Unit 7. Radon-Resistant New Construction

Contents

Objectives

07.01 [1]*/**Describe the relationship between soil tests and indoor radon concentrations in new buildings.

07.02 Identify steps that can be taken during new construction to reduce indoor radon concentration:

a. By controlling indoor/outdoor pressure relationships

b. By reducing radon entry through the foundation

07.03 Identify the stepped ASD approaches to new house systems:

a. Radon ready

b. Passive systems

c. Fully active systems

07.04 Identify the construction requirements for passive radon control in the Florida Standard For Passive Radon-Resistant New Residential Building Construction (Chapter 9B-52, Florida Administrative Code).

[1] *These objectives are only for radon measurement specialists.
**These objectives are only for radon mitigation specialists.

I. Overview

The best way to avoid high indoor radon levels is to implement simple radon resistant construction techniques when the house is built. Use of all proven, radon resistant techniques normally results in a lower indoor radon environment. If the use of only passive soil depressurization techniques does not offer acceptable levels of indoor radon, it is easy and inexpensive to add a fan later.

Like many other contaminants that originate outside, radon can be controlled by taking steps to stop or reduce entry into the home, or by diluting the contaminant with fresh air once it has entered the home. The following approaches have been tried or suggested:

- Reducing radon entry by installing barriers in the foundation to retard soil gas entry.
- Controlling the indoor-outdoor pressure relationship by:
    - depressurizing the soil or crawl space.
    - minimizing the pressure differentials between the building and the soil.
- Diluting indoor radon concentrations by supplying fresh air.

Figure 7-1 illustrates the major topics discussed in this unit. These topics include sub-slab depressurization systems, methods used to tighten the building foundation, and the use of the HVAC system to pressurize the basement or half (walk-out) basement. Methods used to evaluate the radon potential of a site will also be discussed. The unit also describes methods that are currently under evaluation, but have not yet been fully tested.

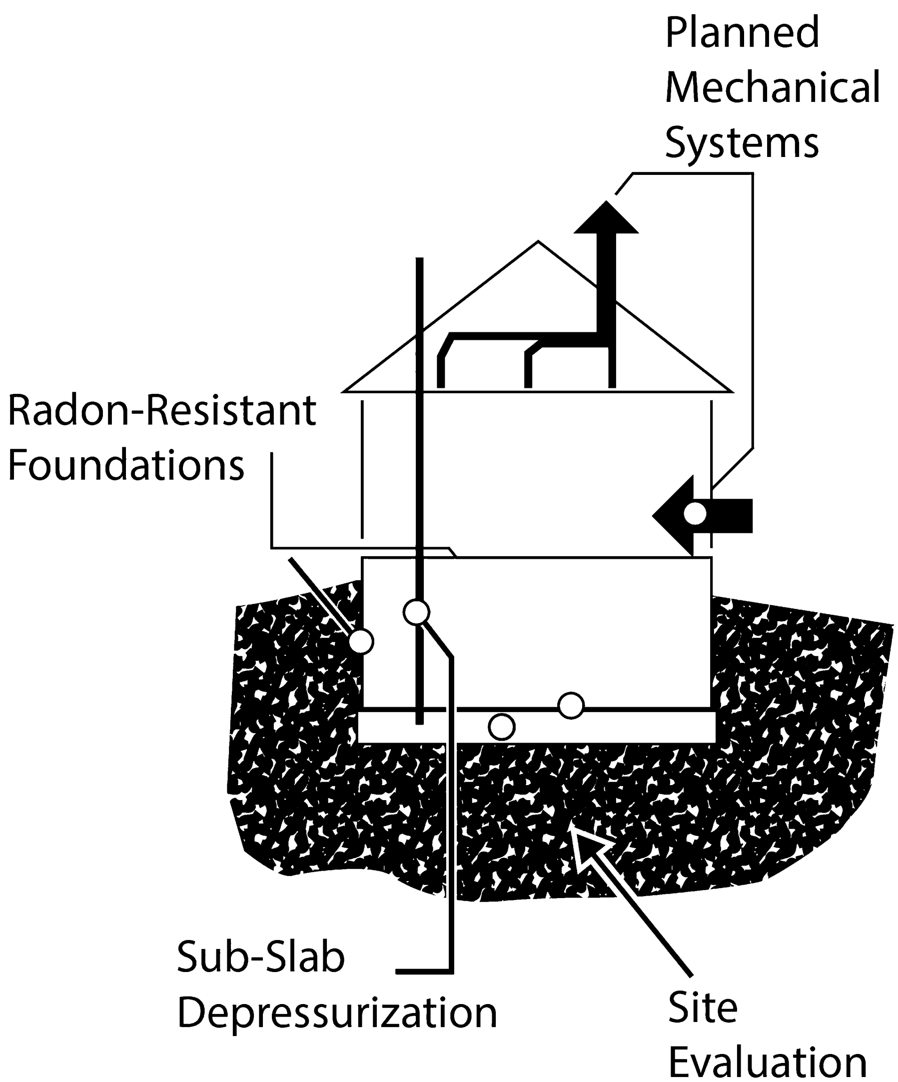

Figure 7-1. Radon-Resistant New Construction Topics, Source: MURC

II. Site Evaluation

Homebuilders often ask, "Can soil measurements made before the house is built indicate if radon-resistant techniques are necessary?" If a builder is interested in accurately predicting what the indoor radon concentration will be in a home after it is built, the answer is, "No," because:

- Houses vary greatly in their ability to resist radon entry.
- Bedrock and soils interact in complex ways with dynamic house conditions.
- Environmental factors make accurate predictions virtually impossible.
- There are too many combinations of factors that affect indoor radon concentrations for simple correlations to exist.

If the builder's interest is in determining the potential for elevated indoor radon in a home built on a particular site, the answer is "maybe." Soil radon, radium, and permeability measurements can be made; however, interpretation of the results can still be difficult or misleading. Clearly, a soil that contains high levels of radon, and is very permeable to airflow, has a potential for causing elevated indoor radon, and use of radon-resistant construction techniques should be considered. However, a soil with low radon content and low permeability does not necessarily indicate a low potential for elevated indoor radon concentrations. A soil-gas radon level reveals what the radon concentration was at the time of the measurement. However, radon concentrations can fluctuate over time, sometimes by several orders of magnitude. Also soil-gas radon concentrations can change from one area to another several feet away, again by several orders of magnitude. Although soil permeability is often more consistent at a given depth on a site, once the foundation hole is excavated. the permeability of the soil will be changed.

