CONF-900724--4

PERFORMANCE EXPERIENCE WITH RADON MITIGATION SYSTEMS*

CONF-900724--4

DE90 009236

R. B. Gammage
D. L. Wilson
Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6383

Indoor Air '90, Toronto, Canada
July 29-August 3, 1990

PERFORMANCE EXPERIENCE WITH
RADON MITIGATION SYSTEMS*

R. B. Gammage
D. L. Wilson
Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6383

KEYWORDS

Mitigation pits, subslab depressurization, vapor barrier, permeability, pressure field, diagnostics, crawlspace, slab-on-grade

PERFORMANCE EXPERIENCE WITH
RADON MITIGATION SYSTEMS*

R. B. Gammage
D. L. Wilson
Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge, TN 37831-6383

Both passive and active radon mitigations were installed in four houses with slab-on-grade or combined crawlspace/slab-on-grade basements. Passive mitigation reduced indoor radon by 40 to 80%, but not necessarily below 150 Bq m^{-3}. Combined passive and active mitigation was necessary for reducing radon levels to below 150 Bq m^{-3}. Active mitigation employed sub vapor-barrier and/or subslab depressurization. The number of subslab mitigation pits needed at each house was determined by diagnostic measurements of permeability and pressure-field extension. Performances of the mitigation systems at three houses were stable over one year. Increasing permeability in the hard-packed clay beneath the slab of one house may result in decreased effectiveness of the subslab depressurization.

INTRODUCTION

Radon is widely perceived as one of the most significant health risks present in indoor air. According to recent state surveys, radon levels in excess of the Environmental Protection Agency (EPA) guideline of 150 Bq m^{-3} are widely distributed throughout the United States. As a result, research programs have been supported on a regional basis to more quickly develop mitigation technologies required for variant geologic and house-construction characteristics. We describe part of a radon research program in the Tennessee Valley, sponsored by multiple agencies, with the following goals:

1. better understanding of the physical basis of factors underlying radon entry and its control;

2. refining diagnostic methods for implementation of effective radon control methods; and

3. improving radon control technologies while systematically reducing radon levels in study houses.

Installations of passive and active radon mitigation systems were made and their performances were followed for one year in two houses in Tennessee and two houses in Alabama.

*Research sponsored by U.S. Department of Energy under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

MATERIALS AND METHODS

The four study houses (two pairs) were selected from the areas of Oak Ridge (OR), Tennessee and Huntsville (HU), Alabama. Selection was made on the basis of comparatively high indoor radon levels detected in state-wide surveys and from a data base generated from a radon survey of 500 houses. The paired houses were within 1 km of one another to minimize variability in underlying geology and meteorological events.

Each of the Huntsville houses (HU 13 and 14) had foundations consisting of a mixture of crawlspace and slab-on-grade basement. The Oak Ridge houses (OR 15 and 16) were basement houses using slab-on-grade construction. Three of the four houses had an attached garage. The exception was house OR 15. Electric furnaces or heat pumps and air distribution systems were located in the basements except for House HU 14 whose heat pump was in the crawlspace.

The first stage of radon mitigation was simple weatherization and sealing of heating and air conditioning (HAC) systems. A second stage of mitigation involved sealing of cracks in concrete foundations and block walls. Slab-wall expansion joints were also sealed. Further passive mitigation in houses HU 13 and 14 involved installation of vents in each of the crawlspace walls.

Active mitigation measures were applied next. Diagnostic and subslab-suction holes were drilled to evaluate subslab pressure fields, communication and permeability. Pits for actual subslab ventilation were 60 cm X 60 cm and dug to a depth dictated by results of permeability tests. Due to excellent subslab communication, houses HU 13 and 14 required only 1 mitigation pit each. At house OR15, because of variable depths of gravel and widely ranging permeability, two mitigation pits were installed. Only a few cm of aggregate lay beneath the slab of house OR16; the overall poor permeability necessitated the digging of four mitigation pits.

Vapor barriers and active subbarrier ventilation systems were additionally installed in the crawlspaces of the houses HU 13 and 14. The vapor barrier was laid over a manifold of PVC pipe. Considerable care was needed to custom trim and seal the barrier at all joints and edges to obtain as air-tight a unit as possible.

