

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:

1. 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 $\frac{1}{4}$ -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.
3. 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 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 not less than 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 sheathing and connected to a 3- or 4-inch-diameter (76 or 102 mm) fitting with a vertical vent pipe installed through the sheathing. The vent pipe shall be extended up through the building floors, and terminate not less than 12 inches (305 mm) above the roof in a location not less than 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. 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*.

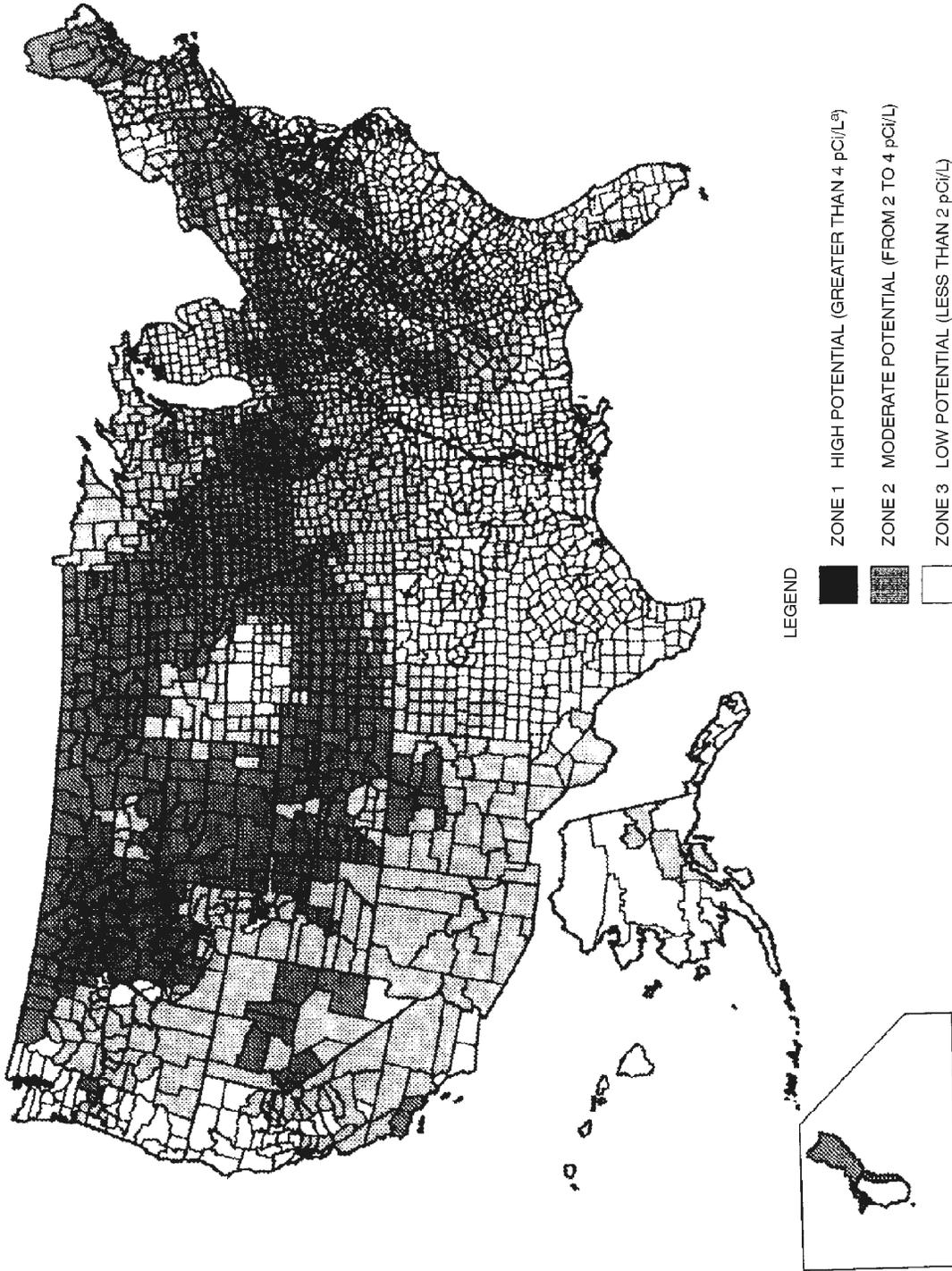
Exception: The radon vent pipe need not be accessible in an *attic* space where an *approved* roof-top electrical supply is provided for future use.

