# Unit 8. Worker Health

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# Objectives

08.01 Identify hazards associated with each type of activity in the radon measurement and mitigation process.

a. Identify opportunities for exposure to radon.

b. Identify non-radon hazards.

08.02 Identify precautions to follow to protect oneself from these radon and non-radon hazards.

08.03 [1]*/**Identify and compare the various monitoring procedures and exposure calculations used to document worker exposure.

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1 *These objectives are only for radon measurement specialists.

**These objectives are only for radon mitigation specialists.

***These objectives are only for measurement applicants.

****These objectives are only for mitigation applicants.

# I. Overview and Introduction

This unit guides radon mitigation contractors and workers in reducing exposure to ionizing radiation, particulates, and organic vapors, as well as other occupational hazards. It does not address all possible safety problems, however. The student should consult documents and manuals for equipment and supplies, related regulations, and experts to develop a written company worker protection plan that may be required by agencies and others. The unit supplements but does not replace Occupational Safety and Health Administration (OSHA) or other regulations. Students are encouraged to seek further training including OSHA respirator training.

# II. Opportunities for Exposure to Radon and Radon Decay Products

The chance of encountering moderate to high radon concentrations on the job occurs in at least the following situations:

- Entering a house with a radon problem.
- Investigating a house for the best way to lower its radon levels.
- Installing radon mitigation systems.
- Repairing radon mitigation systems.

## A. Entering a House with a Radon Problem

Public health officials, radon testing personnel, radon assessment specialists, and radon mitigators all have reasons to spend substantial amounts of time in houses that are known to have greater than average radon concentrations. A few hours of exposure may not seem like a lot, but the time can quickly add up.

## B. Investigating the House

When investigating a house to select a mitigation technique, the chance of high exposure is greater than it is when entering the building to place detectors or talk to the homeowner. During a radon investigation, much time will be spent in the basement or crawlspace (where the highest radon levels are expected) in order to collect the appropriate information. Making matters worse, time will be spent near soil gas entry routes, such as sump holes and drain pipes, where concentrations are often several hundred pCi/L and may range up to tens of thousands of pCi/L

When investigating buildings, three things may aggravate the worker exposure problem:

- When radon measurements are being taken, it is unlikely that the area has been vented to reduce levels.
- Holes may have been drilled in the floor, thereby facilitating radon entry, raising dust, and increasing the equilibrium ratio.
- The vacuum suction test, which is used to draw soil gas from under the basement slab. It is important that exhaust from the vacuum be vented to the outside or, better still, that the vacuum cleaner remain outside.

### C. Installing Radon Mitigation Systems

When installing a radon control system, a person works around the entry routes trying to seal them; making large holes in the slab; raising dust; and spending a great deal of time in the basement or crawlspace. However, an advantage of this situation over that of the building investigator is that there is no reason that the work space cannot be properly ventilated while the job is being performed. The first thing that should be done on entering the basement or crawlspace is to set up ventilation equipment. It has been demonstrated that proper workplace ventilation can successfully minimize worker exposure to the various hazardous/toxic substances used during mitigation, including radon and RDPs, and eliminate the need for respiratory protection (Ref. 1).

### D. Repairing Radon Mitigation Systems

Another major opportunity for radon worker exposure arises while troubleshooting a malfunctioning mitigation system. Exhausts from sub-slab suction systems have been measured between 50 and 13,000 pCi/L (Ref. 2, 3); in fact, any of the soil depressurization methods has a rather high exhaust stream radon concentration. It is easy to stand in the exhaust without realizing how much radon one is breathing.

## III. Respiratory Hazards and Protection in Radon Mitigation Work

### A. The Need for Respiratory Protection and Limitations of Engineering Controls

A properly fitted, selected, and maintained respirator can provide significant protection against the inhalation of RDPs. Greater than 90% of RDPs can be effectively filtered from breathable air, provided the proper respirator is worn according to instructions.

The use of respirators in radon mitigation work is no substitute for ventilating the work space and other proper work practices, however. The first thing to do on entering the basement or crawlspace - unless there is friable asbestos-containing material - is to set up ventilation equipment and pressurize the space with outdoor air to ensure worker exposure is as low as reasonably achievable. Without adequate ventilation radon and RDP levels can build up without one realizing how much radon may be breathed. The philosophy that "conditioning the environment for the person, not the person for the environment" should be a guiding principle. Note, that the use of polyurethane requires adequate ventilation. As some of the fumes cannot be filtered out if adequate ventilation cannot be maintained, the next step is use of supplied air respirators or self-contained breathing apparatus.

During an initial radon investigation, ventilation of the work area may be limited, because pressure and/or radon measurements need to be taken. However, when conducting sub-slab or wall pressure-field diagnostics, vacuum cleaners should be discharged to the outside to prevent the build up of soil gas into occupied spaces. Vacuum cleaners or ventilation fans should also be used to control dust from diagnostic and mitigation activity.

While investigating and taking measurements, it is particularly important to use respiratory protection in the absence of adequate ventilation, especially if the radon level is suspected to be above 100 pico-Curies per liter or 1 working level, whichever is lower. Personnel wearing respirators should be properly

trained and medically qualified. Some employers require employees to submit an annual physical examination report, including chest x-ray and pulmonary function.

## B. Selecting the Proper Respirator

Radon mitigation work presents workers with at least two general types of inhalation hazards - particles, such as RDPs, asbestos, mold, dust from concrete grinding and drilling; and vapors from caulks, sealants, or paints that may be used in the course of mitigation work. Several types of respirators are commonly used by mitigators depending on the type of protection needed.