Researchers have been trying to develop a method for determining the relationships between site measurements and indoor radon concentrations for specific areas and regions (Ref. 7). Substantial progress has been made identifying areas where a potential for elevated radon concentrations. exists. However, many measurements are required to assess a particular site adequately. The decision that the builder faces is whether or not it is more cost effective to make the building radon-resistant to begin with, or to put the money into site evaluation and possibly avoid the need for radon-resistant construction techniques.

III. Recommended Radon-Resistant Construction Techniques

EPA research projects have investigated many commonly used radon-resistant techniques, including the use of physical barriers to prevent radon entry, sub-slab depressurization systems, and modification of mechanical equipment to control indoor/outdoor pressure relationships. This research has shown that a well-planned approach to radon-resistance, using a mix of techniques, often results in low indoor radon concentrations.

Based upon research project results, the approach suggested in this unit includes the installation of a passive sub-slab depressurization system enhanced by foundation tightening techniques. Design considerations are discussed in the following sections.

A. Controlling Indoor/Outdoor Pressure Relationships

1. Sub-Slab Depressurization

One of the most frequently used radon reduction techniques in existing homes is an active sub-slab depressurization (SSD) system. There are many common considerations when designing either an active (with a fan) or passive (without a fan) sub-slab depressurization system. For example, provisions must be made in both system types to allow for the drainage of condensation that forms in the exhaust pipe. The routing of the pipes from the basement to the roof must be considered. Location of the exhaust is important for reasons discussed in Unit Four.

Several factors determine whether the system should be active or passive, including the radon potential in the area and the degree of sub-slab preparation. Current EPA guidance sates that a layer of permeable material should be placed beneath the slab prior to the pour, to facilitate sub-slab communication of air. In areas of the country where it is readily available, crushed stone, typically DOT #2 or ASTM #57, in a 4-inch-deep layer beneath the slab, provides excellent sub-slab communication and greatly improves the chance of a passive system maintaining a low indoor radon concentration. If it is later found that the passive system is not adequate, a fan can be easily and inexpensively added to the system. In areas where crushed stone is not available, alternatives such as drainage mats, perforated pipe networks, or other suitable indigenous materials may be used. Studies have shown that a network or loop of inexpensive, 3-inch perforated, corrugated pipe in native soil with an interior vent stack to roof line, provides a benefit as a passive system. Activation of these systems with a fan have demonstrated short-term test results of less than 1pCi/L (Ref. 3, 4).

Most builders and mitigation contractors use 4 in schedule 40 PVC pipe for their systems. Other sizes can be used, but 4 inch is readily available, commonly used by builders, and easily connects to the fans most often used in ASD systems. The fans normally used in a system are rated in a range of about 75 to 150 cfm in free air. Fans of this range work well with a layer of highly permeable sub-slab material. Manufacturers of fans used by the radon industry have been fairly quick to improve their products on advice from their customers. When the radon industry first started, many of the fans leaked at seams and joints and required disassembly to seal those leaks. Most manufacturers now supply fans that do not leak but builders should be aware that this problem did exist, and may still exist in some fans. Additional materials and components that are normally included in a system should satisfy safety needs, system performance indications, and common sense. For example, service switches should be placed within a service person's view of the fan in an active system, to ensure that the system will not be activated while fan maintenance is being performed. Local electrical codes will dictate the appropriate hook up for the radon exhaust fan.

Active and passive systems should be clearly marked as radon reduction devices, to ensure that future owners of the house do not remove or defeat the system. An operation manual describing the system and its purpose should be included with the system.

Some type of device should be included in the system to advise the occupants of system performance. These devices may be simple pressure gauges that tap into the pipe to measure and display the pressure in the system. A visual check of the gauge will alert the occupant to possible system malfunctions. Electronic pressure sensing devices, which illuminate a warning light or sound an audible alarm when a pressure drop occurs, are also used, but they cost more than a simple gauge. Installation of volumetric flow sensors have also been utilized as a method of system monitoring. These must be easily interpreted and sensitive to small system changes. The use of a feed-back system, which actually indicates fan and volumetric flow, is acceptable, provided the sensitivity and logic is obvious to the homeowner. Simple indications that power is available to the blower (e.g. a light wired parallel to blower supply lines) would not be acceptable, since the light would still be on even when the fan burns out.

Figure 7-2 illustrates a typical sub-slab depressurization system.

