

Lawton Chiles
Governor



James T. Howell, M.D., M.P.H.
Secretary

This Document Includes the Following:

**Florida Standard for Passive Radon-Resistant
New Residential Building Construction
July 1, 1995**

**Attachment
Design Guidance for Residential Active
Radon Control Systems
July 1995**

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**Florida Standard for Passive Radon-Resistant
New Residential Building Construction**

July 1,1995

State of Florida
Florida Department of Community Affairs
Radon Program
2555 Shumard Oak Blvd
Tallahassee, FL 32399-2100

Linda Loomis Shelley, Secretary

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CHAPTER ONE

GENERAL

101 General

Provisions in the following chapters and sections shall constitute and be known as and may be cited as the Florida Standard For Passive Radon-Resistant New Residential Building Construction, hereinafter referred to as "this standard."

102 Intent

102.1 General This standard shall apply to the design and construction of new residential buildings as determined in Section 103 "Scope" to enable control of human exposure to indoor radon and its progeny.

102.2 Compliance This passive standard will provide radon protection beyond that provided by standard building code provisions. Compliance with existing local building codes and with the Florida Energy Efficiency Code for Building Construction, current edition, is assumed.

103 Scope

103.1 Applicability The provisions of this standard shall apply to the construction of new residential buildings and additions to existing residential buildings. Residential buildings are defined for the purposes of this standard as one- or two-family detached houses and town house apartments with no more than three stories (distinguished from condominiums, apartments and commercial buildings that employ different construction practices).

103.2 Additions When the cost of an addition exceeds a cumulative total of 50% of the assessed value of the existing building, only the addition to the building must meet the requirements for new buildings in Section 104.1.

104 Compliance

104.1 New Buildings and Additions All new residential buildings and additions to existing residential buildings shall use passive radon protection measures, as determined in Chapter 3 of this standard.

104.2 Exemptions Exempt buildings are as follows:

- (1) Buildings of classifications not listed in Section 103.1 Applicability, and
- (2) Residential buildings built on piers or pilings that elevate the bottom of the floor joists a minimum of 18 inches above grade, which do not have skirting or stem walls that restrict air ventilation, and which comply with the following additional provisions:
 - (a) The perimeter of the building from the ground plane to the lower surface of the

floor shall be totally open for ventilation, except for the occurrence of enclosures complying with item (c) below.

- (b) All pilings, posts or other supports shall be solid, or if hollow, shall be capped by an 8-inch solid masonry unit or sealed by a permanent barrier that is impermeable to air flow.
- (c) Enclosures of any kind, including chases, storage rooms, elevator shafts and stairwells, etc., that connect between the soil and the structure shall be sealed at the surface of the soil to comply with the sealing provisions of Chapter 3 and shall have a soil contact area of less than 5% of the total building floor area.

CHAPTER TWO

DEFINITIONS

201 General

For the purposes of this standard, certain abbreviations, terms, phrases, words and their derivatives shall be set forth in this chapter. Words not defined herein shall have the meanings stated in the Standard Building Code, Standard Mechanical Code, Standard Plumbing Code, Standard Gas Code, Standard Fire Prevention Code, or the current Florida Energy Efficiency Code for Building Construction. Words not defined in these codes shall have the meanings in Webster's Ninth New Collegiate Dictionary, as revised.

202 Definitions

ADDITION - a building extension or increase in floor area that can be occupied or that exchanges air with the conditioned space of the building.

AIR DISTRIBUTION SYSTEM - for the purposes of this standard, the air distribution system components which include ducts, plenums, air handlers, furnaces, single package air conditioners, etc.

CAULKS AND SEALANTS - those materials which will significantly reduce the flow of gases through small openings in the building shell; Among those used are:

Urethane - a crystalline ester-amide used as a gelatinizing agent for cellulose acetate or cellulose nitrate. A component of polyurethane used in making flexible and rigid foams, elastomers, and resins for coatings and adhesives.

Epoxy - a thermosetting resin characterized by adhesiveness, flexibility and resistance to chemicals and used chiefly as a coating or adhesive.

Polysulfide rubber - a synthetic rubber characterized by impermeability to gases and used in adhesives, binders and sealing compositions and in coatings.

CONDITIONED FLOOR AREA - the horizontal projection (outside measurements) of that portion of space which is conditioned directly or indirectly by an energy-using system.