- Disposable Particulate Respirators: these have high-efficiency filters and are National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) certified for use in atmospheres containing radionuclides and RDP particles. Disposable respirators cannot be fit checked, however, and should not be recommended over other superior respirators. They do not provide adequate protection against organic vapors or radon gas.
- Negative Pressure Respirators with Organic Vapor Cartridges: NIOSH/MSHA certified for use in atmospheres with up to 1,000 ppm of organic vapors from solvents, caulks, sealants, or paints (not for use with polyurethane caulks, paints, or foams). These elastomeric half-mask or, better, full-face respirators are fitted with replaceable cartridges which provide specific protection against organic vapors. Users should determine that the respirator is appropriate for the specific compounds that will be encountered. Organic vapor cartridge respirators do not provide adequate protection against RDPs nor radon.
- Negative Pressure Respirators with Combination Particulate Filter/Organic Vapor Cartridges: half-mask or, better, full-face respirators fitted with both organic vapor cartridges and RDP particulate filters. Because inhaled air is filtered through both types of purifying media, respirators equipped in this way provide NIOSH/MSHA approved protection against radionuclides, RDP particulates, and organic vapors. These organic vapor cartridge systems provide protection up to 1,000 ppm of organic vapors. The combination filter/cartridge systems do not provide protection from radon gas or polyurethane compounds. Note: Organic vapor cartridges have a finite life span - the charcoal filter absorbs whether being breathed through or not. Once the sealed wrapper on the filter is opened, the filter should be disposed of in a few days, whether or not it has been used.

## C. Conditions That May Prevent the Use of an Air-Purifying Respirator

Several conditions can prevent the achievement of a proper fit and an adequate seal of the respirator to the wearer's face. These conditions include:

- A growth of beard or sideburns.
- A skull cap (protective headgear) that projects under the full-faced respiratory face piece.
- The temple pieces on glasses.
- The absence of one or both dentures (upper or lower teeth).
- Facial scars.

If respiratory protection is needed and the wearer is unable to achieve the proper fit using an air-purifying respirator, several types of positive air powered respirators (PAPR) are available which do not require the achievement of a face seal including hooded PAPRs. PAPRs are much more expensive than other air purifying respirators. Note that MSHA does not allow the use of air purifying respiration at RDP levels above 10 WL (about 1,000-2,000 pCi/L), because the dose from radon gas itself is significant.

## D. Respirator Inspection Procedures

Respirators must be inspected by the wearer each time the respirator is worn or at least once a month, whichever is more frequent. Attention must be paid to the following guidelines:

- Disposable Particulate Respirators:

  Examine the foam face seal and metal nosepiece for any tears, creases, or deformities.

  Set aside the respirator if any portion of the face piece is wet and allow to dry in a clean, uncontaminated place. Dispose of respirators which become saturated with water or other fluids.

- Negative Pressure Respirators:

  Check the face piece for cracks, tears, distortions, and dirt: the material must be pliable - not stiff.

  Examine the inhalation valves for signs of distortion, cracking, or tearing. Lift valves and inspect valve seat for dirt or cracking.

  Examine that the head-straps are intact and have good elasticity.

  Examine all plastic parts for signs of cracking or fatiguing; make sure the gaskets are properly sealed.

  Remove the exhalation valve cover and examine the exhalation valve and valve seat for signs of dirt, distortion, cracking, or tearing. Replace the exhalation valve cover.

## E. Conducting Face fit Checks Prior to Entering a Contaminated Area

The techniques described here apply to face fit checks of half-mask and full-face negative pressure cartridge respirators. Before wearing a respirator in a contaminated area, carefully follow the fitting instructions applicable to each specific respirator model:

- Positive Pressure Face fit Check: place palm of hand over the exhalation cover and exhale gently. If the face piece bulges slightly and no air leaks between the face and the face piece are detected, a proper fit has been obtained. If air leakage is detected, reposition the respirator on the face and/or readjust the tension of the elastic straps to eliminate the leakage. If you CANNOT achieve a proper fit, DO NOT enter the contaminated area. See your supervisor.

- Negative Pressure Face fit Check: place the palms of the hands over the open area of the cartridge cap (alternatively, surgical gloves can be used to cover the openings), inhale gently and hold your breath for five to ten seconds. If the face piece collapses slightly a proper fit has been obtained If air leakage is detected, reposition the respirator on the face and/or readjust the tension of the elastic straps to eliminate the leakage. If you CANNOT achieve a proper fit, DO NOT enter the contaminated area. See your supervisor.

These face fit checks must be conducted by the respirator wearer prior to each entry into a contaminated area.

## F. Conducting Qualitative Respirator Fit Testing

Two test types exist:

- Saccharin solution aerosol test for disposable particulate respirators.
- Iso-Amyl acetate test for organic vapor respirators.

It is determined that if the individual can detect the taste of saccharin or the odor of iso-amyl acetate, then that respirator is incorrectly fitted. Please note that the validity of qualitative fit-testing is dependent upon the individual's response.

## G. Cleaning, Maintenance, and Storage of Respirators

The steps of cleaning, maintenance, and storage of respirators are very important. They influence the effectiveness and quality of respirator protection as well as the life- span of the respirator:

- Cleaning and sanitizing is required after each use and shall be the user's responsibility. Disassemble the respirator by removing the cartridges, pre-filters, headbands, and other parts.
- Immerse the face piece and headband in warm cleaning solution detergent if necessary or use a cleaner-sanitizer solution. Avoid using detergents containing lanolin or other oils.
- Rinse in plain warm water and air dry in a non-contaminated atmosphere. Do not use excessively warm water (over 120 degrees), to avoid possible overheating and distortion of the respirator pieces.
- After the cleaned and sanitized respirator is dry, the respirator shall be inspected and any parts that show excessive wear or deterioration should be discarded and replaced. The respirator needs to be kept in good condition to provide the best protection.
- When the respirator is not in use, it shall be stored after cleaning in a dry location or container (such as a self-lock plastic bag) that is free of contaminants such as heat, extreme cold, sunlight, excessive moisture, dust, and organic solvents. Do not distort the face piece during storage, as it will affect its fit and protection value.