Permeability was monitored at the suction pits employing techniques described by Matthews et al (1). Radon concentrations were measured each 30 minutes using automated Wrenn chambers.

RESULTS AND DISCUSSION

The results of measurements of pressure field extensions over a period of nearly a year are shown in Fig. 1. More complete details are available in Ref. 2. At three houses there were no discernible changes with time in induced pressure fields and the mitigation systems continued to operate normally. There were, however, marked anisotropies in pressure field extensions under different sections of the slabs.

Subslab permeabilities remained essentially constant through the course of the study at three of the houses. The exception was house OR16 (Table 1); continuous monitoring through 1988, and also 1989, showed continuously increasing permeability at pits 1 and 4. The slab at this house was poured directly onto packed clay. We suspect that drying and cracking of the clay was opening up channels. If channeling to the outside air were to occur in the future, the efficiency of the mitigation system might become compromised.

The results of radon levels measured in each of the four houses are shown in Fig. 2. The radon levels pertain to each of three different phases: (1) prior to mitigation (1977); (2) with the mitigation systems operating (late 1988); and (3) with the mitigation systems switched off (1989). Radon reduction efficiencies were quite good, and stable over a one year period, following installation and tuning of the mitigation systems. Radon reductions of 89 to 97% was achieved in 1988. Within each house, radon concentrations were brought down to below 150 Bq m^{-3}.

The radon levels measured with the active mitigation systems switched off allows a gauging of the effectiveness of the passive mitigation procedures; 40 to 80% of the radon reductions appear attributable to passive modifications made to the houses.

The increasing permeability at house OR 16 is cause for some concern. The indoor radon levels while mitigating actively are about 100 Bq m^{-3}. Any deterioration in the efficiency of the active mitigation caused by ground cracks opening to the outside air could allow indoor radon levels to rise above the level of acceptability.

CONCLUSIONS AND RECOMMENDATIONS

Active mitigation systems consisting of subslab and sub vapor-barrier depressurization installed in four houses with crawlspace and crawlspace/slab-in-grade foundations effectively reduced radon levels from above to below 150 Bq m^{-3}. The number of subslab mitigation pits that are required depends on the depth and uniformity of the subslab aggregate and the resultant permeability and pressure field extensions. Passive mitigation measures produced radon reduction of 40 to 80%. Increasing permeability beneath the slab of a house built on hard-packed clay is probably related to drying and cracking of the clay; future channeling to the outside air could compromise the effectiveness of the subslab depressurization in maintaining indoor radon levels at below 150 Bq $m^{-3.}$

REFERENCES

1. Matthews TG, Wilson DL, Terkonda PK, Saultz RJ, Goolsby, G, Burns, SE, Haas JW (1989) Radon diagnostics: Subslab communication and permeability measurements. Proc. 1988 Symposium on Radon and Radon Reduction Technology, Vol. 1, EPA-600/9-89-006a (NTIS PB89-167480), pp 7-65.

2. Dudney CS, Wilson DL, Saultz RJ, Matthews TG (1990) One year follow up study of performance of radon mitigation systems installed in Tennessee Valley homes. in press. The 1990 International Symposium on Radon and Radon Reduction Technology, Atlanta, Georgia, February 1990.

TABLE 1. VARIATIONS IN SUBSLAB PERMEABILITY (x 10^{-7} cm^{-2}) AT OR16 IN 1988

Date	Pit 1	Pit 2	Pit 3	Pit 4
5/88	4.0 ± 0.5	7.4 ± 1.8	5.1 ± 1.3	----
6/88	----	----	----	10.3 ± 1.2
11/88	16.7 ± 1.0	5.5 ± 0.5	5.1 ± 1.3	20.0 ± 1.1
12/88	14.6 ± 0.9	5.2 ± 0.5	5.1 ± 0.8	18.8 ± 2.0

