APPENDIX F

RADON CONTROL METHODS

(The provisions contained in this appendix are not mandatory unless specifically referenced in the adopting ordinance.)

SECTION AF101 SCOPE

AF101.1 General. This appendix contains requirements for new construction in *jurisdictions* where radon-resistant construction is required.

Inclusion of this appendix by *jurisdictions* shall be determined through the use of locally available data or determination of Zone 1 designation in Figure AF101 and Table AF101(1).

SECTION AF102 DEFINITIONS

AF102.1 General. For the purpose of these requirements, the terms used shall be defined as follows:

DRAIN TILE LOOP. A continuous length of drain tile or perforated pipe extending around all or part of the internal or external perimeter of a *basement* or crawl space footing.

RADON GAS. A naturally occurring, chemically inert, radioactive gas that is not detectable by human senses. As a gas, it can move readily through particles of soil and rock, and can accumulate under the slabs and foundations of homes where it can easily enter into the living space through construction cracks and openings.

SOIL-GAS-RETARDER. A continuous membrane of 6-mil (0.15 mm) polyethylene or other equivalent material used to retard the flow of soil gases into a building.

SUBMEMBRANE DEPRESSURIZATION SYSTEM. A system designed to achieve lower submembrane air pressure relative to crawl space air pressure by use of a vent drawing air from beneath the soil-gas-retarder membrane

SUBSLAB DEPRESSURIZATION SYSTEM (Active). A system designed to achieve lower subslab air pressure relative to indoor air pressure by use of a fan-powered vent drawing air from beneath the slab.

SUBSLAB DEPRESSURIZATION SYSTEM (Passive). A system designed to achieve lower subslab air pressure relative to indoor air pressure by use of a vent pipe routed through the *conditioned space* of a building and connecting the subslab area with outdoor air, thereby relying on the convective flow of air upward in the vent to draw air from beneath the slab.

SECTION AF103 REQUIREMENTS

AF103.1 General. The following construction techniques are intended to resist radon entry and prepare the building for

post-construction radon mitigation, if necessary (see Figure AF102). These techniques are required in areas where designated by the *jurisdiction*.

AF103.2 Subfloor preparation. A layer of gas-permeable material shall be placed under all concrete slabs and other floor systems that directly contact the ground and are within the walls of the living spaces of the building, to facilitate future installation of a subslab depressurization system, if needed. The gas-permeable layer shall consist of one of the following:

- A uniform layer of clean aggregate, a minimum of 4 inches (102 mm) thick. The aggregate shall consist of material that will pass through a 2-inch (51 mm) sieve and be retained by a ¹/₄-inch (6.4 mm) sieve.
- 2. A uniform layer of sand (native or fill), a minimum of 4 inches (102 mm) thick, overlain by a layer or strips of geotextile drainage matting designed to allow the lateral flow of soil gases.
- Other materials, systems or floor designs with demonstrated capability to permit depressurization across the entire subfloor area.

AF103.3 Soil-gas-retarder. A minimum 6-mil (0.15 mm) [or 3-mil (0.075 mm) cross-laminated] polyethylene or equivalent flexible sheeting material shall be placed on top of the gas-permeable layer prior to casting the slab or placing the floor assembly to serve as a soil-gas-retarder by bridging any cracks that develop in the slab or floor assembly, and to prevent concrete from entering the void spaces in the aggregate base material. The sheeting shall cover the entire floor area with separate sections of sheeting lapped at least 12 inches (305 mm). The sheeting shall fit closely around any pipe, wire or other penetrations of the material. All punctures or tears in the material shall be sealed or covered with additional sheeting.

AF103.4 Entry routes. Potential radon entry routes shall be closed in accordance with Sections AF103.4.1 through AF103.4.10.

AF103.4.1 Floor openings. Openings around bathtubs, showers, water closets, pipes, wires or other objects that penetrate concrete slabs, or other floor assemblies, shall be filled with a polyurethane caulk or equivalent sealant applied in accordance with the manufacturer's recommendations.

