

Ohio Radon Measurement Device Protocol

A. Quality Assurance

1. Licensees providing measurement services using radon and radon product measurement devices shall establish and maintain a quality-assurance program (QAP).
 - a. These programs shall include written procedures for attaining quality-assurance objectives and a system for recording and monitoring the results of the quality-assurance measurements for each device used.
 - b. The QAP shall include the act of documenting the quality-assurance activities outlined in this section. This includes documenting all quality-assurance information in a log, tracking the information over time, charting the quality-assurance results and maintaining the related statistical data. These records shall be retained for at least five years. These records are auditable by the director.
 - c. All licensees are required to follow manufacturer's instructions for use and calibration of all devices.
2. The objective of quality assurance is to ensure that data are scientifically sound and of known precision and accuracy. This paragraph discusses the six general categories of quality-control measurements. Specific guidance is provided for each method in the relevant protocol.
 - a. Calibration Measurements. Calibration measurements are samples collected or measurements made in a known radon environment, such as a radon chamber. Instruments providing immediate results, such as continuous working level and radon monitors, shall be operated in a radon chamber to establish individual instrument calibration factors.
 - i. Two of the key components of quality assurance and quality control for radon devices are annual calibration and background checks. Providers of annual calibration include:
 - a. The device manufacturer; or
 - b. A radon chamber or calibration facility that has received written authorization from the device manufacturer to provide calibration and is listed by a national radon proficiency program.

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- ii. Calibration measurements must be conducted to determine and verify the conversion factors used to derive the concentration results. These factors are determined normally for a range of concentrations and exposure times, and for a range of other exposure or analysis conditions pertinent to the particular device.
 - iii. Determination of these calibration factors is a necessary part of the laboratory analysis and is the responsibility of the laboratory. These calibration measurement procedures, including the frequency of tests and the number of devices to be tested, shall be specified in the QAP maintained by manufacturers and analysis laboratories.
 - iv. Licensees providing measurements with active devices are required to recalibrate and conduct background checks on their instruments at least once every twelve months.
- b. Known Exposure Measurements (Spikes). Known exposure measurements or spiked samples consist of detectors that have been exposed to known concentrations in a radon chamber. These detectors, such as charcoal canisters, alpha-track detectors, liquid scintillation devices and electret ion chambers, are labeled and submitted to the laboratory in the same manner as ordinary samples to preclude special processing.
- i. Licensees using passive measurement devices shall conduct spiked measurements at a rate of three per one hundred measurements, with a minimum of three per year and a maximum required of six per month. Devices should be exposed in a radon chamber at a minimum of three different radon concentrations, such as approximately four, ten to thirty, and thirty to one hundred picocuries per liter. Devices also should be exposed in a radon chamber with varying levels of humidity.
 - ii. Spikes shall be labeled in the same manner as field detectors to ensure identical processing. The results of analyses of detectors exposed to known radon concentrations shall be monitored and recorded. These results also shall be reported back to the radon lab upon completion so the lab may assess their own quality-control processes. Any significant deviation from the known concentration to which they were exposed shall be investigated and corrective action taken.

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- c. Background Measurements. Background measurements are required both for continuous monitors and for passive detectors requiring laboratory analysis.
- i. Licensees using continuous monitors shall perform sufficient instrument background measurements to establish a reliable instrument background and to act as a check on instrument operation.
 - ii. Passive detectors requiring laboratory analysis require one type of background measurement made in the laboratory and another in the field.
 - iii. Licensees using passive detectors shall employ field controls (called blanks) equal to approximately five per cent of the detectors that are deployed, or twenty-five each month, whichever is smaller.
 - iv. These controls shall be set aside from each detector shipment, kept sealed and in a low radon environment, labeled in the same manner as the field samples to preclude special processing, and returned to the analysis laboratory along with each shipment. These field blanks measure the background exposure that may accumulate during shipment and storage. The results shall be monitored and recorded.
 - v. The recommended action to be taken if the concentration measured by one or more of the field blanks is significantly greater than the lower limit of detection (LLD) is dependent upon the type of detector and is discussed in the protocol for each method.
 - vi. The storage area of all radon test devices shall be measured for radon and recorded annually.
- d. Duplicate Measurements. Duplicate measurements provide a check on the precision of the measurement result and allow the user to make an estimate of the relative precision. Large precision errors may be caused by detector manufacture or improper data transcription or handling by suppliers, laboratories, or technicians performing placements. Precision error can be an important component of the overall error; therefore, licensees performing measurements shall monitor precision.

