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2006 BC Building Code Technical Provisions 9.13.4 and 9.32.4

9.13.4. Soil Gas Control

(See Appendix A.)

9.13.4.1. Required Soil Gas Control

1) Except as provided in Sentence (2), all wall, roof and floor assemblies in contact with the ground shall be constructed to resist the leakage of soil gas from the ground into the building.

2) Construction to resist the leakage of soil gas into the building is not required for

a) garages and unenclosed portions of buildings, or

b) buildings constructed in areas where it can be demonstrated that soil gas does not constitute a hazard.

3) Where soil gas control is required, a soil gas barrier shall be installed at walls and roofs in contact with the ground, in accordance with Articles 9.13.4.3. and 9.13.4.4.

4) Where soil gas control is required, it shall consist of one of the following measures at floors in contact with the ground:

a) a soil gas barrier installed according to Articles 9.13.4.5. and 9.13.4.7., or

b) where the building contains a single dwelling unit only, a subfloor depressurization system installed according to Article 9.13.4.6.

(See Appendix A.)

9.13.4.2. Material Standards

1) Materials used to provide a barrier to soil gas ingress through floors-on-ground shall conform to CAN/CGSB-51.34-M, "Vapour Barrier, Polyethylene Sheet for Use in Building Construction."

9.13.4.3. Soil Gas Control in Masonry Walls

(See A-9.13.4.3., 9.13.4.5. and 9.13.4.7. in Appendix A.)

1) Masonry walls required to provide a barrier to soil gas ingress shall

a) include a course of masonry units without voids, or

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b) be sealed with flashing material extending across the full width of the masonry.

2) The masonry course or flashing described in Sentence (1) shall

a) be located at the level of the adjoining floor and be sealed to it in accordance with Article 9.13.4.7., or

b) in the absence of a floor, be located at the level of the ground cover required by Article 9.18.6.1. and be sealed to it.

9.13.4.4. Soil Gas Control in Underground Roofs

1) Waterproofing systems for roofs of underground structures shall be sealed to the soil gas barrier in the walls.

9.13.4.5. Soil Gas Barriers in Floors

(See A-9.13.4.3., 9.13.4.5. and 9.13.4.7. in Appendix A.)

1) Where the floor-on-ground is a concrete slab, the soil gas barrier shall be

a) installed below the slab, or

b) applied to the top of the slab, provided a separate floor is installed over the slab.

(See A-9.13.4.5.(1) and (2) in Appendix A.)

2) Where the soil gas barrier is installed below a slab-on-ground, joints in the barrier shall be lapped not less than 300 mm. (See A-9.13.4.5.(1) and (2) in Appendix A.)

3) Where the soil gas barrier is installed above a slab-on-ground, joints in the barrier shall be sealed.

4) Where installed in conjunction with a framed floor-on-ground, the soil gas barrier shall be installed in accordance with Articles 9.25.3.2. and 9.25.3.3.

9.13.4.6. Providing for Subfloor Depressurization

(See Appendix A.)

1) Except as required in Sentence (3), granular material shall be installed below the floor-on-ground according to Sentence 9.16.2.1.(1).

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- 2)** A pipe not less than 100 mm in diameter shall be installed vertically through the floor, at or near its centre, such that
- a) its bottom end opens into the granular fill described in Sentence (1), and
 - b) its top end will permit connection to depressurization equipment.
- 3)** The granular material described in Sentence (1), near the centre of the floor, shall be not less than 150 mm deep for a radius of not less than 300 mm centred on the pipe described in Sentence (2).
- 4)** The upper end of the pipe described in Sentence (2) shall be provided with a removable seal.
- 5)** The pipe described in Sentence (2) shall be clearly labelled to indicate that it is intended only for the removal of soil gas from below the floor-on-ground.
- 6)** Except as provided in Sentence (8), when a building constructed in accordance with Sentences (1) to (5) is complete, testing shall be conducted according to EPA 402-R-93-003, "Protocols for Radon and Radon Decay Product Measurements in Homes," to determine the radon concentration in the building.
- 7)** A copy of the results of testing required in Sentence (6) shall be provided by the building owner to the authority having jurisdiction.
- 8)** The testing required in Sentence (6) shall include basement concentration measurements.
- 9)** Where the radon concentration determined as described in Sentences (6) and (8) exceeds the Canadian Action Level for radon in residential indoor air, as specified in HC H46-2/90-156E, "Exposure Guidelines for Residential Indoor Air Quality," a subfloor depressurization system shall be installed to reduce the radon concentration to a level below the Canadian Action Level.
- 10)** Where a subfloor depressurization system is installed,
- a) makeup air shall be provided as specified in Article 9.32.3.8., and
 - b) measures shall be taken to ensure that any resultant decrease in soil temperature will not adversely affect the foundation.