AF103.4.2 Concrete joints. All control joints, isolation joints, construction joints, and any other joints in concrete slabs or between slabs and foundation walls shall be sealed with a caulk or sealant. Gaps and joints shall be cleared of loose material and filled with polyurethane caulk or other elastomeric sealant

applied in accordance with the manufacturer's recommendations.

AF103.4.3 Condensate drains. Condensate drains shall be trapped or routed through nonperforated pipe to daylight.

AF103.4.4 Sumps. Sump pits open to soil or serving as the termination point for subslab or exterior drain tile loops shall be covered with a gasketed or otherwise sealed lid. Sumps used as the suction point in a subslab depressurization system shall have a lid designed to accommodate the vent pipe. Sumps used as a floor drain shall have a lid equipped with a trapped inlet.

AF103.4.5 Foundation walls. Hollow block masonry foundation walls shall be constructed with either a continuous course of *solid masonry*, one course of masonry grouted solid, or a solid concrete beam at or above finished ground surface to prevent the passage of air from the interior of the wall into the living space. Where a brick veneer or other masonry ledge is installed, the course immediately below that ledge shall be sealed. Joints, cracks or other openings around all penetrations of both exterior and interior surfaces of masonry block or wood foundation walls below the ground surface shall be filled with polyurethane caulk or equivalent sealant. Penetrations of concrete walls shall be filled.

AF103.4.6 Dampproofing. The exterior surfaces of portions of concrete and masonry block walls below the ground surface shall be dampproofed in accordance with Section R406.

AF103.4.7 Air-handling units. Air-handling units in crawl spaces shall be sealed to prevent air from being drawn into the unit.

Exception: Units with gasketed seams or units that are otherwise sealed by the manufacturer to prevent leakage.

AF103.4.8 Ducts. Ductwork passing through or beneath a slab shall be of seamless material unless the air-handling system is designed to maintain continuous positive pressure within such ducting. Joints in such ductwork shall be sealed to prevent air leakage.

Ductwork located in crawl spaces shall have all seams and joints sealed by closure systems in accordance with Section M1601.4.1.

AF103.4.9 Crawl space floors. Openings around all penetrations through floors above crawl spaces shall be caulked or otherwise filled to prevent air leakage.

AF103.4.10 Crawl space access. Access doors and other openings or penetrations between *basements* and adjoining crawl spaces shall be closed, gasketed or otherwise filled to prevent air leakage.

AF103.5 Passive submembrane depressurization system. In buildings with crawl space foundations, the following

components of a passive submembrane depressurization system shall be installed during construction.

Exception: Buildings in which an *approved* mechanical crawl space ventilation system or other equivalent system is installed.

AF103.5.1 Ventilation. Crawl spaces shall be provided with vents to the exterior of the building. The minimum net area of ventilation openings shall comply with Section R408.1.

AF103.5.2 Soil-gas-retarder. The soil in crawl spaces shall be covered with a continuous layer of minimum 6-mil (0.15 mm) polyethylene soil-gas-retarder. The ground cover shall be lapped a minimum of 12 inches (305 mm) at joints and shall extend to all foundation walls enclosing the crawl space area.

AF103.5.3 Vent pipe. A plumbing tee or other *approved* connection shall be inserted horizontally beneath the sheeting and connected to a 3- or 4-inch-diameter (76 or 102 mm) fitting with a vertical vent pipe installed through the sheeting. The vent pipe shall be extended up through the building floors, and terminate at least 12 inches (305 mm) above the roof in a location at least 10 feet (3048 mm) away from any window or other opening into the *conditioned spaces* of the building that is less than 2 feet (610 mm) below the exhaust point, and 10 feet (3048 mm) from any window or other opening in adjoining or adjacent buildings.

AF103.6 Passive subslab depressurization system. In *basement* or slab-on-grade buildings, the following components of a passive subslab depressurization system shall be installed during construction.