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- i. Duplicate measurements shall be side-by-side measurements made in at least ten per cent of the total number of measurement locations, or fifty each month, whichever is smaller. The locations selected for duplicate measurement shall be distributed systematically throughout the entire population of samples.
 - ii. The precision of duplicate measurements shall be monitored and recorded in the quality-assurance records. The analysis of data from duplicates shall be plotted on control charts. These results shall also be reported back to the radon lab upon completion so the lab may assess their own quality-control processes. If the precision estimated by the user is not within the precision expected of the measurement method, the cause of the problem shall be investigated.
 - iii. Detectors shall be treated identically in every respect. They shall be shipped, stored, opened, installed, removed and processed together, and not identified as duplicates to the processing laboratory.
- e. Routine Instrument Performance Checks. Proper functioning of analysis equipment and operator usage requires that the equipment and measurement system be subject to routine checks. Regular monitoring of equipment and operators is vital to ensure consistently accurate results. Performance checks include the frequent use of an instrument check source. Components of the device (such as a pump, battery or electronics) shall be checked regularly and the results noted in a record. Each user shall develop methods for regularly monitoring (preferably daily with use) their measurement system and for recording and reviewing results.
- f. Cross-checks. Licensees using active monitors shall check their monitors for bias on a regular basis. Ideally, such measurements are made in a radon chamber. Exposure in a radon chamber is required during calibration. It can be difficult to expose active monitors more often than once every twelve months. It is important to more frequently assess the continued satisfactory operation of the instrument response and to ensure damage from shipping has not occurred prior to an instrument being placed into service after calibration. Cross-checks shall be performed prior to placing an instrument being returned to service after calibration and at six months (plus or minus a month) after calibration. The following conditions shall be met:
- i. Where feasible, a cross-check shall begin with an instrument background measurement.

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- ii. The cross-check measurement shall be made in an environment that has been chosen for its stability and radon concentration that is above the lower limit of detection.
 - iii. Cross-checks shall be side-by-side measurements.
 - iv. One of the instruments shall have been calibrated within the last forty-five days.
 - v. A measurement of at least forty-eight hours duration shall be conducted.
 - vi. The bias of cross-check measurements shall be monitored and recorded in the quality-assurance records. If the bias estimated by the user is not within the bias expected of the measurement, the cause of the problem shall be investigated and corrective action taken in accordance with the licensee's director-approved QAP.
- B. Protocol for using continuous radon monitors (CRs) to measure indoor radon concentrations
1. Refer to appendix A to rule 3701-69-07 of the Administrative Code for a list of general conditions that shall be met and standard information that shall be documented.
 2. When performing a radon measurement, the CR shall:
 - a. be programmed to run continuously;
 - b. record periodically the average radon concentration over the integration period (hourly or more frequently) in a manner that is readily accessible; and
 - c. record these data for at least forty-eight hours. Longer measurements may be required depending on the continuous monitor type and the radon level being measured.
 3. If the first four hours of data from a radon measurement are discarded because data are produced prior to the establishment of equilibrium conditions in the test device, there must be a minimum of forty-eight remaining hours of data to be averaged and shall be sufficient to represent a two-day measurement.
 4. Every CR shall be calibrated in a radon chamber before initially being placed into service and after any repairs or modifications that could affect the calibration. Subsequent recalibrations and background checks shall be performed at least once every twelve months. Each scintillation cell requires an individual calibration factor.

