WASHINGTON'S RADON CONSTRUCTION STANDARDS: THE BUILDING CODE PROCESS

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ABSTRACT

Washington's radon prescriptive construction standards went into effect on an interim basis on July 1, 1991, as part of the state's Ventilation and Indoor Air Quality (VIAQ) Code adopted by the State Building Code Council. The code requires some state-wide radon resistive construction measures and the provision of a three-month alpha track detector to all single family homes and to all first floor units of multi-family dwellings. The homeowner's use of the monitor is voluntary. An additional requirement is for a passive stack system and sub-slab aggregate to be installed in new slab-on-grade and basement homes located in eight counties designated as having higher radon potential. The final VIAQ Code was implemented on July 1, 1993.

INTRODUCTION

The VIAQ Code identifies eight counties as having higher radon potential than the rest of the state. Residential occupancies built in Ferry, Grant, Okanogan, Pend Oreille, Skamania, Spokane, Stevens and Wahkiakum counties must comply with requirements to reduce radon entry into certain residences, and to prepare them for possible additional future mitigation. The additional prescriptive measures for the eight counties address slab-on-grade and basement construction. (See Appendix A for excerpts from the Code) All new residences are required to have some radon resistive construction measures and to receive a radon detection device at the time of final inspection provided by the building inspector. Washington's radon requirements for residences are placed within the VIAQ Code which is separate but related to the 1991 Washington State Energy Code.

PLAYERS

Some of the key players in the building code process are:

Northwest Power Planning Council (NWPPC) wants Washington, Oregon, Idaho and Montana to pass and implement model energy construction standards for residential and commercial structures reducing the need to develop new and more costly energy resources.
Bonneville Power Administration (BPA), within the U.S. Department of Energy, is directed by NWPPC to administer marketing and incentive programs for energy efficient construction.
Washington State Energy Office (WSEO) is a regional leader in identifying and implementing a variety of cost-effective conservation programs for the citizens of Washington.
Association of Washington Cities and the **Washington Association of Counties** want cities and counties to be reimbursed for costs associated with energy code enforcement.
Washington Association of Building Officials wants to ensure that the energy code is enforceable and that training and technical assistance is available.
Building Industry Association of Washington, concerned with the issue of affordable housing, believes the energy and VIAQ Code will drive up the cost of housing and take first time home buyers out of the market; they want builders to be reimbursed for added construction costs related to energy conservation.
Public and private electric utilities want one code for all fuels that would be enforced at the local level; **private gas utilities** want a dual fuel code with less stringent requirements for gas heated homes.

State Building Code Council (SBCC), with a legislative mandate for developing the building code of the state, need clear guidelines written into the legislation to be able to write the new code.
Washington Department of Health (DOH) and U.S. Environmental Protection Agency (EPA) focus their attention on health related issues.

HISTORY

In the late 1970's, BPA began encouraging the practice of energy conservation. The official beginning of the regional process which ended with the 1991 Washington State Energy Code is the 1980 Pacific Northwest Electric Power Planning and Conservation Act. The Act by the U.S. Congress established the NWPPC and dictated conservation as a priority resource. The BPA was proactive in their concern to determine the indoor air quality of energy efficient homes. Lawrence Berkeley Laboratory was contracted by BPA to do extensive research for both residential and commercial structures. A major question addressed was whether energy efficient buildings would trap pollutants. In the case of radon, the research results indicated there is no direct correlation between energy efficient structures and indoor radon levels.

In 1977 the state adopted the first state-wide mandatory standard, House Bill 98. This bill set forth minimum thermal performance standards for new buildings. In 1979 the SBCC was appointed to encourage thermal efficiency and lighting standards of the 1975 Energy Policy and Conservation Act. On June 30, 1980 Washington adopted the 1980 State Energy Code (WSEC). The 1980 WSEC was based in ASHRAE 90-75, but included more stringent envelope requirements and a lighting section based on work done by the City of Seattle. With the adoption of the 1980 WSEC, Washington found itself with two co-existent codes. In addition, some building jurisdictions enforced other versions of energy codes or none at all. This inconsistency remained until the adoption of House Bill 1114 in April 1985. This bill repealed House Bill 98 and established the 1980 WSEC as the only state energy code.

In 1983 NWPPC published Model Conservation Standards (MCS) to promote energy conservation on a voluntary basis. These Standards included indoor air quality requirements, addressing formaldehyde, combustion products and radon. Two paths were available to meet the MCS. Super Good Cents was promoted by the utilities and provided BPA payments to builders. The Northwest Energy Code was adopted by building jurisdictions and provided payments to the building jurisdictions and builders. To meet these codes the jurisdiction was required to offer radon monitoring. Also, the builder was required to place aggregate under all slabs and mitigate when indicated. The primary indoor air quality objective of this Code were source control and secondarily ventilation.

