Where is the Radon coming from? Bill Brodhead

A single family one story 1800 sq.ft. (sf) newly constructed home near the coastline of Massachusetts was purchased in June of 2016. Under the entire house is a poured concrete wall basement with sand gravel mix under the slab. The only adjoining concrete slab is a two car garage. The HVAC system in the basement is gas fired hot air with central air conditioning. The 1653 sf basement is unfinished except for a 200 sf finished work room.

Initial radon level in May of 2016 was 6.5 pCi/l. In June a certified company installed a single suction point into the basement slab with a GP501 fan. The post mitigation test in August of 2016 was 4.9 pCi/l. After four additional tests ranged from 3.9 to 5.7 pCi/l, the contractor installed a 2nd basement sub-slab suction and sealed perimeter crack. A long term follow-up test in 2017 was 4.2 pCi/l. Four years later in March of 2021 the mitigation contractor changed the fan to a high capacity RN4EC3 and added a third basement suction. The radon levels came back at 7.8 pCi/l. The owner then purchased a Radon Eye monitor and observed radon levels were now averaging around 11 pCi/l and increasing the speed of the fan did not lower the radon levels. The home owner then contacted the radon hot line and a FanTech engineer, Hamid Massali, who suggested concrete may be the source or the garage sub-slab. Hamid also provided consulting on the HRV design. In May of 2021 the mitigator installed a garage suction but it produced no additional radon reduction. At this point the mitigation contractor gave up on the house and returned the money he had charged for the additional work.

With help from hotline advisors and a borrowed micro-monometer the homeowner measured the basement sub-slab as negative 25 to 50 pascals (- 0.100" to – 0.200"). Thirty charcoal test kits were also spread around the basement and first floor but all the basement detectors read between 9.8 and 11.6 pCi/l. I was then contacted about doing flux testing of the slab and foundation wall.

Radon flux coming through or out of concrete is best measured with a small CRM and a 3 or 5 liter stainless steel mixing bowl. The Radon Eye or newer Eco-Tracker works out well for this test because of its small size and high sensitivity to changing radon levels although it does require an external charger unless a small battery is used. The owner placed the Radon Eye inside a 5 liter bowl that was sealed against the slab or foundation wall using plumber's putty. Note that the oil in plumbers putty will stain concrete. The exposure is typically 12 to 24 hours. The first 12 hours typically gives the best straight line of increasing radon because longer exposures have a flattening radon curve. It is helpful to plot the results on a spreadsheet to pick out the most consistent rise of radon levels under the bowl. See Figure 1 showing the Flux bowl test on the slab and at two locations against the poured foundation wall.

Flux bucket radon level change is divided by hours of the change to give pCi ingrowth per hour. Ingrowth per hour is multiplied by the volume of the bowl in liters minus the volume of the CRM. This result is divided by the slab Sq. Ft. area the bowl covers to give the pCi/SF/Hr result. If the flux is assumed to be the same across the slab, the result is then multiplied by the sq. ft. area of basement slab and the same for the foundation wall area. Both of these added together is the total amount of radon entering the basement per hour from concrete. The total radon entry is divided by the total number of liters of ventilation per hour entering the basement.

Unless the basement ventilation rate is measured an assumed air change per hour (ACH) must be used. Latest USA ventilation standards recommend about 0.35 air changes ACH. Basements however tend to have much less than this, especially with new well insulated homes. The owner also reported lower basement radon levels in the winter than the summer which happens if the radon source is steady but ventilation increases. Winter stack effect tends to increase basement ventilation (ACH) and cause lower radon levels if the radon source is steady. A variable with this is the run time of a basement located air handler which may run more in the winter than summer and raise or lower radon levels. In this house if the HVAC ran continuously it lowered the radon levels about 40%. In Figure 1 the concrete total radon contribution is divided by the volume of 0.05 ACH to indicate an 8.05 pCi/l contribution of basement radon from concrete flux.