CONDITIONED SPACE - all spaces which are provided with heated and/or cooled air or which are maintained at temperatures over 50⁰F during the heating season, including adjacent connected spaces separated by an un-insulated component (e.g. basements, utility rooms, garages, corridors).

CONTRACTION JOINT - a formed, sawed, or tooled groove in a concrete slab to create a weakened plane and control the location of cracking resulting from drying and thermal shrinkage (also sometimes called control joint).

CRAWL SPACE - the unconditioned space between the lowest structural member of the floor and the earth. The crawl space is created when the floor spans between structural supports rather than being directly supported by the earth beneath the floor.

ELASTOMERIC - that property of macromolecular material of returning rapidly to approximately the initial dimensions and shape, after substantial deformation by a weak stress and release of stress.

HIGH RANGE WATER REDUCER- a chemical admixture added to the concrete capable of reducing the water content at least 12%. This admixture shall conform to ASTM C494 type F or G.

HVAC - heating, ventilating and air conditioning.

INFILTRATION BARRIER - a product or system designed to limit the free passage of air through a building envelope component (wall, ceiling or floor). Such products and systems may be continuous or non-continuous discrete elements which are sealed together to form a continuous barrier against air infiltration.

MANUFACTURED SANDS sands resulting from the crushing of rock, gravel, or slag.

MASTIC - a sealant with putty-like properties.

MID RANGE WATER REDUCER - a water reducing admixture capable of reducing water content from 6-15%. This admixture shall conform to ASTM C494 Type A and or F.

MITIGATE - make less severe, reduce, relieve.

NATURAL SANDS - sands resulting from the natural disintegration and abrasion of rock.

OCCUPANCY - the purpose for which a building or part thereof is used or intended to be used. For the purposes of determining changes of occupancy for this code, the occupancy shall be considered the major occupancy group designations established by the locally adopted building code.

OUTSIDE AIR - air taken from the outdoors and, therefore, not previously circulated through the system.

PASSIVE RADON PROTECTION SYSTEM - indoor radon reducing building design, material, or construction features that increase the barriers to radon entry and require no mechanical operation, operating costs, or user attention beyond normal home maintenance (such as re-caulking floor cracks, etc.).

PERM - unit of measurement of the water vapor permeance of materials. Value of one perm is equal to one grain of water vapor per square foot hour per inch of mercury vapor pressure difference.

PICOCURIE (pCi) - a unit of measurement of radioactivity. A curie is the amount of any radionuclide that undergoes exactly 3.7×10^{10} radioactive disintegrations per second. A PICOCURIE is one trillionth (10^{-12}) of a curie, or 0.037 disintegrations per second.

PICOCURIE PER LITER (pCi/L) - a common unit of measurement of the concentration of radioactivity in a gas. A PICOCURIE per liter corresponds to 0.037 radioactive disintegrations per second in every liter of air.

RADIUM (Ra) - a naturally occurring radioactive element resulting from the decay of uranium. For the purposes of this standard, radium applies to radium-226. It is the parent of radon gas.

RADON - a naturally occurring, chemically inert, radioactive gas. It is part of the uranium - 238 decay series. For the purposes of this standard, radon applies to radon-222; thus, it is the direct decay product of radium - 226.

REMOTE SPACE - a space isolated from the main conditioned area of a building by intermediate non-conditioned spaces.

RESIDENTIAL BUILDING - residential occupancies which include single-family and multifamily buildings that are three or fewer stories above grade. Hotels, motels and other transient occupancies are considered non-residential buildings for the purpose of this standard.

SLUMP - A measure of the relative consistency or stiffness of fresh concrete mix, as defined by ASTM-C 143.

SOIL GAS - gas which is always present underground, in the small spaces between particles of the soil or in crevices of rock. Major constituents of soil gas include air and water vapor. Since radium-226 is essentially always present in the soil or rock, trace levels of radon-222 also will exist in the soil gas.

SUB-STRUCTURE MEMBRANE - flexible, non-degrading material sheet placed between the soil and the building for the purpose of reducing the flow of soil gas and moisture into the building. Examples are: polyethylene, ethylenepropylene diene terpolymer (EPDM), neoprene, and cross laminated HDPE.

