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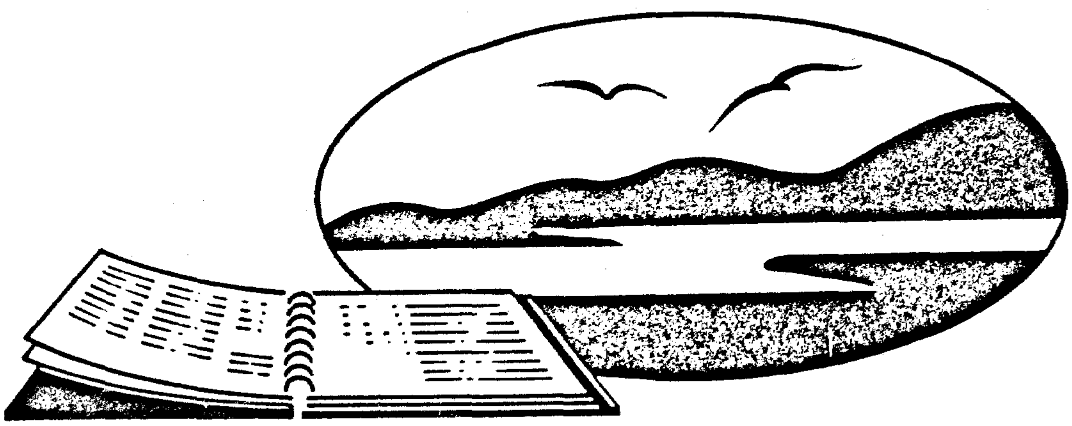
# Radon Mitigation Employee Health And Safety: A Student Manual



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# RADON MITIGATION EMPLOYEE HEALTH AND SAFETY: STUDENT MANUAL

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July 23, 1991

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## I. OVERVIEW AND INTRODUCTION

Radon mitigation is focused upon reduction of occupant risks to environmental hazards. Thus, radon mitigation contractors have the obligation to act safely at all times and to complete mitigation in a manner that poses no hazard to workers or occupants.

This manual is intended to guide radon mitigation contractors and workers through training that reduces exposure to ionizing radiation, particulates and organ vapors as well as excessive noise, electrical hazards, eye hazards, and chemical hazards. However, neither this manual nor related training will address all possible safety problems. Thus, the user of this manual is responsible for consulting with applicable documents and manuals for equipment and supplies used, to establish appropriate health and safety practices (e.g.: 29 CFR 1926; 29 CFR 1910; and 29 CFR 1910.1200---see appendices), to determine the application of related regulations, and, if necessary to consult with an industrial hygienist and other experts to develop a written company worker protection plan that may be required by agencies and others.

This manual supplements but does not replace Occupational Safety and Health Administration (OSHA) or other regulations. The students and instructors using this manual should obtain, read, understand, and comply with companion OSHA and other regulatory standards including those cited in this manual and subsequent revisions. Students are encouraged to seek further training including OSHA respirator training.

This manual draft reflects the review of OSHA's Office of Standards Analysis and Promulgation but not OSHA's Safety Standards Directorate (for electrical and eye safety). This additional review has been requested by the U.S. Environmental Protection Agency's (EPA) Office of Air and Radiation and will be incorporated in future drafts.

## II. 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 radon decay products. Greater than 90% of RDPs can be effectively filtered from breathable air provided the proper respirator is worn according to instructions.

**However, the use of respirators in radon mitigation work is no substitute for ventilating the work space and other proper work practices. The first thing that you should 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 insure worker exposure is as low as reasonably achievable.** Without adequate ventilation, radon and RDP levels can build up without your realizing how much radon you may be breathing. The philosophy that "conditioning the environment for the person, not the person for the environment" should be a guiding principal.

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 subslab or wall pressure-field diagnostics, vacuum cleaners should be discharged to the outside to prevent re-entrainment of soil gas into occupied spaces. Vacuum cleaners 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 picoCuries per liter or 1 working level, whichever is lower. Personnel wearing respirators should be properly trained and medically qualified. Some employers require new employees to submit a physical examination report, including chest x-ray and pulmonary function, and each year thereafter.