AF103.6.1 Vent pipe. A minimum 3-inch-diameter (76 mm) ABS, PVC or equivalent gas-tight pipe shall be embedded vertically into the subslab aggregate or other permeable material before the slab is cast. A "T" fitting or equivalent method shall be used to ensure that the pipe opening remains within the subslab permeable material. Alternatively, the 3-inch (76 mm) pipe shall be inserted directly into an interior perimeter drain tile loop or through a sealed sump cover where the sump is exposed to the subslab aggregate or connected to it through a drainage system.

The pipe shall be extended up through the building floors, and terminate at least 12 inches (305 mm) above the surface of the roof in a location at least 10 feet (3048 mm) away from any window or other opening into the *conditioned spaces* of the building that is less than 2 feet (610 mm) below the exhaust point, and 10 feet (3048 mm) from any window or other opening in adjoining or adjacent buildings.

AF103.6.2 Multiple vent pipes. In buildings where interior footings or other barriers separate the subslab aggregate or other gas-permeable material, each area shall be

fitted with an individual vent pipe. Vent pipes shall connect to a single vent that terminates above the roof or each individual vent pipe shall terminate separately above the roof.

AF103.7 Vent pipe drainage. All components of the radon vent pipe system shall be installed to provide positive drainage to the ground beneath the slab or soil-gas-retarder.

AF103.8 Vent pipe accessibility. Radon vent pipes shall be accessible for future fan installation through an *attic* or other area outside the *habitable space*.

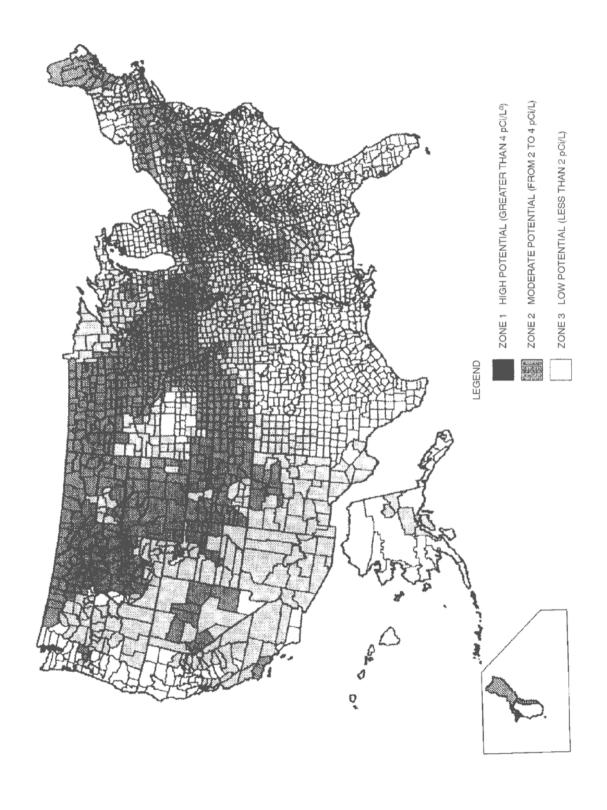
Exception: The radon vent pipe need not be accessible in an *attic* space where an *approved* roof-top electrical supply is provided for future use.

AF103.9 Vent pipe identification. All exposed and visible interior radon vent pipes shall be identified with at least one *label* on each floor and in accessible *attics*. The *label* shall read: "Radon Reduction System."

AF103.10 Combination foundations. Combination *base-ment*/crawl space or slab-on-grade/crawl space foundations shall have separate radon vent pipes installed in each type of foundation area. Each radon vent pipe shall terminate above the roof or shall be connected to a single vent that terminates above the roof.

AF103.11 Building depressurization. Joints in air ducts and plenums in un*conditioned spaces* shall meet the requirements of Section M1601. Thermal envelope air infiltration requirements shall comply with the energy conservation provisions in Chapter 11. Fireblocking shall meet the requirements contained in Section R302.11.

