A LABORATORY TEST OF THE EFFECTS VARIOUS RAIN CAPS ON SUB-SLAB DEPRESSURIZATION SYSTEMS

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ABSTRACT

Many sub-slab depressurization systems are installed with some type of rain cap intended to keep rain water from entering the exhaust pipe. There is some question among researchers and radon mitigators whether a rain cap in necessary, and what effects a rain cap has on the sub-slab depressurization system. This paper makes no effort to explore the necessity of a rain cap, only the effect that certain rain caps have on the system. To help answer that question, a series of tests were performed to determine: 1. the additional resistance the caps place on a pipe, and, 2. the effect of wind on the system with the various rain caps installed. The results of those tests are presented in this paper.

The work described in this paper was not funded by the U.S. Environmental Protection Agency and therefore the contents do not necessarily reflect the views of the Agency and no official endorsement should be inferred.

INTRODUCTION

Many radon mitigation contractors routinely install some type of cap on the end of a sub-slab depressurization system to prevent rain from entering the exhaust pipe. While the use of a rain cap may or may not be necessary, this paper takes neither side of the argument. The objectives of the tests described herein were to explore the effect that various types of hardware that are often used as rain caps have on sub-slab depressurization systems. To reach those objectives, a series of measurements were made to determine the backpressures the rain caps induced on the system. Additional tests were made to determine the draft generated by each rain cap on a passive sub-slab depressurization system.

TYPE OF CAPS TESTED

OPEN PIPE

The open pipe was a length of 4 inch, schedule 20, PVC plastic pipe.

CAP A

This cap is manufactured for the purpose of preventing rain from entering a sub-slab depressurization system. The cap consists of a PVC plastic collar which slips over the end of the exhaust pipe, a PVC plastic cover to keep rain out, and a PVC grill on each end to keep other objects out of the exhaust pipe.

Air, flowing vertically up the SSD exhaust pipe, strikes the cover, and is diverted horizontally through the grills. This cap is designed to slide over the end of the SSD exhaust pipe, therefore the area available for exhausting air is not reduced by the cap.

DRYER VENT CAP

This type of cap is manufactured for the purpose of capping a horizontal clothes dryer exhaust pipe. The cap is constructed of plastic and has movable louvers which remain normally closed until an airflow of sufficient volume and velocity opens the louvers. The cap is designed to fit on the inside of the 4 inch exhaust pipe, which decreases the exhaust pipe area from to 12.7 to 10.3 square inches. The louvers, depending on the degree of opening, causes a change in exhaust area that ranges from nearly nothing when closed, to approximately 9.7 square inches when fully open.

DRAFT INDUCER

The draft inducer tested was a 6 inch diameter stainless steel unit. The inducer was connected to the test system with a 6 in. to 4 in. rubber reducing fitting.

Draft inducers are designed to be placed on the end of a chimney to increase the amount of draft and assist in the proper exhaust of combustion gases. The draft inducer is designed to fit over the end of the exhaust pipe, therefore exhaust pipe area is not reduced. Air, flowing vertically up the SSD exhaust pipe, strikes the top of the inducer and is diverted horizontally. The draft inducer, when used in radon control systems, is usually used to provide additional suction in a passive SSD system, and is not normally installed for the purpose of keeping rain from entering the system.