VENTILATION - the process of supplying or removing air, by natural or mechanical means, to or from any space. Such air may or may not have been conditioned.

WATER-REDUCING ADMIXTURE - a chemical additive to concrete capable of increasing its flowability without increased mixing water, without set retardation, and without increased air entrainment.

CHAPTER THREE
CONSTRUCTION REQUIREMENTS
FOR PASSIVE RADON CONTROL

301 General

This chapter provides minimum design and construction criteria for passive control of radon entry into residential buildings. Construction to these standards will limit radon entry points through building floors and foundations and will limit mechanical depressurization of buildings which can enhance radon entry.

302 Sub-Slab and Soil Cover Membranes

302.1 Membrane Material A sub-slab or soil-cover membrane shall consist of a minimum 0.006 inches (6 mil) thick single layer of polyethylene. Polyvinylchloride (PVC), ethylene propylene diene terpolymer (EPDM), neoprene, or other non-deteriorating non-porous material may be used instead of polyethylene, provided the installed thickness has greater or equal resistance to air flow, puncturing, cutting and tearing, and a permeance of less than 0.3 perms, as determined in accordance with ASTM E96. The membrane shall be placed to minimize seams and to cover all of the soil below the building floor.

302.2 Tape Tape used to install the membrane shall have a minimum width of 2 inches and shall be pressure sensitive vinyl or other non-deteriorating pressure sensitive tape compatible with the surfaces being joined. Paper tape and/or cloth shall not be used for these purposes.

302.3 Mastic Mastic used to install the membrane shall be compatible with the surfaces being joined, and shall be installed in accordance with the manufacturer's recommendations for the materials, surface conditions and temperatures involved. Mastic may be used to join sections of membrane to one another or to elements of the building foundation, or to seal penetrations in the membrane.

302.4 Installation The membrane shall be placed under the entire soil-contact area of the floor in a manner that minimizes the required number of joints and seams. Care shall be taken to prevent damage to the membrane during the construction process.

302.5 Seams Seams between portions of the membrane shall be lapped a minimum of 12 inches and shall be secured in place with a continuous band of tape or mastic centered over the edge of the top membrane.

302.6 Slab Edges and Joints The membrane shall fully cover the soil beneath the building floor. Where the slab edge is cast against a foundation wall or grade beam, the membrane shall contact the foundation element, and shall not extend vertically into the slab more than one inch.

302.7 Penetrations, Punctures, Cuts and Tears At all points where pipes, conduits, stakes, reinforcing bars or other objects pass through the membrane, the membrane shall be fitted to within 1/2 inch of the penetration and sealed to the penetration. Penetrations may be sealed with either mastic or

tape. When necessary to meet this requirement, a second layer of the membrane, cut so as to provide a minimum 12 inches lap on all sides, shall be placed over the object and shall be sealed to the membrane with a continuous band of tape.

302.8 Repairs Where portions of an existing slab have been removed and are about to be replaced, a membrane shall be carefully fined to the opening, and all openings between the membrane and the soil closed with tape or mastic.

303 Floor Slab-on-Grade Buildings

303.1 General All concrete slabs supported on soil and used as floors for conditioned space or enclosed spaces connected or adjacent to a conditioned space shall be constructed in accordance with the provisions of Section 302 and Section 303.

303.2 Slab Edge Detail Slabs and foundations shall be constructed using a slab edge detail that eliminates cracks that could connect the house interior to sub-slab soil and is consistent with other construction constraints such as terrain. Monolithic slab construction should be used where possible. Only the following slab edge detail options may be used:

- (1) Thickened Edge Monolithic - The sub-slab membrane shall extend beyond the outside face of the slab edge.
- (2) Slab Poured Into Stem Wall - where concrete blocks are used as slab forms, the sub-slab membrane shall extend horizontally at least 1 inch into the stem wall, but shall not extend upward along any vertical faces of the stem wall. The concrete slab shall be poured into the stem wall to completely fill its open volume to form a continuous and solid stem wall cap of minimum 8 inch thickness. Framed exterior walls shall be sealed or gasket to the slab.
- (3) Slab Capping Stem Wall - where the floor slab is formed and placed to completely cover the stem wall, the sub-slab membrane shall extend horizontally beneath the slab to its outer edge. The supporting stem wall shall be capped with a solid masonry unit of at least 4 inch thickness beneath the membrane and the slab.