AF103.12 Power source. To provide for future installation of an active submembrane or subslab depressurization system, an electrical circuit terminated in an *approved* box shall be installed during construction in the *attic* or other anticipated location of vent pipe fans. An electrical supply shall also be accessible in anticipated locations of system failure alarms.



The EPA and the U.S. Geological Survey have evaluated the radon potential in the United States and have developed a map of radon zones designed to assist building officials in deciding whether radon pCi/L standard for picocuries per liter of radon gas. The U.S. Environmental Protection Agency (EPA) recommends that all homes that measure 4 pCi/L and greater be mitigated. resistant features are applicable in new construction.

The map assigns each of the 3,141 counties in the United States to one of three zones based on radon potential. Each zone designation reflects the average short-term radon measurement that can be expected to be measured in a building without the implementation of radon-control methods. The radon zone designation of highest priority is Zone 1. Table AF101 lists the Zone 1 counties illustrated on the map. More detailed information can be obtained from state-specific booklets (EPA-402-R-93-021 through 070) available through State Radon Offices or from EPA Regional Offices.

FIGURE AF101 EPA MAP OF RADON ZONES

TABLE AF101(1) HIGH RADON-POTENTIAL (ZONE 1) COUNTIES^a

				,		
ALABAMA	CONNECTICUT	Morgan	Wabash	Trego	Hillsdale	Watonwan
Calhoun	Fairfield	Moultrie	Warren	Wallace	Jackson	Wilkin
Clay	Middlesex	Ogle	Washington	Washington	Kalamazoo	Winona
Cleburne	New Haven	Peoria	Wayne	Wichita	Lenawee	Wright
Colbert	New London	Piatt	Wells	Wyandotte	St. Joseph	Yellow Medicine
Coosa	GEORGIA	Pike	White	IZENITLICIZM	Washtenaw	MICCOLIDI
Franklin Jackson	Cobb	Putnam Rock Island	Whitley	KENTUCKY Adair	MINNESOTA	MISSOURI Andrew
Lauderdale	De Kalb	Sangamon	IOWA	Allen	Becker	Atchison
Lawrence	Fulton	Schuyler	All Counties	Barren	Big Stone	Buchanan
Limestone	Gwinnett	Scott	7 III Counties	Bourbon	Blue Earth	Cass
Madison	O Williams	Stark	KANSAS	Boyle	Brown	Clay
Morgan	IDAHO	Stephenson	Atchison	Bullitt	Carver	Clinton
Talladega	Benewah	Tazewell	Barton	Casey	Chippewa	Holt
	Blaine	Vermilion	Brown	Clark	Člay	Iron
CALIFORNIA	Boise	Warren	Cheyenne	Cumberland	Cottonwood	Jackson
Santa Barbara	Bonner	Whiteside	Clay	Fayette	Dakota	Nodaway
Ventura	Boundary	Winnebago	Cloud	Franklin	Dodge	Platte
COLOBADO	Butte	Woodford	Decatur	Green	Douglas	MONTEANIA
COLORADO	Clark	INIDI A NI A	Dickinson	Harrison	Faribault	MONTANA
Adams	Clark Clearwater	INDIANA Adams	Douglas Ellis	Hart Jefferson	Fillmore Freeborn	Beaverhead Big Horn