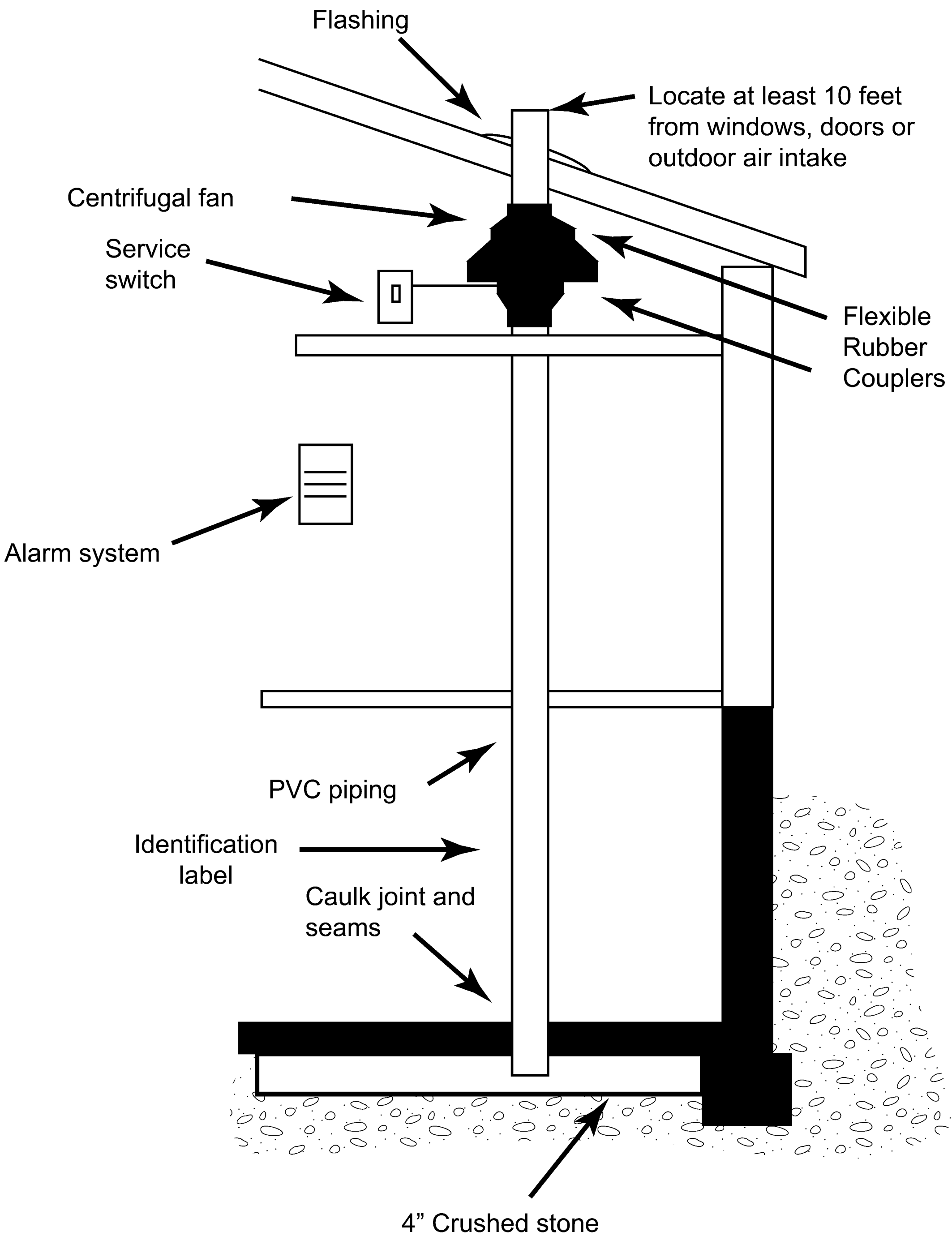

Figure 7-2. Typical Attic Sub-Slab Depressurization Installation, Source: MURC

Attention to detail during the installation process will facilitate the proper operation and long life of the system:

- Starting beneath the slab, comply with the sub-slab preparations that have been previously explained. Seal the void between the vent pipe and floor slab with a non-shrink grout or a flexible, highly adhesive sealant, such as polyurethane caulk.
- Place a sticker or other labeling device on the pipe, identifying it as a radon reduction system. Ideally, labels should be placed at regular intervals along the entire pipe run.
- Run the pipe as straight to the attic as possible to ensure proper drainage of condensation and enhance its performance as a passive system.
- Visual system performance monitoring devices should be placed in an area that is often visited and in plain view of the occupant.
- Audible alarms can be placed in any area, as long as the occupant can hear them. It is a good idea to place alarm sensors in easily accessible areas, because they sometimes need adjusting. Audible alarms are not recommended in passive sub-slab depressurization systems because the pressure developed by such systems is not very consistent, which could cause the alarm to sound sporadically. This could result in numerous call backs or intentional disabling of the alarm system by the homeowner.
- The fan in an active system should always be located in a non-living area as close to the exhaust as possible. This is extremely important because a leak in the fan, or in the piping above the fan will blow radon back into the home. The fan should be mounted vertically, so that condensation in the system can drain back down the vent pipe and under the slab. Proper fan placemen however, is no substitute for a well constructed system.
- Connect the fan to the pipe system with flexible rubber connectors. This allows for easy replacement of the fan, if that should become necessary, and minimizes annoying fan noise.
- Run the pipe through the roof and flash.

Some builders use an alternative pipe route and run the pipe from the basement, through the sidewall, and through an attached garage. The fan is installed in the garage, and the exhaust pipe runs through the garage roof. If this method is used, the placement of the fan is the same; that is, put it as close to the exhaust end of the pipe as possible. One other important consideration to this alternative routing is the penetration of firewalls. The CABO One and Two Family Dwelling Code, Section R-210.2, requires that "the garage shall be completely separated from the residence and its attic area by means of 1/2 inch gypsum board or equivalent applied to the garage side" (Ref. 3). When this firewall is penetrated by ductwork as would be the case in this SSD route, fire dampers are required. Fire dampers may be in the pipe itself, or may consist of a collar that is fastened around the pipe. An alternative to fire dampers is to box in the pipe and penetration with a material of the same fire rating as the firewall.

Figure 7-3 illustrates an attached garage installation.