9.13.4.7. Sealing of the Perimeter and Penetrations

(See A-9.13.4.3., 9.13.4.5. and 9.13.4.7. in Appendix A.)

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- 1) A floor-on-ground shall be sealed around its perimeter to the inner surfaces of adjacent walls using flexible sealant.
- 2) All penetrations of a floor-on-ground by pipes or other objects shall be sealed against soil gas leakage.
- 3) All penetrations of a floor-on-ground that are required to drain water from the floor surface shall be sealed in a manner that prevents the upward flow of soil gas without preventing the downward flow of liquid water.

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9.32.4. Additional Protection Against Depressurization

9.32.4.1. Protection Requirements

- 1) Additional make-up air for the actual appliance exhaust rate shall be provided for any appliance which discharges air to the exterior at an installed rate exceeding 0.5 air change per hour when it is located within a *dwelling unit* that
 - a) contains a vented appliance that is subject to back drafting (Naturally Aspirating Fuel Fired Vented Appliance) (See A-9.32.3.8.(1)(a) in Appendix A), or
 - b) is located in an area where soil gas is deemed to be a problem and incorporates no soil gas mitigation system.

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Appendix Note for A-9.13

A-9.13.4. Exclusion of Soil Gas. Outdoor air entering a dwelling through above-grade leaks in the building envelope normally improves the indoor air quality in the dwelling by reducing the concentrations of pollutants and water vapour. It is only undesirable because it cannot be controlled. On the other hand, air entering a dwelling through below-grade leaks in the envelope may increase the water vapour content of the indoor air and may also bring in a number of pollutants which it picks up from the soil. This mixture of air, water vapour and pollutants is sometimes referred to as "soil gas." One pollutant often found in soil gas is radon.

Radon is a colourless, odourless, radioactive gas that occurs naturally as a result of the decay of radium. It is found to varying degrees as a component of soil gas in all regions of Canada and is known to enter dwelling units by infiltration into basements and crawl spaces. The presence of radon in sufficient quantity can lead to increased risk of lung cancer.

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The potential for high levels of radon infiltration is very difficult to evaluate prior to construction and thus a radon problem may only become apparent once the building is completed and occupied. Therefore various sections of Part 9 require the application of certain radon exclusion measures in all dwellings. These measures are

- low in cost,
- difficult to retrofit, and
- desirable for other benefits they provide.

There are two principal methods of excluding soil gas:

- Sealing the interface between the soil and the occupied space, so far as is reasonably practicable. Sections 9.13. and 9.18. include requirements for soil gas barriers in crawl spaces. Providing control joints to reduce cracking of foundation walls and airtight covers for sump pits are other measures which can help achieve this objective. The requirements provided in Articles 9.13.4.3., 9.13.4.5., and 9.13.4.7. are described in Appendix Notes A-9.13.4.3., 9.13.4.5. and 9.13.4.7., and A-9.13.4.5.(1) and (2).
- Ensuring that the pressure difference across the soil/space interface is positive (i.e., towards the outside) so that inward soil gas flow through any remaining leaks will be prevented. The requirements provided in Article 9.13.4.6. are described in Appendix Note A-9.13.4.6.