The classification of respirators includes: 1) air purifying respirators (APR) that work on the basis of a negative pressure seal with the user's face, such as disposable particulate and half-or full-faced respirators with disposable cartridges; and 2) supplied air respirators such as self-contained breathing apparatus (SCUBA). Selection of respirators should be guided by EPA Order 1440.3 found in the appendix of this manual. EPA Regional Offices may offer additional policy and guidance concerning respiratory selection, training, fit tests and pre-requisite physicals (c.f. US-EPA Region 2, "Respiratory Protection Program", undated).

Although air-purifying respirators can provide significant protection against the inhalation of RDPs, they provide no protection against the inhalation of radon. Protection from the inhalation of radon can only be achieved through the use of air line respirators (self-contained breathing apparatus). It is unclear at this time what the health effects are from high levels of radon with low RDP concentrations.

B. Selecting the Proper Respirator

Radon mitigation work presents workers with at least two general types of inhalation hazards---particles such as radon decay products, asbestos, mold, dust from concrete grinding and drilling as well as vapors from caulks, sealants, or paints that may be used in the course of mitigation work. Particular types of respirators are available which provide specific protection for either or both types of hazards.

Several types of respirators are commonly used by mitigators depending on the type of protection needed.

1. Disposable Particulate Respirators

(a) These respirators, with high efficiency filters, are National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) certified for use in atmospheres containing radionuclides and radon decay product (RDP) particles that account for the major portion of the radiation dose received in most mitigation situations. However, as noted in Section E, disposable respirators cannot be fit checked and thus, should not be recommended over other superior respirators.

(b) Examples: 3M #9970 High Efficiency Respirators; North #10030 Disposable Respirator.

(c) Indications for Use: To be used in environments where RDP's may be present (especially when adequate ventilation is not available). Does not provide adequate protection against organic vapors or radon gas.

2. Organic Vapor Respirators

(a)These respirators are NIOSH/MSHA certified for use in atmospheres with up to 1000 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.

(b) Examples: 3M #5001 series Easi-Care Respirator; 3M #7000 series Easi-Air Respirator; MSA Comfo II Respirator; as well as North, Survivair, Willson and other Models.

(c) Indications for Use: To be used in environments where organic vapors may be present. Organic vapors are released during the application of most paints, caulks, and sealants and during the use of solvent based cleaning solutions. Organic vapor cartridge respirators do not provide adequate protection against RDPs nor radon.

3. Combination Particulate Filter/Organic Vapor Respirators

(a) These are 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.

(b) Examples: 3M #5001 series Easi-Care Respirator fitted with 3M #2040 HEPA pre-filter; 3M #7000 series Easi-Air Respirator fitted with #7251 organic vapor cartridge and #7255 radionuclide particulate filter; MSA Comfo II Respirator fitted with Type GMC-S filter/cartridge combination; and similar North, Survivair, Willson, and other models.

(c) Indications for Use: To be used in environments where both RDPs and organic vapors may be present. 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 (xylene?).

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 facepiece
- the temple pieces on glasses
- the absence of one or both dentures (upper or lower teeth)
- facial scars.

If any of these or other conditions prevent the proper fit of an air-purifying respirator, this type of respirator cannot be worn. 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.

D. Respirator Inspection Procedures

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

1. Disposable Particulate Respirators

(a) Examine the foam face seal for any tears or deformities that might interfere with the achievement of a proper face seal.

(b) If any portion of the respirator facepiece is wet, it should be set aside and allowed to dry in a clean, uncontaminated place. Respirators which become saturated with water or other fluids should be disposed of.

(c) Inspect the metal nosepiece for creases or any deformity that might interfere with the achievement of a proper face seal.

(d) If the respirator has become contaminated or crushed, deformed, or damaged such that the fit or face seal can no longer be achieved, dispose of the respirator and replace it with a new one.

2. Organic Vapor Respirators

(a) Check the facepiece for cracks, tears and dirt. Be certain the facepiece, especially the seal area, is not distorted. The material must be pliable---not stiff.

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

(c) Examine that the heads straps are intact and have good elasticity.