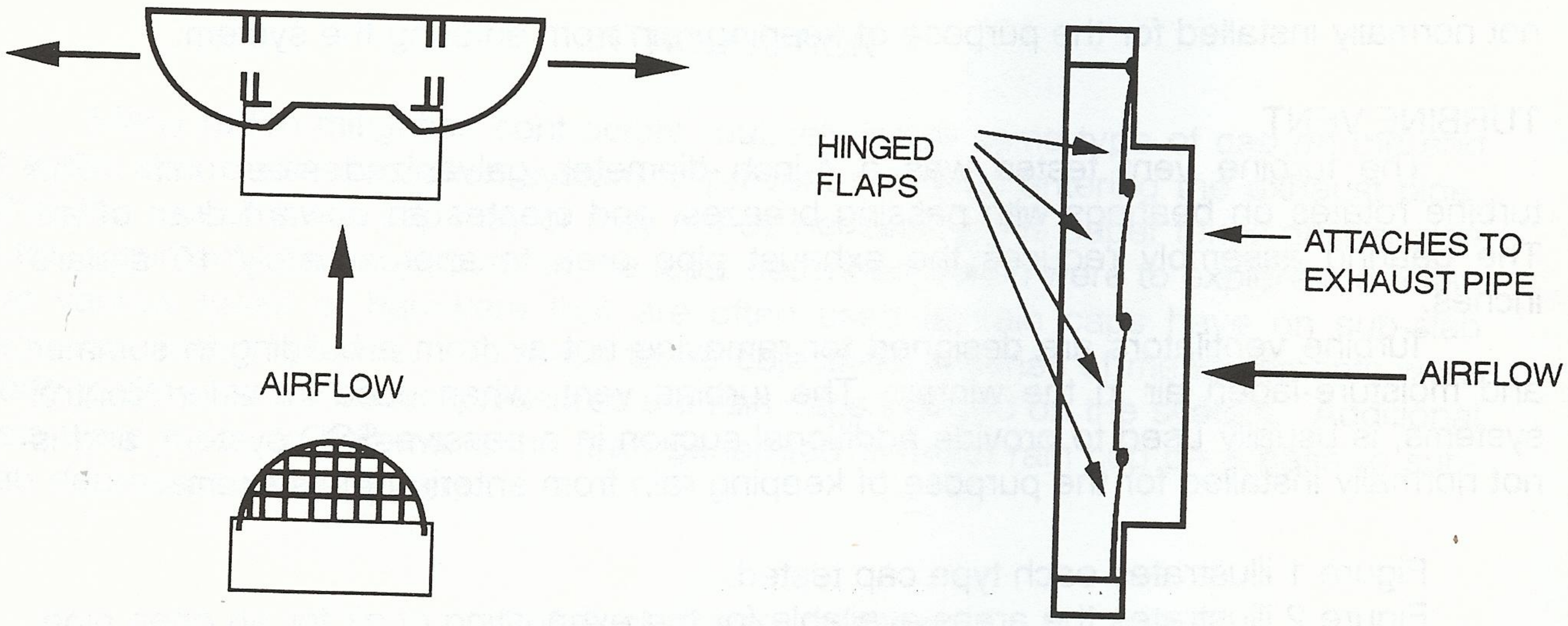
TURBINE VENT

The turbine vent tested was a 4-inch diameter, galvanized steel unit. The turbine rotates on bearings with passing breezes, and creates an upward draft of air. The bearing assembly reduces the exhaust pipe area to approximately 10 square inches.

Turbine ventilators are designed for removing hot air from