

Guidelines for Radon Measurement Audit for Single Family Homes

VERSION 1

EFFECTIVE JANUARY 1, 2019

1. Type of testing conducted

- Each type of testing conducted (single family, multifamily and schools and large buildings) must be
 - Multifamily is considered a building with more than three attached dwellings.
 - When testing is being conducted for more than one dwelling of a shared building, conduct tests in accordance with the ANSI/AARST MAMF
 - listed on your application;
 - listed in your QA Plan;
 - NRPP standards for each testing type conducted must be listed in QA Plan;
 - And QA plan must contain all necessary elements for each testing type.

2. Devices

- Passive devices must use a laboratory certified by MDH. <https://radon.web.health.state.mn.us/index.faces>
- Passive devices and CRMs must be an approved NRPP or NRSB device.
 - <http://aarst-nrpp.com/wp/certification/approved-devices/>
 - <http://www.nrsb.org/wp-content/uploads/2018/11/NRSB-Approved-Devices-110218.pdf>
- If conduct a test during an audit, then must demonstrate that follow manufacturer's instructions
- Manufacturer's operating manual or a link to manual must be included in QA Plan

3. Notifications

- Written instructions with keys elements required for compliance shall be provided prior to start of test. Information can be submitted in email or form. Requirements include:
 - Initiate closed-building conditions 12 hours prior to test
 - Maintain closed-building conditions throughout test
 - Must close: All windows and all exterior doors except for normal entry and exit.
 - Heating and cooling systems should operate normally for occupancy with the thermostat set between 65 and 80° F.
 - Continue normal operation of permanently installed energy or heat recovery ventilators so long as the equipment is regularly maintained and continuously operated; and
 - If applicable, do not block passive combustion or make-up air supplies.
 - Do not operate: Whole house fans; fireplaces unless they are the primary and normal sources of heat; and any temporary device that draws air into or out of the house (for example, window fans).
 - Avoid excessive use of: Clothes dryers; Kitchen exhaust fans; and Bathroom exhaust fans.
 - Do not disturb test devices. Detectors cannot be moved, covered or have their performance altered during the test.
 - For any questions, contact name and phone number.
- Radon test in progress must be put in conspicuous locations stating required conditions of test. (Same as requirements as written instructions plus radon test in progress).
- Voluntary compliance form:
 - If your client is the occupant or homeowner, a voluntary compliance form must be requested to be signed and if they do not sign, note in client file that form was not signed. Email or electronic signature acknowledging they will follow voluntary compliance form is sufficient.

- If your client is not the occupant or homeowner (e.g. buyer during real estate transaction) then you must show what efforts were made to get instructions to occupant prior to testing (e.g. sent form to real estate agent)

4. Testing Placement

Placement requirements

- Are there multiple foundation types? Conduct a test for each type.
- Closed building conditions met for short-term tests?
 - CRMs: If no, was house closed and test delayed or test extended by 12 hours and first 12 hours of test disregarded.
 - Passive devices: If no, was house closed and test delayed or test extended to at least 4 days
- Necessary house conditions checked and noted (air cleaners, crawlspace info, fireplace dampers, air-to-air heat exchangers, radon mitigation systems)?
- Test placed in breathing zone and away from exterior windows/doors/walls and away from items that may influence the test?
- Leave testing in progress and closed house conditions (for short-term tests) in conspicuous places?
- Note exact location of detector?

Retrieval requirements

- Closed building conditions met for short-term tests?
- Was device moved?

Test Each Unique Foundation Type

- If a house has multiple foundation types, each must be tested. Some examples include:
 - A house with a basement and slab on grade would require 2 tests;
 - A house with a walk out basement and slab on grade would require 2 tests;
 - A house with a basement and two crawl spaces would require 3 tests; and
 - A house with a basement, a crawl space and slab on grade would require 3 tests.

Deployment period minimum of 46 hours

- It is recommended that tests be done in 24-hour increments, as close as possible to reflect day to night fluctuations in radon concentrations

Short-term test of less than 4 days (recommendation)

- It is recommended not to conduct a test lasting less than 4 days during periods of unusually severe storms, such as unusually high winds or high precipitation.
- It is recommended to either extend the test to 4 days or greater or to conduct the test at another time

Post-mitigation testing

- The test must be conducted in the same location(s) as pre-mitigation.
- All unique foundation types must be tested.
- Initial post-mitigation test must be done 24 hours to 30 days after the system was installed.

