RADON TESTING FOR LARGE NONRESIDENTIAL BUILDINGS

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ABSTRACT

Recently, considerable attention has been dedicated to ascertaining the best approach to perform radon testing in large, nonresidential buildings. From 1988 to 1995, Oak Ridge National Laboratory (ORNL) performed radon testing studies within large buildings to collect data sufficient to perform statistical analysis on radon distribution within large buildings. Briefly, the protocol entailed the sampling of 100% of all ground-contact rooms, pipe chases, elevator shafts, and stairwells of a large building. From 1991 through 1995, ORNL has collected more than 40,000 large building measurements in radon priority areas. The building ground-contact areas range from 1K ft^2 to 1,000K ft^2. Overall, the presence of elevated radon within rooms of large buildings was found to be a random, nonstatistical distribution. Therefore, all rooms within large buildings must be tested in order to determine whether elevated radon is present.

INTRODUCTION

Radon is a naturally occurring, odorless, colorless, radioactive gas arising from the decay of uranium in the soil. For many years, radon was not considered to be a health problem in residential buildings. But in 1984, private homes in the Reading Prong area of Pennsylvania were discovered to have levels of radon in excess of federally mandated exposure limits for radiation workers. Radon is not considered to be a human carcinogen; however, the short-lived, alpha-emitting progeny have been demonstrated to induce lung cancer. Excessive exposure to radon progeny is known to have resulted in more than the predicted number of deaths from lung cancer in mining populations (Bier, et al. 1988). Nero (1986) estimated that about one million American homes have levels in excess of 8 pCi/L (1 pCi/L = 37 Bqm^{-3}). Based on this and other information, the U. S. Environmental Protection Agency (EPA) estimated that between 5,000 to 20,000 lung cancer deaths per year are attributed to radon exposure (*A Citizen's Guide to Radon*, OPA-86-004).

In recognition of the public health hazard presented by indoor radon, the U.S. Congress passed and the President signed into law the Indoor Radon Abatement Act of 1988 (IRAA). IRAA declares the national goal to be "that the air within buildings in the United States should be as free of radon as the ambient air outside the buildings." In addition, the law stipulates that the head of each Federal Agency that manages a building will design a study to assess the extent of radon contamination in buildings within its jurisdiction. In response to IRAA, all federal agencies began a multiyear, multiphase program that entailed limited screening for the identification of high-risk radon areas.

At the time that the legislation was passed, very little was known about the presence or behavior of radon in nonresidential buildings. Because IRAA mandated that EPA provide guidance documentation for federal agencies to follow, they issued draft interim guidance in 1989 based on testing data collected for large houses and schools. Essentially, the protocol called for the placement of one detector for every 2,000 ft^2 of ground contact area. This approach assumes that the room-to-room radon distribution within a large building follows a statistical distribution (i.e., normal, lognormal, etc.) as observed in individual houses within a population (Nero et al. 1986).

1988 Nonresidential Survey

In 1988, Oak Ridge National Laboratory (ORNL) conducted an international residential radon survey. The primary goal of the survey was to determine the extent of elevated radon in single and multifamily buildings. To gain some insight into the prevalence of elevated radon in the workplace, 614 nonresidential buildings (2 to 3 per site) were included in the study as well. For comparison purposes, most of the nonresidential buildings were located within 5 miles of the residential test sites.

For the residential testing, existing EPA guidelines were followed (*Interim Protocols for EPA Screening and Follow Up Radon Decay Products Measurements*, EPA 520/1-86-014-1). However, testing guidance for nonresidential buildings was nonexistent. In lieu of guidance, ORNL developed a preliminary protocol based on a review of nonresidential construction and mechanical standards. The ORNL 1988 protocol called for the placement of one detector for every 6,000 ft^2 of ground contact area.

The test results indicated that 3.4% (451 of 13,476 results) of the homes tested had radon above 4 pCi/L (Fig. 1.) To our surprise, the nonresidential test data had virtually the same frequency of elevated radon, 3.2% (34 of 1,061 results). These data corresponded to 26 of the 614 buildings (4.2%) having radon above the 4 pCi/L action level. Using commercially available statistical software, both data sets were analyzed and found to follow a lognormal distribution.