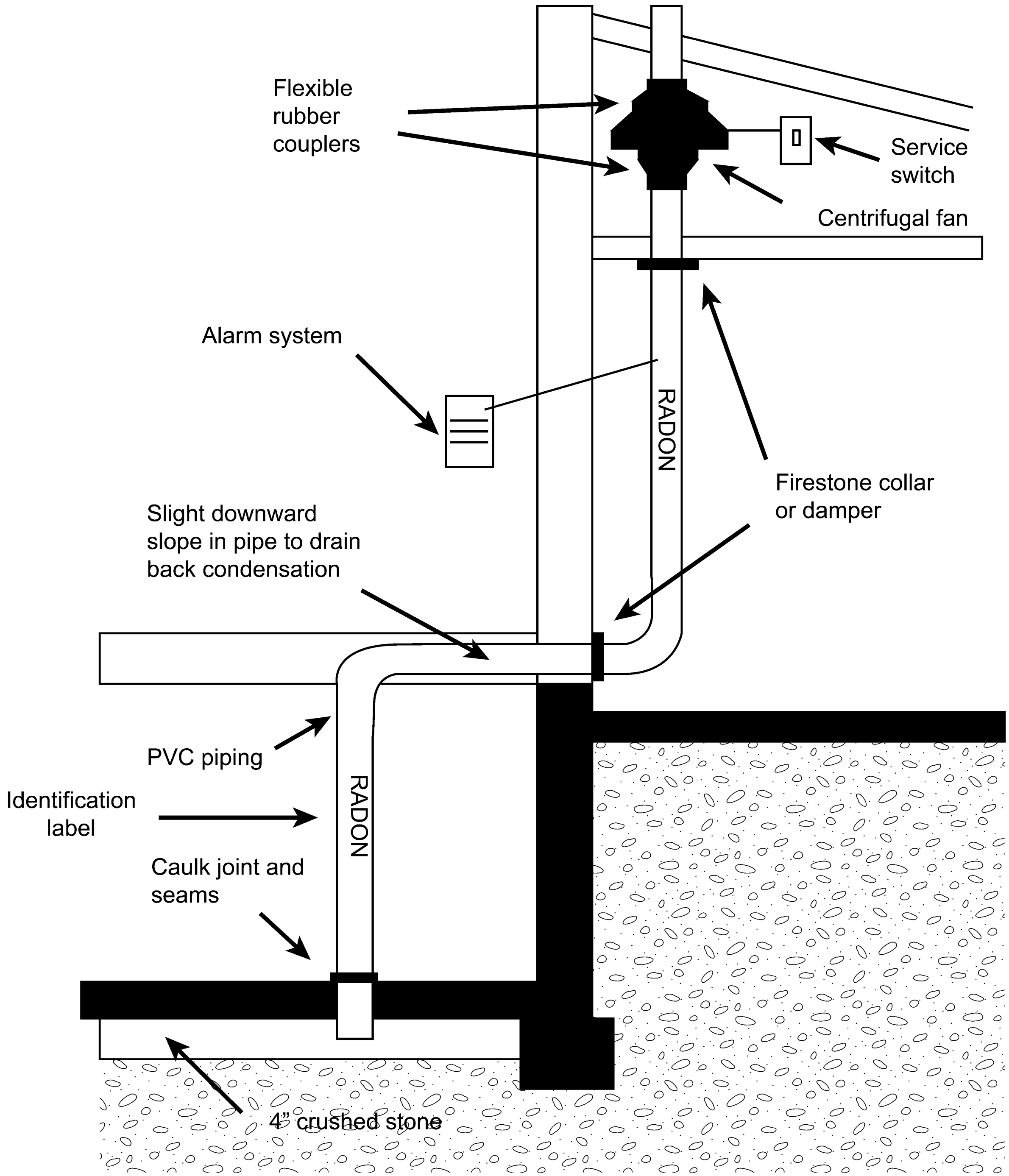

Figure 7-3. Alternative Basement to Garage Sub-Slab Depressurization Installation, Source: MURC

2. Drain Tile Depressurization

As mentioned in Unit Four, another form of ASD is drain tile depressurization (DTD). In some areas foundation drains are required, which have proven to be a very effective mitigation technique when depressurized. During new home construction. the addition of a

4 inch PVC riser from the drain tile to the surface outside the home, in a visually acceptable location. is an inexpensive option. When left uncapped, this riser does not provide much benefit as a passive system, because the pipe is not warmed by the interior air of the home as an internal stack would be (Ref. 4). However, to activate the system, the addition of a fan and exhaust stack would be very simple.

3. Planned Mechanical Systems

The previous section described keeping pressure-driven radon out of the house by building a tight foundation and reversing the basement to sub-slab pressure relationship. This section describes control of the pressure differences that drive the radon indoors by proper planning of the mechanical systems.

Traditionally, the mechanical systems in a home have been viewed as having no impact on the household environment, except that for which the equipment was designed. For example, a furnace only provides space heating, an exhaust fan simply removes stale air, and so on. Recent interest in indoor air quality, however, has shown that this is often not the case. A furnace does provide space heating, but can also introduce combustion gases into the home, and the distribution fan can be the dominant force in determining internal air pressure relationships. An exhaust fan does remove stale air, but can also depressurize a home to an extent that soil gases are drawn in. Mechanical systems can depressurize the home and have a dramatic impact on some radon-resistant techniques. Passive sub-slab depressurization (PSD) systems normally operate on a relatively low pressure difference, on the order of 1 to 10 pascals. Whole house fans have been observed to depressurize a home as much as 50 pascals, which would certainly defeat a PSD. The mechanical systems of the house should be planned so that the sub-slab system, especially if it is passive, has minimum competition from the other mechanical systems. The major equipment of concern is the heating/ cooling system air handler and its ductwork, as well as large exhaust fans.

In some areas of the country, slab on grade homes have their HVAC ductwork installed under the slab in the sub-grade soil. In areas with potential for elevated indoor radon, the practice should be discouraged. The sub-slab ductwork serves as an excellent radon collection/distribution system.

B. Reducing Radon Entry Through the Foundation

Theoretically, a gas-tight foundation should eliminate pressure-driven radon entry. In practice, this is extremely hard to accomplish. The problem is effectively sealing joints, cracks. and other penetrations. Recent EPA research projects have studied newly constructed houses with barriers and foundation-tightening techniques intended to prevent the entry of radon (Ref. 2). Preliminary results indicate that the techniques were not adequate to ensure basement levels below 4 pCi/L. The results of these projects should not be used as an argument against spending the additional effort required to ensure a relatively tight foundation. In fact, there are good reasons to tighten the foundation. A tight foundation will enhance the performance of and reduce the energy penalty due to the use of sub-slab depressurization systems (Ref. 5).

There are two approaches to ensuring a tight building foundation:

- Limiting the number of intentional penetrations, such as sump holes, weep holes, and channel drains.
- Employing techniques that will help prevent unintentional penetrations, such as floor and wall cracks.

1. Poured Concrete versus Masonry Foundations

The materials that a builder uses to construct a foundation can often be used as an effective barrier to the entry of radon. Below-grade foundation walls may be constructed of poured concrete, masonry blocks, or other materials, such as pressure- treated wood or stone. This section will cover the two, most common building materials - poured concrete and masonry blocks. Details for radon-resistant techniques in permanent wood foundations can be found in a National Forest Products Association publication entitled "Radon Reduction in Wood Floor and Wood Foundation Systems" (Ref. 9).