Then followed the first Environmental Impact Statement (EIS), written by BPA, for new energy efficient homes. The Record of Decision (ROD), based on the EIS and issued in 1989, objective is to maintain indoor air quality at 1983 conditions for residential construction. In order to meet the ROD, builders had to provide occupants with radon information and install certain measures (gravel under the slab and ventilated crawl spaces) or provide a three month alpha track detector (ATD) and mitigate if above 5 pCi/l.

EPA's recommendation to test all homes for radon added momentum to the VIAQ Code's radon provisions development. In 1989 BPA funded WSEO's Energy Extension Service to develop the Northwest Residential Radon Standard which proposed both performance and prescriptive path options. The development of the standard as an appendix to the Uniform Building Code of the International Conference of Building Officials was impeded by EPA but parts of it resurfaced in the VIAQ Code.

The Washington State Energy Code (and the Washington State VIAQ Code) was legislated by the state in 1990. This was the most comprehensive energy code in the United States at the time. It was mandated to be "a more efficient, statewide code."

The efforts by the SBCC to develop the law into code met with resistance. BPA could not provide several million dollars in payments unless the indoor air quality commitments of its' ROD were satisfied. Builders did not

want to meet the ROD. The radon portion of the law was the focus of the difficulty. Ultimately it was successfully negotiated with BPA that equivalency to the ROD could be achieved by providing monitors to all new homeowners in addition to some state-wide radon resistive construction measures and requiring a passive stack system to be built into residences located in higher radon potential counties.

On July 1, 1991 enforcement of the new codes began. Some builders did not want to place detectors in new homes. To meet these Codes either crawl spaces, slab-on-grade or basements were installed with the offer to monitor for radon. High radon potential counties were designated by identifying any county, regardless of the number of test results in the county, with a county average of 2 pCi/l as a high radon potential county. Data used in the analyses were from BPA's program on electrically heated new and weatherized homes.

DOH and WSEO entered into a two year interagency agreement to develop an informational brochure for homeowners, and to send out two letters to each new homeowner--the first encouraging the homeowner to install the detector, the second reminding them to send the detector to the labs. The agencies also established a data retrieval and analysis mechanism.

On April 22, 1993 BPA issued a Resource Programs ROD, revising the 1989 ROD, and stating that it was no longer necessary to require builders to provide specific foundation treatments nor offer radon monitoring and mitigation to homeowners of electrically heated homes. In addition to research results, BPA based this determination on EPA's campaign to test all homes and EPA's development of certification standards and procedures for radon mitigators.

LESSONS LEARNED

Much was learned during the first year's enforcement of the VIAQ Code, including the inability of WSEO to access new homeowner addresses or certain ATD companies to make available to DOH summaries of results. Some ATDs were even distributed without return postage or laboratory fees included. There was also a resistance of some builders to place ATDs in new homes.

During the second year of the VIAQ Code, the law changed to specify that the ATDs include postage and lab fees. The responsibility for delivering the detectors was placed with the building inspector to furnish at final inspection. An ending date of June 30, 1995 is specified, which coincides with the ending of BPA payments.

Because of the difficulty of locating adequate supplies of ATDs, particularly in remote building jurisdictions, DOH sponsored a contract through the Washington General Administration's procurement office to guarantee a supply of ATDs at a low cost to the building departments. To date 34,000 detectors have been sold to building jurisdictions. DOH developed a new brochure for building departments to distribute to new home owners and an information sheet to be included with the ATD results.

Although changes have been made to the code and its' support programs, there are still some inadequacies. There is no reporting requirement for either the detector results or the number of passive stack systems installed. There is also a lack of field data to demonstrate the effectiveness of installed passive stack systems in eastern Washington, the location of most of the high radon potential counties.

The next challenge will be to extend the Radon Resistive Construction Standards past June 30, 1995. Without the incentive of BPA payments, the task for continuing these standards remains with DOH working with the Washington State Legislature. The DOH position on this is presented in the paper "Toward Resolving the Radon Controversy: A New Approach." (See Proceedings).

Chapter 5
Radon Resistive Construction Standards

WAC 51-13-501 Scope.

501.1 General: The criteria of this chapter establishes minimum radon resistive construction requirements for all Group R Occupancies. These requirements are adopted pursuant to the ventilation requirements of Section 7, of Chapter 2 of the Session Laws of 1990.