303.3 Sealing of Joints, Penetrations and Cracks in Slabs

303.3.1 Contraction Joints All contraction joints shall be cleaned and sealed against soil-gas entry by use of an approved sealant (see Section 303.6) applied according to the manufacturer's instructions. (Note: most sealants require the concrete to be cured and dried.) For bottom-induced joints, inverted T-split ribbed waterstops at least 6 inches wide made of impermeable material may be formed into the slab and shall not require top-surface sealing for radon control.

303.3.2 Horizontal Joints Horizontal joints between two slabs of different elevations that are poured at different times shall provide horizontal contact between the two slabs that is at least 8 inches wide, or shall be sealed by an approved sealant (Section 303.6).

303.3.3 Vertical Joints Through Slabs Vertical joints through slabs shall be formed with a recess of not less than 1/4 inch by 1/4 inch and sealed with an approved sealant. Exception: Slab-edge vertical joints occurring in slab poured into stem wall construction (see Section 303.2(2)). The sealant (see Section 303.6) shall be applied according to the manufacturer's instructions. (Note: most sealants require the concrete to be cured and dried.)

303.3.4 Penetrations

303.3.4.1 Stake Penetrations Any stake that extends through more than 1/4 the thickness of the slab shall be of a non-porous material resistant to decay, corrosion, and rust, and shall be cast tightly against the slab, or sealed to the slab in accordance with Section 303.6. All stakes shall either be solid, or shall have the upper end tightly sealed by installation of an end cap designed to provide a gas-tight seal.

303.3.4.2 Work Spaces Work spaces formed into a slab, such as beneath a shower or bath tub drain, shall be sealed gas tight. The exposed soil shall be compacted and then shall be fully covered with a solvent-based plastic roof cement or a foamed-in-place polyurethane sealant or other approved elastomeric material to a minimum depth of 1 inch.

303.3.4.3 Pipe Penetrations Plastic pipes shall be in contact with the slab along the slab's depth by casting the concrete tightly against the pipe. Where pipes are jacketed by sleeves they shall be sealed by one of the following methods:

- (1) Formation of a slot in the slab around the pipe and casting with asphalt or an approved sealant from the slab to a point above the sleeve, or
- (2) Seal the space between the sleeve and the pipe with an appropriate joint sealant (see Section 303.6).
- (3) Pipes and wiring penetrating the slab through chases or conduit shall be sealed by placing an approved sealant between the pipe or wiring and chase or conduit. Plastic sheath, foam or insulation material shall not be used alone around pipes or conduit for sealing purposes.
- (4) Where multiple pipes are ganged, block out a work space around the multiple pipes and seal as in Section 303.3.4.2.

303.3.5 Cracks All slab cracks greater than 1/32 inch wide; all cracks that exhibit vertical displacement; all cracks that connect weakened zones in the slab such as vertical penetrations or re-entrant corners; and, all cracks that cross changes in materials or planes in the structure, shall be cleaned and sealed against radon entry, prior to applying floor covering, with a flexible field-molded elastomeric sealant installed in accordance with Section 303.6. Cracks less than 1/32 inch in width that do not meet any of the above criteria may be left unsealed.

303.4 Concrete for Slabs

303.4.1 Mix Design Mix designs for all concrete used in the construction of slab on grade floors shall specify a minimum design strength of 3,000 psi at 28 days and a design slump not to exceed 4 inches. On site slumps shall not exceed 5 inches, provided total water added to the mix including plant, transit and site added water does not exceed the following parameters:

- (1) For Mixes Using Natural Sands - 275 pounds per cubic yard (33 gallons).
- (2) For Mixes Using Manufactured Sands - 292 pounds per cubic yard (35 gallons).

303.4.2 Concrete Placement For improved workability of concrete used in the construction of slab on grade floors, additional water and/or water-reducing admixtures shall be used within the following constraints:

- (1) Slumps in excess of 5 inches shall be achieved through the use of mid-range or high-range water reducing admixtures. Water shall not be used in excess of the limitations.
- (2) Slumps of concrete containing mid-range or high range water reducing admixtures shall not exceed 8 inches.

