

## **RADON DIAGNOSTICS: INEFFECTIVE TECHNIQUES & UNSOLVED PROBLEMS**

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### **ABSTRACT**

The diagnostic techniques for radon mitigation which have formed the basis for EPA's mitigation guidance and protocols have their origins in EPA's 1986 Technical Guidance Manual and 1987 studies outlining methods for mapping subslab radon concentrations and air flow characteristics. A brief review of the treatment of remediation methods and diagnostic techniques in EPA's Technical Guidance manuals since 1986 and AARST conference proceedings since 1990 indicates that these techniques are largely ineffective tools under current mitigation practices.

### **INTRODUCTION**

In June, 1986, the publication of EPA's first technical guidance document for radon remediation defined eight different methods for remediation (1) and in April, 1987, EPA convened a workshop on radon diagnostics at Princeton University to explore techniques for determining which of these eight remediation methods might be most appropriate in specific houses (2). How, for example, could one determine when ventilation should be used for remediation, if heat recovery ventilation or block wall depressurization were likely to be more effective, or if sub-slab depressurization would work?

A variety of techniques were reviewed -- including a "simplified diagnostic system" mapping radon sources (using continuous monitors for "sniffing") and sub-slab pressure/flow characteristics (using blower doors modified for sub-slab measurements) (3) -- and in January 1988, EPA's revised technical guidance manual (4) outlined the diagnostic techniques which have become incorporated into EPA's training and mitigation protocols; e.g., visual inspection of structural characteristics, source mapping, grab sampling, and sniffing to identify radon sources, and sub-slab communication tests. (5) Unfortunately, these techniques are largely ineffective.

### **BASIC DIAGNOSTIC TECHNIQUES**

The diagnostic techniques outlined by the EPA technical guidance manual listed a wide variety of techniques and underscored three as the most important: a visual inspection of the possible entry routes and structural characteristics of the building; measurement of subslab permeability "whenever subslab soil ventilation is being considered as a control technique"; and measurement of the natural infiltration rate (when ventilation techniques are being considered). This technical guidance manual, like the first edition which preceded it in 1987 and the third edition which followed it in December 1993, was carefully written and included many important caveats. It noted, for example, that "no one set of diagnostic testing procedures... can be considered universally applicable and 'correct,'" and it noted that cost-effectiveness to the homeowner was an important consideration in deciding which, if any, of these techniques ought to be employed. With these caveats, and the promise that EPA would eventually publish guidance on protocols for diagnostic tests and "how the results from these tests can be used in mitigation selection and design," twelve different techniques were discussed and a sample six-page survey form was provided.

The twelve diagnostic techniques were:

1. Visual survey of entry routes and of driving forces causing entry
2. Radon measurements in room air
3. Radon measurements at potential soil gas entry routes
4. Radon measurements in well water
5. Gamma measurements
6. Measurements of house leakage area and ventilation rate
7. Pressure measurements
8. Measurement of sub-slab permeability
9. Measurement of pressure fields inside block walls
10. Soil permeability measurements (outside the foundation)
11. Working level measurements
12. Logging of weather conditions and house-hold activities

In the most recent publication of mitigation protocols, these diagnostic tests have been reduced to the requirement that all mitigation contractors must "conduct a thorough visual inspection of the building prior to initiating any radon mitigation work" and the recommendation that contractors "conduct diagnostic tests to assist in identifying and verifying suspected radon sources and entry points."

Nonetheless, after almost ten years of research, field experience, and policy proclamations, EPA's guidance on radon diagnostics provides very little technical guidance for the interpretation of data collected from these measurements.

By 1992 it was apparent that of the eight strategies initially considered for remediation, sub-slab ventilation was, in fact, clearly the most effective in the widest range of applications. Although listed last in the remediation options outlined in 1986, by 1992 the third edition of the technical guidance manual (6) recognized "active soil depressurization (as) the most consistently effective radon reduction method in existing houses, and.. the technique most widely used by commercial mitigators..." "By comparison," the guidance manual noted "the other mitigation approaches... have each been found to be distinctly less effective and/or less reliable than active soil depressurization."

### **THE SHORTCOMINGS OF BASIC DIAGNOSTICS**

It is in this context that EPA's guidance -- and the state of the art -- on diagnostic measures should be evaluated. For this purpose, let us consider several paradigms.

#### **Paradigm 1: Simple structures with drainage fields**

Most mitigators today would probably agree that in any houses with drainage fields, whether sumps, drainage tiles, or aggregate beds, active soil depressurization (ASD) should be applied to the drainage field. This is true regardless of radon levels and other potentially complicating factors, and in general the only technical decision for the mitigator to make regards sizing the fan (and in extreme cases, the pipe) to accommodate the anticipated air flow.

#### **Paradigm 2: Simple structures without drainage fields**

In houses without drainage fields, whether slab on grade, or with basements, ASD is still generally considered the first choice for remediation for several reasons. Nonetheless, these houses pose potential complications. In slab on grade houses and basements which have been largely finished, there are likely to be few spaces, if any, where pipes can be installed without intruding in the living space of the house. In this case, reliable diagnostic tests for sub-slab permeability and radon source location could be very useful.

