

A DESCRIPTION OF THE NEW RADON  
CALIBRATION LABORATORY IN DAYTON, OHIO

by: Phillip H. Jenkins, PhD, CHP  
Bowser-Morner, Inc.  
P. O. Box 51  
Dayton, OH 45401-0051

ABSTRACT

Bowser-Morner, Inc. has established a new radon calibration facility in Dayton, Ohio. A key component of this facility is a 39-m<sup>3</sup> radon/environmental chamber, in which devices used for measuring radon can be exposed to controlled conditions of temperature, relative humidity, and radon concentration. The radon chamber is designed to be comparable in size and operation to those used by the US EPA.

A quality assurance program, including a system of calibrations, internal comparisons, and interlaboratory comparisons, is used to ensure accurate and consistent results. Calibrations of scintillation cells are performed using flow-through radon sources to provide known concentrations of radon. Results of interlaboratory comparisons with US EPA and EML are used, as necessary, to adjust the radon emission rate values of the radon sources, and calibration factors of scintillation cells.

A DESCRIPTION OF THE NEW RADON  
CALIBRATION LABORATORY IN DAYTON, OHIO

Bowser-Morner, Inc., an engineering and environmental testing laboratory in Dayton, Ohio, has established a new radon calibration facility, which is scheduled to begin operations in the Fall of 1991. The initial thrust of this facility is to provide calibrations and quality control exposures for measurements of radon in air. Provisions for calibrations for measurements of radon decay products will be added sometime in 1992. The discussion here, however, is limited to radon.

A key component of this new facility is a radon chamber that is comparable in size and operation to those used by the US Environmental Protection Agency (EPA). The radon chamber has interior dimensions of 3.8 m x 3.8 m x 2.7 m (12.5 ft x 12.3 ft x 8.9 ft) and an internal volume of 39 m<sup>3</sup> (1375 ft<sup>3</sup>). An attached interlock room with interior dimensions of 1.4 m x 2.5 m x 2.7 m (4.5 ft x 8.3 ft x 8.9 ft) is provided to minimize the disturbance to conditions in the chamber when someone enters or leaves the chamber. Figure 1 shows a diagram of the chamber and interlock.

Temperature and relative humidity in the chamber are controlled by using a 0.2-m<sup>3</sup> (8-ft<sup>3</sup>) environmental chamber as a remote conditioner. The air conditioning system is designed to provide control of temperature in the range of 10-38 degrees Centigrade (50-100 degrees Fahrenheit) and relative humidity in the range of 20-80%. The remote conditioner contains a blower which can provide air flow through the larger radon chamber at a rate up to

