentrations see 3.2.1.

6.10.4 *Radon Test Correctness*—Most of the time initial radon testing and post-mitigation tests using U.S. EPA or state protocols and devices that meet U.S. EPA requirements and are listed by a recognized proficiency program should be expected to produce test results that are within ±10 % of the actual radon concentration being measured; however, radon test results that are within ±25 % of actual concentrations (at 4 pCi/L (150 Bq/m^3)) satisfy current device performance criteria. Because of this radon test result uncertainty, results between 2 pCi/L (75 Bq/m^3) and 4 pCi/L (150 Bq/m^3) should be confirmed with an additional confirmatory radon test. Test result confirmation can be accomplished with a concurrent duplicate co-located test (to save time) or a follow-up test placed in the same location as the first test. The average of the first test and confirmatory/duplicate test should be the basis used to determine if and how the radon system should be enabled. *Discussion*—As the radon concentrations increases from 4 pCi/L (150 Bq/m^3) the measurement error decreases, and vice versa. To accurately measure radon concentrations that are less than 2 pCi/L (75 Bq/m^3) is difficult. These radon measurement phenomena are important to remember when evaluating the difference between two radon test results that are less than 2 pCi/L (75 Bq/m^3). The test results may not only have large measurement errors, but also have one result higher than the actual radon concentration and the other lower.

6.10.5 *Independent Radon Tests*—Required radon tests, including initial tests, confirmatory initial radon tests, and post-mitigation tests shall be provided by an independent certified or licensed, or both, third party tester using test devices that meet U.S. EPA requirements and are listed by a recognized proficiency program. Post-mitigation radon tests which are performed only on complete and operating radon systems, shall be initiated no sooner than one day (24 h) after the radon system began operation. *Exception*—If an owner agrees to occupy a new residential building that has a radon system built in, before the initial test or post-mitigation test(s) have been performed, the contractor shall be permitted to obtain the required initial or post-mitigation radon test result(s): *(1)* from an owner/occupant who *(a)* had purchased test devices and deployed them, *(b)* had hired a third party radon tester, or *(c)* had used short-term radon test kit(s) and the device manufacturer's testing instructions, supplied by the building contractor; or *(2)* from a third party radon tester who had been hired by the building contractor. All testing shall be done using devices that meet U.S. EPA requirements and are listed by a recognized proficiency program and in accordance with applicable U.S. EPA and state protocols.

NOTE 28—Additional radon testing by the building contractor is permitted for quality control or other purposes, but such testing shall not remove the requirement for independent radon testing.