1990 Nonresidential Survey

During the 1988 residential survey, 68% (68 of 100) of the homes surveyed in a subdivision in Pennsylvania were found to have readings above 4 pCi/L. Located adjacent to the subdivision was a large industrial park. Seeing this as a unique research opportunity to study radon in the workplace, 32 buildings at the park were surveyed in 1990. The test buildings were 1 or 2 stories and ranged in size from 10,000 to 65,000 ft^2. Thirty-one of the buildings were office buildings, and one was a day care center.

In the 1988 study, sizable room-to-room variations in radon concentrations were observed in some buildings. To investigate the extent of the variation, all ground contact rooms and areas within the 32 buildings were tested with 2 to 5 day charcoal canisters.

As in the adjacent subdivision, a very high percentage (81% or 26 of 32) of buildings were found to have elevated radon. Also, as in the 1988 study, both residential and nonresidential data sets were determined to be lognormal. However, only 33.7% of all the nonresidential test results were above the action level (Fig. 2), which means that slightly more than half of the buildings had fewer than five elevated readings with two buildings having only a single reading above the action level. Very sizable room-to-room variations were also observed within buildings. Although the nonresidential data set as a whole was found to be lognormal, at the individual building level, that finding did not hold true. Statistical analysis performed on the radon distribution found in each of the 26 elevated radon buildings found the following: 14 lognormal, 8 normal, and 4 random distributions.

To evaluate the ability of the 1988 protocol (1 detector per 6,000 ft^2) to identify elevated buildings, randomly selected radon test data were chosen from each of the 32 buildings. Buildings that had more than 10% of the readings above the action level had 99+% success in identifying at least one elevated area. However, buildings that had only one or two elevated readings had less than a 90% success rate of finding elevated radon.

To confirm these initial findings, a 1-year follow-up test was conducted at the site starting in the fall of 1990. Included in the study were the original 32 buildings plus 59 warehouses located in and near the industrial park. Each of the warehouses was single story and ranged in size from 80,000 to 125,000 ft^2. As in the previous screen, all ground contact rooms and areas were tested in the office buildings. For the warehouses, each enclosed office area was tested, and 1 detector was placed for every 5,000 ft^2 of open storage area. In the 32 previously tested buildings, all the original data were confirmed. However, the warehouses were found to have a slightly lower frequency of elevated radon: 61% of the enclosed offices and 20% of the open storage spaces tested. The lower frequency of elevated radon in the open areas was probably due to the continuous use of exterior high bay doors present in all the warehouses.

1991 National Nonresidential Study

Because of the high frequency of room-to-room variations observed in 1990 survey, a year-long, ATD survey was performed in 1991 and 1992. The plan called for testing all ground-contact areas within 138 office buildings located nationwide. The purpose of the study was to compare the 1988 (1 detector for 6,000 ft^2) and 100% testing methods on a national basis.

Nationwide, 14% (20 of 138) of the buildings tested were found to have at least a single reading above 4 pCi/L (Fig.3). This was sharply higher than the 4.2% found in the 1988 survey. However, as a whole, the frequency of elevated data agreed reasonable well: 3.2% (1988) vs 3.6% (1991). As found in all of the previous studies, the data follows a lognormal distribution. The most significant finding, was the discovery that of the 20 elevated buildings, 11 had only a single reading above 4 pCi/L.

1992 to 1995 National Radon Survey

The purpose of the 3-year study was to further evaluate the all ground contact area testing protocol in a larger more diverse building population. To perform this study, a total of 44,664 measurements were performed in 1,061 buildings in 34 states. The buildings' sizes ranged from 1,000 ft^2 to more than 1,000K ft^2 and from single to five stories. Geographical selection was based on historical presence of elevated radon in the area.

Although a key selection criteria for building testing was the presence of historically elevated radon in the area, the frequency of radon measurements greater than 4 pCi/L increased to only 5% (vs 3.2% found in the 1991 national survey) (Fig 4.). However, 12% of the buildings tested had at least 1 measurement greater than 4 pCi/L.

Statistical analysis of the data indicates that radon distribution of the population follows a lognormal distribution. However, 53.4% of the individual building data was found to follow a random distribution (Fig 5.).