Arapahoe Baca	Custer	Allen	Ellsworth	Jessamine	Goodhue	Blaine
Bent	Elmore	Bartholomew	Finney	Lincoln	Grant	Broadwater
Boulder	Fremont	Benton	Ford	Marion	Hennepin	Carbon
Chaffee	Gooding	Blackford	Geary	Mercer	Houston	Carter
Cheyenne	Idaho	Boone	Gove	Metcalfe	Hubbard	Cascade
Clear Creek	Kootenai	Carroll	Graham	Monroe	Jackson	Chouteau
Crowley	Latah	Cass	Grant	Nelson	Kanabec	Custer
Custer	Lemhi	Clark	Gray	Pendleton	Kandiyohi	Daniels
Delta	Shoshone	Clinton	Greeley	Pulaski	Kittson	Dawson
Denver	Valley	De Kalb	Hamilton	Robertson	Lac Qui Parle	Deer Lodge
Dolores	** * ****	Decatur	Haskell	Russell	Le Sueur	Fallon
Douglas	ILLINOIS	Delaware	Hodgeman	Scott	Lincoln	Fergus
El Paso	Adams	Elkhart	Jackson	Taylor	Lyon	Flathead
Elbert	Boone	Fayette	Jewell	Warren	Mahnomen	Gallatin
Fremont Garfield	Brown Bureau	Fountain Fulton	Johnson Kearny	Woodford	Marshall Martin	Garfield Glacier
Gilpin	Calhoun	Grant	Kingman	MAINE	McLeod	Granite
Grand	Carroll	Hamilton	Kiowa	Androscoggin	Meeker	Hill
Gunnison	Cass	Hancock	Lane	Aroostook	Mower	Jefferson
Huerfano	Champaign	Harrison	Leavenworth	Cumberland	Murray	Judith Basin
Jackson	Coles	Hendricks	Lincoln	Franklin	Nicollet	Lake
Jefferson	De Kalb	Henry	Logan	Hancock	Nobles	Lewis and Clark
Kiowa	De Witt	Howard	Marion	Kennebec	Norman	Madison
Kit Carson	Douglas	Huntington	Marshall	Lincoln	Olmsted	McCone
Lake	Edgar	Jay	McPherson	Oxford	Otter Tail	Meagher
Larimer	Ford	Jennings	Meade	Penobscot	Pennington	Missoula
Las Animas	Fulton	Johnson	Mitchell	Piscataquis	Pipestone	Park
Lincoln	Greene	Kosciusko	Nemaha Ness	Somerset York	Polk	Phillips Pondera
Logan Mesa	Grundy Hancock	LaGrange Lawrence	Norton	1 01 K	Pope Ramsev	Powder River
Moffat	Henderson	Madison	Osborne	MARYLAND	Red Lake	Powell
Montezuma	Henry	Marion	Ottawa	Baltimore	Redwood	Prairie
Montrose	Iroquois	Marshall	Pawnee	Calvert	Renville	Ravalli
Morgan	Jersey	Miami	Phillips	Carroll	Rice	Richland
Otero	Jo Daviess	Monroe	Pottawatomie	Frederick	Rock	Roosevelt
Ouray	Kane	Montgomery	Pratt	Harford	Roseau	Rosebud
Park	Kendall	Noble	Rawlins	Howard	Scott	Sanders
Phillips	Knox	Orange	Republic	Montgomery	Sherburne	Sheridan
Pitkin	La Salle	Putnam	Rice	Washington	Sibley	Silver Bow
Prowers	Lee	Randolph	Riley	35100	Stearns	Stillwater
Pueblo	Livingston	Rush	Rooks	MASS.	Steele	Teton
Rio Blanco	Logan	Scott	Rush	Essex	Stevens	Toole
San Miguel	Macon	Shelby St. Joseph	Saline	Middlesex	Swift	Valley
Summit Teller	Marshall	St. Joseph	Scott Sheridan	Worcester	Todd	Wibaux Yellowstone
Washington	Mason McDonough	Steuben		MICHIGAN	Traverse Wabasha	1 enowstone
Wasnington	McDonough McLean	Tippecanoe Tipton	Sherman Smith	Branch	w abasna Wadena	
Yuma	Menard	Union	Stanton	Calhoun	Waseca	
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TABLE AF101(1)—continued HIGH RADON-POTENTIAL (ZONE 1) COUNTIES^a