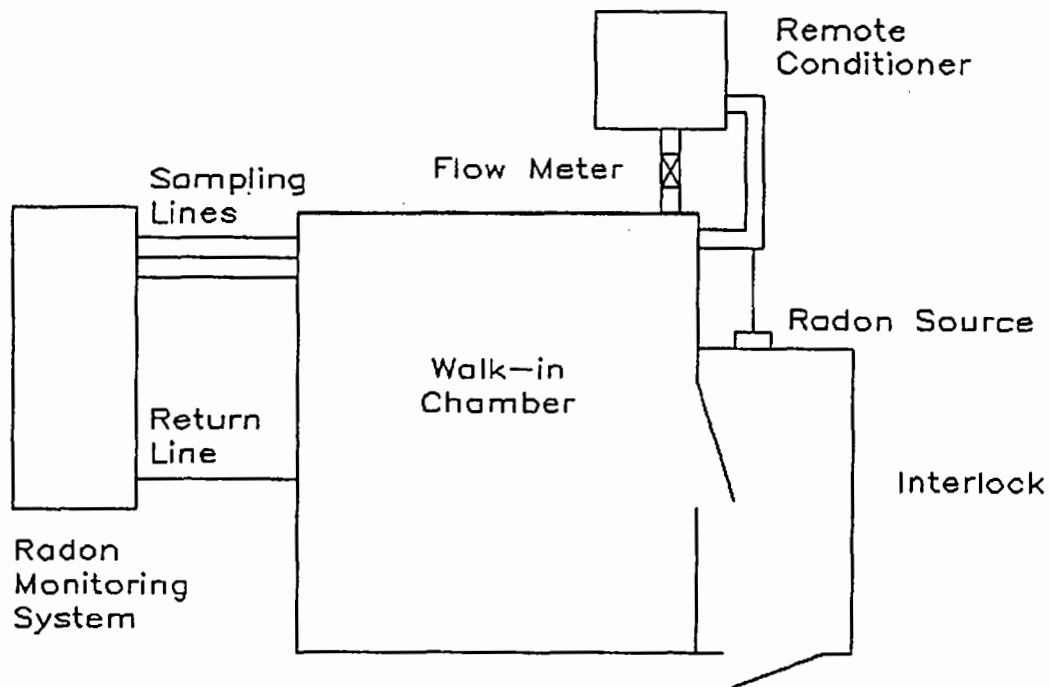


Figure 1. Layout of Bowser-Morner Radon Chamber

510 m<sup>3</sup> h<sup>-1</sup> (300 ft<sup>3</sup> min<sup>-1</sup>). The flow rate through the chamber will normally be maintained at 170 m<sup>3</sup> h<sup>-1</sup> (100 ft<sup>3</sup> min<sup>-1</sup>) to match the flow conditions in the EPA chambers. The linear air flow rate inside the chamber is measured periodically using a hot-wire anemometer probe to ensure that air flows are in the range recommended by the EPA; i.e., 0.05-0.10 m s<sup>-1</sup> (10-20 ft min<sup>-1</sup>). The radon chamber, the remote conditioner, and the ducts connecting them form a closed loop through which air is recirculated. Air enters the radon chamber through a perforated duct mounted along the interface of the ceiling and walls, and leaves through a similar duct on the floor.

A flow-through radon source is used to provide a controlled quantity of radon injected continuously into the chamber. Air is pumped at a rate of about  $1 \text{ L min}^{-1}$  through the source and into the remote conditioner, where the radon is mixed well with air before being transferred to the radon chamber. The flow of radon from the source is split into two legs; one sent to the chamber, and one purged to a roof vent. The quantity of radon injected into the chamber is controlled by manually setting valves to achieve the desired ratio of radon purged vs. radon directed to the chamber.

Air is sampled continuously from three locations within the chamber, pumped through the Radon Monitoring System, and returned to the chamber. Figure 2 shows a diagram of the Radon Monitoring System. Three monitors, similar to those used by EPA and DOE's Environmental Measurements Laboratory (EML), are used to determine the concentration of radon in the sampled air. Each of these monitors consists of a 1.4-liter flow-through scintillation cell coupled to a 13-cm (5-inch) photomultiplier tube, and electronics modules for pulse shaping and counting. A computer collects counting data from this system, and calculates the radon concentration, at half-hour intervals. Longer intervals can be used to improve the counting statistics at low concentrations.

#### QUALITY ASSURANCE

The Bowser-Morner radon calibration facility utilizes a formal quality assurance program, including a system of calibrations and quality control measurements which is