a building in summer and moisture-laden air in the winter. The turbine vent, when used in radon control systems, is usually used to provide additional suction in a passive SSD system, and is not normally installed for the purpose of keeping rain from entering the system.

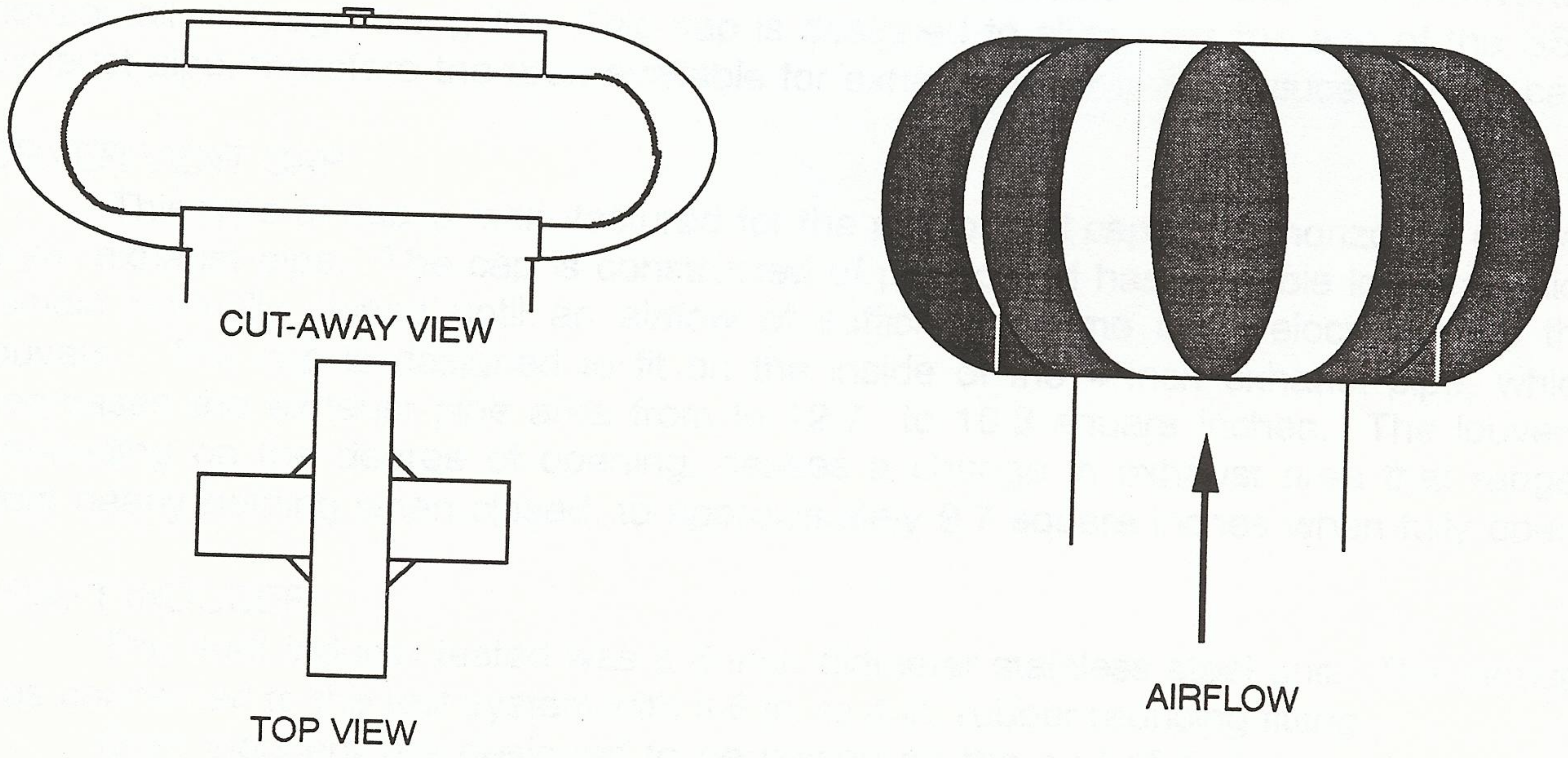
Figure 1 illustrates each type cap tested.