A poured concrete wall can be a good barrier to pressure-driven radon transport. The major weaknesses in concrete are joints, and penetrations. It is recommended that concrete walls be built in compliance with guidelines established by the American Concrete Institute publication "Guide to Residential Cast in Place Concrete Construction" (ACI 332R-84) (Ref. 1).

Foundation walls built of concrete masonry units have open cores, which can become major radon entry points. The top course of such walls should be constructed of solid blocks. If solid blocks are not. readily available, fill the cores of the top course with non-shrink grout or concrete. Masonry walls are often coated with an exterior layer of cementitious material for control of water. Block walls can vary greatly in porosity. It is recommended that concrete block walls be constructed and sealed according to guidelines issued by the National Concrete Masonry Association (Ref. 8).

The decision to construct either a poured concrete or masonry foundation should be based on factors other than radon resistance. A recent study conducted in New Jersey (Ref. 1) found mean radon concentrations in 581 basements with poured concrete walls of 6.3 pCi/L ± 14.1%, and mean concentrations in 3,408 basements with concrete blocks of 5.7 pCi/L ± 11.1%. There is no statistical difference between the two means. Simply stated, elevated radon levels can be found in homes with either type foundation. Build the foundation you want, therefore, and take steps to limit intentional penetrations and prevent unintentional penetrations.

2. Limiting Intentional Foundation Penetrations

There are numerous penetrations that must be made in a building foundation. Water entrances and waste pipes are examples. These penetrations should be properly scaled. Sumps, weep holes, perimeter channel ("French") drains, and other penetrations can be eliminated by alternative designs in many cases. When these penetrations must be used in a home, additional steps must be made to isolate them from the interior of the home. Each type of intentional penetration uses different techniques to make them radon-resistant; however, all have the common objective of preventing radon entry and limiting the amount of air that is drawn through a sub-slab depressurization system. Figures 7-4 and 7-5 illustrate suitable methods. As shown, all of the techniques are designed to let water out, but keep radon from getting in. The sump is covered with a child-proof air-tight cap, and the channel drain and weep holes are isolated from the interior of the building. These details keep the radon out of the building and provide many other benefits. Additionally, the sump pump drainage line has a reverse flow valve installed, and the top row of the hollow core masonry walls is either a solid core or filled core course. These additional details help limit the amount of heated, indoor air that is being exhausted by the sub-slab depressurization system.

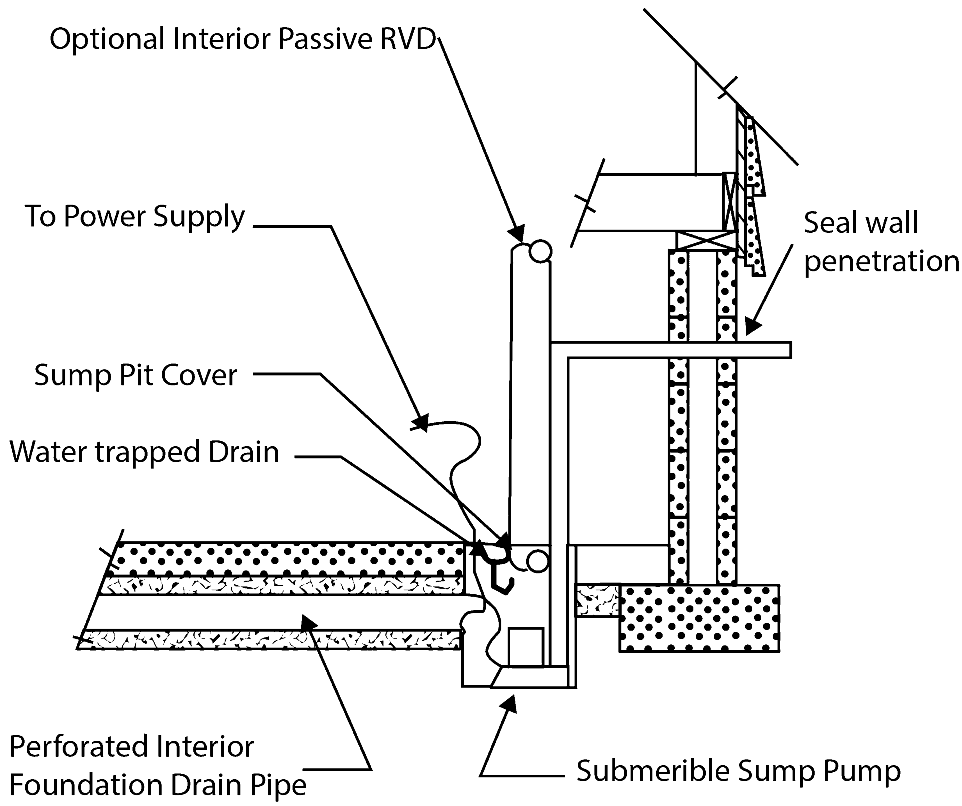

Figure 7-4. Typical Radon-Resistant Technique for Sump Holes, Source: RF Simon Co., Inc.