A-9.13.4.1.(4) Subfloor Depressurization in Houses with Preserved Wood Foundations. Standard CAN/CSA-S406, "Construction of Preserved Wood Foundations," requires that a polyethylene sheet ground cover be installed under all floors-on-ground in buildings with preserved wood foundations. The use of a subfloor depressurization system may be acceptable with such constructions, seeing as the standard doesn't mention otherwise, but the polyethylene sheet ground cover is an unconditional requirement of that standard. The polyethylene sheet cannot be forfeited in houses intended to conform to the standard and the depressurization system would have to be installed under the ground cover membrane.

A-9.13.4.3., 9.13.4.5. and 9.13.4.7. Soil Gas Barriers. The requirements provided in Article 9.13.4.3., Soil Gas Control in Walls, Article 9.13.4.5., Soil Gas Barriers, and Article 9.13.4.7., Sealing of the Perimeter and Penetrations, are illustrated in Figures A-9.13.4.3., 9.13.4.5. and 9.13.4.7.-A and A-9.13.4.3., 9.13.4.5. and 9.13.4.7.-B.

The requirement in Sentence 9.13.4.7.(2) regarding sealing of penetrations of the slab also applies to hollow metal and masonry columns. Not only the perimeters but also the centres of such columns must be sealed or blocked.

Figure A-9.13.4.3., 9.13.4.5. and 9.13.4.7. -A

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Dampproofing and soil gas control at foundation wall/floor junctions with solid walls

The requirement in Sentence 9.13.4.7.(3) regarding drainage openings in slabs can be satisfied with any of a number of proprietary devices that prevent soil gas entry through floor drains. Some types of floor drains incorporate a trap that is connected to a nearby tap so that the trap is filled every time the tap is used. This is intended to prevent the entry of sewer gas but would be equally effective against the entry of soil gas.

Figure A-9.13.4.3., 9.13.4.5. and 9.13.4.7. -B

Dampproofing and soil gas control at foundation wall/floor junctions with hollow walls

A-9.13.4.5.(1) and (2) Polyethylene Soil Gas Barriers under Slabs-on-Ground. Floors-on-ground serving all types of occupancies other than garages must be constructed to reduce the potential for entry of radon or other soil gases. In most cases, this will be accomplished by placing 0.15 mm polyethylene under the floor.

Finishing a concrete slab placed directly on polyethylene can, in many cases, cause problems for the inexperienced finisher. A rule of finishing, whether concrete is placed on polyethylene or not, is to never finish or "work" the surface of the slab while bleed water is present or before all the bleed water has risen to the surface and evaporated. If finishing operations are performed too early, such as before all the bleed water has risen and evaporated, surface defects such as blisters, crazing, scaling and dusting can result. This is often the case with slabs placed directly on polyethylene. The amount of bleed water that may come to the surface and the time required for this to happen is increased from that of a slab placed on a compacted granular base. The excess water in the mix from the bottom portion of the slab cannot bleed downward and out of the slab and be absorbed into the granular material below, because of the polyethylene. Therefore, all bleed water, including that from the bottom of the slab, must now rise through the slab to the surface. Quite often in such cases, finishing operations are begun too soon and surface defects result.

One solution that is often suggested is to place a layer of sand between the polyethylene and the concrete. However, this is not an acceptable solution for the following reason: it is unlikely that the polyethylene will survive the slab pouring process entirely intact. Nevertheless, the polyethylene will still be effective in retarding the flow of soil gas if it is in intimate contact with the concrete; soil gas will only be able to penetrate where a break in the polyethylene coincides with a crack in the concrete. The majority of concrete cracks will probably be underlain by intact polyethylene. On the other hand, if there is an intervening layer of a porous medium, such as sand, soil gas will be able to travel laterally from a break in the polyethylene to the nearest crack in

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the concrete and the total system will be much less resistant to soil gas penetration.