Figure 2 illustrates the areas available for the exhausting of air for an open pipe, and each cap tested.



CAP A

DRYER VENT



DRAFT INDUCER

TURBINE VENT

Figure 1. Types of caps tested.

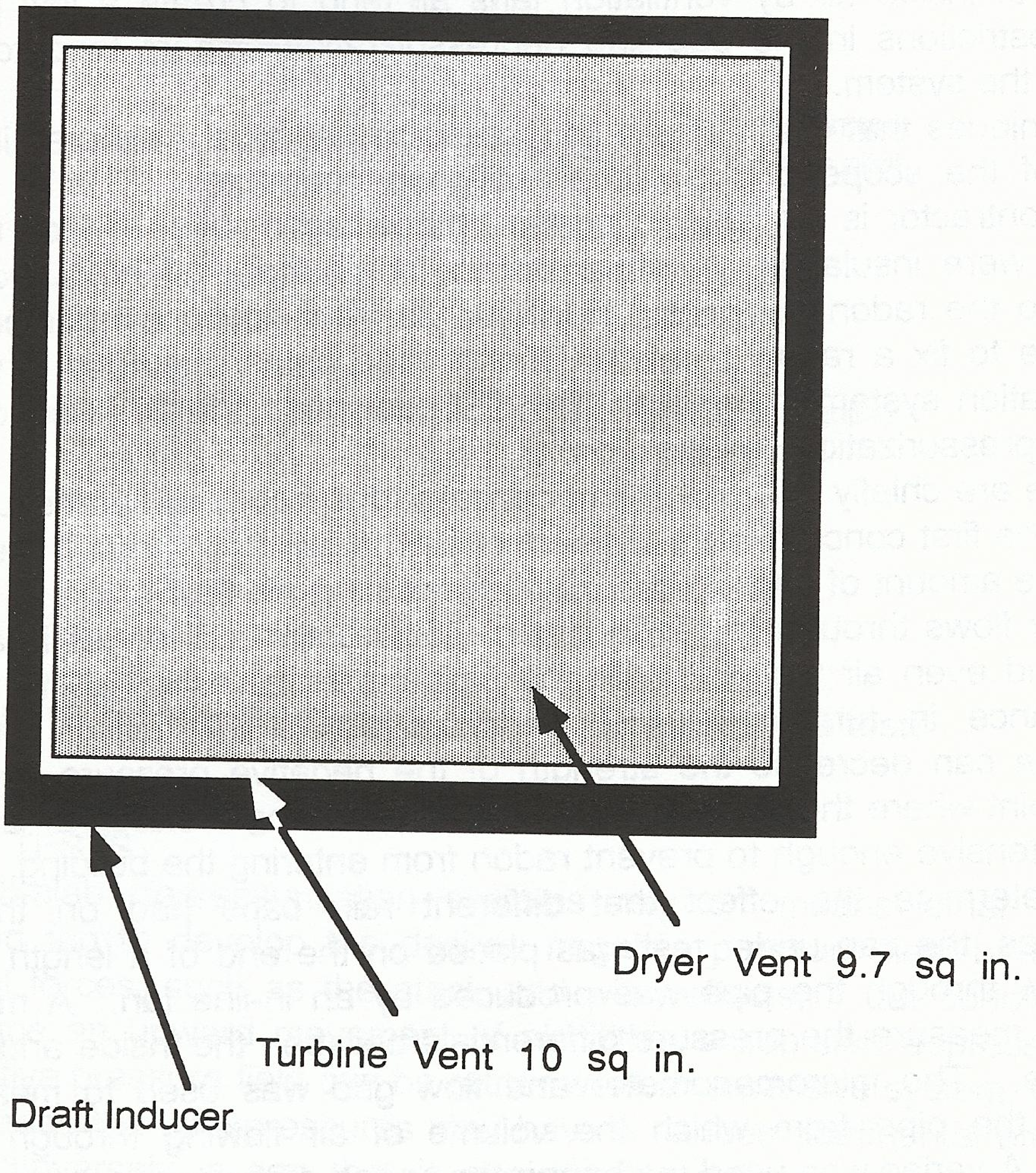


Figure 2. Relative exhaust areas. Drawings are approximately to scale.

TEST PROCEDURES

BACKPRESSURES CAPS PLACE ON THE PIPE

The objective of a sub-slab depressurization system is to create an air pressure field beneath the floor slab that is less than the air pressure in the building. This is commonly referred to as the "negative pressure". To maintain the negative pressure beneath the slab, the system must overcome conditions which tend to equalize the pressure differences between the sub-slab and the interior of the building. Air, exhausted from the house by temperature differences, wind effects, and the exhausting of inside air by ventilation fans all tend to create a low pressure in the house. Restrictions in the sub-slab depressurization system tend to create a high pressure in the system.

Techniques that can be used to lessen the negative pressures in the home are often out of the scope of the radon mitigation contractor. This is not to say the mitigation contractor is not able to perform those techniques. In fact, many mitigation contractors were insulating, weatherproofing, or performing HVAC work long before they got into the radon business. However, as a mitigation contractor, they are at a clients home to fix a radon problem. One of the primary methods is with a sub-slab depressurization system, therefore, the SSD designer normally is concerned with the sub-slab depressurization system only.

There are chiefly two issues of concern to the sub-slab depressurization system designer. The first concern is the amount of air that will flow through the system. The second is the amount of backpressure that is resisting the flow of air.

As air flows through the exhaust pipe, obstructions, changes in airflow direction (elbows), and even air friction inside the pipe create a resistance to the flow of air. This resistance in turn creates a backpressure in the pipe. An increase in backpressure can decrease the strength of the negative pressure field beneath the slab, to a point where the negative pressure field no longer exists, or is not sufficiently strong or extensive enough to prevent radon from entering the building.

To determine the effect that different rain caps had on the airflow and backpressures, the cap under test was placed on the end of a length of 4 inch PVC pipe. Airflow through the pipe was produced by an in-line fan. A micromanometer was used to measure the pressure differentials between the inside and outside of the exhaust pipe. The micromanometer and flow grid was used to measure the pitot pressure in the pipe from which the volume of air flowing through the pipe was determined. A variac was used to change the speed of the fan to provide several data points at different airflows and pressure differences. Figure 3 illustrates the equipment configuration for this test.

