

APPENDIX F

RADON CONTROL METHODS

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.

SECTION AF102 DEFINITIONS

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

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

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

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-sub-membrane air pressure relative to crawl space air pressure by use of a vent drawing air from beneath the soil-gas-retarder membrane.

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 sub-slab 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 sub-floor 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 sub-slab or exterior drain tile loops shall be covered with a gasketed or otherwise sealed lid. Sumps used as the suction point in a sub-slab 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 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 of this code.

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 M1601.3.1.

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 sub-membrane 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 of this code.

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 mm or 102 mm) fitting with a vertical vent pipe installed through the

sheeting. The vent pipe shall be extended up through the building floors, 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 sub-slab 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 sub-slab 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 sub-slab 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 sub-slab aggregate or connected to it through a drainage system.

The pipe shall be extended up through the building floors, 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 sub-slab 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."

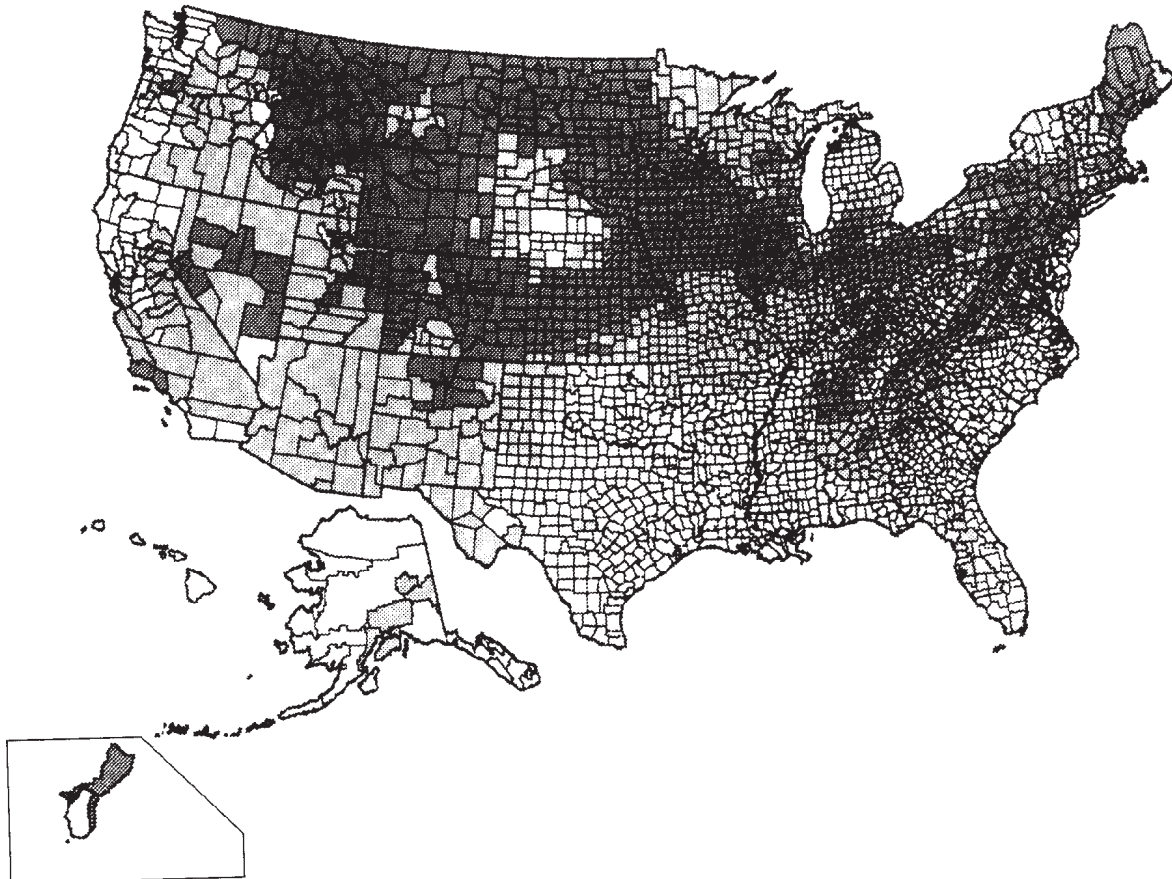
AF103.10 Combination foundations. Combination basement/crawl space or slab-on-grade/crawl space foundations shall have separate radon vent pipes installed in each type of foundation area. Each radon vent pipe shall terminate above the roof or shall be connected to a single vent that terminates above 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. Firestopping shall meet the requirements contained in Section R602.8.

AF103.12 Power source. To provide for future installation of an active sub-membrane or sub-slab 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.