AF103.9 Vent pipe identification. Exposed and visible interior radon vent pipes shall be identified with not less than one *label* on each floor and in accessible *attics*. The *label* shall read: "Radon Reduction System."

AF103.10 Combination foundations. Combination *basement/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 *unconditioned 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.



a. pCi/L standard for picocuries per liter of radon gas. The U.S. Environmental Protection Agency (EPA) recommends that homes that measure 4 pCi/L and greater be mitigated. 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-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	Watsonwan
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		Pike	White		Washtenaw	
Franklin	GEORGIA	Putnam	Whitley	KENTUCKY		MISSOURI
Jackson	Cobb	Rock Island		Adair		Andrew
Lauderdale	De Kalb	Sangamon	IOWA	Allen	MINNESOTA	Atchison
Lawrence	Fulton	Schuyler	All Counties	Barren	Becker	Buchanan
Limestone	Gwinnett	Scott		Bourbon	Big Stone	Cass
Madison		Stark	KANSAS	Boyle	Blue Earth	Clay
Morgan	IDAHO	Stephenson	Atchison	Bullitt	Brown	Clinton
Talladega	Benewah	Tazewell	Barton	Casey	Carver	Holt
	Blaine	Vermilion	Brown	Clark	Chippewa	Iron
CALIFORNIA	Boise	Warren	Cheyenne	Cumberland	Clay	Jackson
Santa Barbara	Bonner	Whiteside	Clay	Fayette	Cottonwood	Nodaway
Ventura	Boundary	Winnebago	Cloud	Franklin	Dakota	Platte
	Butte	Woodford	Decatur	Green	Dodge	
COLORADO	Camas		Dickinson	Harrison	Douglas	MONTANA
Adams	Clark	INDIANA	Douglas	Hart	Faribault	Beaverhead
Arapahoe	Clearwater	Adams	Ellis	Jefferson	Fillmore	Big Horn
Baca	Custer	Allen	Ellsworth	Jessamine	Freeborn	Blaine
Bent	Elmore	Bartholomew	Finney	Lincoln	Goodhue	Broadwater
Boulder	Fremont	Benton	Ford	Marion	Grant	Carbon
Chaffee	Gooding	Blackford	Geary	Mercer	Hennepin	Carter
Cheyenne	Idaho	Boone	Gove	Metcalfe	Houston	Cascade
Clear Creek	Kootenai	Carroll	Graham	Monroe	Hubbard	Chouteau
Crowley	Latah	Cass	Grant	Nelson	Jackson	Custer
Custer	Lemhi	Clark	Gray	Pendleton	Kanabec	Daniels
Delta	Shoshone	Clinton	Greeley	Pulaski	Kandiyohi	Dawson
Denver	Valley	De Kalb	Hamilton	Robertson	Kittson	Deer Lodge
Dolores		Decatur	Haskell	Russell	Lac Qui Parle	Fallon
Douglas	ILLINOIS	Delaware	Hodgeman	Scott	Le Sueur	Fergus
El Paso	Adams	Elkhart	Jackson	Taylor	Lincoln	Flathead
Elbert	Boone	Fayette	Jewell	Warren	Lyon	Gallatin
Fremont	Brown	Fountain	Johnson	Woodford	Mahnomen	Garfield
Garfield	Bureau	Fulton	Kearny		Marshall	Glacier
Gilpin	Calhoun	Grant	Kingman	MAINE	Martin	Granite
Grand	Carroll	Hamilton	Kiowa	Androscoggin	McLeod	Hill
Gunnison	Cass	Hancock	Lane	Aroostook	Meeker	Jefferson
Huerfano	Champaign	Harrison	Leavenworth	Cumberland	Mower	Judith Basin
Jackson	Coles	Hendricks	Lincoln	Franklin	Murray	Lake
Jefferson	De Kalb	Henry	Logan	Hancock	Nicollet	Lewis and Clark
Kiowa	De Witt	Howard	Marion	Kennebec	Nobles	Madison
Kit Carson	Douglas	Huntington	Marshall	Lincoln	Norman	McCone
Lake	Edgar	Jay	McPherson	Oxford	Olmsted	Meagher
Larimer	Ford	Jennings	Meade	Penobscot	Otter Tail	Missoula
Las Animas	Fulton	Johnson	Mitchell	Piscataquis	Pennington	Park
Lincoln	Greene	Kosciusko	Nemaha	Somerset	Pipestone	Phillips
Logan	Grundy	LaGrange	Ness	York	Polk	Pondera
Mesa	Hancock	Lawrence	Norton		Pope	Powder River
Moffat	Henderson	Madison	Osborne	MARYLAND	Ramsey	Powell
Montezuma	Henry	Marion	Ottawa	Baltimore	Red Lake	Prairie
Montrose	Iroquois	Marshall	Pawnee	Calvert	Redwood	Ravalli
Morgan	Jersey	Miami	Phillips	Carroll	Renville	Richland
Otero	Jo Daviess	Monroe	Pottawatomie	Frederick	Rice	Roosevelt
Ouray	Kane	Montgomery	Pratt	Harford	Rock	Rosebud
Park	Kendall	Noble	Rawlins	Howard	Roseau	Sanders
Phillips	Knox	Orange	Republic	Montgomery	Scott	Sheridan
Pitkin	La Salle	Putnam	Rice	Washington	Sherburne	Silver Bow
Prowers	Lee	Randolph	Riley		Sibley	Stillwater
Pueblo	Livingston	Rush	Rooks	MASS.	Stearns	Teton
Rio Blanco	Logan	Scott	Rush	Essex	Steele	Toole
San Miguel	Macon	Shelby	Saline	Middlesex	Stevens	Valley
Summit	Marshall	St. Joseph	Scott	Worcester	Swift	Wibaux
Teller	Mason	Steuben	Sheridan		Todd	Yellowstone
Washington	McDonough	Tippecanoe	Sherman	MICHIGAN	Traverse	
Weld	McLean	Union	Smith	Branch	Wabasha	
Yuma	Menard	Vermillion	Stanton	Calhoun	Wadena	
	Mercer		Thomas	Cass	Waseca	
					Washington	