CONCLUSIONS

The following two conclusions can be made based on the nonresidential testing results collected:

(1) In a large population, radon levels follow a statistical distribution that can lend itself for statistical modeling.

(2) The radon distribution within individual buildings may not follow a statistical pattern.

For radon testing in nonresidential buildings, the studies have indicated that the sampling interval is critical. If the goal of a radon study is to identify geographic populations of buildings at risk, a statistical screening approach based on building size will work. However, if the goal is to certify that a building does not contain any elevated radon, then testing of all ground contact rooms and areas is required.

REFERENCES

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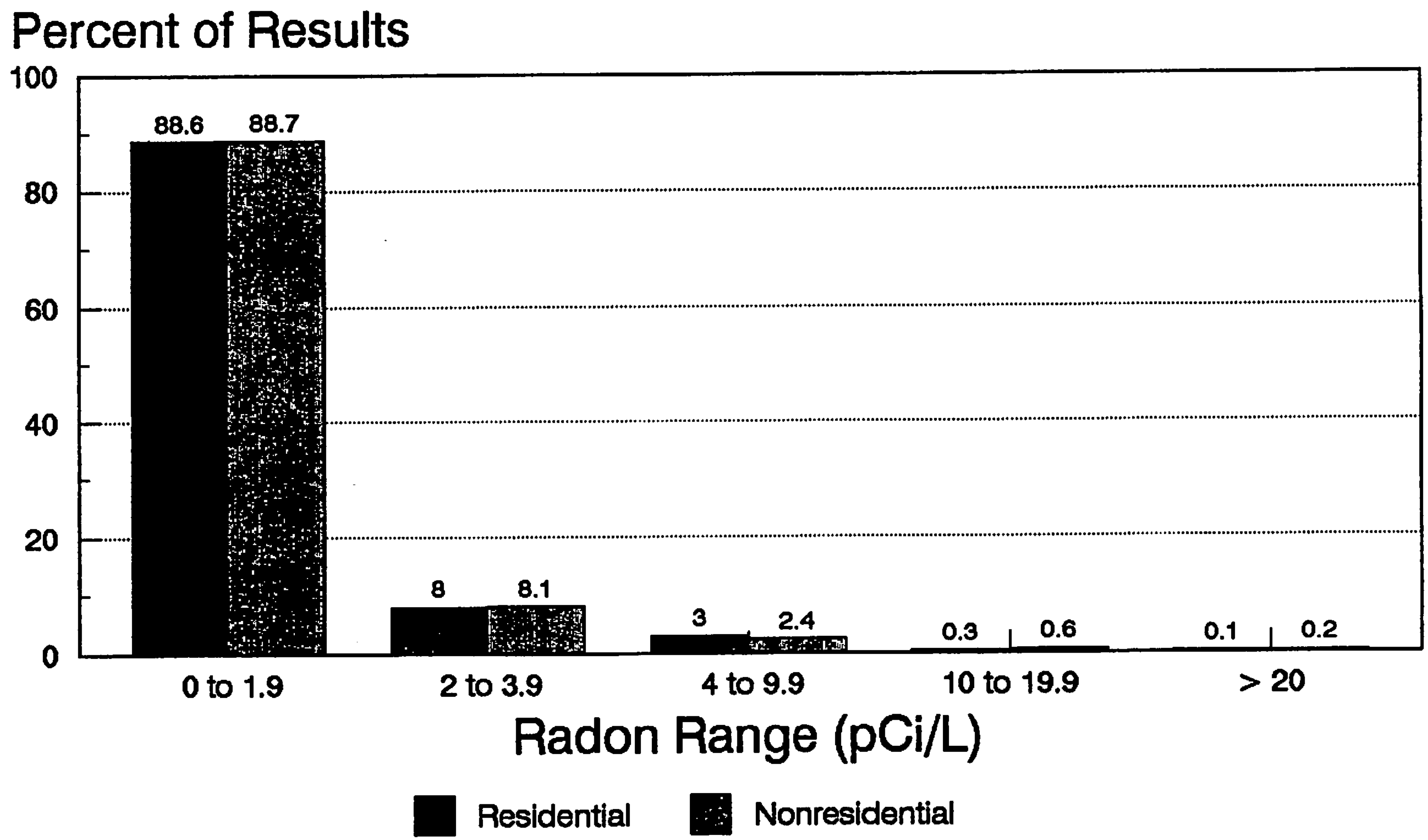
Fig. 1. 1988 Survey: Residential vs Nonresidential Radon