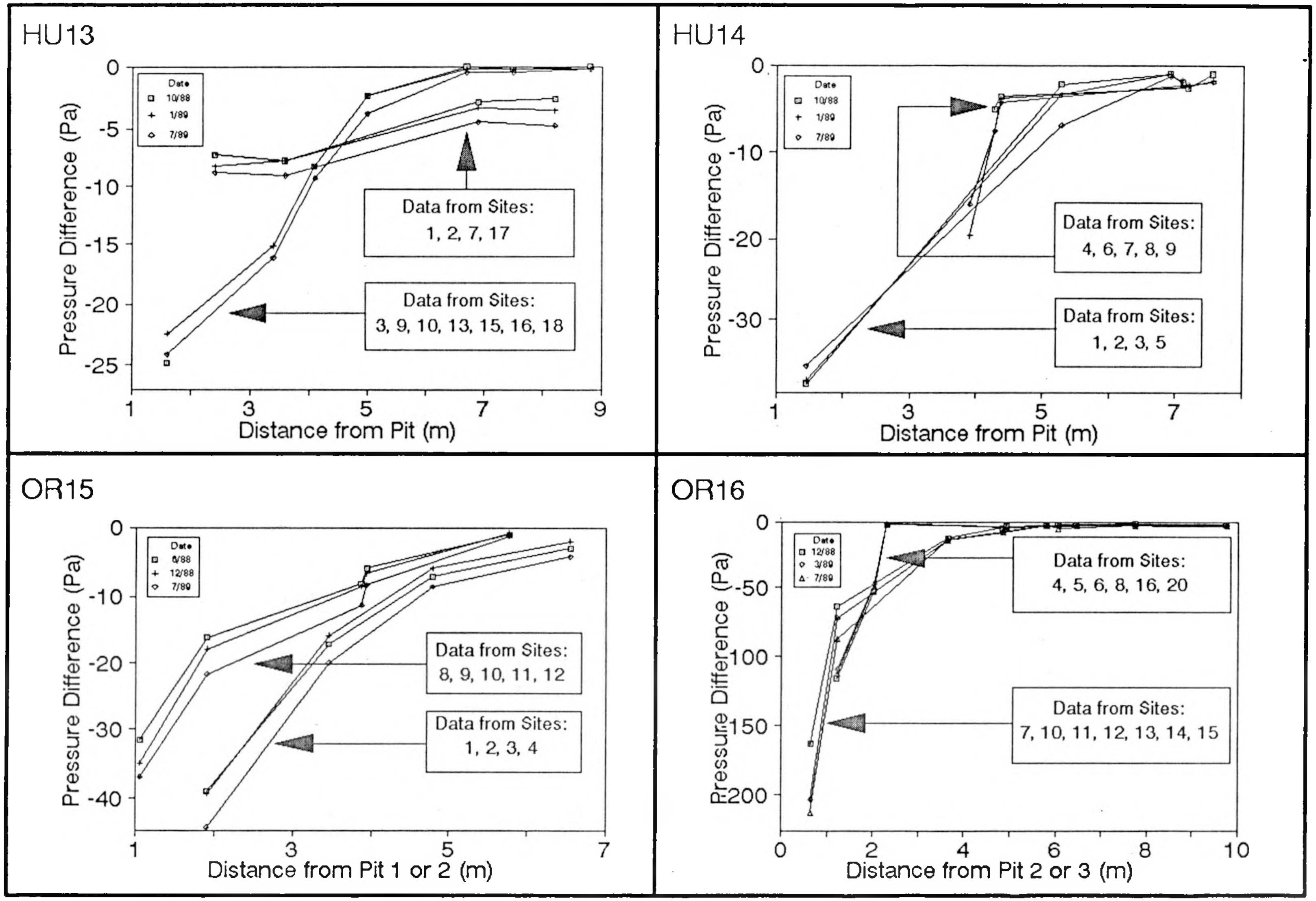


Fig. 1. Variation of pressure with distance under slab for four houses.