## H. When To Change Respirators or Respirator Filters and Cartridges

The following conditions indicate the need to discard and replace the respirator or respirator cartridges. Leave the area immediately if you are in a contaminated area and experience:

- Smell or taste contaminants.
- Difficulty breathing.
- Irritation.
- Dizziness or other distress.
- Damage or deformation of respirator.

### I. Physical Examination Requirements and Respirator Use

The OSHA standard on respiratory protection (29 CFR 1910.134) stipulates that,

> "persons should not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. A local physician shall determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (for instance, annually)."

### J. Documentation of Training and Instructions to Respirator Users

Employers are strongly advised to maintain written records of all worker health and safety training activities, including those pertaining to respiratory protection. An example of a training record is found in the appendix to this unit.

*Note: Mitigators who provide respiratory protection for their employees must comply with the requirements of OSHA Respiratory Protection (29 CFR 1910.134).*

## IV. Monitoring Worker Radon Exposure

There is currently no single recommended method of monitoring radon mitigator workers for exposure to radon and RDPs. A method of monitoring employee exposure to RDPs is described in part C of this section.

### A. Calculating Worker Exposure to Radon and Radon Decay Products

Using the units of measurement for radon (pCi/L), for RDPs (WL), and the concept of an equilibrium ratio (ER) (and given various levels of radon and RDPs present in a building during mitigation work), the exposure of radon workers to these substances can be calculated:

- Occupational exposure to RDPs is measured in working level months (WLM).
- One WLM is the equivalent of exposure to 1WL for 170 hours. (This assumes 170 working hours per month).
- RDPs measurement levels (in WLs) are multiplied by the duration of exposure (in hours) and divided by 170 to obtain exposure levels in WLMs.

The following is an example of a WLM calculation:

**Question: listed below are the RDP levels and corresponding exposure times for your employees during radon diagnostic and mitigation work. Calculate the total RDP exposure in WLM.**

1.10 WL for 2 Hours

0.50 WL for 8 Hours

0.65 WL for 4 Hours

0.04 WL for 3 Hours

| | | | |
|---|---|---|---|
| Calculation: | 1.10 WL x 2 Hours | divided by 170 = | 0.013 WLM |
| | 0.50 WL x 8 Hours | divided by 170 = | 0.024 WLM |
| | 0.65 WL x 4 Hours | divided by 170 = | 0.015 WLM |
| | 0.04 WL x 3 Hours | divided by 170 = | 0.001 WLM |
| | TOTAL | = | 0.053 WLM |

## B. Current Guidelines for Occupational Exposure to Radon Decay Products

Exposure to radon and RDPs on the job is regulated either by OSHA (for most workers) or MSHA (for underground miners). The OSHA regulation (29 CFR 1910.96 (C) (1)), based on limits set by the nuclear Regulatory Commission in Title 10 of the Code of Federal Regulations, Part 20 (10 CFR 20), limits exposure to either 30 pCi/L or 0.33 WL (based on continuous work place exposure for 40 hours per week, 52 weeks per year). MSHA limits the annual exposure for underground uranium miners to less than 4 WLM per year, which corresponds to an exposure of 0.33 WL for 173 hours per month, 12 months per year. These are essentially equivalent limits.

## C. Procedure for Employee Monitoring

### *1. Importance of Respiratory Protection During Diagnostic Testing*

The ALARA (as low as reasonably achievable) principle should be followed when considering work practices and procedures during any radon related activity. Diagnostics and/or follow-up radon testing are more often performed in homes suspected of having elevated radon concentrations. Testing devices should be deployed and retrieved spending a minimum amount of time in the lower areas (basement, etc.), while still obtaining any needed information (floor layout, HVAC description, etc.). Recording of data and any discussions with the homeowner or others should be conducted in areas less likely to have elevated radon concentrations.

Diagnostics by its very nature means attempting to locate and identify source points or areas. Introducing ventilation may be impractical and self-defeating during diagnostics, but it should be considered in sites with very elevated ambient radon concentration. (Normally source points and areas will be easier to identify in these sites). Any intrusive activities should be accompanied by the use of a shop-vac exhausted to the outside. Sub-slab communication tests should also be performed with exhausts terminating in the outside air. All test holes should be covered over when not being used and carefully sealed when the diagnostics are completed.

Respirator use should be considered (only if following an approved respirator plan) when performing inspections on suspected elevated radon sources such as crawlspaces, sumps, floor drain, etc.

Workers performing diagnostics should participate in employee monitoring programs similar to workers who install mitigation systems.

This unit does not consider the issue of "respirator credit." which is to say, if respirators are properly worn by workers, the workers' exposure to radon and its decay products may be significantly less than the levels reflected in measurement of the indoor environment. Students should be alert to future decisions concerning credit for a proper respirator program. Ignoring the respirator credit issue results in a conservative occupational exposure practice.

### *2. General Employee Monitoring Considerations*

Methods used for monitoring employee exposure to RDPs should follow the general precautions for all measurement activities. The key goal in deploying detectors for employee monitoring is to obtain measurements that are as representative of actual worker exposures as possible. Detectors should closely reflect conditions in the normal breathing zone of the worker; therefore, detectors should be worn in an appropriate position. This positioning should not increase the discomfort level of the worker nor create an additional danger. As with all measurement activities, detectors should be kept away from obstructions, heat sources, and other disturbances of ambient conditions.