303.4.3 Curing Concrete slabs shall be cured continuously after pouring according to one of the following procedures:

- (1) Moist curing by means of ponding, fog spray or wet burlap for at least 7 days.
- (2) Moist curing using impermeable cover sheet materials conforming with ASTM C171 for at least 7 days.
- (3) Curing with liquid membrane forming compound according to manufacturer's specifications and conforming with ASTM C309.

Curing compounds shall be compatible with materials specified in Section 303.6.

303.4.4 Loading Loading or use of the slab shall be delayed for a minimum of 48 hours after concrete placement. When the slab is used for material storage after the minimum 48 hour period, caution should be used to prevent impact loading.

303.4.5 Slab Reinforcement Floor slabs shall be reinforced by steel reinforcing bars at re-entrant corners such as inside corners of an L-shaped slab. Re-entrant corners shall have two pieces of #4 reinforcing bar 36 inches long placed diagonally to the corner, 12 inches apart, with the first bar placed 2 inches from the corner. All reinforcement shall be appropriately positioned in the upper third of the slab.

303.5 Sealing Walls Penetrations for electrical receptacle and switches, wiring, plumbing, etc. in the interior surface of the concrete block walls shall be sealed.

303.6 Approved Sealant Material Acceptable polyurethane, polysulfide and epoxy caulks and sealants shall conform with ASTM C920-87 "Standard Specifications for Elastomeric Joint Sealants" and ASTM C1193-91 "Standard Guide for Use of Joint Sealants." Sealant material and the method of application shall be compatible with curing compounds, admixtures and floor finishing materials; withstand light traffic; be impermeable to soil-gas; and have an allowable extension and compression of at least 25 percent with 100 percent recovery. Sealants shall be applied to dried and cured concrete in accordance with manufacturers' instructions. Backer rods may be used to support sealants in cracks and joints.

304 Slab-Below-Grade Construction

304.1 General For the purposes of this standard, slab-below-grade construction is defined as any conditioned space with the finished floor below finished grade at any point.

304.2 Slab Construction Slabs shall have a sub-slab membrane, conforming with Section 302 that extends to the slab perimeter, but does not vertically separate the slab from the foundation wall. The slab and membrane shall be placed in accordance with Section 303, or may utilize a floating slab design with all of the following conditions:

- (1) The stem wall is solid poured concrete.
- (2) The slab-wall joint is tooled and sealed with flowable polyurethane (according to Section 303.6).
- (3) All other provisions of Section 303 are satisfied.

304.3 Sealing Walls

304.3.1 Walls Walls surrounding slab-below-grade space shall be constructed from solid poured concrete, at least 8 inches thick, and shall be sealed with a continuous waterproofing coating applied to their outside surface from the top of the footing to finished grade. This coating shall completely seal any joint between the footing and the wall.

304.3.2 Utility Penetrations All utility penetrations through walls in partial or full contact with the soil shall be closed and sealed with an approved sealant material (see Section 303.6) on the interior and exterior faces of the wall.

304.4 Sumps Any sump located in a habitable portion of a building, or in an enclosed space directly attached to a portion of a building, shall be covered by a lid. An air tight seal shall be formed between the sump and lid and at any wire or pipe penetrations.

305 Buildings with Crawl Spaces

305.1 General For the purposes of this standard, buildings with crawl spaces include all buildings with floor supported above grade which do not meet the requirements of Section 306.

305.2 Floor Systems Reinforced concrete floors constructed over crawl spaces shall conform to all applicable provisions of Section 303. Wood framed floors constructed over crawl spaces shall include an air infiltration barrier in compliance with the Florida Energy Efficiency Code for Building Construction, current edition. All joints and penetrations through the floor, including plumbing pipes, conduits, chases, wiring, ductwork and floor-wall joints, shall be fully sealed with an approved caulk. Where large openings are created (such as at bath tub drains), sheet metal or other rigid materials shall be used in conjunction with sealants to close and seal the openings.

305.3 Crawl Space Ventilation Screened vents without closures shall be installed around the perimeter of the house to connect the crawl space with outdoor air.

305.3.1 Vent Area The crawl space vents shall have a total area equal to either:

- (1) at least 1/150 of the area enclosed by the crawl space if the crawl space is exposed to bare soil; or
- (2) at least 1/300 of the area enclosed by the crawl space if the crawl space is completely covered by a sub-structure membrane.