(continued)

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

NEBRASKA	Morris	Columbiana	Lehigh	Union	Fairfax	Crawford
Adams	Somerset	Coshocton	Luzerne	Walworth	Falls Church	Dane
Boone	Sussex	Crawford	Lycoming	Yankton	Fluvanna	Dodge
Boyd	Warren	Darke	Mifflin		Frederick	Door
Burt		Delaware	Monroe	TENNESSEE	Fredericksburg	Fond du Lac
Butler	NEW MEXICO	Fairfield	Montgomery	Anderson	Giles	Grant
Cass	Bernalillo	Fayette	Montour	Bedford	Goochland	Green
Cedar	Colfax	Franklin	Northampton	Blount	Harrisonburg	Green Lake
Clay	Mora	Greene	Northumberland	Bradley	Henry	Iowa
Colfax	Rio Arriba	Guernsey	Perry	Claiborne	Highland	Jefferson
Cuming	San Miguel	Hamilton	Schuylkill	Davidson	Lee	Lafayette
Dakota	Santa Fe	Hancock	Snyder	Giles	Lexington	Langlade
Dixon	Taos	Hardin	Sullivan	Grainger	Louisa	Marathon
Dodge		Harrison	Susquehanna	Greene	Martinsville	Menominee
Douglas	NEW YORK	Holmes	Tioga	Hamblen	Montgomery	Pepin
Fillmore	Albany	Huron	Union	Hancock	Nottoway	Pierce
Franklin	Allegany	Jefferson	Venango	Hawkins	Orange	Portage
Frontier	Broome	Knox	Westmoreland	Hickman	Page	Richland
Furnas	Cattaraugus	Licking	Wyoming	Humphreys	Patrick	Rock
Gage	Cayuga	Logan	York	Jackson	Pittsylvania	Shawano
Gosper	Chautauqua	Madison		Jefferson	Powhatan	St. Croix
Greeley	Chemung	Marion	RHODE ISLAND	Knox	Pulaski	Vernon
Hamilton	Chenango	Mercer	Kent	Lawrence	Radford	Walworth
Harlan	Columbia	Miami	Washington	Lewis	Roanoke	Washington
Hayes	Cortland	Montgomery		Lincoln	Rockbridge	Waukesha
Hitchcock	Delaware	Morrow	S. CAROLINA	Loudon	Rockingham	Waupaca
Hurston	Dutchess	Muskingum	Greenville	Marshall	Russell	Wood
Jefferson	Erie	Perry		Maury	Salem	
Johnson	Genesee	Pickaway	S. DAKOTA	McMinn	Scott	WYOMING
Kearney	Greene	Pike	Aurora	Meigs	Shenandoah	Albany
Knox	Livingston	Preble	Beadle	Monroe	Smyth	Big Horn
Lancaster	Madison	Richland	Bon Homme	Moore	Spotsylvania	Campbell
Madison	Onondaga	Ross	Brookings	Perry	Stafford	Carbon
Nance	Ontario	Seneca	Brown	Roane	Staunton	Converse
Nemaha	Orange	Shelby	Brule	Rutherford	Tazewell	Crook