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5. Background measurements shall be performed after every one thousand hours of operation of scintillation-cell-type CRs and whenever any type of CR is calibrated. The background shall be checked by purging the monitor with clean, aged air or nitrogen in accordance with the manufacturer's instructions. In addition, the background count rate shall be monitored in accordance with the manufacturer's instruction.
 6. Licensees providing measurement services with CR devices shall perform duplicate measurements. The performance and analysis of duplicates shall be completed in accordance with paragraph (A)(2)(d) of this appendix.
 7. Pumps and flow meters shall be checked before and after each measurement in accordance with the manufacturer's instruction.
 8. Licensees providing measurement services with CR devices shall perform cross-checks. The performance and analysis of cross-checks shall be completed in accordance with paragraph (A)(2)(f) of this appendix.
- C. Protocol for using alpha-track (AT) detectors to measure indoor radon concentrations
1. Refer to appendix A to rule 3701-69-07 of the Administrative Code for a list of general conditions that shall be met and standard information that shall be documented.
 2. Licensees providing measurement services with AT devices shall perform known exposure measurements (spikes). The performance and analysis of spikes shall be completed in accordance with paragraph (A)(2)(b) of this appendix.
 3. Licensees providing measurement services with AT devices shall perform duplicate measurements. The performance and analysis of duplicates shall be completed in accordance with paragraph (A)(2)(d) of this appendix.
 4. Licensees providing measurement services with AT devices shall perform background measurements. The performance of background measurements shall be completed in accordance with paragraph (A)(2)(c) of this appendix.
 - a. The results shall be monitored and recorded. If any field blank has a concentration significantly greater than the LLD established by the supplier,

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it may indicate defective packaging or handling and the licensee shall investigate the cause. If the average value from the field blanks is significantly greater than the LLD established by the supplier, this average value shall be subtracted from the individual values reported for the other devices in the exposure group.

- b. It may be advisable to use three sets of detectors (preexposure, field and postexposure background) in order to allow the most thorough and complete evaluation of radon levels. For example, one group of detectors (preexposure detectors) may be earmarked for background measurement and returned for processing immediately after the other detectors are deployed. The results from these detectors determine if the number of tracks acquired before deployment is significant and should be subtracted from the gross result. The second set of background detectors (postexposure background detectors) are obtained just before the field monitors are to be collected and are opened and kept in the same location as the returning field monitors for the same duration, and returned with them. Finally, this "postexposure background" is subtracted from the field results, if found to be significant. In general, a value of one picocurie per liter or greater for any blank AT indicates a significant level that should be investigated and potentially subtracted from the field AT results.

D. Protocol for using electret ion chamber radon (ES or EL) detectors to measure indoor radon concentration.

1. Refer to appendix A to rule 3701-69-07 of the Administrative Code for a list of general conditions that shall be met and standard information that shall be documented.
2. Every short-term and long-term electret system and the electret reader(s) shall be calibrated by the manufacturer. Calibrations shall be performed prior to initial use, after any repairs or modification that could affect the calibration and at least once every twelve months. Determination of calibration factors for short-term or long-term detectors requires exposure of detectors to known concentrations of radon-222 in a radon exposure chamber. Since short-term and long-term electret detector systems are also sensitive to gamma radiation, a gamma exposure rate measurement in the test chamber is also required at least once every twelve months.
3. Licensees providing measurement services with ES or EL devices shall perform known exposure measurements (spikes). The performance and analysis of spikes shall be completed in accordance with paragraph (A)(2)(b) of this appendix.

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4. Licensees providing measurement services with ES or EL devices shall perform duplicate measurements. The performance and analysis of duplicates shall be completed in accordance with paragraph (A)(2)(d) of this appendix.
 5. Licensees providing measurement services with short-term or long-term electrets shall set aside a minimum of five per cent of the electrets or ten, whichever number is smaller, from each shipment and evaluate them for voltage drift. The electrets shall be kept covered with protective caps in a low radon environment and analyzed for voltage drift over a time period similar to the time period used for those deployed in measurements. Any voltage loss found in the control electrets of more than one volt per week over a three week test period for short-term electrets, or one volt per month over a three month period for long-term electrets, shall be investigated.
 6. Proper operation of the surface voltmeter shall be monitored following the manufacturer's procedures for zeroing the voltmeter and analyzing a reference electret. These checks shall be conducted at least once a week while the voltmeter is in use. These checks shall also be recorded.
- E. Protocol for using activated charcoal adsorption (AC) devices to measure indoor radon concentrations:
1. Refer to appendix A to rule 3701-69-07 of the Administrative Code for a list of general conditions that shall be met and standard information that shall be documented.
 2. Licensees providing measurement services with AC devices shall perform known exposure measurements (spikes). The performance and analysis of spikes shall be completed in accordance with paragraph (A)(2)(b) of this appendix.
 3. Licensees providing measurement services with AC devices shall perform duplicate measurements. The performance and analysis of duplicates shall be completed in accordance with paragraph (A)(2)(d) of this appendix.
 4. Licensees providing measurement services with AC devices shall perform background measurements. The performance of background measurements shall be completed in accordance with paragraph (A)(2)(c) of this appendix.
 - a. If any field blank has a concentration significantly greater than LLD established by the laboratory, it may indicate a defective device or poor procedures and the licensee shall investigate the cause.