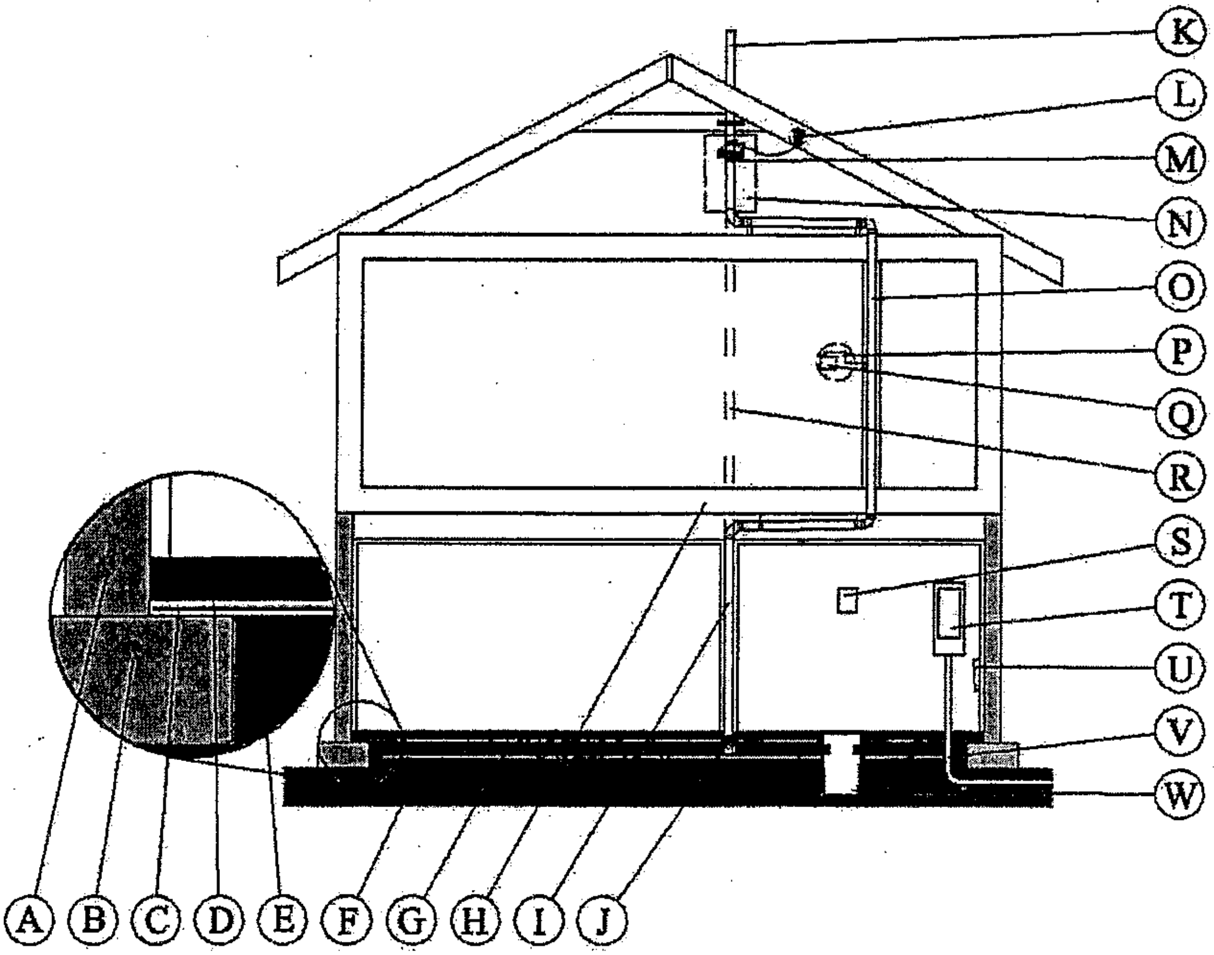


FIG. X2.1 Construction Details for Radon Control

X2. SUMMARY OF PRACTICE E 1465'S REQUIREMENTS FOR RADON REDUCTION IN NEW LOW-RISE RESIDENTIAL BUILDINGS

NOTE X2.1—This summary is not mandatory nor does it establish alternatives to modify the requirements of the practice.

A Foundation Walls—Three solid foundation wall types are recommended, that is, poured concrete, 100 % solid concrete masonry units and solidly grouted masonry (see 6.3). Damp-proofing should be applied to all below grade portions of foundation walls, (see 6.3.5). Four foundation types are covered: a) slab-on-grade, b) basement, c) crawlspace, and d) certain foundations without walls (see 6.3).

B Footings—support foundation walls, seal the edges of gas-permeable layer and seal leakage into bottom of gas-permeable layer where footings rest on soil. Gas-permeable soil or other permeable materials under footings, which causes air leakage into the gas-permeable layer must be avoided (see 6.4.5.3).

C Soil-Gas-Retarders—(aka vapor barriers) are loose laid unsealed membranes. These membranes are installed over the gas-permeable layer (see 6.2.3).

D Ground Cover—Ground covers seal the top of the gas-permeable layer. All soil within building's footprint must be covered by a sealed ground cover, either a poured concrete slab or, in unused crawlspaces, a sealed membrane (see 6.2). A thin concrete slab is recommended in lightly used crawlspaces (see 6.1.3). Slabs must be sealed (see 6.2.5). Membranes must be sealed and protected (see 6.1.3.3).