5. Test Report – Basic Information - reports must include:

- Begin and end dates and times

- Detector location (should be more descriptive than basement, bedroom, etc.)
- Complete address of building measured including zip code
- Detector model or type, serial number
- Calibration date
- Name and ID # of service used to analyze detectors (passive devices)
- Name of measurement company
- Name & certification number of measurement professional
- Contact information of measurement company and/or professional

6. Test Report – Test Conditions - reports must include:

Closed building conditions

- If closed house conditions were not met prior to or during the test, then this must be noted on the report.
- If closed house conditions were not met when test was activated, for a CRM
 - test period must be extended 12 hours; and
 - The average of the test results shall exclude the first 12 hours of the test.
- If closed house conditions were not met when test was activated, for a passive device, the test must be extended to at least 4 days or the test postponed.

Deviation from protocol - examples include:

- Devices placed in locations that don't meet minimum requirements of this standard and the reason was unavoidable;
- Observed noncompliance with or deviations from required conditions such as closed-building conditions;
- Observed deviation from a normal occupied temperature;
- Changes in the detector's placement, whether any seal has been altered or test interfered with; and
- Any observed anomalies in data produced by a CRM that in the test professional's opinion may indicate a deviation from testing protocols.

Mitigation system

- If a mitigation system was observed, it must be noted and if it appeared to be operational.
- If any temporary mitigation strategies were observed, this must be noted in the report.
- It is okay to provide a statement in the report that the measurement company offers no findings as to the proper operation of the mitigation system.

Air exchanger present

- If a permanently installed ventilation system, such as a heat recovery ventilator or air-to-air heat exchanger, is active during the test but ready access exists for deactivation or it functions intermittently, this must be noted in the report.

Description of building conditions or other temporary factors must be report, examples include:

- Unusually severe storms or periods of unusually high winds;
- Condition of any permanent vents (i.e. open/closed) such as crawlspace vents; and
- The condition of active or passive air supplies to the building or to combustion appliances.
- Any construction activities being done to the house that could affect radon levels.

7. Test Report – other information

- Provide info on how to obtain state or federal guidance documents (e.g. For more information on radon, please contact the Minnesota Department of Health at 651-201-4601 or health.indoorair@state.mn.us or visit their website at <http://www.health.state.mn.us/divs/eh/indoorair/radon/index.html>.)
- Provide state contact information (see above)
- The test report must match what is in the QA Plan. If not, the QA Plan must be updated and submitted to MDH for review.
- If duplicate measurements are taken, the results must be reported individually and averaged together. Results can only be reported to one decimal point (e.g. 3.2)

Recommended Actions

- For elevated radon concentration, include equivalent statements:
 - Fix the building if test results indicate occupants may be exposed to radon concentrations that meet or exceed the 4 pCi/L action level.
 - Post-mitigation requirements: Conduct a short-term radon measurement no sooner than 24 hours after a mitigation system is operational and within 30 days after installation of the system(s) to provide an initiation measure of radon-reduction system effectiveness.
 - Additional testing is recommended at least every two years to ensure that the system remains effective.
 - <If tested with a single short-term passive detector, include these recommendations>
 - If this test is the first test and it was conducted using a single short-term passive detector, test this location again.
 - If the first short-term test is more than twice the action level (8 pCi/L or more); conduct a second short-term test immediately.
 - If the first short-term test is less than twice the action level (4-8 pCi/L) conduct either a short-term or a long-term test.
 - If the average of two short-term tests or the average of a long term test meets or exceeds the action level of 4 pCi/L, fix the building.
- For low concentrations, include equivalent statements:
 - Recommendations:
 - Consider fixing the building if test results indicate radon concentrations greater than half the action level (2-4 pCi/L)
 - Retest the building at least every five years if no mitigation system is installed.
 - If radon mitigation has been conducted, testing is recommended at least every two years to ensure the system remains effective.
 - Retest the building in conjunction with any sale of new or existing buildings.
 - Be certain to test again when any of the following occur:
 - If the home was unoccupied during the test, the home should be retested after occupancy;
 - If the home is located in an area of karst or glacial moraine geology, it should be retested over a 12-month period;
 - If occupied by a new owner;
 - If a new addition is added;
 - If an alteration is made that could change the home's ventilation patterns;
 - If major cracks or penetrations occur in the home's foundation walls or slab;
 - If significant nearby construction blasting or earthquakes occur;
 - If changes are made or happen to an installed mitigation system; or
 - If a ground-contacted area is occupied that was not previously tested.

8. Other License requirements

- All individuals that place and/or retrieve test devices must be licensed by MDH.
- Any changes to the license application must be submitted to MDH within 30 days. Changes include:
 - Change of address or change of company;
 - Addition/deletion of measurement devices;
 - Changes to QA Plan; and
 - Changes to type of testing conducted.
- Must have proof of a valid radon measurement license while at job site. This proof can be keeping a hard copy of license or being able to pull it up electronically in the field.