305.3.2 Ventilation Obstructions The crawl space shall not contain structures that restrict ventilation in the crawl space. If freeze protection is provided for plumbing in the crawl space, the protection shall not restrict air ventilation in the crawl space.

305.4 Sealing Walls and Doors Penetrations from the crawl space into wall cavities shall be fully sealed with an approved caulk or sealant. When a door is located between the crawl space and the conditioned space, it shall be fully weatherstripped or gasketed.

305.5 Closing and Sealing Other Paths Any openings that connect a crawl space and the closed space between floor or ceiling joists, wall studs, or any other cavity adjoining conditioned space shall be closed and sealed.

305.6 Soil Connection Foundation walls and piers or other intermediate supports that intersect the floor plane shall be solid across the entire horizontal section at a point above the ground plane.

306 Buildings with Combination Floor Systems

306.1 Floor System Construction Where slab-on-grade, slab below-grade, crawl space or elevated building construction are combined in one structure, the provisions for each construction type shall be met.

306.2 Walls A wall located between a crawl space and conditioned space shall be designed and constructed in compliance with the Florida Energy Efficiency Code for Building Construction, current, and the provisions of the applicable Sections 303 through 305 of this standard.

307 Space Conditioning Systems

307.1 Equipment Enclosures

307.1.1 Crawl Spaces Return ducts, return plenums, and air handlers shall not be located in crawl spaces. Crawl spaces shall not be used as supply or return plenums.

307.1.2 Condensate Drains, Piping and Wiring Chases Condensate drain pipe joints shall be sealed (chemical weld, soldered, etc.) gas tight and shall terminate outside the building perimeter at a height of at least 6 inches above the finished grade ground level. Chases through which the condensate and refrigerant lines run shall not terminate in the return sections of the air distribution system. Where chase lines terminate within the house or garage, they shall be sealed.

307.2 Air Distribution Systems

307.2.1 Sealing All ducts and plenums shall be made airtight, constructed and installed in accordance with the current edition of the Florida Energy Efficiency Code for Building Construction. Where rigid fibrous glass ductboard is used, the seal must be on the foil air barrier side of the ductboard.

307.2.2 Return Plenums and Ducts Return air shall be separated from any floor that is in contact with the soil or a crawl space, by a plenum or duct fabricated in compliance with Section 307.2.1 and all local codes. Construction of the return plenum or duct shall provide a continuous air barrier that completely separates the depressurized plenum or duct from adjacent building components including but not limited to floors, walls, chases, enclosures, etc. The support platform shall not be used as a return plenum. Where the support platform provides a protective enclosure for a duct, one side shall have a removable panel or door to provide access for inspection and/or repair of the duct and duct-to-air handler connection. Ducts shall carry the return air from the return grills or return plenums to the air handler and shall have a positive airtight seal to the air handler. A closet shall not be used as a return plenum.

307.2.3 Return Grill Connection The return pathway from the return grill shall be a part of the return duct or plenum and shall have a continuous air barrier along its boundary. Where the return pathway passes through a wall cavity, the cavity shall be sealed around the duct in all directions to prevent the leakage of air into the return air stream.

307.2.4 Location of Ducts and Plenums Supply and return ducts shall not be located below concrete slab on grade floors, and return ducts and plenums shall not be located in crawl spaces.

307.3 Exhaust Fans

307.3.1 Bathroom Fans Bathroom exhaust fans shall be controlled by an independent separate switch. Manually operated timers should be used as applicable.

307.3.2 Attic Fans If used, attic exhaust fans shall be installed with unobstructed vent and intake areas in accordance with the minimum areas prescribed by their manufacturer. In no case shall effective open vent area be less than the minimum areas prescribed by the manufacturer.

ATTACHMENT

The following Design Guidance for Residential Active Radon Control Systems is NOT part of the Florida Standard. It is provided as information that is useful for residential construction in recognized areas of high radon potential.

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AVAILABLE FOR RELEASE AS PUBLIC INFORMATION. THIS IS NOT A PART OF THE
FLORIDA STANDARD FOR PASSIVE RADON-RESISTANT NEW RESIDENTIAL
CONSTRUCTION.