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Franklin FrontierTaos Guernsey Guernsey MontourMontgomery 	Summers
Frontier Furnas NEW YORK Hamilton Gage Albany Hancock Harrison Gosper Harrison Harrison Harrison Harrison Harrison Harys Harlin Hayes Chautauqua Hitchcock Chemung Hitchcock Horlumbia Logan Jefferson Johnson Cortland Jefferson Kearney Johnson Kearney Madison Mercer Madison Madison Madison Madison Madison Madison Mercer Madison Madison Madison Mercer Madison Madison Madison Mercer Madison Madison Madison Mercer Morrow Ment Madison Mercer Morrow Ment Madison Mercer Morrow Ment Madison Nuckolls Madison Perry Otoe Onondaga Pickaway Pickaway Pickaway Pawnee Ontario Pike Greenville Lewis Powhatan Phelps Orange Preble Pierce Otsego Richland Ross Aurora Marshall Roanoke Marthashll Roanoke	Wetzel
Gage GosperAlbany AlleganyHancock HardinNorthumberland PerryAnderson BedfordFluvanna Frederick Frederick Frederick Frederick GreeleyGreeleyBroome HarrisonHarrison Schuylkill SnyderBlount Bradley Bradley GilesHamilton Harlan HayesCayuga Chautauqua Cheutauqua Hitchcock Chemung Hitchcock Chemung Chenango Chenango Columbia Logan Logan Logan Venango Venango Venango Westmoreland Westmoreland Wyoming Hancock Hawkins Hickman Hickman Hickman Hickman MontgomeryHarrisonburg Harrisonburg Harrisonburg Highland Lea Lee Lee Union Westmoreland Wyoming Hancock Hawkins Hickman Hickman Hickman Montgomery Montgomery Nance Offeene Nemaha Livingston Nuckolls Madison Madison Perry Otoe Onondaga Pickaway Pierce Onsange Preble Pierce Otsego Otsego Otsego Pickaland RossNorthumberland Northumberland Northumberland Perry Northumber Northumb	
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KearneyDelawareMarionWyomingHancockLouisaKnoxDutchessMercerYorkHawkinsMartinsvilleLancasterErieMiamiHickmanMontgomeryMadisonGeneseeMontgomeryRHODE ISLANDHumphreysNottowayNanceGreeneMorrowKentJacksonOrangeNemahaLivingstonMuskingumWashingtonJeffersonPageNuckollsMadisonPerryKnoxPatrickOtoeOnondagaPickawayS. CAROLINALawrencePittsylvaniaPawneeOntarioPikeGreenvilleLewisPowhatanPhelpsOrangePrebleLincolnPulaskiPierceOtsegoRichlandS. DAKOTALoudonRadfordPlattePutnamRossAuroraMarshallRoanoke	Iowa
KnoxDutchess LancasterMercer ErieYorkHawkins HickmanMartinsville MontgomeryMadisonGeneseeMontgomery 	Jefferson
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MadisonGeneseeMontgomery AnceRHODE ISLAND KentHumphreys JacksonNottowayNance NemahaGreeneMorrow MuskingumKent WashingtonJackson JeffersonOrange PageNuckollsMadisonPerryKnoxPatrickOtoeOnondaga PawneePickaway PikeS. CAROLINA GreenvilleLawrence LewisPittsylvaniaPawneeOntarioPikeGreenvilleLewisPowhatanPhelpsOrangePrebleLincolnPulaskiPierceOtsegoRichland PlatteS. DAKOTA AuroraLoudonRadfordPlattePutnamRossAuroraMarshallRoanoke	Langlade
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PhelpsOrangePrebleLincolnPulaskiPierceOtsegoRichlandS. DAKOTALoudonRadfordPlattePutnamRossAuroraMarshallRoanoke	Portage
PierceOtsegoRichlandS. DAKOTALoudonRadfordPlattePutnamRossAuroraMarshallRoanoke	Richland
Platte Putnam Ross Aurora Marshall Roanoke	Rock
	Shawano
	St. Croix Vernon
Red Willow Schoharie Shelby Bon Homme McMinn Rockingham	Walworth
Richardson Schuyler Stark Brookings Meigs Russell	Washington
Saline Seneca Summit Brown Monroe Salem	Waukesha
Sarpy Steuben Tuscarawas Brule Moore Scott	Waupaca
Saunders Sullivan Union Buffalo Perry Shenandoah	Wood
Seward Tioga Van Wert Campbell Roane Smyth	
Stanton Tompkins Warren Charles Mix Rutherford Spotsylvania	WYOMING
Thayer Ulster Wayne Clark Smith Stafford	Albany
Washington Washington Wyandot Clay Sullivan Staunton	Big Horn
Wayne Wyoming Codington Trousdale Tazewell	Campbell
Webster Yates PENNSYLVANIA Corson Union Warren	Carbon
York Adams Davison Washington Washington N. CAROLINA Allegheny Day Wayne Waynesboro	Converse
	Crook Fremont
NEVADA Alleghany Armstrong Deuel Williamson Winchester Carson City Buncombe Beaver Douglas Wilson Wythe	Goshen
Douglas Cherokee Bedford Edmunds	Hot Springs
Eureka Henderson Berks Faulk UTAH WASHINGTON	
Lander Mitchell Blair Grant Carbon Clark	Laramie
Lincoln Rockingham Bradford Hamlin Duchesne Ferry	Lincoln
Lyon Transylvania Bucks Hand Grand Okanogan	Natrona
Mineral Watauga Butler Hanson Piute Pend Oreille	Niobrara
Pershing Cameron Hughes Sanpete Skamania	Park
White Pine N. DAKOTA Carbon Hutchinson Sevier Spokane	Sheridan
All Counties Centre Hyde Uintah Stevens	Sublette
NEW Chester Jerauld	Sweetwater
HAMPSHIRE OHIO Clarion Kingsbury VIRGINIA W. VIRGINIA	
Carroll Adams Clearfield Lake Alleghany Berkeley	Uinta Washakia
Allen Clinton Lincoln Amelia Brooke	Washakie
Columbia Lyman Appomattox Grant	