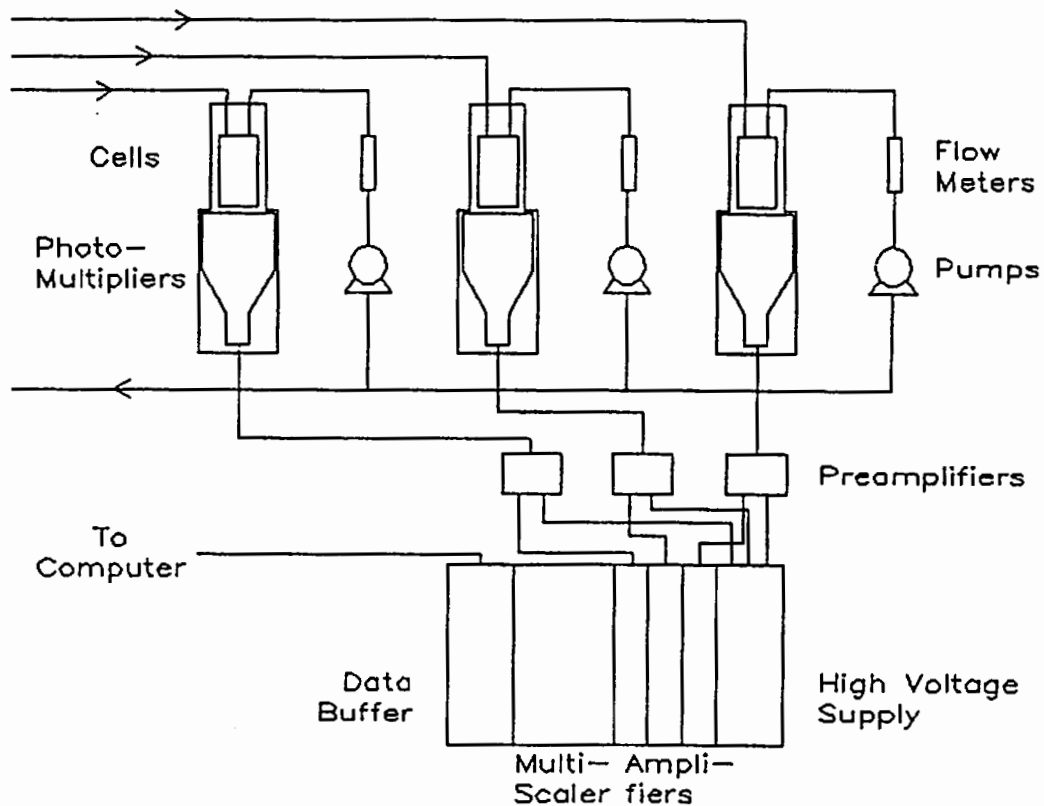


Figure 2. Diagram of Radon Monitoring System

diagramed in Figure 3. Flow-through radon sources are used to calibrate scintillation cells by filling them with air containing a known concentration of radon. The cells are counted using two counting systems, and calibration factors ( $\text{cpm pCi}^{-1} \text{L}$ ) are calculated for the cell/counter combinations. Although the activity of radium-226 in each of the radon sources is traceable to the National Institute of Standards and Technology (NIST), the rate of delivery of radon from the sources is not traceable to NIST. Therefore, it is essential that the calibration factors of the scintillation cells be verified, and corrected if necessary, through formal interlaboratory comparisons

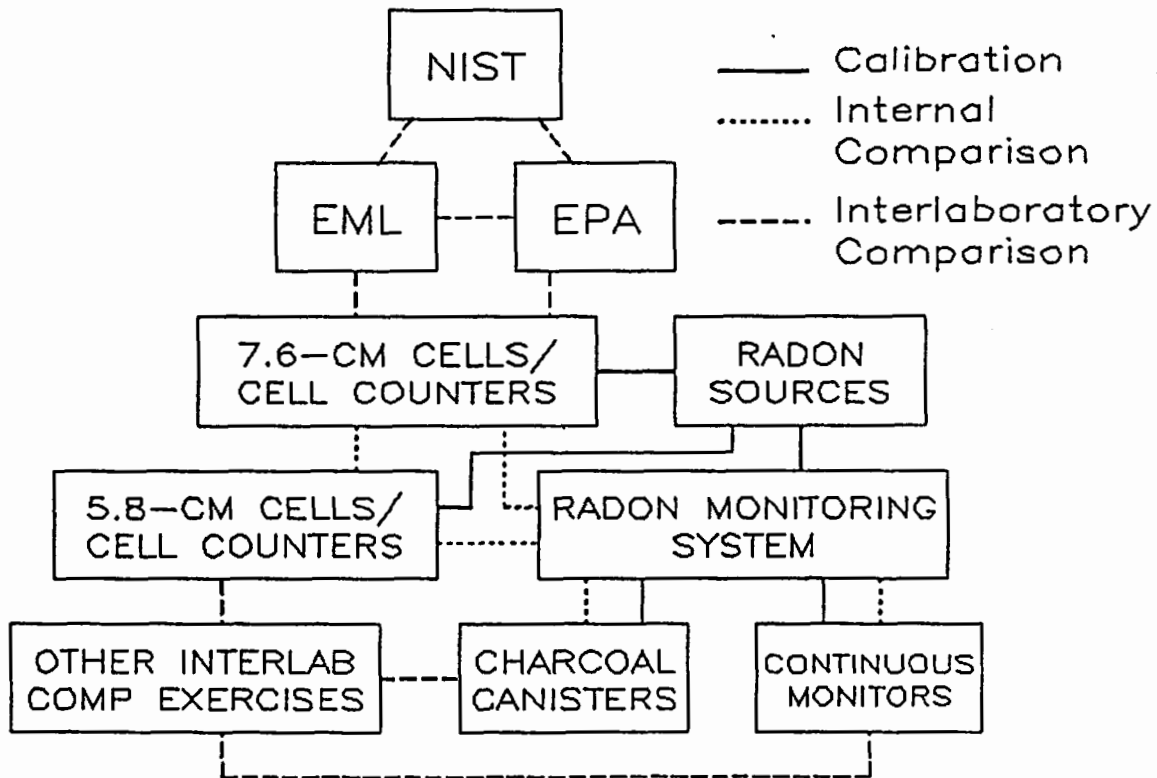


Figure 3. Diagram of Calibrations and Comparisons

programs conducted by the US EPA and EML. EPA and EML perform interlaboratory comparisons with NIST and with each other.