Report results to MDH

- Each measurement professional must submit all test results to MDH quarterly, by either submitting the csv file or entering each resulting manually into the licensing system.
 - April 30 for period of January 1 – March 31
 - July 30 for period of April 1 – June 30
 - October 30 for the period of July 1 – September 30; and
 - January 30 for the period of October 1 – December 31
- Information reported must include:
 - Street address, city, county and zip code where work was performed;
 - Test start date and completion date;
 - Test device used;
 - Identification of test as initial, follow-up or post-mitigation test;
 - If the test was done for a real estate transaction;
 - Reported radon concentration;
 - Age of building tested;
 - Type of building tested;
 - If there is a radon mitigation system present; and
 - System tag #, if present.

9. QA Plan - General

- Records must be kept for at least three years (as of January 1, 2019).
 - Records prior to January 1, 2019 do not have to be kept for MDH purposes. If an audit is conducted in June 2019, we would look at records from January 1 – June 2019.
 - If an audit is conducted on May 2, 2022, then records must be available for the previous three years (May 3, 2019 – May 2, 2022)
- Records must be kept per the QA Plan. If the QA Plan says records will be kept indefinitely, then in 2027, records must be kept from January 1, 2019 – 2027. If you change your record retention schedule, then update QA Plan and submit to MDH. Records must be kept a minimum of three years.
- The QA Plan must be followed. If operations change, the QA Plan must be revised and submitted to MDH. Operations must be conducted in accordance with MDH rules and a MDH approved QA Plan.
- When the QA Plan is revised, it must be submitted to MDH.

10. QC Measurements - CRMs

Routine instrument checks

- Use devices or detectors in compliance with device-specific instructions provided by the manufacturer.
- Most CRM user's manuals have specifics for storage, care, checking cables, batteries, and doing self-tests.
- Most Passive device manuals specify storage specifics and package inspection.

Calibration and background check

- Must be conducted at least annually, unless otherwise required by manufacturer

- Manufacturer or facility approved by manufacturer
- Maintain calibration records for 3 years or as stated in QA Plan (must be a minimum of three years)
- Calibration records must include manufacturer, model, serial number of calibrated device, calibration date and calibration facility.

Crosscheck

- Crosscheck are made with a machine that is 5-7 months from calibration and one that has been calibrated within the last 12 months but not at the same time. Ideally, it made with one recently calibrated and one 5-7 months from calibration.
- Relative percent error = [(measured value – reference value)/reference value]*100 Expected precision (between +10% and -10%)
- In control (between +20% and -20%)
- Warning range (outside +/-20% but inside +/-30%)
- Control limit (outside +/-30%)

Duplicates

Conc. 1 – Conc. 2/[(Conc. 1+Conc. 2)/2]=RPD *100

If Results are	Expected Precision	Within Control	Warning	Limit
<2.0 pCi/L				+ or – 1.0 pCi/L
2.0 – 3.9 pCi/L	0-25%	0-49%	50-67%	>67%
≥4.0 pCi/L	0-14%	0-27%	28-36%	>36%

When ≥20 duplicates are made in a month

- If more than 5% of duplicates are in the warning range or more than 1% of duplicates are outside control limits, the measurement system is generally considered “out of control” and all measurements are questionable

If one duplicate is ≥4.0 pCi/L and the other is below, the higher result may not be twice or more than the other. This measurement is to be repeated.

Track QC Measurements

- QC measurements must be tracked in a spreadsheet or log to determine if measurements are within expected precision.

Investigate when control limits are exceeded or other issues are discovered

- Investigation and corrective action should match what is in QA Plan and document what was done when investigations are conducted.

10. QC Measurements – Passive devices

Duplicates

Conc. 1 – Conc. 2/[(Conc. 1+Conc. 2)/2]=RPD *100

If Results are	Expected Precision	Within Control	Warning	Limit
<2.0 pCi/L				+ or – 1.0 pCi/L
2.0 – 3.9 pCi/L	0-25%	0-49%	50-67%	>67%
≥4.0 pCi/L	0-14%	0-27%	28-36%	>36%

When ≥ 20 duplicates are made in a month

- If more than 5% of duplicates are in the warning range or more than 1% of duplicates are outside control limits, the measurement system is generally considered “out of control” and all measurements are questionable

If one duplicate is ≥ 4.0 pCi/L and the other is below, the higher result may not be twice or more than the other. This measurement is to be repeated.