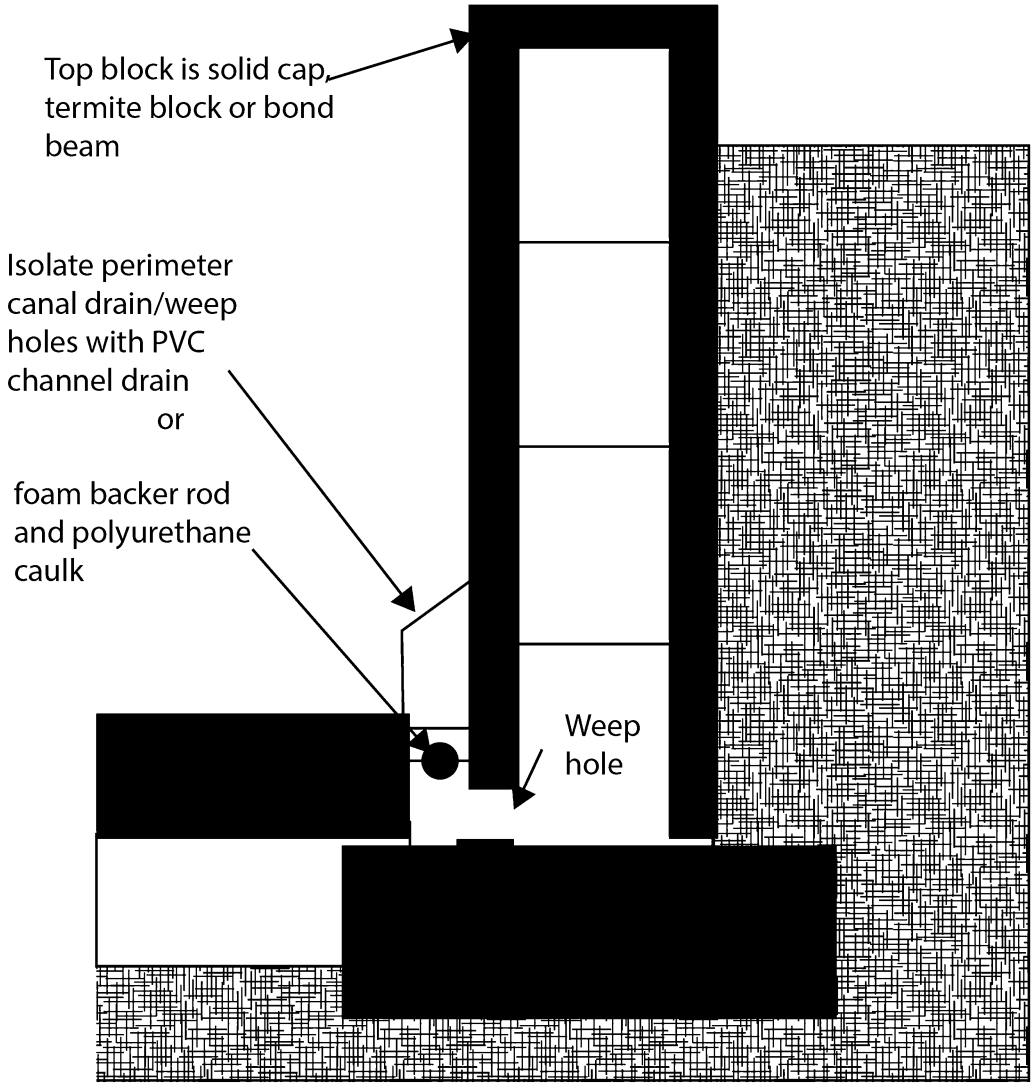

Figure 7-5. Typical Radon-Resistant Techniques For Channel Drains and Weep Holes, Source: MURC

3. Preventing Unintentional Foundation Penetrations

The formation of unintentional foundation penetrations, such as cracks, is a function of the curing of concrete. Cracks can also be formed as a foundation settles. Completely preventing cracks is probably impossible. Some cracks are going to occur, no matter what you do. However, the number, size, and extent of the cracks can be minimized by using proper procedures and materials. The builder should refer to a number of American Concrete Institute (ACI) publications that outline standard building practices; specifically, ACl302.1 R-80, Guide for Concrete Floor and Slab Construction, and ACI332 R-84, Guide to Residential Cast in Place Concrete.

An unintentional but unavoidable crack is the perimeter crack, or floor/wall joint. This crack is located between the edge of the floor slab and the foundation wall. This applies to all foundation types that have a concrete floor slab (except monolithic slabs). The perimeter crack is always a potential radon entry point. Contractors building a radon-resistant house often deliberately create a significant perimeter crack for easy sealing. Many builders tool a valley along the crack for ease of sealing later with polyurethane caulk. There is also a closed-cell flexible foam strip that can be placed between the floor slab and the wall when the slab is poured. The top 1/2 inch of the strip is perforated and can be removed after the slab cures. Polyurethane caulk is then poured into the void, creating a tight seal. Particular attention should be given to the perimeter crack in slab-on-grade homes, because the crack is often inaccessible after the interior walls are finished.

4. *Crawl Space Foundations*

Radon-resistant techniques in crawl spaces are somewhat different from those used in other foundation types. Crawl spaces with large areas of exposed earth should be isolated from the living areas. The major radon entry points are through the numerous electrical, beating, and plumbing penetrations in the floor of the house, as well as through HVAC system ducts that are often located in the crawl space.

During construction of a crawl-space house, all possible penetrations between the crawl space and the living area should be sealed to prevent the passage of radon into the living areas. Penetrations can be sealed with expandable, closed-cell foams and polyurethane caulks. HVAC system ductwork should not be routed through the crawl space, if at all possible. When ductwork does go through the crawl space, the builder's HVAC subcontractor should use seamless ductwork. Duct tape is not recommended, because it dries out and falls off. The use of floor joists and sub-flooring as three sides of the ductwork is also not recommended, due to the difficulties encountered when trying to seal those type ducts. If the space between the joists must be used, fit rectangular, seamless duct into the space.

The ICBO, CABO and BOCA codes both require crawl spaces to have 1 square foot of free vent area for every 150 square feet of floor area for moisture control. BOCA will also allow a power vent option. Passive vents are not needed when mechanical ventilation is supplied at a rate of 0.02 cfm per square foot of crawl space floor area.

IV. Other Approaches: HVAC Systems to Pressurize the Basement

A recent research project, sponsored by EPA's Office of Research and Development, involved modifying a home's HVAC system to supply additional air to the basement and thus pressurize the basement with respect to the outside air pressure. Simple modifications to the HVAC system included installing an opening in the supply air ductwork in the basement and operating the fan continuously on low speed. Sealing leaks in the· supply and return ductwork, and in the foundation and the first floor deck, decreased the amount of basement air leaking outside and upstairs. This approach has been tested in the summer months only, but basement radon concentrations were maintained at an average of 1.1pCi/L with the air handler operating continuously. When the HVAC system was turned off, basement radon concentrations averaged 14.3 pCi/L. Although these results look promising, it is not known how well this approach will work in the colder months, or in homes with very leaky basements or ductwork. Research is continuing on this approach. Figure 7.6, illustrates the HVAC system approach. Figure 7-7 presents data with the system operating and with the system off.