E Gas-Permeable Layer—A gas-permeable layer/soil-gas collector assembly is required under all slabs and membranes (see 6.4). The gas-permeable layer must be sealed on top, on the bottom, and at its sides/edges (see 6.4.5). An excellent gas-permeable layer is a 4 in. (100 mm) bed of clean aggregate of (1 to 1¼ in. (25 to 28 mm) broken stone); certain other gas-permeable layer types are permitted (see Table 2).
F Soil—Undisturbed soil is assumed to seal the bottom of the gas permeable layer (see 6.4.5.3).
G Soil-Gas Collector—Soil-gas collectors must be built into every gas-permeable layer (see 6.4.2). A common soil-gas collector is 4 in. (100 mm) perforated rigid or flexible drain pipe; others are permitted (see 6.2.4, 6.5.1.3, and Table 4). The soil-gas collector must be connected to the radon vent stack (see 6.4.3 and Table 5).
H Thermal Envelope—Non-insulated passive vent stacks must pass through the space within the thermal envelope of the building (see 6.5.5).
I Radon System Piping—is plastic (PVC or ABS) pipe (see 6.5); it terminates above the roof; it must have been designed to have sealed joints and for use above ground (see 6.5.1.2). It is connected to the gas-permeable layer (see 6.5.3). Its pipe routes are configured for either fan-powered (see 6.5.5.1) or passive (see 6.5.5.2) operation. The nominal pipe size is 4 in. (100 mm) ID (see 6.5.2). All required fire ratings must be maintained as radon piping is installed (see 6.6). Radon system piping must be supported and labeled and could require insulation (see 6.5.8; see also Notes O and R).
J Rubber Coupling/Adaptor—joins suction point pipe (an above ground pipe type) to soil-gas collector (a below ground pipe type) (see Note 1 of Table 6); the rubber coupling/adaptor should be installed under the sealed ground cover.
K Discharge Separation—Vent stack discharge must be separated from openings into occupiable spaces (see 6.5.4). Radon vent stacks should terminate above the ridge of the highest roof.
L Electrical Junction Box—A non-switched circuit terminating in an electrical junction box must be installed within 6 ft (2 m) of the fan's planned location (see 6.8). A junction box is required for each passive or fan-powered vent stack pipe.
M Radon Fan—Radon fan is required when radon test result is not acceptable (see 6.5.9). Radon fan must be located in unconditioned space and must be above occupiable space (see 6.5.10).
N Space for Radon Fan—Adequate space, along the pipe route, must be reserved for the possible future installation of a radon fan (see 6.5.7).
O Fan-Powered Pipe Route—can be located against exterior walls outside the building's thermal envelope and can include pipe runs that are nearly horizontal (see 6.5.5.1). Nearly horizontal vent stack pipe runs must be pitched so as to drain rain water and condensate down into the gas-permeable layer (see 6.5.6; see also Note 1).
P Space for Radon System Monitor—Adequate space where a radon system monitor can be mounted and easily seen must be reserved (see 6.5.7). Access along the radon vent stack for connecting the pressure operated radon system monitor also must be provided.
Q Radon System Monitor—A radon system monitor is required whenever a radon fan is installed (see 6.5.11). A pressure operated radon system monitor, which should indicate the actual and normal vent stack suction pressures, should be installed in a place where it can be easily read and seen routinely and frequently by the building's occupants while they are performing normal household activities.
R Passive Pipe Route—Passive vent stack piping must be positioned vertically or nearly vertically and extend from the slab through the building's thermal envelope, up through the attic, and terminate above the roof. The passive vent stack pipes should be insulated where they pass through unconditioned attic spaces to help keep the vent stack warm (see 6.5.8.2; see also Note 1).
S Radon Labels—Radon labels are required, (see 6.9.) There are five types of radon labels, namely: (1) pipe labels; (2) membrane inspection labels, when membrane is installed; (3) radon system labels; (4) sump cover inspection labels, when a sump is installed; and (5) radon service provider identification labels. The radon system labels contain recommendations to owners and occupants, including: "Test the dwelling units in this building for radon soon after occupancy" (see 6.9.3). Recommendations to the owner/occupants are provided in other sections as well (see 6.9.1 through 6.9.5 and 6.13).
T Utility Connections—Horizontal runs of utility piping and conduits in the gas-permeable layer shall be avoided; such horizontal runs should be installed below the gas-permeable layer or above the ground covering slab or membrane (see 6.4.1). Note that all pipes and conduits for underground utilities like electric, water, sewer, phone, TV, and so forth, shall pass through the gas-permeable layer in vertical runs; electric utility connection is shown in Fig. X2.1 as an example.
U Documentation Package—Radon system documentation package is required (see 6.12.4).
V Soil-Gas/Air Leakage—Soil-gas and air leakage through the gas-permeable layer's seals, like where utilities penetrate the seals of the gas-permeable layer shall be minimized (see 6.4.5). Such leakage can occur through cracks and openings in slabs, membranes and foundation footings, and permeable soil; leakage reduces the effectiveness of radon reduction by soil depressurization (see Appendix X1).
W Water Control Devices—When water control devices are present certain sealing devices shall be installed to prevent soil-gas and air leakage into gas-permeable layer or into buildings' interior spaces. Interior perimeter drains that are dewatered by gravity must be fitted with backwater check valves. Floor drains must be trapped. Interior and exterior perimeter drains must not be joined within the building's footprint. Interior perimeter drains and certain soil-gas collectors are shared facilities. Air flow in gas-permeable layer must not be blocked by horizontally laid water control or other utility piping or conduit. Sump pits and tubs must have removable airtight covers. (See 6.2.4, 6.4.2, 6.4.4, Fig. 9, and Fig. 10.)