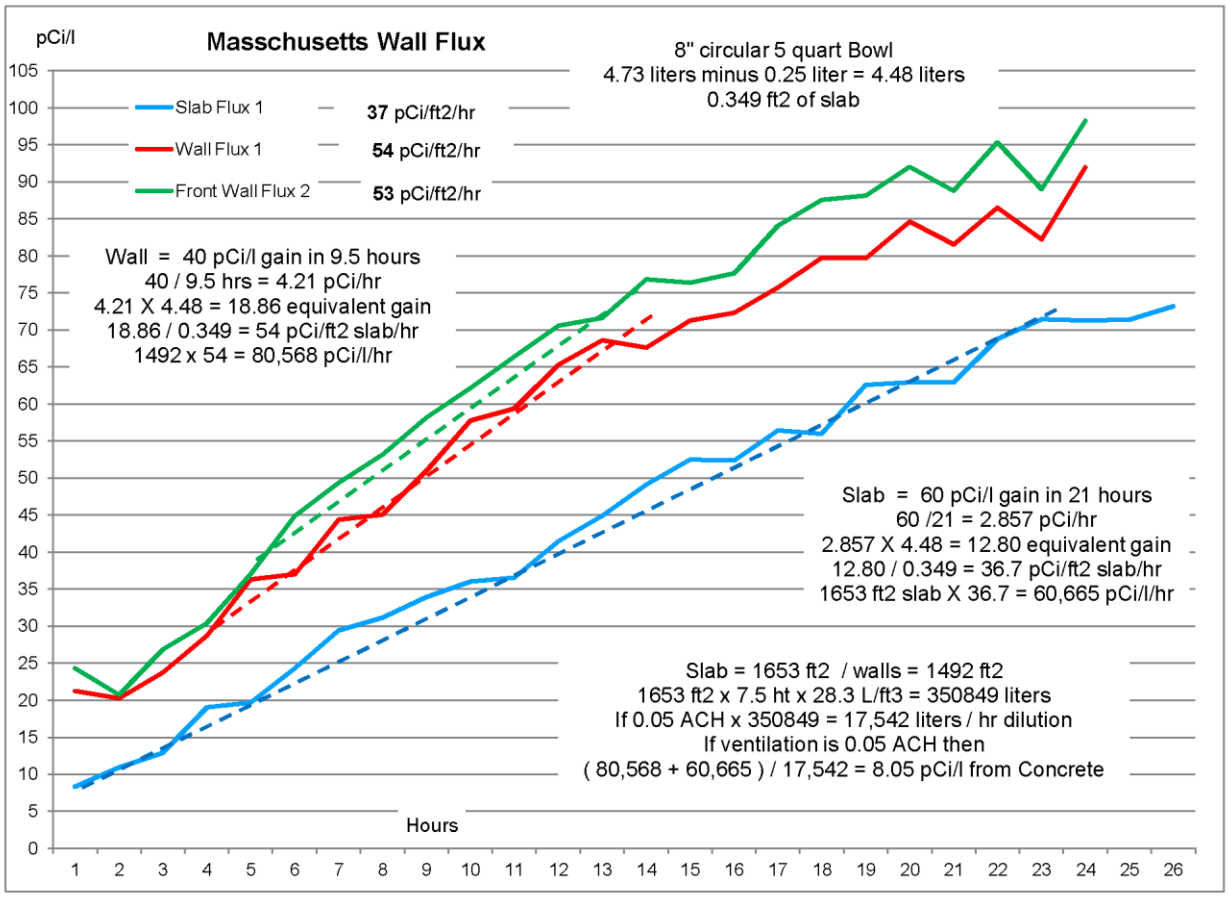


Figure 1: Flux radon ingrowth

To determine the basement natural ventilation rate in order to size a Heat Recovery Ventilator (HRV) two tests were done. One test requires turning off the radon system and after the new radon level is reached, turn the system on and measure the time it takes to return to the radon system running basement level. The other more definitive test is to introduce a measured amount of air from the

outside into the basement and measure what the new radon level is. In both these tests it is necessary to establish a steady base line radon level and a steady modified radon level.

For this simple ventilation test the radon fan was turned off until radon levels plateau and then the fan was turned back on. It is best to keep HVAC off for this test. Determine the ventilation rate by counting the number of hours it takes to double or half the radon levels. The rough ACH estimate is 1 divided by the total number of hours it took to half the radon levels. See Figure 2 below. This test indicates the ACH is around 0.05 ACH. The rising radon level often takes longer because the ASD system depleted the ground source.