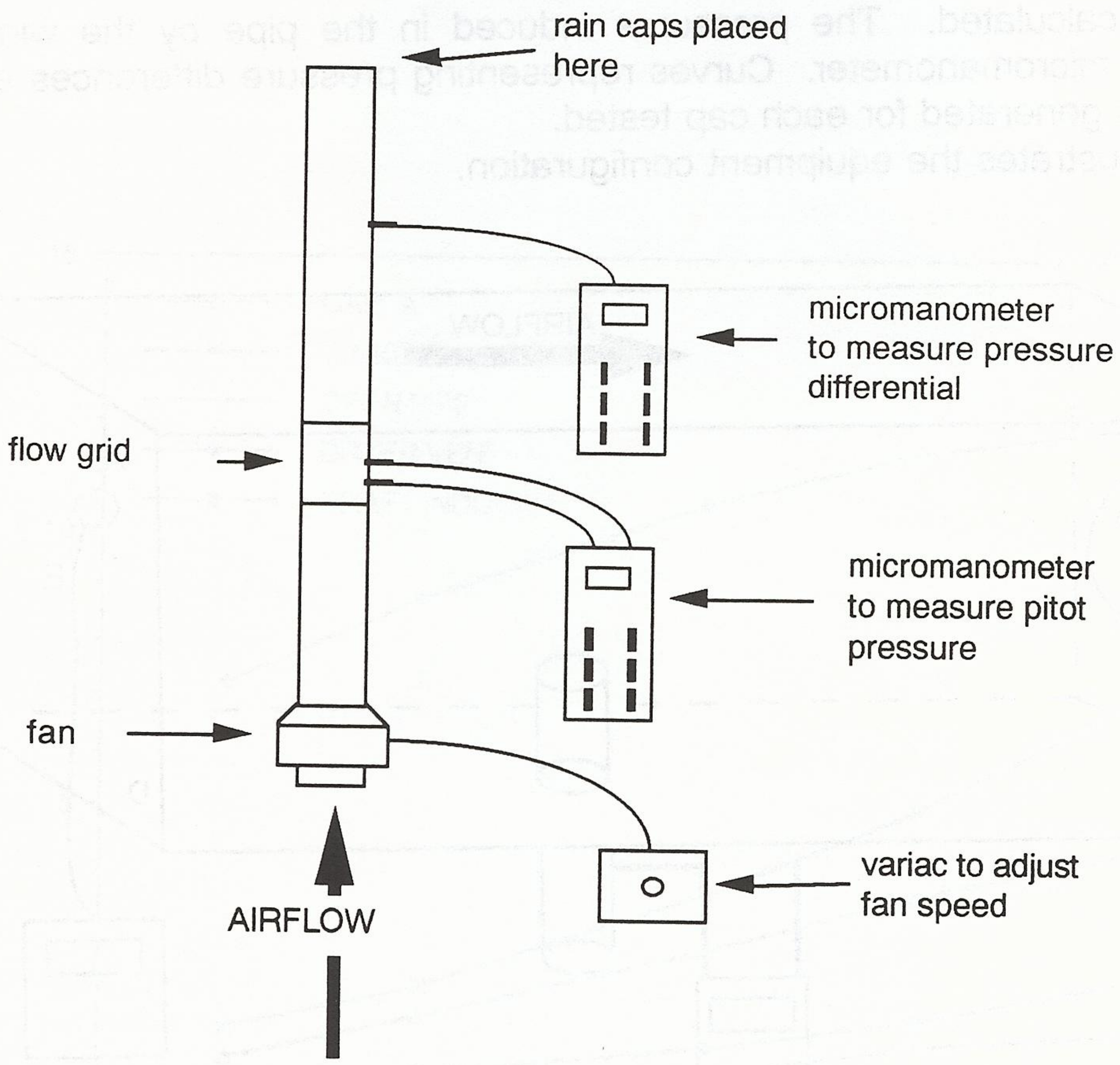


Figure 3. Equipment layout for system backpressure tests.

INDUCED DRAFT TESTS

Passive sub-slab depressurization systems rely on means other than an electrically powered fan to develop the desired negative pressure field beneath the floor slab. Natural forces, such as the stack and wind effects, if the conditions are correct, can produce an upward movement of air within a sub-slab depressurization system. The negative pressure field can be rather weak in a passive system, therefore rain caps that increase the backpressures may have a serious detrimental effect on a passive system. Conversely, a cap that is designed to induce airflow may have a positive effect on the system.

To determine the draft that the cap induced on a passive sub-slab depressurization system, pressure differences between the interior of the pipe and the outside air were measured at various wind speeds. A wind tunnel was constructed to direct the flow or air across the cap. The cap to be tested was placed on a length of 4 in. PVC pipe within the wind tunnel. A large blower door fan was used to draw air from the open end of the tunnel and across the cap. A vaned anemometer was used to measure the windspeed at different locations within the tunnel, and the average windspeed was calculated. The pressures induced in the pipe by the wind were measured with a micromanometer. Curves representing pressure differences at those windspeeds were generated for each cap tested.

Figure 4 illustrates the equipment configuration.