501.2 Application: The requirements of this chapter shall be adopted and enforced by all jurisdictions of the state according to the following subsections.

501.2.1: All jurisdictions of the State shall comply with Section 502.

501.2.2: Ferry, Grant, Okanogan, Pend Oreille, Skamania, Spokane, Stevens, and Wahkiakum counties shall also comply with Section 503.

WAC 51-13-502 State-wide Radon Requirements.

502.1 Crawlspaces

502.1.1 General: All crawlspaces shall comply with the requirements of this section.

502.1.2 Ventilation: All crawlspaces shall be ventilated as specified in Section 2516(c) of the Washington State Uniform Building Code (Chapter 51-20 WAC).

If the installed ventilation in a crawlspace is less than one square foot for each three hundred square feet of crawlspace area, or if the crawlspace vents are equipped with the operable louvers, a radon vent shall be installed to originate from a point between the ground cover and soil. The radon vent shall be installed in accordance with Sections 503.2.6 and 503.2.7.

502.1.3 Crawlspace plenum systems: In crawlspace plenum systems used for providing supply air for an HVAC system, aggregate, a permanently sealed soil gas retarder membrane and a radon vent pipe shall be installed in accordance with Section 503.2. Crawlspaces shall not be used for return air plenums.

In addition, an operable radon vent fan shall be installed. The fan shall be located as specified in Section 503.2.7. The fan shall be capable of providing at least one hundred cfm at one inch water column static pressure. The fan shall be controlled by a readily accessible manual switch. The switch shall be labeled "RADON VENT FAN."

502.2 Radon monitoring

502.2.1 Three month etched track radon monitors: Beginning July 1, 1992 and ending June 30, 1995, at the time of final inspection, the building official shall deliver the following to each new Group R, Division 3 Occupancy and to all ground floor dwelling units in new Group R, Division 1 apartment houses:

a) A three month etched track radon device that is listed on a current federal EPA radon measurement proficiency list, and includes prepaid fees for postage, test analysis and notification of the test results to the owner; and

b) Manufacturer's instructions for the device; and

c) Instructions prepared by the State Building Code Council, posted in a conspicuous place.

The building official is not responsible for returning the radon measurement device to the testing laboratory. The owner of a new Group R, Division 3 Occupancy or Group r, Division 1 apartment houses shall be responsible for returning the radon measurement device left by the building inspector to the appropriate testing laboratory in accordance with the instructions provided.

WAC 51-13-503 Radon Prescriptive Requirements.

503.1 Scope: This section applies to those counties specified in Section 501.2.2. This section establishes prescriptive construction requirements for reducing the potential for radon entry into all Group R occupancies, and for preparing the building for future mitigation if desired.

In all crawlspaces except crawlspace plenums used for providing supply air for an HVAC system, a continuous air barrier shall be installed between the crawlspace area and the occupied area to limit air transport between the areas. If a wood sheet subfloor or other material is utilized as an air barrier, in addition to the requirements of Section 502.1.6.2 of the Washington State Energy Code, all joints between sheets hall be sealed.

503.2 Floors in Contact with the Earth

503.2.1 General: Concrete slabs that are in direct contact with the building envelope shall comply with the requirements of this section.

Exception: Concrete slabs located under garages or other than Group R occupancies need not comply with this chapter.

503.2.2 Aggregate: A layer of aggregate of four inch minimum thickness shall be placed beneath concrete slabs. The aggregate shall be continuous to the extent practical.

503.2.3 Gradation: Aggregate shall:

a) Comply with ASTM Standard C-33 Standard Specification for Concrete Aggregate and shall be size No. 67 or larger size aggregate as listed in Table 2, Grading Requirements for Coarse Aggregate; or

b) Meet the 1988 Washington State Department of Transportation Specification 9-03.1 (3) "Coarse Aggregate for Portland Cement Concrete", or any equivalent successor standards. Aggregate size shall be of Grade 5 or larger as listed in Section 9-03.1 (3) C, "Grading"; or

c) Be screened, washed, and free of deleterious substances in a manner consistent with ASTM Standard C-33 with one hundred percent of the gravel passing a one-inch sieve and less than two percent passing a number four sieve. Sieve characteristics shall conform to those acceptable under

ASTM Standard C-33.

Exception: Aggregate shall not be required if a substitute material or system, with sufficient load bearing characteristics, and having approved capability to provide equal or superior air flow, is installed.