Florida Department of Community Affairs, Codes and Standards Radon Program

DESIGN GUIDANCE FOR RESIDENTIAL ACTIVE RADON CONTROL SYSTEMS (July 1995)

The Florida Radon Research Program (FRRP) developed design and construction criteria for radon control systems that were tailored for Florida construction techniques and conditions. Passive techniques were approved by the Legislature for inclusion in a standard, now titled the Florida Standard for Passive Radon-Resistant New Residential Building Construction (the Standard); the following design criteria for active control systems are compatible with the Standard's passive control features and provide reliable radon control for residential buildings in Florida. This design guidance summarizes results from FRRP research. The information is available as public information; it is presented in this format only to ensure that when active soil depressurization systems are installed, they are compatible with the passive radon protection systems of the Standard and do not damage the passive system components. Section 1 applies to buildings built as slabs-on-grade. Sections 2 and 3 apply to buildings built as above-grade floors.

1 Sub-Slab Depressurization Systems

1.1 General These systems apply to residential buildings with floor types using thickened edge monolithic, slab poured into stem wall, slab capping stem wall, and slab-below-grade solid stem wall construction. Active soil depressurization systems should be designed to maintain under the entire building a pressure less than the indoor air pressure by strict adherence to the requirements of Sections 1.2, 1.3, and 1.4, and either 1.5, 1.6, or 1.7, as appropriate. If surface soils are less permeable than specified by Sections 1.5 or 1.6, placement of permeable fill materials is necessary for proper operation of these sub-slab depressurization systems.

1.2 Suction Fans

A. Suction fans should be rated for continuous operation and have thermal overload with automatic reset features. Pressurized components of the vent system should not be located in conditioned space.

B. The suction fan should be designed and manufactured to provide an air-tight seal between the inlet and outlet ducts and the fan housing. The fan housing must remain air-tight at air pressure equal to the rated maximum operating pressure.

1.3 Alarm The soil depressurization system should include a system failure alarm, which should be a labeled device with visual signal (a light of not less than 1/5 footcandle at the floor level) and/or audio signal (a minimum 60 db audible signal) to indicate when a depressurization fan ceases operation.

1.4 Vent System

A. Piping material of any type approved by locally adopted codes for plumbing vents.

B. All horizontal vent piping should maintain a minimum slope of 1/8 inch per foot in order to drain condensation back to soil beneath the sub-slab membrane. The system should be designed and installed so that no portion will allow the excess accumulation of condensation. [Note: Minimize horizontal runs of vent piping in attic spaces, especially in northern areas of Florida. During colder winter months, cooler attic spaces increase condensation in pipes.]

C. Vertical vent pipes shall be terminated in locations that minimize human exposure to their exhaust air, such that location is:

- 1) At least 12 inches above surface of the roof;
- 2) At least 10 feet from any window, door, or other opening (e.g., operable skylight or air intake) to conditioned spaces of the structure; and
- 3) 10 feet from any opening into an adjacent building.

The total required distance (ten feet) shall be measured either directly between the two points or be the sum of measurements made around intervening obstacles. If the discharge point is within two feet of elevation of the opening into conditioned space, the distance (ten feet) shall be the horizontal distance between the points

D. All exposed components of the soil depressurization system should be clearly identified to prevent accidental damage or misuse. In an effort to standardize radon system labeling, the label "**Radon Reduction System**" is recommended as a yellow band, two inches wide printed with 1-inch black lettering, and spaced not more than three feet apart on all components.

E. Keeping vapor barriers intact is a critical concern in preventing entrance of radon into structures. Vapor barriers must be sealed at all penetrations, especially at sub-slab depressurization system vertical vent pipes. All sealing techniques for the vapor barrier and pipe penetrations as required in the Standard should be carefully followed to prevent short circuiting of the active system, moisture buildup, and structural problems.

1.5 Depressurization Systems in Permeable Soils: Suction Pit Design Depressurization systems in sands or other granular soils (having an air permeability greater than or equal to 10^{-12} m² as measured according to "Standard Measurement Protocols, Florida Radon Research Program," U.S. Environmental Protection Agency report EPA-600/8-91-212, 1991) at least 8 inches deep should meet the following requirements of this section.

A. Suction points should be distributed over the house area as follows:

- (1) A maximum of 1300 square feet per suction point,
- (2) Each suction point should be located approximately centrally between perimeters and other suction points, and at least 6 feet or further from the nearest perimeter, and
- (3) Multiple suction points should be located within 36 feet of each other.