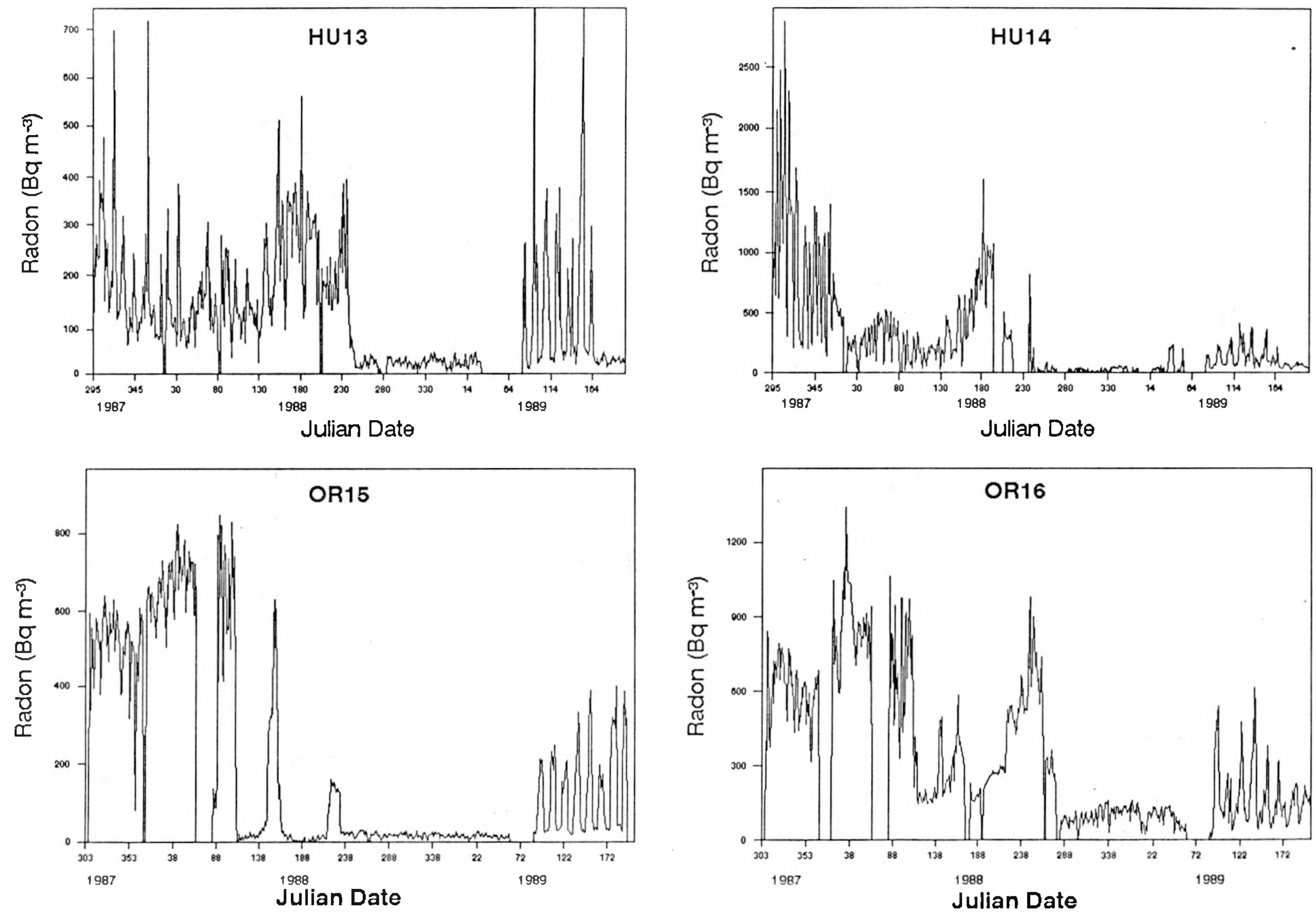


Fig. 2. Daily average radon concentration in four houses.