Other Requirements and Information:
1 Crawlspace Requirements—Debris must be removed from crawlspaces; the crawlspace soil must be graded even, smoothed and sloped for drainage. A gas-permeable layer and ground cover must be installed in all crawlspaces. When membrane ground covers are used they must be protected (see 6.1.3). For prohibitions on using crawlspace depressurization and natural ventilation for radon controls and about installing air handling equipment in crawlspaces (see 6.7).
2 Radon Tests, Test Result Interpretation, and Required QA—Independent radon testing is required before occupancy to determine whether radon fan and system monitor should be installed. The radon test should not be attempted before the interior and exterior of the building are complete and weather tight, the HVAC equipment is installed and capable of being operated normally. Fan-powered and passive radon systems shall have been operating for a minimum of 24 hours before their radon test is started. Closed-house conditions shall be established at least 12 hours immediately prior to starting a short term (48 to 72 h) radon test and maintained for the duration of that radon test. See 6.10, 6.11, 6.12 and Table 12.
3 Documented Evidence of Acceptable Radon Concentrations—is required before occupancy (see 6.10.6 and 6.12.5). For background supporting the meaning of "acceptable radon concentration" (see 1.4, 3.2, 5.1-5.6, 5.10, 6.10, 6.11, 6.12 and Table 12). For professional radiation protection disciplines' radiation exposure reduction goals (see 6.11.4).
4 Occupational Radon Exposure—See Section 7 for certain worker's safety requirements.
5 User Aids—User aids are included in practice: a) Outline of Practice with hyperlinks in Adobe .PDF versions (see 4.4), b) Summary of Construction Steps (see Table 1), Summary of Radon Test Requirements (see Table 11), Summary of Test Result Interpretations (see Table 12), Principals of Fan Powered Soil Depressurization Radon Control (see Appendix X1), and this practice's Summary of Requirements, with its visual table of contents (see Appendix X2).