503.2.4 Soil-Gas Retarder Membrane: A soil-gas retarder membrane, consisting of at least one layer of virgin polyethylene with a thickness of at least six mil, or equivalent flexible sheet material, shall be placed directly under all concrete slabs so that the slab is in direct contact with the membrane. The flexible sheet shall extend to the foundation wall or to the outside edge of the monolithic slab. Seams shall overlap at least twelve inches.

Exception: If the membrane is not in direct contact with the bottom of the concrete slab, all overlapping seams shall be sealed with an approved tape or sealant, and the material shall be sealed to the foundation wall in a permanent manner. The membrane shall also be fitted tightly to all pipes, wires, and other penetrations of the membrane and sealed with an approved sealant or tape. All punctures or tears shall be repaired with the same or approved material and similarly lapped and sealed. In no case shall the membrane be installed below the aggregate.

503.2.5 Sealing of Penetrations and Joints: All penetrations and joints in concrete slabs or other floor systems and walls below grade shall be sealed by an approved sealant to create an air barrier to limit the movement of soil-gas into the indoor air.

Sealants shall be approved by the manufacturer for the intended purpose. Sealant joints shall conform to manufacturer's specifications. The sealant shall be placed and tooled in accordance with manufacturer's specifications. There shall be no gaps or voids after the sealant has cured.

503.2.6 Radon Vent: One continuous sealed pipe shall run from a point within the aggregate under each concrete slab to a point outside the building. Joints and connections shall be permanently gas tight. The continuous sealed pipe shall interface with the aggregate n the following manner, or by other approved equal method: The pipe shall be permanently connected to a "T" within the aggregate area so that the two end openings of the "T" lie within the aggregate area. A minimum of five feet of perforated drain pipe of three inches minimum diameter shall join to and extend from the "T." The perforated pipe shall remain in the aggregate area and shall not be capped at the ends. The "T" and it's perforated pipe extensions shall be located at least five feet horizontally from the exterior perimeter of the aggregate area.

The continuous sealed pipe shall terminate no less than twelve inches above the eave, and more than ten horizontal feet from a woodstove or fireplace chimney, or operable window. The continuous sealed pipe shall be labeled "radon vent." The label shall be placed so as to remain visible to an occupant.

The minimum pipe diameter shall be three inches unless otherwise approved. Acceptable sealed plastic pipe shall be smooth walled, and may include either PVC schedule 40 or ABS schedule of equivalent wall thickness.

The sealed pipe system may pass through an unconditioned attic before exiting the building; but to the extent practicable, the sealed pipe shall be located inside the thermal envelope of the building in order to enhance passive stack venting.

Exception: A fan forced sub-slab depressurization system includes:

1) Soil-gas retarder membrane as specified in Section 503.2.4;

2) Sealing of penetrations and joints as specified in Section 503.2.5;

3) A three-inch continuous sealed radon pipe shall run from a point within the aggregate under each concrete slab to a point outside the building.

4) Joints and connections may be gas tight, and may be of either PVC schedule 40 or ABS schedule of equivalent in wall thickness;

5) A label of "radon vent" shall be placed on the pipe so as to remain visible to an occupant;

6) Fan circuit and wiring a specified in Section 503.2.7 and a fan.

If the sub-slab depressurization system is exhausted through the concrete foundation wall or rim joist, the exhaust terminus shall be a minimum of six feet from operable windows or outdoor air intake vents and shall be directed away from operable windows and outdoor air intake vents to prevent radon re-entrainment.

503.2.7 Fan Circuit and Wiring and Location: An area for location of an in-line fan shall be provided. The location shall be as close as practicable to the radon vent pipe's point of exit from the building, or shall be outside the building shall; and shall be located so that the fan and all downstream piping is isolated from the indoor air.

Provisions shall be made to allow future activation of an in-line fan on the radon vent pipe without the need to place new wiring. A one hundred ten volt power supply shall be provided at a junction box near the fan location.

503.2.8 Separate Aggregate Areas: If the four-inch aggregate area underneath the concrete slab is not continuous, but is separated into distinct isolated aggregate areas by a footing or other barrier, a minimum of one radon vent pipe shall be installed into each separate aggregate area.

Exception: Separate aggregate areas may be considered a single area if a minimum three-inch diameter connection joining the separate areas is provided for every thirty feet of barrier separating those areas.

503.2.9 Concrete Block Walls: Concrete block walls connected to below grade areas shall be considered unsealed surfaces. All openings in concrete block walls that will not remain accessible upon completion of the building shall be sealed at both vertical and horizontal surfaces, in order to create a continuous air barrier to limit the transport of soil-gas into the indoor air.