The ideal detector for employee monitoring needs to be inexpensive, light weight, and able to integrate quickly with the room concentration, and not need to come into equilibrium immediately to accurately measure concentrations to which employees are exposed. Two detector types considered are:

- Alpha track detectors (ATDs): although they do not meet all of these criteria, several features of ATDs make them a candidate for monitoring employee exposure:
    - Inexpensive
    - Small and unobtrusive
    - Measure radon, not RDPs
    - Convenient and easy to use
    - Light weight
    - Measure integrated radon concentrations over long periods - typically 3 months to a year
    - Yield truly integrated radon levels (not biased toward most recent exposure).

The following limitation of ATD use for personnel monitoring should be considered when evaluating worker exposure:

- Slow response time: short-term exposure in high radon concentrations may not be reflected in analysis due to slow diffusion through filter.
- Dirt, caulk, solvents, etc., clogging the filter or further delaying monitor response time.
- Non-work related exposure: location of monitor during non-working hours.

  - Uncertainty of the health risks caused by short-term, high-level exposure vs. long-term, low-level exposure. Some worker exposure may be in the hundreds to thousands of pCi/L range and result in only a tenth or less of an increase in the reported average radon exposure.
- Electret-Ion Chamber Radon Monitors (EICs) are another option for monitoring employee exposure. EICs share many of the characteristics of ATDs.

### *3. Monitoring Employee RDP Exposure*

Currently, the only officially sanctioned employee RDP exposure monitoring procedure is described in 30 CFR 57.5037-.5047. This is MSHA's procedure for monitoring RDP exposure in underground mines. It basically amounts to weekly WL grab samples with location occupancy logs. Since this method does not lend itself to radon mitigation, an alternative approach has been considered. The following steps should be taken:

- Monitor each worker with his/her own ATD or EIC and document measurement results on his/her own Personal Radon Exposure Record (see Figure 8-1 at the end of this Unit, page 26).
- In addition to separate ATDs or EICs for individual employee monitoring, make allowance for background radiation and dedicate a monitor for this purpose. ATDs or EICs for the detection of background radiation should be deployed in areas where the detector used for occupational monitoring will be kept during off-work hours. The most common locations are at the employee's home, at contractor's office, or perhaps in the contractor's truck.
- Clearly label each ATD or EIC with the initial deployment date and its location (i.e., either the name of the employee to wear the monitor or the location of background radiation monitoring).
- In accordance with current EPA protocols for screening measurements, minimum ATD deployment time is 720 hours (i.e., 90 eight-hour working days). At the end of the exposure monitoring period, subtract representative background radiation measurements, corresponding to each employee's personal ATD, from employee ATD measurements to estimate actual work-related exposure. EIC users should follow manufacturers recommendations and future EPA guidance.
- Consult with monitor suppliers about the storage, deployment, collection, shipping, and quality assurance/quality control involving employee monitoring.
- Convert radon measurement results from the lab from pCi/L to WLs and enter on each employee's Personal Radon Exposure Record (see Figure 8-1 at the end of this Unit, page 26).

# V. Safe Mitigation Practices and Precautions

## A. Radiation Protection (ALARA)

The ALARA (as low as reasonably achievable) principle should be followed when considering work procedures and practices during any radon related work:

- Ventilation: immediately upon arrival at the work site, ventilate work spaces suspected of having elevated radon levels (ventilation should be initiated prior to commencing work whenever possible, particularly in elevated radon environments). The amount of ventilation required depends upon a number of factors including: existing radon concentrations and size (air volume) of the work space. Ventilation should normally be performed in a positive mode to maximize its effectiveness. Where ventilation of outside air is not feasible or sufficient to reduce radon concentrations, interior circulation of air should be considered to reduce decay product concentration (plate out). A respirator should be worn (only if following an approved respirator plan), when the other measures do not sufficiently reduce radon and/or decay product concentrations.
- Logistics: whenever possible, radon mitigation tasks should be performed in areas with low radon concentrations (outside, garage, first floor, breezeway, etc.). This includes work activities, discussions with homeowners, and break and lunch periods. Radon concentrations within the main work areas (basement, crawl spaces) should determine to what degree this practice is followed.
- Intrusive Activity: any intrusive activity (drilling floor and/or wall holes, cracks grinding, etc.) should include the use of a shop-vac device exhausting to the outside area. This helps to minimize air particulates, which are a hazard in themselves and more so when attached to RDPs. The shop-vac should also be used to control sub-slab radon concentrations when drilling and/or coring to install a floor or wall tap (extended work in sump areas may also benefit from this procedure). The inlet hose of the shop-vac should remain within 6 inches of the hole drilled. This directs most of the available sub-soil radon and RDPs to the outside air. Care should be taken by the worker to avoid breathing in the area between the floor hole and the inlet of the shop-vac.
- Miscellaneous: certain mitigation situations may require special arrangements or procedures to minimize worker exposure.
    - some crawlspace and basement activities can be minimized by using a team approach in handling equipment and materials, thereby reducing the overall group's exposure.
    - modification to the exhaust of any active depressurization system should only be performed with the system inactivated.
    - installation of mitigation systems, other than active depressurization systems, should include equal attention to minimizing worker exposure to radon. Increased ventilation will normally be the primary procedure to achieve this goal.

## B. Asbestos and Radon Mitigation Work

Asbestos may be found in the course of radon mitigation work in:

- Pipe, duct, furnace, boiler and electric wiring insulation.
- Asbestos cement, roofing and siding.
- Asbestos cement sheets and floor tiles.
- Floor tile adhesives.

- Underlay for sheet flooring.
- Textured ceiling finishes.
- Gaskets and packings.
- Equipment and storage tank insulation.

Asbestos bonded in finished products is not a risk to health, as long as the product is not damaged or disturbed (for example, by sawing or drilling) in such a way as to release fibers into the air. Since the fibers are nearly indestructible, a risk exists if they are set free. Once the asbestos particles enter the lungs, they may remain for prolonged periods.