a. The EPA recommends that this county listing be supplemented with other available State and local data to further understand the radon potential of a Zone 1 area.

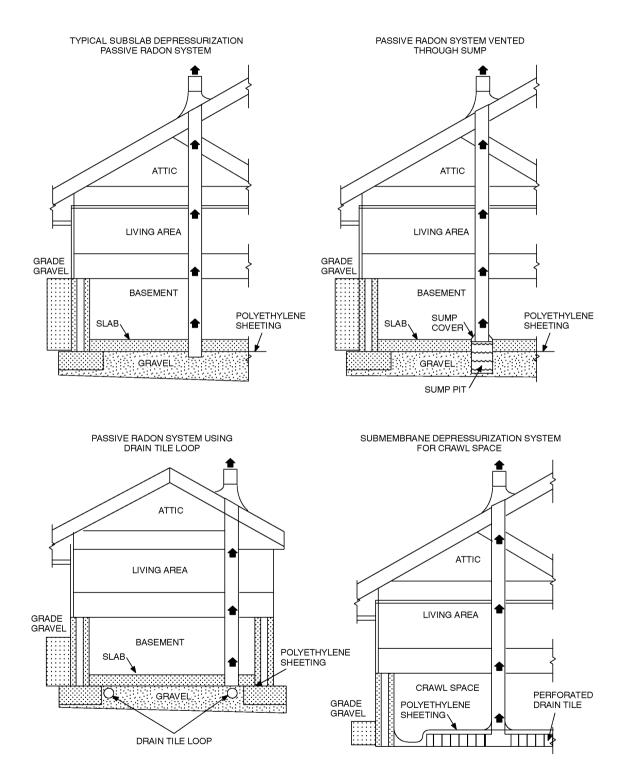


FIGURE AF102
RADON-RESISTANT CONSTRUCTION DETAILS FOR FOUR FOUNDATION TYPES