B. Suction point pits should conform to one of the following designs:

- (1) A pit at least 32 inches in diameter and 16 inches deep filled with 1 inch or larger washed gravel and covered by the soil-gas barrier, or
- (2) A manufactured ventilation mat having a minimum net suction area in contact with the soil of 10 square feet, installed below the sub-slab membrane.

C. Suction pipe should be no smaller than 2 inches in diameter, carried full size through the roof.

D. Each suction fan should be rated for not less than 15 cfm at 1.5 inch water column.

1.6 Depressurization Systems in Permeable Soils: Ventilation Mat(s) Design Depressurization Systems in sands or other granular soils (as identified in Section 1.5) at least 8 inches deep and utilizing a continuous ventilation mat should meet the following requirements of this section.

A. Suction points and mat strips should be distributed as follows:

- (1) The suction point is to be centrally located along the length of each unconnected strip of mat,
- (2) Mat strips should be oriented along the central axis of the longest dimension of the slab or diagonally to maximize the mat length,
- (3) A minimum of one strip should be used for slabs having widths up to 50 feet [additional strips are needed for each additional slab width increment of up to 50 feet, located in either parallel or crossed diagonal configurations],
- (4) The mat strip should extend toward the most distant perimeters of the building, but is to be no closer than 6 feet from any perimeter, and
- (5) A separate suction point and fan should be installed for each 100 feet linear length of ventilation mat.

B. The ventilation mat should have a minimum of 216 square inches of soil contact area per lineal foot.

C. Suction pipe should be no smaller than 2 inches in diameter, carried full size through the roof.

D. Each suction fan should be rated for not less than 50 cfm at 1 inch water column.

1.7 Depressurization Systems in an Aggregate Fill Base Depressurization systems using an aggregate fill base material directly below the slab and vapor barrier should meet the following requirements of this section.

- A. Suction points should be uniformly distributed and centrally located with a maximum of 2500 square feet floor area per suction point.
- B. Washed aggregate is to be equal to or larger than the following: 100% passing a 2 inch grate; 90 to 100% passing a 1-1/2 inch grate; 20-55% passing a 1 inch grate; 0-15% passing a 3/4 inch grate; and 0-5% passing a 3/8 inch grate. The aggregate should form a continuous layer which is a minimum of 4 inches deep.
- C. Suction points should be connected to the depressurization fan by a minimum 3 inch diameter riser pipe fitted with a "T" fitting, or other approved fitting that provides bearing and air flow, embedded into the gravel layer.
- D. Each suction fan should be rated for not less than 50 cfm at 1 inch water column.

2 Sub-Membrane Depressurization Systems

2.1 General These systems apply to residential buildings with the floor type identified as crawl spaces by the Standard. Active soil depressurization system should be designed to maintain under the entire building a pressure less than the indoor air pressure by strict adherence to the requirements of each specific section below and Sections 1.2, 1.3, and 1.4. Soil cover membranes should meet the criteria within the Standard.

2.2 Sub-Membrane Systems on Permeable Soils: Suction Pit Design Sub-membrane soil depressurization systems of suction pit designs covering sand or other granular soils at least 8 inches deep (known to have an air permeability equal to or greater than 10^{-12} m^2) should meet the requirements of Section 1.5.

2.3 Sub-Membrane Systems on Permeable Soils: Ventilation Mat(s) Design Sub-membrane soil depressurization systems of continuous ventilation mat design on sands or granular soils at least 8 inches deep (known to have an air permeability equal to or greater than 10^{-12} m^2) should meet the requirements of Section 1.6.

2.4 Sub-membrane Systems in an Aggregate Fill Base Sub-membrane suction systems covering a minimum 6 inch deep layer of aggregate having a 1 inch or larger average diameter stone should meet the requirements of Section 1.7. Care should be especially taken to avoid aggregate puncturing the vapor barrier; punctures should be sealed with tape per the Standard.

3 Crawl Space Ventilation Systems

3.1 General This system applies to residential buildings with the floor type identified as crawl spaces by the Standard.

3.2 Ventilation Rate When crawl space ventilation rates of tile Standard can not be achieved by use of natural flow and vent openings, then one or more electrically-driven ventilation fans can be installed to cause not less than 3 air changes per hour in the crawl space by drawing crawl space air from the central region of the crawl space.