If you discover a substance that might be asbestos during the course of performing mitigation work (e.g., in floors, walls, insulating materials) and the substance is far enough removed from the immediate area of the mitigation work, no health risk likely exists, as long as the substance is left undisturbed and does not become friable or airborne.

If the substance suspected to be asbestos is directly in the way of work to be done, or close enough to the work that you cannot assure that it would be left undisturbed (i.e., drilling needs to be done through asbestos-containing materials), leave the substance alone and notify the homeowner and your supervisor of the suspected presence of asbestos. Asbestos which may be disturbed during radon mitigation should be taken care of by a qualified asbestos remediation contractor.

In accordance with the respirator selection criteria of the OSHA asbestos standard, the air purifying respirators with high efficiency filters often worn during mitigation work for protection against RDPs and/or organic vapors only provide adequate protection against airborne asbestos up to concentrations of 10 fibers per cc (f/cc) of air.

This is a moderate amount of respirable asbestos (10 times the current "action level" for asbestos) and airborne asbestos dust of this concentration would be visible to those present. It is strongly recommended that radon mitigation work not be undertaken in such an environment, unless employees have had special asbestos training and a number of specific health and safety precautions for worker protection detailed in the OSHA standard have been put in place. (OSHA requires the use of high efficiency, air- supplied respirators for asbestos exposures above the level of 10 fibers per cc of air.)

## C. Electrical Safety

Since radon mitigation work usually involves the use of electrical equipment and power tools, electrical hazards and the potential for electrical injuries exist. Hazards commonly arise from the electrical cords of power tools, drop lights, and extension cords, when used in less than serviceable condition. Cracked or peeling electric cord insulation and frayed, overstressed extension cords can result in an ignition source or exposed wire and the potential for accident or injury. Use of extension cords of a lighter gauge and lower voltage handling capacity than the electrical equipment or power tools they serve results in overloading and the possibility of electrical fires.

When the radon mitigation work involves drilling or cutting through slabs and wall partitions, care must be taken to avoid contact between electrical wiring running beneath slabs and walls and the power tool used to make the penetrations. When working outside the building, such as when installing the roof cap on the ventilation system, care must also be taken in positioning an aluminum ladder if one is used to

access the roof. Serious and possibly fatal electric shock can occur when metal ladders become energized through contact with the power line to the building.

Another potential electrical hazard exists when initially hooking up the ventilation system fan to an electrical circuit for its power supply. Electrical fires, property damage, and possible worker injury can occur if the wiring is fitted improperly. Radon mitigators shall comply with local electrical codes.

Mitigators and others working with electric equipment need to use safe work practices:

- De-energizing electrical equipment. The accidental or unexpected sudden starting of electrical equipment can cause severe injury or death. Before any inspections or repairs are made - even on the so-called low-voltage circuits - the current should be turned off at the switch box and the switch padlocked in the "OFF" position. At the same time, the switch or controls of the machine or other equipment being locked out of service should be securely tagged to show which equipment or circuits are being worked on.
- Tools. To maximize safety, mitigators should always use tools that work properly. Tools should be inspected frequently and, those found questionable, removed from service and properly tagged. Tools and other equipment should be regularly maintained. Inadequate maintenance can cause equipment to deteriorate, resulting in an unsafe condition.
- Good Judgment. Perhaps the single most successful defense against electrical accidents is the continuous exercising of good judgment or common sense. All employees should be thoroughly familiar with the safety procedures for the particular mitigation job. When work is performed around energized lines, for example, some basic procedures are:
    - Have the line de-energized.
    - Ensure that the line remains de-energized by using some type of lockout and tagging procedure.
    - Use insulated protective equipment.
    - Keep a safe distance from energized lines.
- Protective Equipment. Mitigators who work directly with electricity must use the personal protective equipment required for the jobs they perform. This equipment may consist of rubber insulating gloves, hoods, sleeves, matting, blankets, line hose, and industrial protective helmets.

## D. Noise and Hearing Conservation

Environmental experts and sound specialists consider noise to be the most widespread and fastest growing form of pollution in the United States. It affects urban, suburban and rural residents; it is present in homes and is pervasive throughout business and industry. At work, a noisy office can approach 50 decibels (dB); a busy factory can average 85 dB; a print shop, 95 dB; a construction site, 100 dB; a riveting shop, 110 dB; a boiler factory, 118 dB; a lumbering site, 125 dB; and a jet runway, 130 dB.

Noise exposure on the job is a health hazard that costs the United States about 4 billion dollars a year in health care and worker's compensation costs. Yet the nature of noise-induced hearing loss makes it a difficult problem to handle. Although sources of noise are seemingly everywhere and its impact on health can be significant, loss of hearing occurs very slowly. In addition, the harmful effects of noise are

insidious, not sudden or dramatic, and do little to attract attention until the process of hearing loss is far advanced. And worst of all, noise-induced hearing loss is irreversible - no form of medical care or surgery can repair the damage to hearing caused by noise.

Yet the good news is that hearing loss caused by work-related exposure to noise is preventable. The information and guidelines provided in this section can assist in the preservation of hearing for workers exposed to noise.

### *1. Methods of Noise Control*

There are three stages to the noise pathway from the noise source to the ears of the listener. As shown in Figure 8-2, noise is generated from a source (A) and sound waves pass through the air in the form of minute cyclic changes in barometric pressure (B). Health effects occur as the auditory system of the receiver (C) is bombarded with intense levels of noise over extended periods of time. Measures to control noise can be taken at each of these points along the noise transmission pathway.