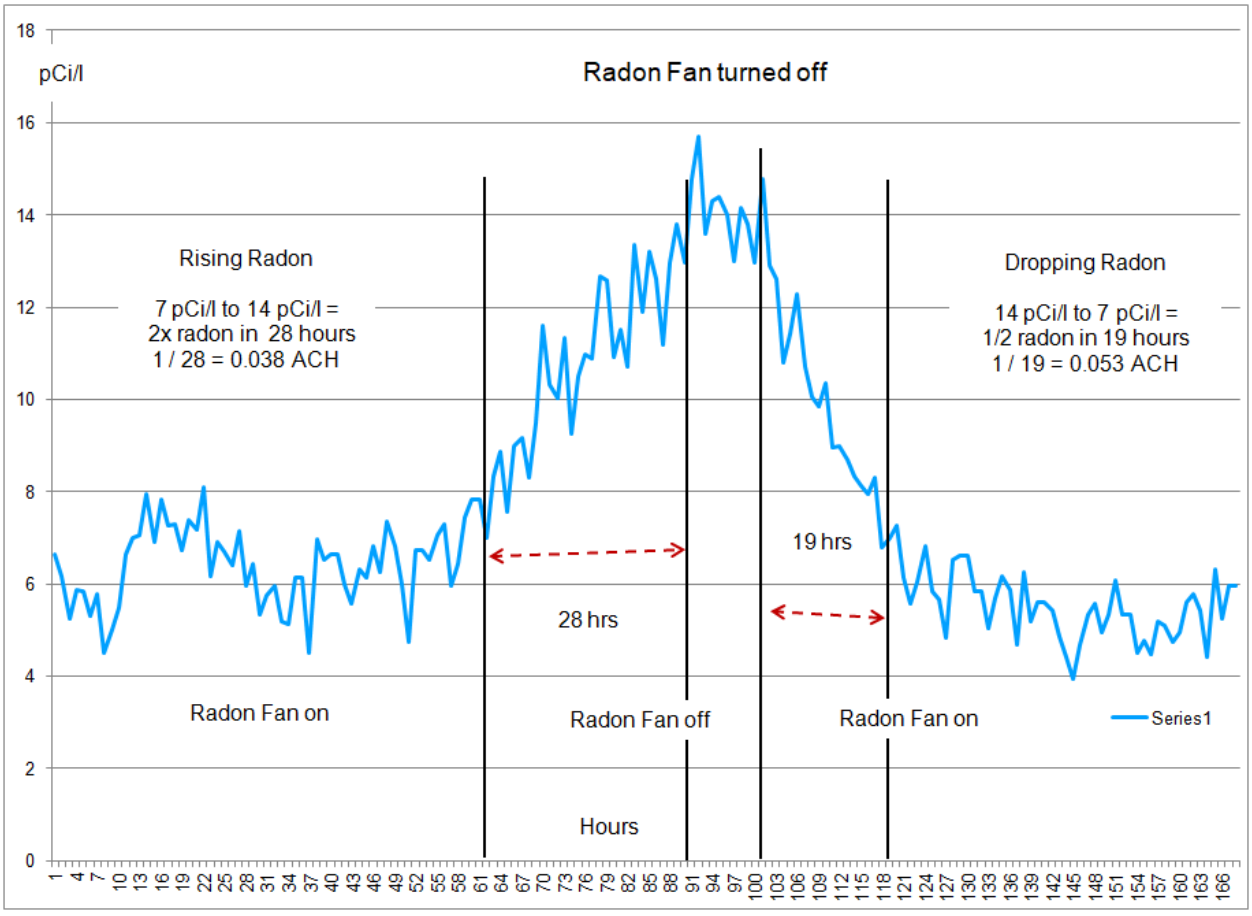


Figure 2: Radon change versus ACH

For the next test a basement window was replaced with cardboard. A radon fan was connected to flexible duct that was routed through the window cardboard. The fan airflow was measured as 100 CFM with the flex duct wide open and 50 CFM with a restricting cap. The results are in Figure 3. The natural ventilation rate of the basement can be determined by dividing the additional CFM by the total of the initial radon divided by final radon minus 1. The natural ventilation plus the added ventilation is the total ventilation that produces the lower radon levels. All of this assumes the total radon is coming from

the concrete. The test indicates a 100 CFM HRV would induce a 1.2 pCi/l basement. Over the eight days of this test it is possible the basement ACH varied from 0.13 to 0.085.