### Paradigm 3: Compound structures

Houses with multiple slabs, basement and adjoining crawl spaces, or other combinations of crawl spaces, slabs on grade, and slabs below grade, pose dilemmas for mitigators. This is clearly illustrated by a hypothetical house with a finished basement, 20 pCi/L in the basement, and an adjacent crawl space of approximately the same area as the crawl space, 4 feet above the level of the crawl space, and at the opposite side of the basement from the utility room (see Figure). In this case, it is unlikely that the radon source is equally distributed between the subslab and the crawl space, it is infeasible to install both a ASD system on one side of the basement and a SMD system in the crawl space, and it would be extremely valuable to have diagnostic tools to determine which of these two potential systems would have the greatest benefit.

### Paradigm 4: Special Cases

Perhaps the three most common forms of "special cases" would be radon in water, building material problems, and subslab air ducts. In the first of these cases there are measurements and rules of thumb which allow mitigators to estimate the contribution from radon in water into the household air; but for the determination of the relative contribution of radon flux and subslab ducts, diagnostic tools are again inadequate.

## **THE FAILURES OF DIAGNOSTIC TECHNIQUES**

Perhaps the failure, or inadequacy, of diagnostic tools for solving these problems is best illustrated by the simple example of a house with an unfinished basement 25 x 30 in area, no drainage field and no other complicating factors. Subslab air flow measurements indicate a pressure field extension of 10 feet in the center of the slab and 20 feet along the perimeter and subslab radon measurements indicate 10,000 pCi/L in the center of the slab and 1,000 pCi/L at the perimeter. Such a uniform picture would suggest both the solution in this case and the nature of the problem in other cases; i.e., with no slab penetrations and a symmetrical radon distribution like this it appears that the radon source is relatively uniform (or concentrated toward the center of the slab) and that there is migration of the radon into the house along the perimeter where the soils were disturbed by initial construction.

In the variation on this case, however, where there is 10,000 pCi/L beneath the slab at one end of the house and 1,000 pCi/L at the other end of the house, the nature of the questions changes. Does the 1,000 pCi/L at one end of the house indicate a lower radon source, or a higher migration rate? If the basement is unfinished the mitigator can avoid answering this question by placing suction points at either end of the basement; but if the basement is finished, a decision must be made. Which is the source? Mitigators have had the diagnostic tools to map the subslab radon distribution and air flow since 1987; but they still do not have the analytic tools to interpret this data.

In the absence of these analytic tools and the ability to interpret these data, radon diagnostics remain more fantasy than reality. As in all other aspects of radon mitigation examples can be found in which diagnostic measurements, carefully thought out and cleverly interpreted, have saved the day. But those examples should not conceal the lack of a basic working model to deal with the routine problems of radon mitigation. How can one discriminate between actual and potential sources? Given 1,000 pCi/L beneath the slab on one side of the house and 100 pCi/L on the other, where should the suction point go? Given a sub-slab environment with 1,000 pCi/L and an adjoining crawl space with 20 pCi/L, should ASD be applied to the basement or SMD to the crawl space? Given basement measurements of 20 pCi/L and block wall measurements of 20 pCi/L, is the block wall a source?

## **CONCLUSIONS**

After almost ten years of research and commercial operations, soil depressurization has clearly become the fundamental tool of radon mitigation. In virtually all cases where a drainage field is known, or believed to exist, it is unquestionably the preferred method. In most cases where a drainage field is uncertain, or known not to exist, it is still generally the preferred method. If soil depressurization fails to create a negative pressure field beneath the building structure, mitigators generally seem to try first to extend the pressure field completely using multiple

suction points or larger fans. In part, this general procedure seems to have evolved out of EPA research and anecdotal evidence which supports it as both cost-effective and responsible. However, it also reflects the absence of diagnostic tools to identify radon sources and to distinguish actual sources from incidental concentrations of radon. The diagnostic tools necessary for the remediation methods being used today are not merely the tools to measure subslab radon concentrations, or relative radon concentrations beneath the slab, in crawl space, and in different interior locations, but the analytical tools to interpret these data and clearly identify the relative source strengths.

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1. **Radon Reduction Techniques for Detached Houses: Technical Guidance, EPA, EPA/625/5-86/019, June, 1986**  
The eight methods listed in the first technical guidance manual were: natural and forced air ventilation; forced air ventilation with heat recovery; active avoidance of house depressurization; sealing major radon sources; sealing radon entry routes; drain tile soil ventilation; active ventilation of hollow block basement walls; ventilation of subslab.
  2. **Radon Diagnostics Workshop, Princeton, NJ, April 13-14, 1987**
  3. **"Guaranteed Radon Remediation Through Simplified Diagnostics", D. Saum and M. Messing, 1987**
  4. **Radon Reduction Techniques for Detached Houses: Technical Guidance (second edition), EPA, EPA/625/5-87/019, January, 1988**
  5. **Radon Mitigation Standards, EPA 402-R-93-078, October, 1993 (Revised April, 1994)**
  6. **Radon Reduction Techniques for Detached Houses: Technical Guidance (Third Edition) for Active Soil Depressurization Systems, EPA, EPA/625/R-93/011, October, 1993**