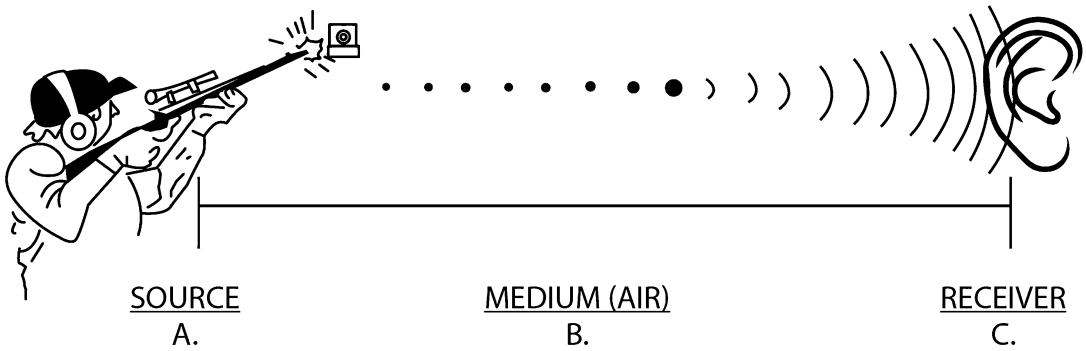


**Figure 8-2. The Three Stages of the Noise Transmission Pathway, Source: MURC**

The simplest intervention for noise control is to increase the distance (B) between the receiver and the noise source. Isolation of loud operations and point sources of noise can also control noise levels. For most radon mitigation activities, however, this intervention is not always practical.

The knowledge and technology to control noise is available and has been for some time. In fact, this is one of the few instances where the knowledge of control technology exceeds the knowledge about the effects of noise on human life and on the environment. There are several approaches to minimizing or eliminating noise through noise reduction at the source (Point A in Figure 8-2). Some examples of these interventions include:

- Designing quieter tools, machines, and operating methods in the first place.
- Maintenance and repair of tools and equipment for the quietest operation.
- Use of noise dampers, acoustic insulation, mufflers, pads, carpet, etc.
- Use of sound barriers, walls, shields, and other separations between the employee and the noise source.

Some of these noise reduction methods are not practical for radon mitigation work. Another point of intervention is to control noise at the receiver (Point C in Figure 8-2) using various types of hearing protection. This is the most practical method of noise control for mitigation work.

### 2. Hearing Protection

From an employee health and safety standpoint the wearing of hearing protection to reduce the harmful effects of noise is the last measure to be used after steps to minimize exposure time and steps to reduce noise at the source have been exhausted. Administrative control of noise (i.e., rotating employees out of noisy environments) and engineering controls (i.e., damping or insulating noisy tools and equipment) are the noise control interventions of choice for preventing noise-induced hearing loss. When these measures are impractical or ineffective in bringing noise down below harmful levels, various types of hearing protection devices are available for protection against the harmful effects of noise. The types of hearing protection in common use are:

- Standard Hearing Protection Devices
  - Earmuffs
  - Earplugs: Pre-molded earplugs and formable earplugs.
- Nonstandard Hearing Protection Devices
  - Canal Caps (super-aural hearing protectors)
  - Custom-molded hearing protection.

### 3. EPA's "Noise Reduction Rating" (NRR) System

EPA has established a numerical system to measure the relative noise-reducing capability of hearing protectors. Each model and brand of hearing protector is given a value or noise reduction rating (NRR) according to its noise-reducing capability. According to EPA regulation, the NRR of a hearing protection device must be shown on the outside of the hearing protector package.

### 4. Procedure for Estimating the Adequacy of Hearing Protector Attenuation

The OSHA noise standard offers several methods of estimating the adequacy of hearing protector noise attenuation. The methods assume that there is a way to determine what noise level exists in the work environment. Noise level surveys can be accomplished using a sound level meter, which can be purchased or rented, or by contracting the services of an industrial hygiene consultant.

Estimates of the adequacy of hearing protector attenuation use the NRR values given each brand and model of hearing protector. Estimating the adequacy of hearing protector attenuation involves a two-step process. First, determine the work place noise level, using a sound level meter or the services of an industrial hygiene consultant (and, if applicable, obtain the employee's 8-hour time-weighted-average (TWA) noise exposure). Second, subtract the NRR of the hearing protector selected from the work place noise level or the employee's 8-hour TWA noise exposure. The resulting level is an estimate of the noise level to which the employee is exposed under the hearing protector.

### *5. OSHA's "Occupational Noise Exposure" Standard (29 CFB 1910.95)*

In the early 1980s, OSHA issued and later amended a comprehensive health standard covering occupational noise exposure in an attempt to reduce the high incidence of noise-induced hearing loss in business and industry. The standard, "Occupational Noise Exposure" (29 CFR 1910.95), requires a comprehensive "hearing conservation program," to insure the protection of employees from work place noise overexposure. According to the standard, “The employer shall administer a continuing, effective hearing conservation program, as described in (the standard) whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels measured on the A scale (slow response) or, equivalently, a dose of fifty percent."

Employers are required to comply with the provisions of this standard if employees are exposed at or above the "action level" of 85 decibels as an 8-hour time weighted average - the minimum noise level at which overexposure is thought to begin, and which triggers the protective measure of the hearing conservation program. It is likely that workers doing residential radon mitigation projects may not be exposed to the OSHA action level. Nevertheless, hearing protection is strongly encouraged when workers are engaged in noisy activities such as hammer-drilling.

As outlined in this standard, other important components of a hearing conservation program include:

- Monitoring noise levels in the work place through surveys or dosimetry.
- Notification of employees if their exposures are at or above the 85 decibel "action level."
- Audiometric testing (hearing acuity tests) for all employees whose exposures equal or exceed an 8-hour time-weighted average of 85 decibels.
- Making hearing protection available to employees at no cost to them and ensuring that the hearing protection is worn by exposed employees.
- Providing annual hearing conservation training to employees exposed at or above the "action level."
- Maintaining accurate written records of work place noise levels, employee audiometric test results, and employee training records.