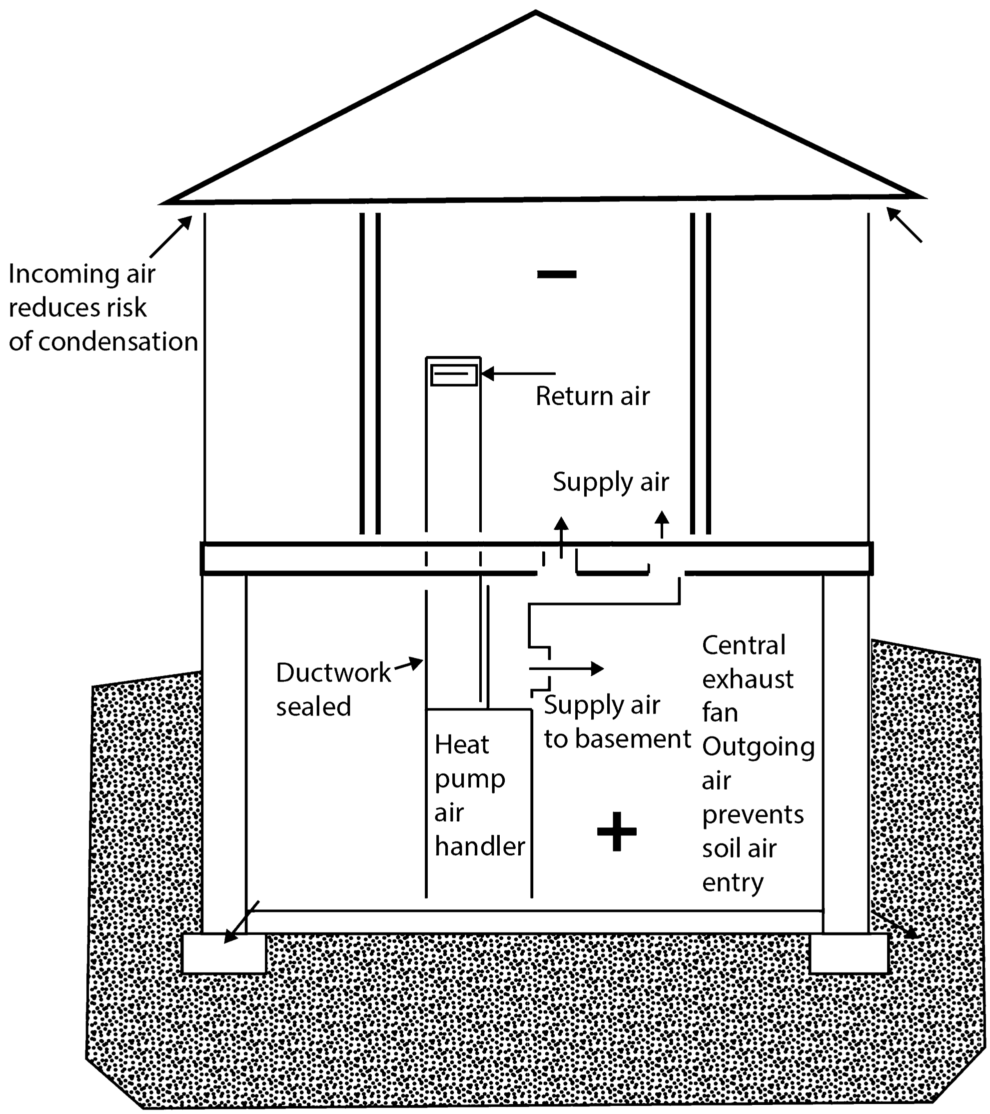

Figure 7-6. HVAC System to Control Basement to Outdoor Pressure Relationships, Source: MURC

V. Stepped ASD Approaches to New House Systems

In a few parts of the United States, building codes have begun to address the subject of radon-resistant construction. At the present time, these practices address aspects of the house construction that would make ASD systems work more cost effectively should radon levels of concern be detected after the house has been built. In most areas of the country, it is primarily at the builder's discretion or at the request of a home buyer that radon-resistant or fully active ASD systems are being built into homes. Although the EPA is working with the Model Code groups to develop building code policies for various pans of the country (based upon radon potential mapping), at present, it is still largely an elective element of new home construction. Therefore, it falls upon the professional mitigator or builder to develop an approach that is consistent with local building practices, radon potential in an area, and market conditions.

New home sales in most areas are very cost sensitive. This is especially true for builders who construct "spec." homes, which are homes marketed to the general public after they are completed. In the case of custom homes, or where an individual will contract to have a house built, the end user of the home can decide whether he or she desires to pay for the additional costs associated with radon systems. Radon mitigators who desire to install radon systems need to be mindful of the economics and the situation involved with each new house system designed and installed. The essence of functioning in the new home market place is to develop a series of options that can progressively lead to a fully active system. There are three major steps which are discussed individually.