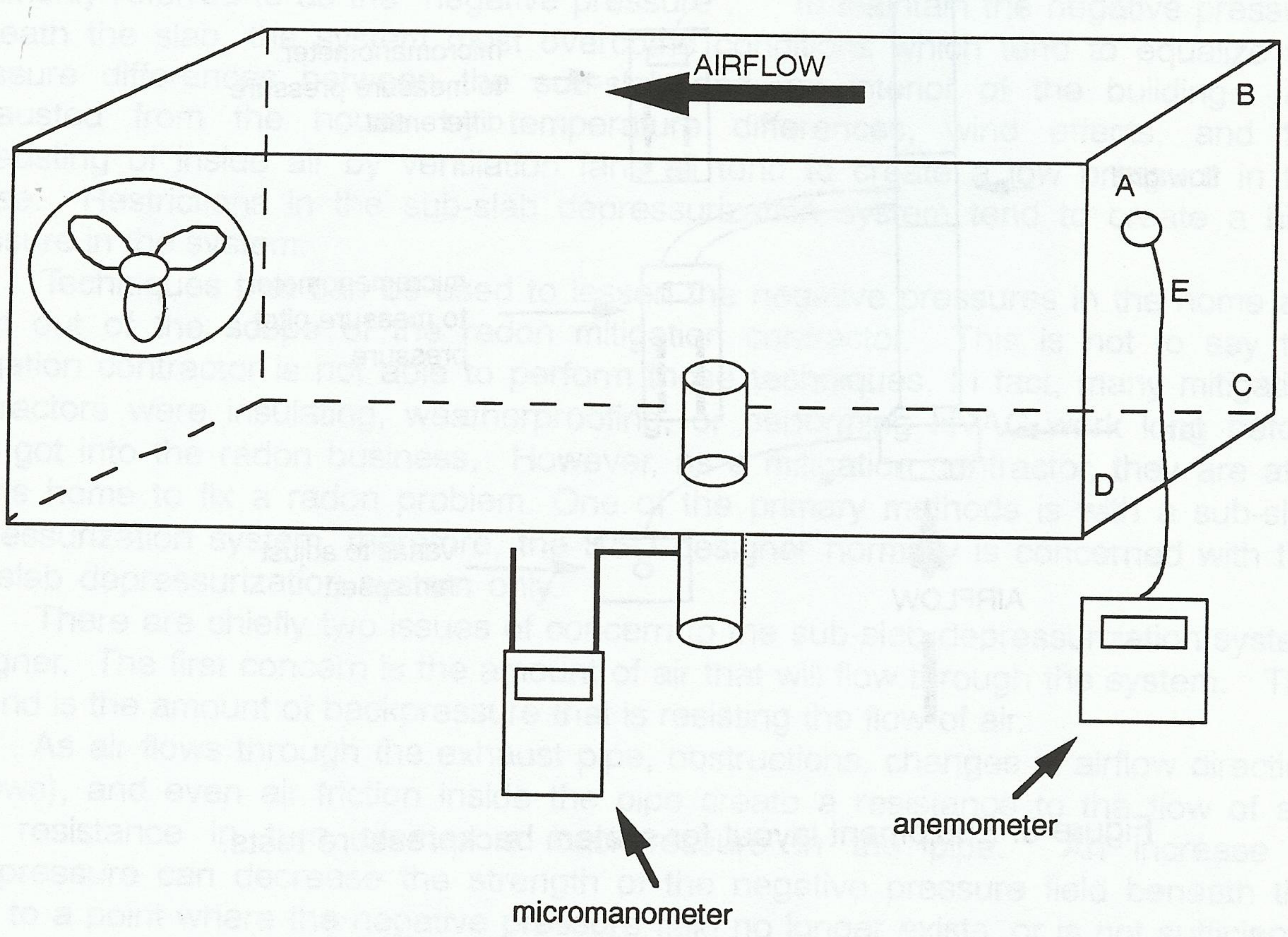


Figure 4. Equipment layout for induced draft tests.

RESULTS

BACKPRESSURE TESTS

As illustrated on Figure 5, all caps tested developed an additional resistance within the exhaust pipe when compared to an open ended pipe. The best performer was the draft inducer, which resulted in the least amount of backpressure across the entire operating range of the fan. The worst performer was the dryer vent. Note that the curve for the dryer vent is inverted when compared to the other caps tested and the open ended pipe. The inversion is due to the vanes on the vent cap opening wider at the higher airflows. All caps resulted in a backpressure that could cause a marginally operating sub-slab depressurization system to fail to reduce indoor radon concentrations.