After this testing the owner installed a Fantech VHR150 HRV that produced an additional 90 CFM of outdoor air and a new basement radon level of a steady 1.27 pCi/l. See Figure 4. Unfortunately we do not have much data on radon flux from concrete in different areas of the country to know how common or significant this radon source is. What is a given is new homes are being built tighter and often without any additional mechanically provided outdoor air.

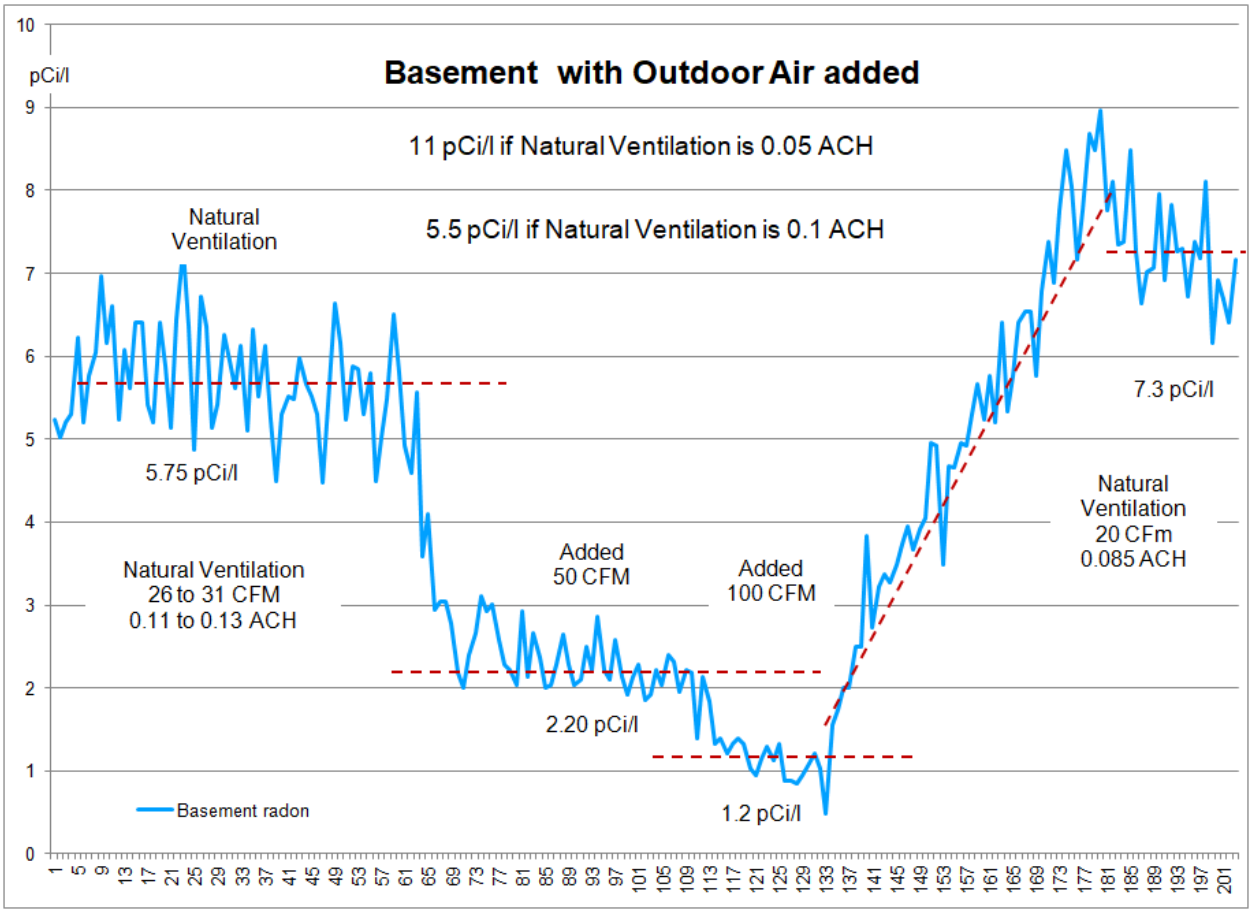


Figure 3: Radon change from supplied Outdoor air

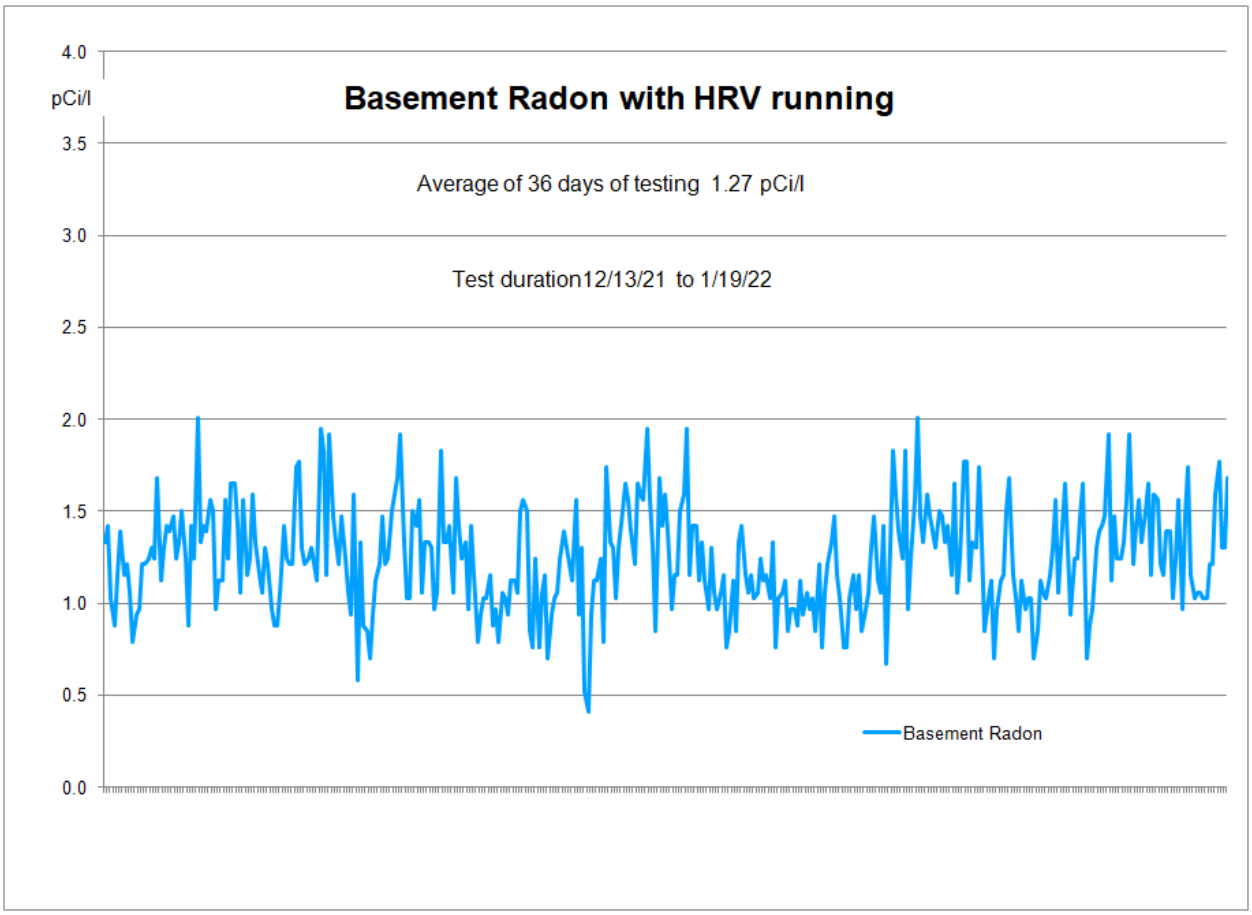


Figure 4: Basement radon with HRV running