LEGEND

- ZONE 1 HIGH POTENTIAL (GREATER THAN 4 pCi/L^a)
- ZONE 2 MODERATE POTENTIAL (FROM 2 TO 4 pCi/L)
- ZONE 3 LOW POTENTIAL (LESS THAN 2 pCi/L)

a. pCi/L standard for picocuries per liter of radon gas. EPA recommends that all homes that measure 4 pCi/L and greater be mitigated. The United States Environmental Protection Agency and the United States 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 1 of this appendix 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 U.S. EPA Regional Offices.

FIGURE AF101
EPA MAP OF RADON ZONES

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

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

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

(continued)

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

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

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

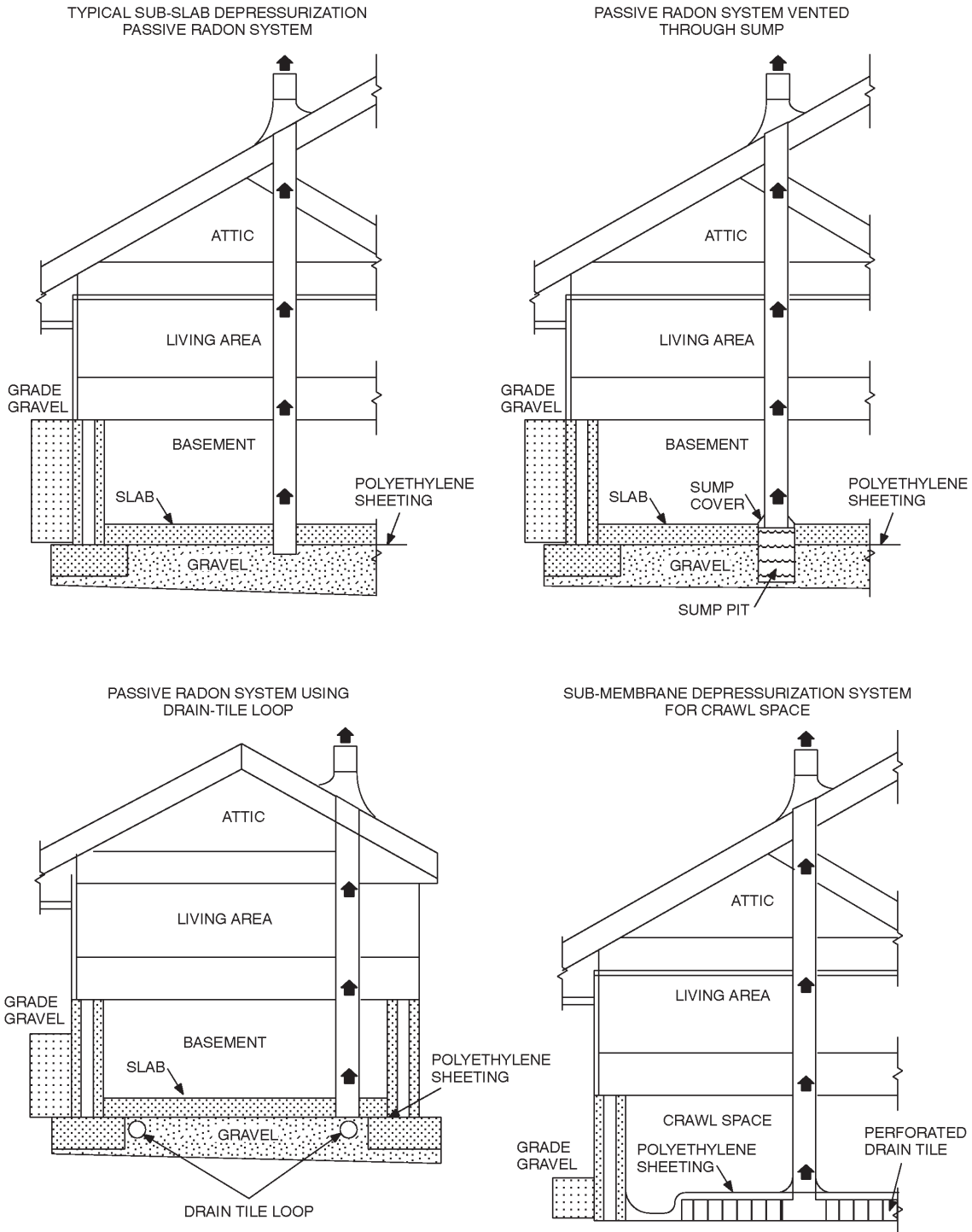


FIGURE AF102
RADON-RESISTANT CONSTRUCTION DETAILS FOR FOUR FOUNDATION TYPES