Performance Experience With Radon Mitigation Systems*

R. B. Gammage
D. L. Wilson
Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6383 USA

Indoor Air'90
Toronto, Canada
July 29-August 3, 1990

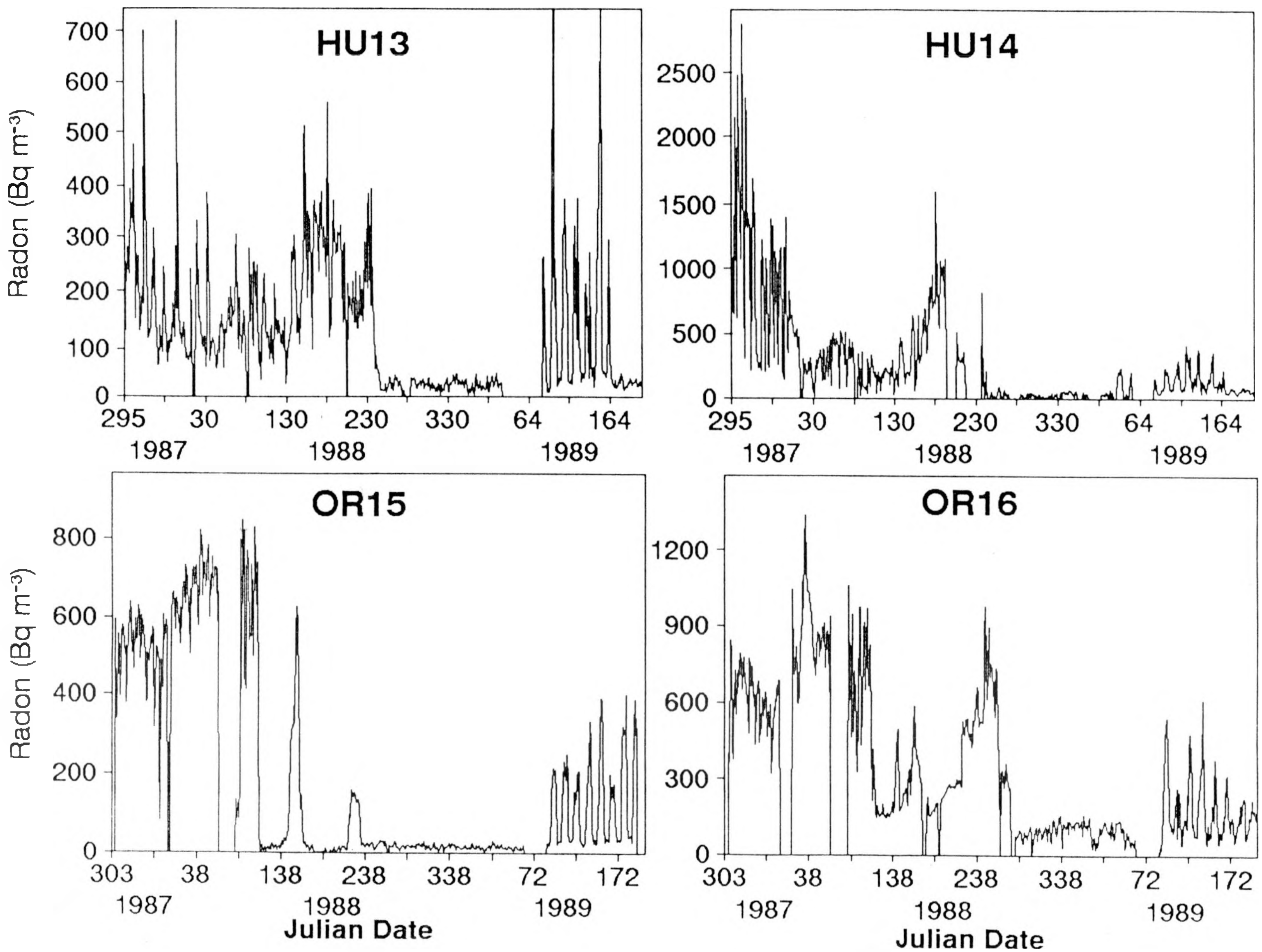
*Research sponsored by U.S. Department of Energy under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

Four houses

- Slab-on-grade
- Combined crawlspace/slab-on-grade

Mitigated

- Passively (40%-80% reduction)
- Actively and passively (89-97% reduction)



HU13
HU14
OR15
OR16
Radon (Bq m-3)
Julian Date
295
30
130
230
330
64
164
303
38
138
238
338
72
172
1987
1988
1989

TABLE 1. VARIATIONS IN SUBSLAB PERMEABILITY (x 10^{-7} cm^{-2}) AT OR16 IN 1988

Date	Pit 1	Pit 2	Pit 3	Pit 4
5/88	4.0 ± 0.5	7.4 ± 1.8	5.1 ± 1.3	----
6/88	----	----	----	10.3 ± 1.2
11/88	16.7 ± 1.0	5.5 ± 0.5	5.1 ± 1.3	20.0 ± 1.1
12/88	14.6 ± 0.9	5.2 ± 0.5	5.1 ± 0.8	18.8 ± 2.0