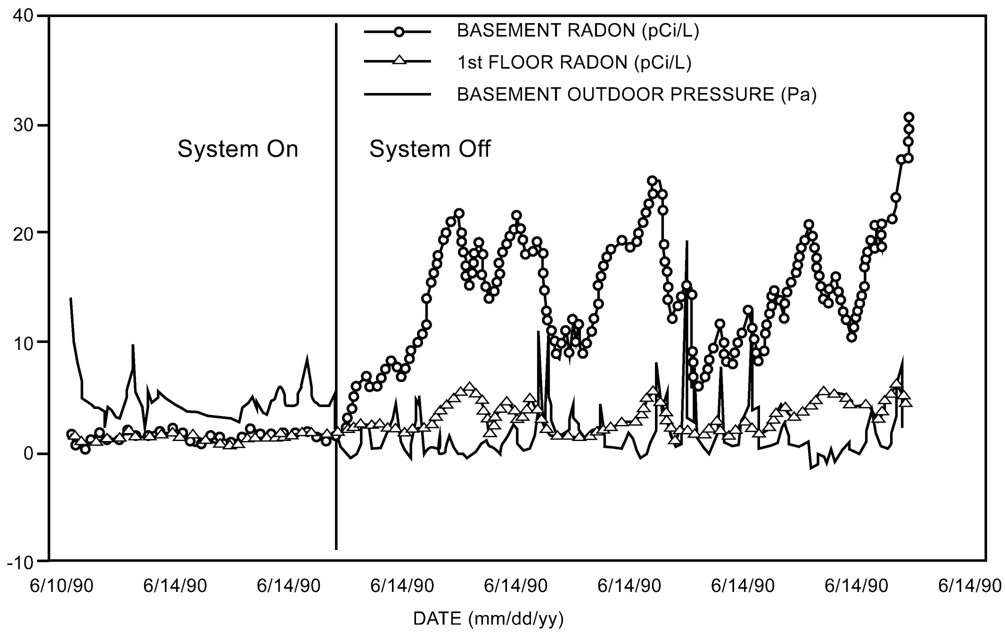

Figure 7-7. Basement and First Floor Radon Concentrations and Basement-to- Outdoor Pressure Differences with HVAC Operating Continuously and with HVAC Off, Source: MURC

A. Radon Ready

If performed during construction, these are a family of items that would facilitate the installation of a fully active soil depressurization system after the completion of the house and radon testing. These could include but not be limited to:

- Large aggregate beneath the slab, with gaps in any grade beams under the slab to enable 1 SSD suction point to extend a negative pressure field fully under the slab.
- A loop of perforated pipe beneath the slab with a PVC riser stubbed of in a location that would be convenient to later install a SSD system. In areas where native soil permeability does not necessitate having aggregate imported, the loop is typically more cost-effective than when aggregate is imported.
- Caulk and seal floor to wall joints, expansion joints, and plumbing penetrations that will be finished during the construction of the home. Determining how much will be caulked will depend upon how much of the basement will be finished, but it may be cost-effective to do all the scaling at the same time.

- Make sure that fresh air make-up for combustion appliances is being introduced to home as per code.
- Review whether furnace ductwork is being planned beneath the slab; if so, recommend against this practice. Also, if ductwork is being routed through crawl spaces, insure that the ductwork is continuous rather than using sheet metal that "pan" the floor joists.
- Review the type of groundwater drainage system that will be installed. If it is an external drain tile, perhaps a riser can be brought up to grade on a . side of the house where a DID system could be installed. Make sure that the riser is located to allow for easy routing up the outside of an inconspicuous portion of the house or garage. If an internal sump with an aggregate or a perforate pipe is used to collect the water, insure that a cover is installed on the sump, such that an ASD system could be installed on the sump lid.
- Review foundation wall construction. If block walls are to be used, insure that the builder makes provisions for top course and head joints to be sealed.

B. Passive Systems

This an extension of radon-ready systems, where the radon vent portion of an ASD system is installed during the construction of the home. Installation of the pipe during construction of the home allows for internal rather than external routing. Internal routing is beneficial not only because of the improved aesthetics of an internal versus external riser, but also because a vent inside a warm home will create a slight vacuum on the underlying soil in the same manner as a chimney or flue will draft. Passive internal venting along with utilization of the techniques associated with radon ready approaches above can often- be sufficient to reduce levels to below 4 pCi/L (Ref. 4). Specific applications of this could include:

ASD riser connected to:

- Floor core into sub-slab gravel.
- Sub-slab perforated pipe loop.
- Sump system.
- A crawl space area or beneath a plastic membrane laid on the crawl space floor and sealed to the foundation walls as would be done in a SMD system.

In all of the above cases it would be prudent to route the pipe up through the house, with as few fittings as possible to augment the passive stack effect. Routing through warm chases, such as the one that would be used for the furnace and hot water flues, will also increase the stack effect.

Another feature that is logical to add to passive systems is that the vent pipe be routed in such a manner that an active fan could be added later. This means that an adequate length of vertical pipe should be routed through the garage or attic. It would also be convenient for the electrician to run electrical power and a junction box to this same general area should subsequent radon testing dictate the need for installation of an ASD fan.

C. Fully Active Systems

This last step is a logical progression from the passive system, which is merely to install an active depressurization fan during construction or after testing has occurred on the finished house. Whether this is done during or after construction will depend upon the experience one obtains in a particular radon potential area. Studies have shown that activation of properly installed passive systems have yielded extremely high radon reduction efficiencies (Ref 3).

What can be a benefit to the new home sale process is that a radon-ready or passive system only be installed. This will allow the builder to represent to the potential buyer that provisions have made to alleviate the problem easily should the buyer test for radon per EPA protocols once they have moved in. If they find radon to be a concern either the builder can install the fan, or the homeowner can contract directly with the mitigation contractor who, via his guarantees and warranties, can remove the builder from the liability loop. In this way, the builder and selling agent can fulfill their disclosure requirements and leave the measurement and mitigation of Florida radon certified contractors.

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Review Questions, Unit 07, Form A

1. When building a house in an area where other houses have high indoor radon levels, what should the contractor do to provide for installation of a future mitigation system?
    - A. Replace the top two feet of soil with washed sand
    - B. Install a permeable material under the slab
    - C. Use a large capacity air conditioning unit
    - D. Caulk around all windows and doors
2. Of the following, which is the BEST reason for constructing a new building foundation using radon-resistant building techniques?
    - A. It requires less labor during construction and therefore costs less to build
    - B. It is significantly more energy efficient than a regular foundation
    - C. It can reduce radon exposure and eliminate the need for a more expensive mitigation system
    - D. It is less likely to incur damage due to climate changes than a regular foundation
3. When designing and installing the HVAC system for a new crawl space foundation building, which procedure is BEST?
    - A. Install all ductwork against the crawl space wall
    - B. " Locate all ductwork between the joists using flex duct
    - C. Hang all ductwork in the crawl away from all walls and floors using seamless ductwork
    - D. Locate all ductwork outside of the crawl space
4. A passive system slab-on-grade home would include:
    - A. a communication layer below the slab
    - B. (A) and caulking of all plumbing penetrations
    - C. (A), (B), and an ASD riser from the slab through the roof
    - D. (A), (B), (C) and an active depressurization fan

Answers to Review Questions, Unit 07

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07.2	C	1-3
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