Nuckolls	Otsego	Stark	Buffalo	Smith	Warren	Fremont
Otoe	Putnam	Summit	Campbell	Sullivan	Washington	Goshen
Pawnee	Rensselaer	Tuscarawas	Charles Mix	Trousdale	Waynesboro	Hot Springs
Phelps	Schoharie	Union	Clark	Union	Winchester	Johnson
Pierce	Schuyler	Van Wert	Clay	Washington	Wythe	Laramie
Platte	Seneca	Warren	Codington	Wayne		Lincoln
Polk	Steuben	Wayne	Corson	Williamson	WASHINGTON	Natrona
Red Willow	Sullivan	Wyandot	Davison	Wilson	Clark	Niobrara
Richardson	Tioga		Day		Ferry	Park
Saline	Tompkins	PENNSYLVANIA	Deuel	UTAH	Okanagan	Sheridan
Sarpy	Ulster	Adams	Douglas	Carbon	Pend Oreille	Sublette
Saunders	Washington	Allegheny	Edmunds	Duchesne	Skamania	Sweetwater
Seward	Wyoming	Armstrong	Faulk	Grand	Spokane	Teton
Stanton	Yates	Beaver	Grant	Piute	Stevens	Uinta
Thayer		Bedford	Hamlin	Sanpete		Washakie
Washington	N. CAROLINA	Berks	Hand	Sevier	W. VIRGINIA	
Wayne	Alleghany	Blair	Hanson	Uintah	Berkeley	
Webster	Buncombe	Bradford	Hughes		Brooke	
York	Cherokee	Bucks	Hutchinson	VIRGINIA	Grant	
	Henderson	Butler	Hyde	Alleghany	Greenbrier	
NEVADA	Mitchell	Cameron	Jerauld	Amelia	Hampshire	
Carson City	Rockingham	Carbon	Kingsbury	Appomattox	Hancock	
Douglas	Transylvania	Centre	Lake	Augusta	Hardy	
Eureka	Watauga	Chester	Lincoln	Bath	Jefferson	
Lander		Clarion	Lyman	Bland	Marshall	
Lincoln	N. DAKOTA	Clearfield	Marshall	Botetourt	Mercer	
Lyon	All Counties	Clinton	McCook	Bristol	Mineral	
Mineral		Columbia	McPherson	Brunswick	Monongalia	
Pershing	OHIO	Cumberland	Miner	Buckingham	Monroe	
White Pine	Adams	Dauphin	Minnehaha	Buena Vista	Morgan	
	Allen	Delaware	Moody	Campbell	Ohio	
NEW HAMPSHIRE	Ashland	Franklin	Perkins	Chesterfield	Pendleton	
Carroll	Auglaize	Fulton	Potter	Clarke	Pocahontas	
	Belmont	Huntingdon	Roberts	Clifton Forge	Preston	
NEW JERSEY	Butler	Indiana	Sanborn	Covington	Summers	
Hunterdon	Carroll	Juniata	Spink	Craig	Wetzel	
Mercer	Champaign	Lackawanna	Stanley	Cumberland	WISCONSIN	
Monmouth	Clark	Lancaster	Sully	Danville	Buffalo	
	Clinton	Lebanon	Turner	Dinwiddie		

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.