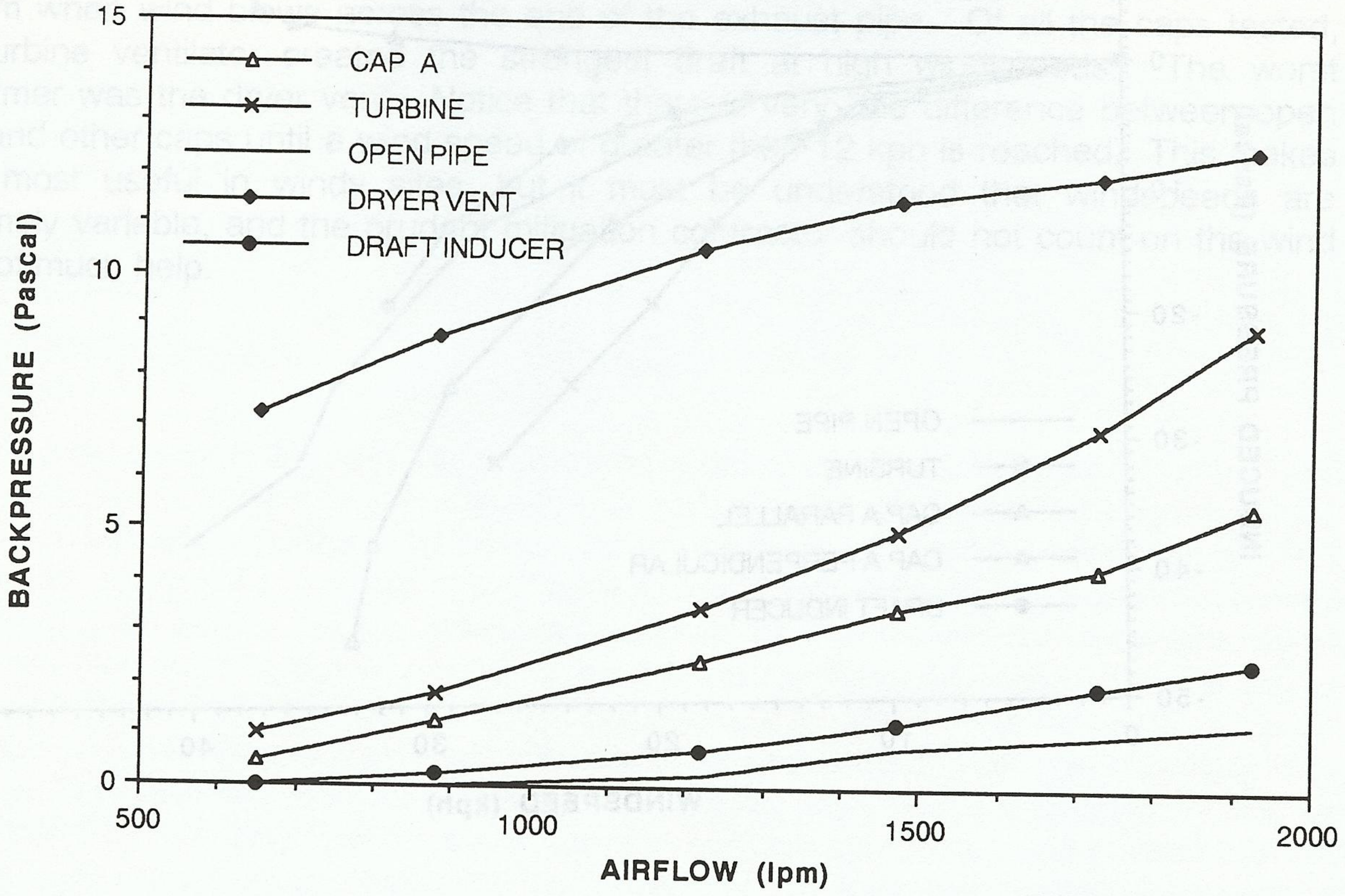


Figure 5. Backpressure in pipe due to caps.

INDUCED DRAFT TESTS

All caps, and the open ended pipe, produced a negative pressure in the pipe when air was flowing across the cap, however, Cap A, which produced a fairly strong negative pressure within the pipe when the airflow was perpendicular to the cap, produced a backpressure in the pipe when the open end of the cap was parallel to the airflow. Perhaps a modification to Cap A, which moved the cap so that the open end was always parallel to the wind would improve the overall performance of this cap. The best performer, when all windspeeds are considered, was the turbine ventilator, which produced a negative pressure in the pipe that ranged from -3 pascals at 11 kph (-0.01 in. at 6.5 mph) to -31 pascals at 27 kph (-0.12 in. WC at 17 mph). Figure 6 shows the results of the tests performed.