Residential Detectors = 13,476
Nonresidential Detectors = 1,061

Fig. 2. 1990 Industrial Park Radon Survey

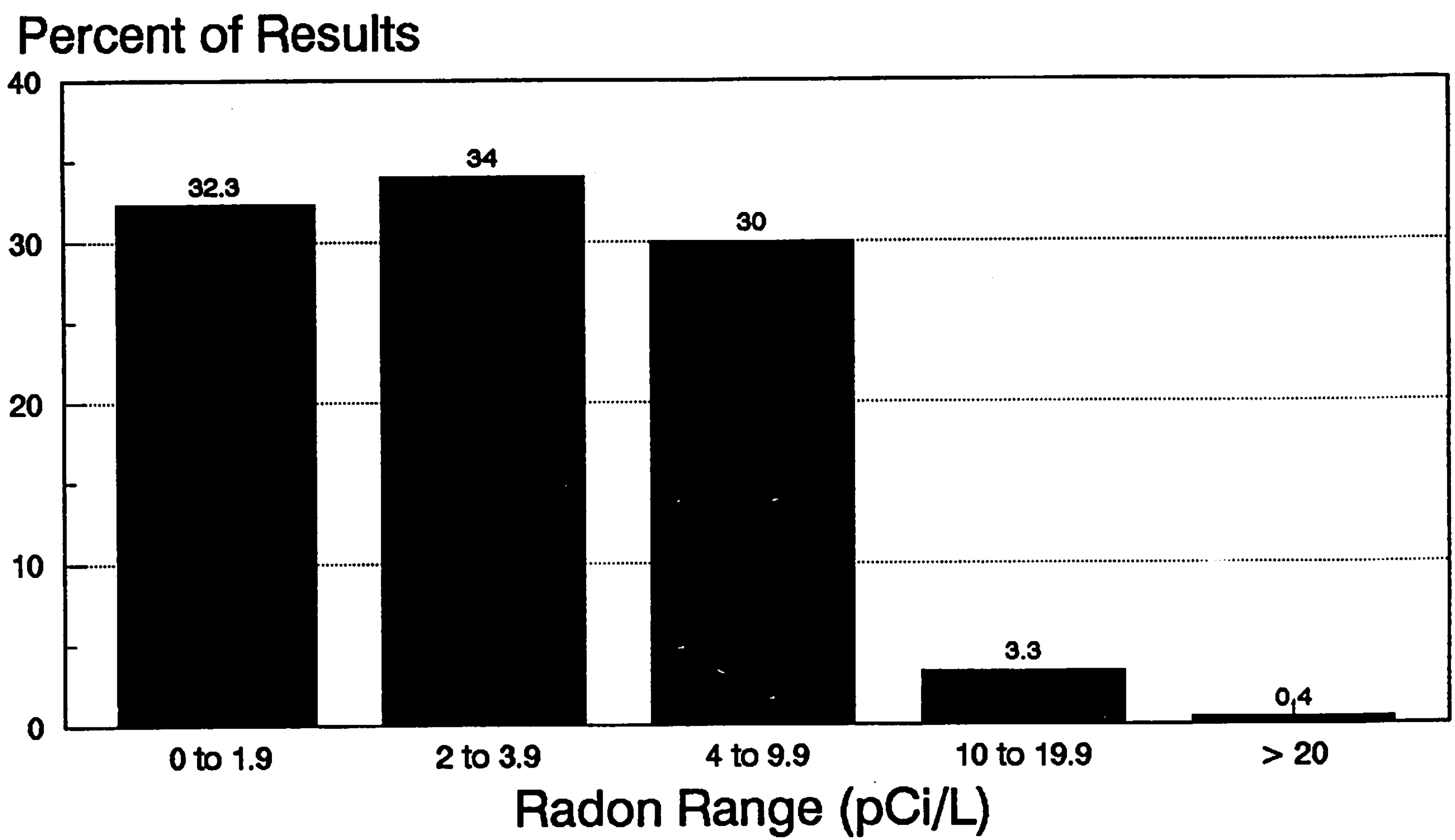