Scintillation cells with a diameter of 7.6 cm (3 in) are used for interlaboratory comparisons with EPA and EML. This cell is similar to those used by EPA, but has two valved connectors, rather than only one, so it can be filled either by flowing air through it or by evacuating it and then opening one of the valves. Scintillation cells with a diameter of 5.8 cm (2.25 in) are used in the laboratory for internal comparisons measurements.

The monitors in the Radon Monitoring System are also calibrated using flow-through radon sources. Air containing a known concentration of radon is pumped continuously through each of the 1.4-liter scintillation cells. After allowing sufficient time for the radon decay products that are deposited in the cell to establish equilibrium, counting data are used to determine a calibration factor for the cell. Each cell is permanently matched to a specific 13-cm (5-inch) photomultiplier tube, preamplifier, and amplifier combination; therefore, only three calibration factors need to be established unless changes are made to the equipment. It is possible to change the radon concentration in the air flowing through the cell by changing the flow rate; however, the flow rate used during the calibration process must match that used during normal operations. Therefore, in order to calibrate the cells at several radon concentrations, multiple radon sources of different activities must be used.

Charcoal canisters, used in the laboratory for quality control measurements, are calibrated by exposing them in the chamber for various time periods and to different conditions of relative humidity. Whenever charcoal devices are exposed in the radon chamber for a customer, measurements will also be made in the chamber using Bowser-Morner's charcoal canisters to verify that the radon concentration measured with charcoal is consistent with that measured by the continuous Radon Monitoring System. This quality control measurement ensures that there is no unusual condition in the chamber, such as a high air flow rate, that is affecting only the charcoal devices and not the Radon Monitoring System.

One commercial continuous radon monitor is used in the radon chamber to provide an additional method of comparison to the Radon Monitoring System. This continuous monitor was initially calibrated by the manufacturer. Comparisons with the Radon Monitoring System provide the basis for determining whether or not the commercial monitor is remaining in calibration. A second, similar continuous monitor is used to measure the radon concentration in the laboratory for personnel protection purposes. These two continuous monitors will be swapped periodically to ensure that they are both measuring accurately.

The Radon Monitoring System produces the calibration data that are provided to customers of the laboratory; therefore, it is essential that this system produce consistent and accurate results. Because this system operates continuously for long periods of time, it is not possible to perform daily background and quality control counts with it, as is often done with other types of counting equipment. Therefore, a system of internal comparisons is used consisting of the following:

- (1) Data are compared among the three different monitors in the system to ensure consistent agreement. It is unlikely that an equipment malfunction would cause all three monitors to change their responses to radon in exactly the same manner; therefore, a problem with this system would likely be detected by this comparison.
- (2) Measurements of radon concentration in the chamber are made on a daily basis by taking grab samples with two 5.8-cm (2.25-in) scintillation

cells. These grab measurements are compared with corresponding measurements from the Radon Monitoring System.

(3) Data from a commercial continuous monitor are compared with measurements from the Radon Monitoring System.

(4) As discussed above, whenever charcoal devices are exposed for a customer, measurements using Bowser-Morner's charcoal canisters are compared with measurements from the Radon Monitoring System.

A measurement assurance program is used for statistical analyses of data from these four comparisons methods, and for production of control charts for easy visualization and recognition of disagreement among the various measurements. The backgrounds and calibration factors of the three monitors in the Radon Monitoring System will be reevaluated periodically. The system of internal comparisons described above will provide assurance that the system is operating consistently between recalibrations.

Bowser-Morner wishes to participate in other interlaboratory comparisons exercises on radon measurements besides those conducted by EPA and EML. The devices potentially available for interlaboratory comparisons are scintillation cells, charcoal canisters, and continuous monitors.