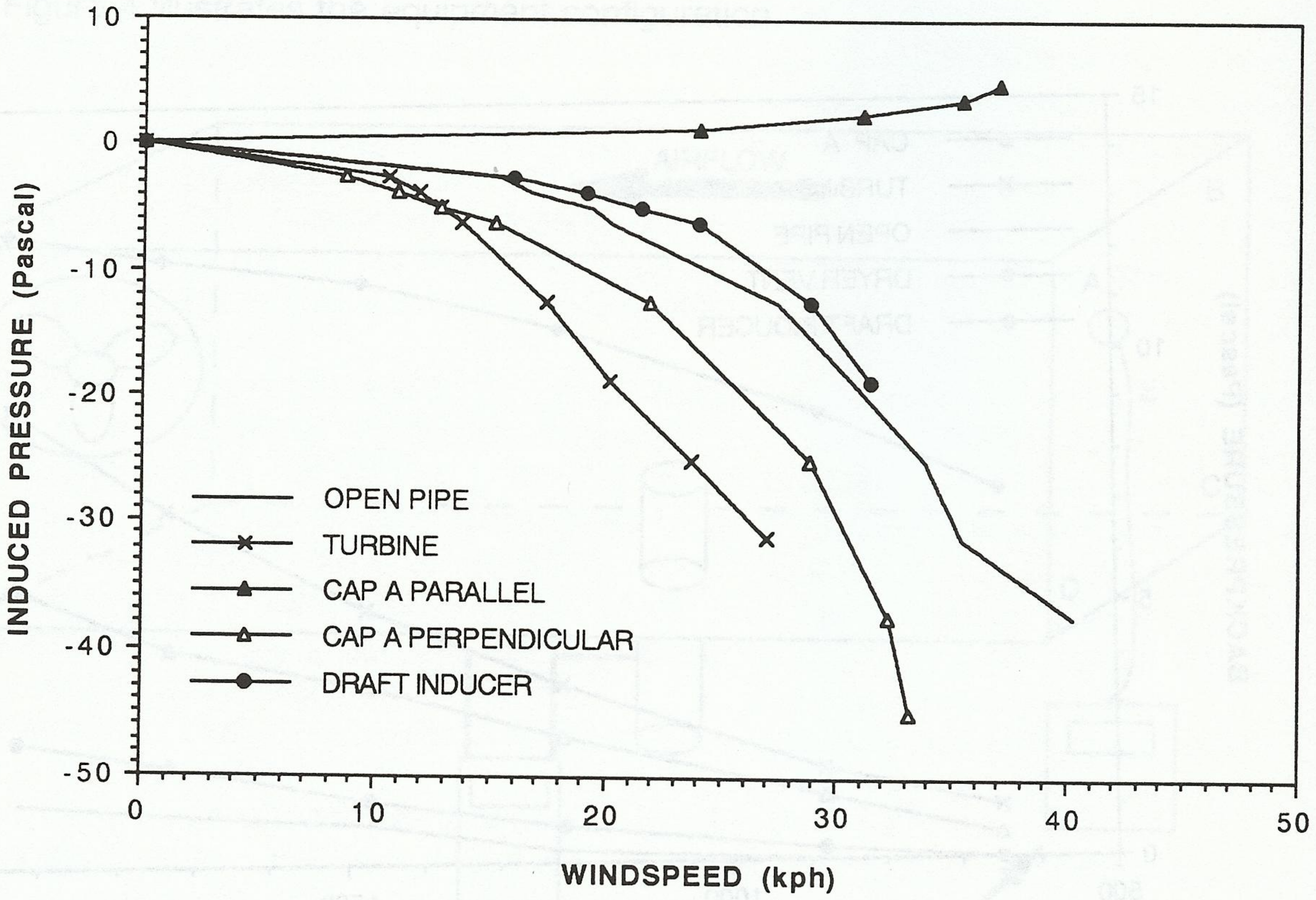


Figure 6. Induced pressure results.

CONCLUSIONS

Caps, when placed on the end of a sub-slab depressurization system can increase the amount of backpressure in the system. In order of increased backpressures, the open pipe results in the least backpressure, followed by the draft inducer, Cap A, the turbine vent, and finally, with the greatest amount of backpressure, the dryer vent. This comes as no great surprise. If we had considered the open exhaust area of each cap with regard to a resistance to airflow, and the diversion of the flow of air from the vertical to the horizontal as another resistance to airflow, we probably could have predicted quite accurately how each cap would rank. However, that would have resulted in a very short paper. The test results indicate that backpressures created by the caps amount to 10 to 12 pascals at most, and, are more likely to be 2 to 5 pascals at the airflows encountered in most SSD installations. This is not a significant backpressure when the air pressure induced under a slab is 50 to 200 pascals. However, when the pressure under the slab is only 5 to 10 pascals, as it may be in a passive SSD, or on very permeable soils, or in spots where there is fine sand or clays under the slab, the backpressure from the caps becomes significant. The best recommendation is when considering whether to use a cap is to measure the sub-slab pressures with the pipe uncapped, and with the cap temporarily installed. If the cap seems to make a significant difference in the sub-slab pressure, don't use it.

A substantial draft can be induced on a passive sub-slab depressurization system when wind blows across the end of the exhaust pipe. Of all the caps tested, the turbine ventilator created the strongest draft at high windspeeds. The worst performer was the dryer vent. Notice that there is very little difference between open pipe and other caps until a wind speed of greater than 12 kph is reached. This makes caps most useful in windy sites, but it must be understood that windspeeds are extremely variable, and the prudent mitigation contractor should not count on the wind to be of much help.