Fig. 3. 1988 vs 1991 National Nonresidential Radon Survey

Fig. 4. 1992-1995 National Nonresidential Radon Survey

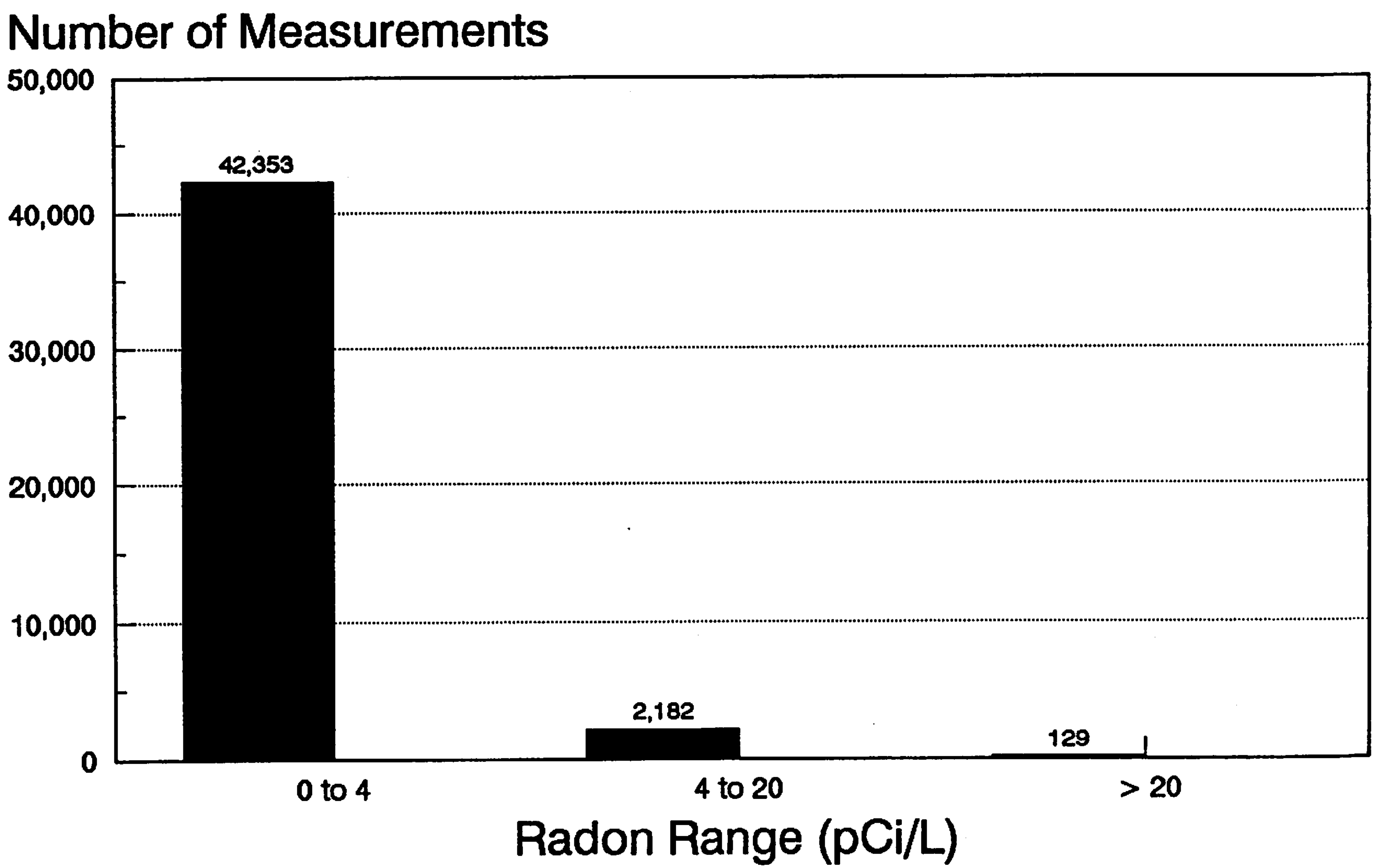


Fig. 5. Percent of Radon Results per Building