To reduce and/or control the cracking of concrete slabs, it is necessary to understand the nature and causes of volume changes of concrete and in particular those relating to drying shrinkage. The total amount of water in a mix is by far the largest contributor to the amount of drying shrinkage and resulting potential cracking that may be expected from a given concrete. The less total amount of water in the mix, the less volume change (due to evaporation of water), which means the less drying shrinkage that will occur. To lessen the volume change and potential cracking due to drying shrinkage, a mix with the lowest total amount of water that is practicable should always be used. To lower the water content of a mix, superplasticizers are often used to provide the needed workability of the concrete during the placing operation. High water/cementing materials ratio concretes usually have high water content mixes. They should be avoided to minimize drying shrinkage and cracking of the slab. The water/cementing materials ratio for slabs-on-ground should be no higher than 0.55.

A-9.13.4.6. Soil Gas Control by Depressurization. As noted in Appendix Note A-9.13.4., one method of excluding soil gas from below-grade living space is to ensure that the pressure difference across the soil/space interface is positive (i.e., towards the outside) so that inward soil gas flow through any leaks will be prevented. This requires consideration of the air pressure on the inside of the envelope and the pressure within the soil. Each is affected by quite different factors.

There is a safe range for the interior pressure in a house. The upper limit is primarily due to the need to minimize outward leakage of the warm, moist interior air through leaks in the building envelope. The lower limit depends on the type of combustion heating equipment present in the house, as discussed in Appendix Note A-9.33.1.1.(2). It also follows from the need to avoid drawing in soil gas, as discussed in Appendix Note A-9.13.4.

Controlling the entry of soil gas by house or basement pressurization is therefore problematic, since it could lead to exfiltration-caused condensation problems in the building envelope. This leaves the option of reducing the pressure outside the envelope as the most practical method of achieving the desired outward pressure difference.

Subfloor depressurization systems have been found to be very effective for controlling soil gas entry into houses. At least in areas which are prone to higher than normal radon levels, or other ground pollutants, this practice is recommended.

Article 9.13.4.6. provides for depressurization as an alternative to the installation of polyethylene below floor slabs. Using this option, a vent pipe for

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use with a subfloor depressurization system is installed through the floor but is only connected if soil gas levels are found to be excessive.

Radon testing must be performed on the house and copies of the results provided to the home owner and the authority having jurisdiction. Since the radon level in a house can vary significantly during the year, the test should be of sufficient duration to provide a reasonable indication of the concentration. The minimum period for testing should be three months or as recommended by the authority having jurisdiction. The preferred testing location is centrally in the basement or the main floor for houses without basements.

The current Canadian Action Level for radon, as specified by Health Canada, is 800 Bq/m³ (see H46-2/90-156E, "Exposure Guidelines for Residential Indoor Air Quality"). If the results of the test indicate a concentration exceeding the Canadian Action Level, the rest of the sub-slab depressurization system must be installed. (It may be noted that Canadian and U.S. action levels are likely to differ.)

Installation of the sub-slab depressurization system requires that the pipe cast through the slab to the sub-slab space be uncapped and connected to a ventilation system exhausting to the outside. Exhaust pipes passing through unheated spaces should be insulated. The exhaust fan should be located outside the occupied space where noise will not be a nuisance. It is also best to locate the fan as close to the final outlet end of the ventilation system as possible so that the pressurized portion of the system downstream of the fan will not be located in or adjacent to the living space. If the pressurized portion of the system were to pass through the living space, then any leak in the system would have the potential to spill high concentration soil gas into the living space, thus exacerbating the situation the system was intended to correct. The fan should be of a type suitable for the application and capable of continuous operation.

Since radon concentration of the vent gases can become quite high, soil gases collected by the sub-slab depressurization system should be vented at the roof level. Therefore, it may be desirable to take some simple steps to facilitate future installation of the system. This could include locating the slab vent pipe below a suitable interior partition, through which the vertical riser could be run, and pre-drilling the partition top and bottom plates, particularly those not accessible from a basement or attic.

The house should be re-tested for radon after completion of the depressurization system.