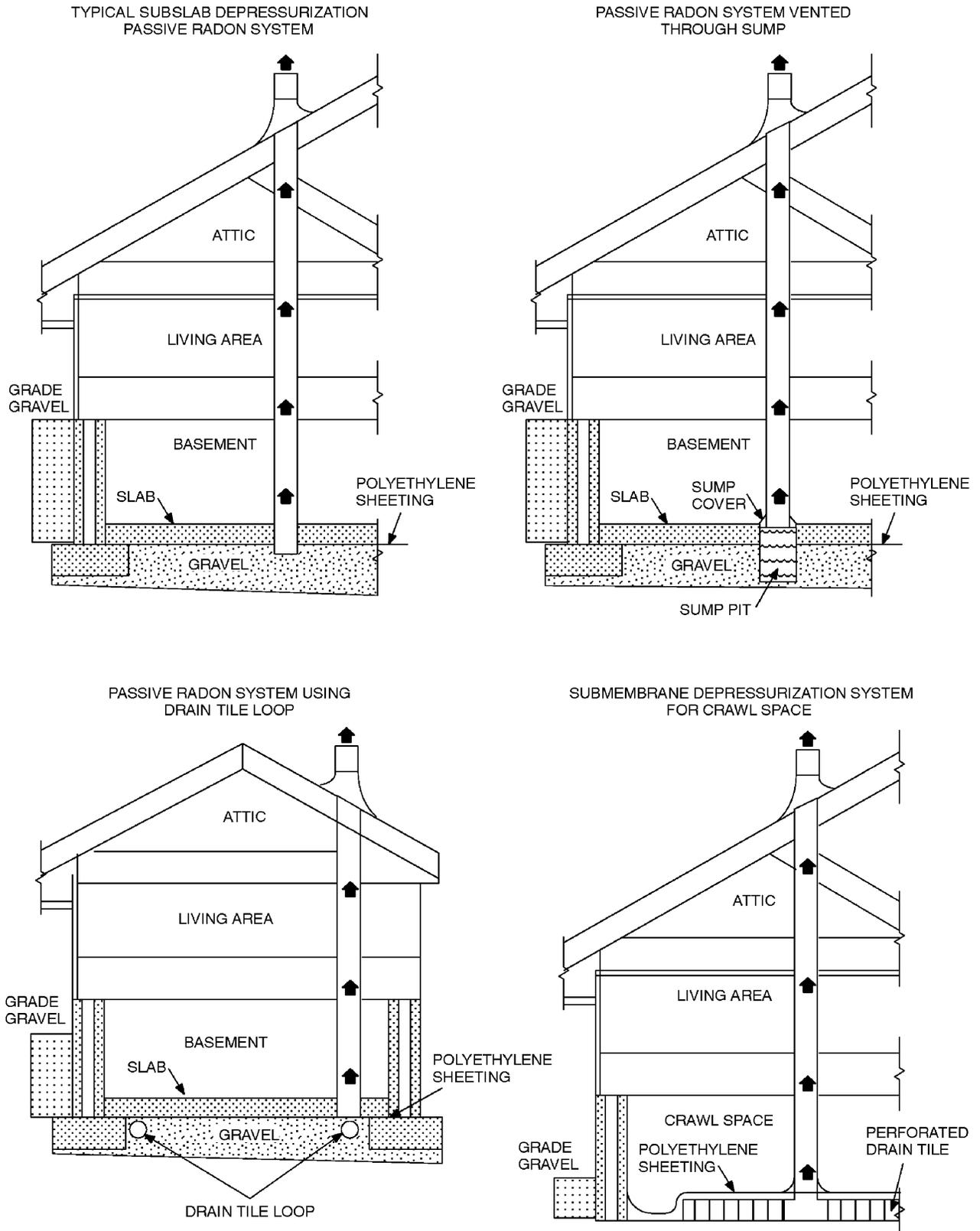


FIGURE AF102
RADON-RESISTANT CONSTRUCTION DETAILS FOR FOUR FOUNDATION TYPES