## E. Eye Safety

Protection of the eyes from injury by physical and chemical agents is vital in any employee health and safety program. In fact, safety eyewear enjoys the widest use of all types of industrial personal protective equipment and offers the widest range of styles, models, and types. In radon mitigation work, eye protection is especially important when hammer-drilling, grinding, applying PVC solvents and cements, and moving acid-battery back-up power sources for sump pumps.

The selection and ready availability of eye protection for employees is the straight-forward portion of a work place eye safety program. Employee compliance with the wearing of prescribed personal protective equipment, including safety eyewear, is uneven at best. The issue of ensuring that employees actually wear their safety eyewear very often represents the most challenging part of an eye safety program.

A work place eye safety program based on protective equipment cannot be effective unless the eye protection is worn and compliance with this is enforced. During radon mitigation jobs, when drilling, sawing, applying solvents to plastic pipe, or other structural alterations are being done, 100 percent compliance with the wearing of eye protection must be insisted upon.

The applicable OSHA health and safety standard, "Eye and Face Protection" (29 CFR 1910.133), states that:

> "protective eye and face equipment shall be required when there is reasonable probability of injury that can be prevented by such equipment. In such cases, employers shall make conveniently available a type of protector suitable for the work to be performed, and employees shall use such protectors. No unprotected person shall knowingly be subjected to a hazardous environmental condition. Suitable eye protectors shall be provided where machines or operations present the hazard of flying objects, glare, liquids, injurious radiation, or a combination of these hazards."

Failure to provide employees with proper eye protection is thus against federal health and safety regulations.

## VI. Hazard Communication and Chemical Safety

OSHA has issued a regulation which affects every contractor in the construction industry entitled the Hazard Communication Standard (29 CFR 1926.59). Called "HazCom" for short, it requires all contractors to educate their employees about the hazardous chemicals they are exposed to in the work place and the methods necessary to protect themselves. Chemical exposure may cause or contribute to many serious health effects, such as heart ailments, kidney and lung damage, sterility, cancer, burns, and rashes. Some chemicals may also be safety hazards and have the potential to cause fires, explosions, and other serious accidents. The basic goal of the standard is to ensure that employers and employees know about chemical hazards and how to protect themselves. This knowledge, in turn, should help to reduce the incidence of chemical source illnesses and injuries.

Many contractors mistakenly believe that they don't use hazardous chemicals in the course of mitigation work. However, hazardous chemicals are found in many commonly used products, such as caulks, sealants, and paint. Contractors also may be very unused to complying with a "performance-oriented" regulation such as HazCom.

Unlike other OSHA standards, which generally require contractors to comply with specific provisions to ensure a safe work place, HazCom establishes certain performance goals and allows employees the flexibility to develop a program appropriate for the specific workplace.

In addition to worker exposure, a radon mitigation contractor should consider potential occupant exposure to such hazards as vapor released from caulks, sealants, and solvents. The contractor should advise the client of these hazards and their protective options such as ventilation.

Material Safety Data Sheets (MSDS) are the primary vehicle for transmitting detailed hazard information to employers and subsequently employees. Manufacturers and distributors are required to provide MSDS on request. Employers must maintain MSDS in the work place and ensure that they are available to employees. Since the mitigator's work place is usually in someone's home or a site away from the

office, a good practice is to assemble a notebook with current MSDS first aid and fire safety that is kept in the work vehicle. This assures that the information is available to both employees and occupants of the buildings being remediated. RCP interim standards require disclosure of potential hazards from materials used in remediation work to the client or occupants.

## VII. First Aid

OSHA standards (29 CFR 1926.50) require that the work place have either "an infirmary, clinic, hospital, or physician that is reasonably accessible in terms of time and distance to the work site, which is available for the treatment of injured employees." or "A person, who has a valid certificate in first-aid or training from the U.S. Bureau of Mines, the American Red Cross, or equivalent training that can be verified by documentary evidence, shall be available at the work site to render first aid." Because radon mitigation can occur almost anywhere, it would be a realistic assumption that a mitigation crew would be beyond a reasonable time and distance to medical assistance. It would seem prudent, therefore, to have at least one trained and certified person with fully stocked first aid kit on every crew.

## VIII. Fire Safety

Contractors are also required to provide fire-fighting equipment that is readily accessible, in case of a fire in the work place (29 CFR 1926.150). Considering the flammability of some of the sealants, glues, and materials used in mitigation, a fire extinguisher in the crew vehicle would be a good idea, as well as satisfying the above requirement.

**WLM CALCULATION EXERCISE**

Question: Listed below are levels of employee exposures to radon and corresponding exposure times. Calculate total employee exposure in WLMs.

| | |
|---|---|
| 180 pCi/l | for 1 Hour |
| 95 pCi/l | for 6 Hours |
| 37 pCi/l | for 2 Hours |
| 8 pCi/l | for 2 Hours |

| Radon Level | Working Level | Hours of Exposure | Working Level Months |
|---|---|---|---|
| (pCi/L) | (WL) | (HR) | (WLM) |
| 180/200 | 0.9 X | 1/170 = | 0.053 |
| 95/200 | 0.475 X | 6/170 = | 0.017 |
| 37/200 | 0.185 X | 2/170 | 0.002 |
| 8/200 | 0.04 | 2/170 | 0.0005 |

(Answer: .0053 WLM + .017 WLM + .002 WLM + .0005 WLM = 0.025 WL)

# References

1. Dehmel, J.C., Fisher, E., Nowlan, P., "Occupational Safety During Radon Mitigation: Field Experience and Survey Monitoring Results," pp II-1 in Preprints of the 1991 International Symposium on Radon and Radon Technology (Volume 3) U.S. Environmental Protection Agency, Research Triangle Park. N.C.: Air and Energy Environments Research Laboratory, 1991.

