APPENDIX D
ASD System Diagnostics, Design, and Description

Exploratory Study of Basement Moisture During Operation of ASD Radon Control Systems

Contractor Report to EPA

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ASD Diagnostic and System Design Procedures

The diagnostic procedures employed in this study include the measurement of air flow and pressure at suction points to enable quantitative characterization of ‘sub-slab’ resistance, and calculation of pipe run resistance, or ‘friction loss’. These two components comprise the total resistance to air flow in an ASD system, which determines the performance (air flow produced) by a particular fan. This process serves as the basis for the system component selection portion of system design.

<u>Air flow and pressure measurement</u>

An apparatus constructed of PVC pipe and a shop-size vacuum cleaner was used for field measurements of air flow and pressure. A Pitot tube was constructed using 2” PVC pipe and 1/8” brass pipe fittings. This device was calibrated against a commercial Pitot tube to derive a flow vs velocity pressure curve for the device. Static pressure was measured in a 4” PVC pipe sanitary “Tee” adapted to seal into a suction hole in a slab or other suction point, and connected to the 2” PVC pipe Pitot tube. The velocity pressure from the Pitot tube and the static pressure in the pipe apparatus were measured with an electronic digital micromanometer.

<u>‘Friction loss’ calculation</u>

Resistance to air flow in plastic pipe was previously determined by ‘bench’ testing 2”, 3” and 4” schedule 40 PVC pipe and assorted common fittings. Using these values, the pipe run resistance or ‘friction loss’ was calculated for proposed pipe runs.

<u>Fan performance determination</u>

The ‘sub slab’ resistance added to the pipe run resistance at a particular air flow yields the total system resistance at that air flow. At least two of these total system resistance values were plotted on log-scale paper with air flow plotted against system static pressure (resistance) on the axes. Already plotted on the graph paper were the performance curves for several common radon fans. These curves were derived by ‘bench’ testing the fans mounted on 4” PVC pipe, with the air flow and static pressure measured in the pipe using the method described above. The intersection of the total system resistance curve and a fan curve indicates the operating point (pressure and air flow) for that fan on that system.

<u>Fan selection</u>

The air flow through the diagnostic apparatus was adjusted to produce the desired degree of depressurization under the slab and/or in the block walls. At that operating level, the air flow or static pressure in the apparatus was used to locate that point on the total system resistance curve. Any fan whose curve crosses the total system resistance curve at or above that operating level will move enough, or more than enough air to produce that level of depressurization. For the purposes of this study, fans were selected which produced more robust depressurization than would commonly be deemed necessary for radon control.

ASD System Description

General considerations

As mentioned elsewhere, the ASD systems for the houses in this study were designed to have more robust performance than would usually be considered necessary or desirable simply for radon control. The major reason for this design decision was that optimal ASD operating parameters for moisture control were not known, and the investigators wanted the greater-than-normal performance capability available. A Fantech HP220 fan was selected for all three houses. The intent was to start the systems at full capacity and reduce the extent and strength of the systems' impact by reducing the number of active suction points and the total system air flow.

In every leg (save one) of each system, a T/RH sensor was installed in the pipe within one foot of the slab or wall penetration. Another T/RH sensor was installed within 2 feet of the discharge end of the pipe in each system.

A condensate drain was installed in each system so that most, if not all, of the condensate draining back down the pipe could be intercepted and re-routed to a sub-slab location rather than allowed to drain back to a suction point. Each drain was equipped with a valve so that the condensate could be directed to either location.

PA01

This house was built with a passive radon vent consisting of 3 inch PVC pipe originating at a "T" in a perforated flexible interior sub-slab drain tile loop located near the wall. The drain tile loop entered a sump from both directions approximately 8 feet from the "Tee." The PVC vent pipe extended up the basement wall and up through the wall between the garage and the house interior into the attic. A horizontal run of approximately 20 feet terminated approximately 8 feet from the back wall of the house, where the pipe turned up and penetrated the roof. The fan for the study was installed in this last vertical section. The sump was sealed with a gas-tight cover.

The investigation team installed a second suction point directly under the top basement stair landing, and ran the pipe to just below where the original vent pipe turned to enter the wall of the garage. The two pipes were joined at that point with a sanitary "Tee." Both suction legs had gate valves installed upstream from the junction point and Pitot tubes were installed upstream from the gate valves.

Diagnostic procedures indicated that friction loss in the rather lengthy 3 inch pipe run, although substantial, did not restrict air flow enough so that substitution of larger pipe was required.

PA02

A partial passive radon vent system was installed during construction of this house, but it was terminated where the 3 inch PVC pipe was stubbed up through the slab from an interior flexible perforated drain tile loop. The pipe was capped at this point, which was directly adjacent to a sump in one corner of the basement. A 3 inch rigid PVC perforated pipe entered the sump after passing through/under the footer from outside the wall, where it connected to a “Tee” in what appeared to be an exterior footer drain. The sump bucket was not perforated to communicate with the sub-slab, although sub-slab water could enter the bucket through the hole for the pipe from the exterior drain tile, or through the pipe itself as it was oriented with the holes down. This pipe passed through approximately 8 inches of sub-slab aggregate between the footer and the sump bucket, and was located just below the interior drain tile.

Investigators installed a 3 inch PVC pipe riser on the stub from the interior tile loop, including a Pitot tube and gate valve. They also installed a gas-tight cover on the sump and a 3 inch riser from the cover, also with a Pitot tube and gate valve. At approximately 4 feet above the floor, both risers were connected into a 4 inch PVC manifold which exited the house through the rim joist. The fan was mounted directly outside the wall, and the discharge continued up to above the roof.

The diagnostic and system performance simulation procedures indicated that the sub-slab pressure field would adequately depressurize the interior of the block walls around the entire perimeter of the structure, obviating the need for direct depressurization of the walls themselves. It proved necessary to seal the wall/floor joint, however, as one-half inch polystyrene bead board had been used as expansion joint which allowed unacceptably large air leakage.

PA03

No ‘radon-resistant’ features were originally incorporated into this house, but it did have a retro-fit water control system consisting in part of a perforated drain tile buried in aggregate under the slab within one foot of the back wall. This tile terminated in the gravel in which the perforated sump bucket was set, but did not penetrate the bucket itself. A gas-tight cover was installed on the sump. A sub-slab suction point was installed adjacent to the back wall, with the radon vent pipe almost touching the sub-slab drain tile. The diagnostic procedures had indicated that even a very robust sub-slab pressure field would not produce adequate depressurization in the block walls except at a few places in the back wall. Thus, direct block wall depressurization was utilized, with two suction points on one leg to the front wall, and one suction point on another leg to the back wall. It was diagnostically determined that both wall suction legs operating simultaneously would produce adequate, if not very robust, depressurization in the walls all around the perimeter.

The air flows required for the system to perform adequately necessitated the use of 4 inch pipe in the system, including all three suction legs. Each leg was equipped with a Pitot tube and gate valve as previously described. The main suction pipe exited the structure through the rim joist on an end wall near the back corner, the fan was mounted directly outside and the discharge terminated above the roof.