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- b. If most of the field blanks have concentrations significantly greater than the LLD established by the laboratory, the licensee shall investigate the cause and notify the manufacturer, supplier and laboratory of a possible problem.
- F. Protocol for using charcoal liquid scintillation (LS) devices to measure indoor radon concentrations
1. Refer to appendix A to rule 3701-69-07 of the Administrative Code for a list of general conditions that shall be met and standard information that shall be documented.
 2. Licensees providing measurement services with LS devices shall perform known exposure measurements (spikes). The performance and analysis of spikes shall be completed in accordance with paragraph (A)(2)(b) of this appendix.
 3. Licensees providing measurements services with LS devices shall perform duplicate measurements. The performance and analysis of duplicates shall be completed in accordance with paragraph (A)(2)(d) of this appendix.
 4. Licensees providing measurement services with LS devices shall perform background measurements. The performance of background measurements shall be completed in accordance with paragraph (A)(2)(c) of this appendix.
 - a. If any field blank has a concentration significantly greater than the LLD established by the laboratory, it may indicate a defective device or poor procedures and the licensee shall investigate the cause.
 - b. If most of the field blanks have concentrations significantly greater than the LLD established by the laboratory, the licensee shall investigate the cause and notify the manufacturer, supplier and laboratory of a possible problem.
- G. Protocol for using continuous working level (CW) monitors to measure indoor radon progeny concentrations
1. Radon decay product measurements may be appropriate under certain conditions in large buildings, but are not currently routinely performed by licensees or recommended by the "American Association of Radon Scientists and Technologists." The director does not recommend their use for home environment

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or residential real estate measurements. Licensees interested in using CWs for measurement purposes shall submit standard operating procedures, consistent with this Part, specific to the model and design of the CW instrument to the director for approval.

2. Conditions and information in appendix A to rule 3701-69-07 of the Administrative Code shall be met.
3. Any measurement result based on radon progeny shall be reported to no more than three decimal places, e.g., 0.033 working level (WL).
4. The integrated average WL over the measurement period shall be reported as the measurement result.
5. When performing a radon measurement, the CW shall be programmed to run continuously, recording the periodic WL and, when possible, the total integrated average WL. The longer the operating time, the smaller the uncertainty associated with using the measurement result to estimate a longer-term average concentration.
6. Working level values shall be converted to picocurie per liter and both shall be reported to the client. The conversions from WL to picocurie per liter shall be presented and explained clearly in the report to the client. A statement shall be included in the measurement report that this approximate conversion is based on a forty per cent equilibrium ratio. In addition, the report shall state that this equilibrium ratio is typical, but that any indoor environment may have a different and varying relationship between radon and radon progeny.
7. Every continuous WL monitor shall be calibrated in a radon chamber before being placed into service and after any repairs or modifications that could affect the calibration. Subsequent recalibrations shall be performed at least once every twelve months.
8. Background measurements shall be performed after every one hundred sixty-eight hours of operation and whenever the unit is calibrated. The CW shall be purged with clean, aged air or nitrogen in accordance with the manufacturer's instructions. In addition, the background count rate may be monitored more frequently by operating the CW in a low radon concentration.
9. Measurement licensees providing measurement services with CW devices shall perform duplicate measurements. The performance and analysis of duplicates shall be completed in accordance with paragraph (A)(2)(d) of this appendix.
10. Pumps and flow meters shall be checked before and after each measurement in accordance with the manufacturer's instruction to ensure accuracy of volume measurements. This may be performed using a dry-gas meter or other flow measurement device of traceable accuracy.

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11. Licensees providing measurement services with CW devices shall perform cross-checks. The performance and analysis of cross-checks shall be completed in accordance with paragraph (A)(2)(f) of this appendix.