Blanks (passive)

- Blanks must not be labeled as blanks but sent with other tests so the lab cannot distinguish them.
- Blanks should be below the lower limit of detection (LLD)
- If one or more results are greater than the LLD, the device supplier must be contacted to evaluate and institute corrective procedures

Spikes (passive)

- Must use NRPP or NRSB approved chamber
- NRPP <http://aarst-nrpp.com/wp/test-chambers/> (January 2019)
 - Bowser-Morner, Dayton, OH
 - Radon Safety Institute of Canada, Saskatoon, SK Canada
 - KSU Radon Chamber, Manhattan, KS
 - Spruce/Radon Away, Ward Hill, MA
- NRSB <http://www.nrsb.org/radon-chambers/nrsb-accredited-chambers/> (January 2019)
 - Bowser-Morner, Dayton, OH
 - TCS Industries Inc., Harrisburg, PA
 - Durrige Company, Billerica, MA
 - Gemmill Associates, Paupack, PA
 - Rad Elec, Inc., Frederick, MD
 - Radalink, Inc., Atlanta, GA
 - Radon Testing Corp. of America, Elmsford, NY
 - Sun Nuclear Corporation, Melbourne, FL
- Relative percent error = $[(\text{measured value} - \text{target value})/\text{target value}] * 100$
- Expected precision (between +10% and -10%)
- In control (between +20% and -20%)
- Warning range (outside +/-20% but inside +/-30%)
- Control limit (outside +/-30%)

Track QC Measurements

- QC measurements must be tracked in a spreadsheet or log to determine if measurements are within expected precision.

Investigate when control limits are exceeded or other issues are discovered

- Investigation and corrective action should match what is in QA Plan and document what was done when investigations are conducted.

Table 1.

Requirements for Test Locations within a Room	
Place detectors within the general breathing zone Locate Detectors no less than:	3 feet from exterior door and windows or other potential openings to the outdoors
	20 inches above the floor
	1 foot from exterior walls
	4 inches from other test detectors and objects that are or to the side of detector. If manufacturer says detectors are not affected by close to proximity to objects, they may be closer. Duplicates must be 4-8 inches apart unless otherwise specified by manufacturer.
	1 foot below ceiling. Optimal height is less than 8 feet above floor.
Place detectors where they are not easily disturbed:	Select a location where the detectors will not be disturbed during the measurement period.
Place detectors where they are not influenced by other factors:	Do not place inside closets or crawlspaces.
	Do not place detectors in enclosed areas of high air velocity such as mechanical/furnace closets.
	Do not place detectors within enclosed areas of high humidity (i.e. bathrooms, laundry, and kitchens). Exception: detector types unaffected by humidity may be used in these locations.
	Do not place detectors inside cupboards or nooks within the building foundation.
	Do not place detector in or on top of sumps.
	Do not place detectors near drafts caused by heating and air conditioning vents, or fans.
	Do not place detectors near heat sources, such as appliances, radiators, fireplaces or in direct sunlight.
Avoid placing detectors on or near objects that may produce radiation such as natural stone (e.g. rock collections, granite counter tops, hearths or slate pool tables).	

Table 2.

Closed Building Conditions	
Windows	Keep closed on all levels including areas that are not being tested
External doors	
Pet doors (a flap is sufficient)	
Door to garage	
Garage doors	
Heating and Cooling Systems	Set to normal
Whole House Fans	Do not operate
Fireplaces (including those that burn solid, liquid or gas fuels) unless they are the primary/normal sources of heat for the building	
Any other systems that may temporarily draw air into or out of the building	
Clothes dryers	Avoid excessive operation
Range hood	
Bathroom Fans	
Broken windows or doors	Seal closed
Interior partition or stairway doors	No special requirements
Ceiling fans and portable fans	Do not blow fans directly toward testing devices
Window air conditioners	Operate in recirculation mode only
Window fans	Remove or seal shut. Do not operate.
Humidifiers and dehumidifiers	Operate normally
Central vacuum cleaner systems	
Portable air cleaners (must note in report)	
Passive crawlspace vents (must note in report)	Operation of vent dampers or vent configuration should reasonably reflect average yearlong operation.
Crawlspace exhaust systems for humidity control (must note in report)	Operate normally
Passive vents for combustion air makeup	Leave open
Fireplace dampers (must note in report)	Close dampers or doors if practicable
Combustion appliance fans	Operate normally
Air cleaning components such as filters and electrostatic filters (must note in report)	
Passive solar systems	
Attic ventilation fans (fans installed to control only attic air and not air within the building)	
Equipment or systems that supply fresh air to the dwelling	Do not operate unless it is an integral part of the HVAC
Energy recovery or heat recovery ventilators (must note in report)	Normal operation of air-to-air heat exchangers is permitted to continue so as long as the system is regularly maintained and continuously operational.
Radon Mitigation systems (must note in report)	Must be operating for at least 24 hours before beginning of test and operational during the test period

Table 3.

Additional Closed Building Requirements for New Construction, Renovations and Repairs	
All openings to the exterior as a result of incomplete construction, structural defect, or disrepair	Close or seal at least 12 hours prior to starting the test
All heating/cooling appliances (functioning and set to run at normal occupied temperatures)	Items shall be completed or installed at least 12 hours prior to starting the test
All insulation	
All exterior door and hardware	
All windows	
All fireplaces and fireplace dampers	
All wall and ceiling coverings to be completed including interior drywall or paneling	
All door and window seals	
All exterior siding, weatherproofing and caulking	