Florida HEALTH

# Bureau of Environmental Health
# Radon Program

## Working Level Month Exposure Form

Employee Name (Print - Last, first and middle) _____ Date of Birth (Month, day, year) _____ Cert. # _____

Business Name _____ Cert. # _____

WLM Occupational Exposure
(See other side for instructions)

| Period of Exposure (From - To) | Dose for the Period (WLM) | Running Total for Calendar Year (WLM) | Method of Exposure Determination |
|---|---|---|---|
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DH 1834, Edition 9/15 (Replaces Aug 90 edition) - email to RadonReports@FLhealth.gov

**INSTRUCTIONS**

**WORKING LEVEL MONTH EXPOSURE FORM**

**Name**: Name of employee.

**Cert. #**: The certificate number of employee.

**Date of Birth**: Date of birth of employee.

**Business Name Cert. #**: The certificate number of the business.

**Occupational Exposure**: This section is used to record exposure. Exposure may be determined by using the results of a radon or radon progeny test with a log of the amount of time spent conducting the test or by using an alpha track detector or long-term electret ion chamber as a personal monitor with the actual number of hours of exposure. All exposures are recorded in units of working level months (WLM). If personal exposure monitoring is performed using a working level monitor, this information may be used to determine WLM exposure directly. If monitoring is performed using a radon measurement device, the radon concentration must be converted to WL.

**Period of Exposure**: The period of exposure in date/time format. An example calculating exposure using a log sheet is 3-23-90, 8:00 AM to 8:30 AM. An example calculating quarterly exposure using an alpha track or an electret ion chamber is 1-1-90, 8:00 AM to 3- 31-90, 5:00 PM.

**Dose for the Period (WLM)**: The exposure dose in working level months for the exposure period. The exposure dose in WLMs is calculated using the following equation:

$$\text{WLM Exposure} = \frac{WL\ (Working\ Level)\ x\ Exposure\ Time\ (in\ hours)}{170(Hours/month)}$$

WL is calculated using the following equation:

$$\text{WL} = \frac{Radon(in\ pCi/l)\ x\ Equilibrium\ Ratio}{100}$$

If the equilibrium ratio is assumed to be 0.5, WL is calculated using the following equation:

$$\text{WL} = \frac{Radon(in\ pCi/I)}{200}$$

**Running Total for Calendar Year (WLM)**: The total of the dose for the calendar year. This total shall not exceed the levels contained in the worker health and safety program established by the certified business and approved by the department.

**Method of Exposure Determination**: The method used to determine personal exposure. If measurement data from a log sheet is used, enter LOG. If an alpha track detector is used, enter AT. If an electret ion chamber is used, enter EC.

## WORKING LEVEL MONTH SUPPLEMENTAL CALCULATION SHEET

Florida HEALTH

Name: Month Reported:

Certification #: Year:

The total cumulative exposure in the last column should be entered on DOH Form 1834 at the end of each month or calendar quarter.

| Date of Exposure | Device Type And Serial # | Job Number or Address | Avg Radon Level (pCi/L) | (Note 2) | Working Level (WL) | | Hours of Exposure | | Working Level Hours | W-Month (Note 4) | Working Level Months (WLM) | Cumulative Exposure (WLM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample entry | 1.3 | ÷200= | 0.0065 | X | 0.5 | = | 0.00325 | ÷170= | 0.00001912 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | |
| | | | | ÷200= | 0 | X | | = | 0 | ÷170= | 0.00000000 | 0.00001912 |

Notes:
1. Avg Radon Level is the average results for all devices placed at the address.
2. Dividing the average radon by 200 assumes an average equilibrium ratio of 1/2.
3. Hours of exposure is the total time, in hours, spent in the building placing and retrieving devices.
4. 170 hours is equivalent to one working month.

**Figure 8.1. Personal Radon Exposure Record, Source: FDOH**

# Review Questions, Unit 8, Dec 2003, Form A

1. Which worker had the highest total radon exposure activities during one year of work:

   Worker A: investigated houses for 400 hours with an average of 30 pCi/l every hour

   Worker B: installed mitigation systems for 1000 hrs with an average of 15 pCi/l every hour

   Worker C: repaired mitigation systems for 100 hrs with an average of 25 pCi/l every hour

   Worker D: performed screening measurements for 2000 hrs with an average of 10 pCi/l every hour

   A. Worker A
   B. Worker B
   C. Worker C
   D. Worker D

2. Of the following equipment which is NOT a recommended worker protection item for a worker installing a radon mitigation system?

   A. respirator
   B. shin guards
   C. safety glasses
   D. hearing protectors

3. As a mitigator, which of the following is the most cost-effective method to monitor your occupational exposure to radon?

   A. Bring a continuous monitor to each job site
   B. Bring a continuous working level monitor to each job site
   C. Carry an alpha track type detector attached to your shirt
   D. Fill out a log of radon levels of homes you have worked in each week

4. In what unit is total occupational exposure to radon decay products usually tracked?

    A. cubic foot per minute (CFM)

    B. picoCuries per liter (pCi/l)

    C. working levels (WL)

    D. working level months (WLM)

# Answers to Review Questions, Unit 8

| Review Question | Answer | Student Manual, Unit 8, Page Number |
|---|---|---|
| 08.1 | D | 8-9 |
| 08.2 | B | 13-23 |
| 08.3 | C | 10-13 |
| 08.4 | D | 8 |