(d) Examine all plastic parts for signs of cracking or fatiguing. Make sure the gaskets are properly sealed.

(e) 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 Facefit Checks Prior to Entering a Contaminated Area

The techniques described here apply to facefit checks of half-mask and full-face cartridge respirators. Disposable respirators cannot be fit checked and thus, should not be recommended as a substitute for superior respirators. Before wearing a respirator in a contaminated area, carefully follow the fitting instructions applicable to specific respirator models provided by the manufacturer with each respirator.

1. Positive Pressure Facefit Check

Place palm of hand over the exhalation cover and exhale gently. If the facepiece bulges slightly and no air leaks between the face and the facepiece 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.

2. Negative Pressure Facefit 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 facepiece 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 facefit checks must be conducted by the respirator wearer prior to each entry into a contaminated area.

F. Conducting Qualitative Respirator Fit-Testing

Both of the following protocols involve two steps. First, it is determined if the individual can detect the taste of saccharin or the odor or isoamyl acetate and, if so, then it is determined if the respirator prevents detection of the taste or odor. NOTE---the validity of qualitative fit-testing is dependent upon the individual's response.

1. Saccharin Solution Aerosol Protocol for Disposable Particulate Respirators

(a) Taste Threshold Screening
The saccharin taste threshold screening, performed **without** wearing a respirator, is intended to determine whether the individual being tested can detect the taste of saccharin.

(1) Threshold screening as well as fit testing subjects shall wear an enclosure about the head and shoulders that is approximately 12 inches in diameter by 14 inches tall with at least the front portion clear and that allows free movements of the head when a respirator is worn.

(2) The test subject shall don the test enclosure. Throughout the threshold screening test, the test subject shall breathe through his/her wide open mouth with tongue extended.

(3) Using a nebulizer the test conductor shall spray the solution into the enclosure.

(4) To produce the aerosol, the nebulizer bulb is firmly squeezed so that it collapses completely, then released and allowed to fully expand.

(5) Ten squeezes are repeated rapidly and then the test subject is asked whether the saccharin can be tasted.

(6) If the first response is negative, ten more squeezes are repeated rapidly and the test subject is again asked whether the saccharin is tasted.

(7) If the second response is negative, ten more squeezes are repeated rapidly and the test subject is again asked whether the saccharin is tasted.

(8) The test conductor will take note of the number of squeezes required to solicit a taste response.

(9) If the saccharin is not tasted after 30 squeezes (step 10), the test subject may not perform the saccharin fit test.

(10) If a taste response is elicited, the test subject shall be asked to take note of the taste for reference in the fit test.

(b) Saccharin Solution Aerosol Fit Test Procedure

(1) The test subject may not eat, drink (except plain water), or chew gun for 15 minutes before the test.

(2) The test subject shall don the enclosure while wearing the respirator selected. The respirator shall be properly adjusted and equipped with a particulate filter(s).

(3) As before, the test subject shall breathe through the open mouth with tongue extended.

(4) The nebulizer is inserted into the hole in the front of the enclosure and the fit test solution is sprayed into the enclosure using the same number of squeezes required to elicit a taste response in the screening test.

(5) After generating the aerosol the test subject shall be instructed to perform the following exercises:

(a) Normal breathing. In a normal standing position, without talking, the subject shall breathe normally.

(b) Deep breathing. In a normal standing position, the subject shall breathe slowly and deeply taking caution so as to not hyperventilate.

(c) Turning head side to side. Standing in place, the subject shall slowly turn his/her head from side to side between the extreme positions on each side. The head shall be held at each extreme momentarily so the subject can inhale at each side.

(d) Moving head up and down. Standing in place, the subject shall slowly move his/her head up and down. The subject shall be instructed to inhale in the up position (i.e., when looking toward the ceiling).

(e) Talking. The subject shall talk out loud slowly and loud enough so as to be heard clearly by the test conductor. The subject can read from a prepared text such as the "Rainbow Passage," count backward from 100, or recite a memorized poem or song. The Rainbow Passage reads as follows:
When the sunlight strikes raindrops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long round arch, with its path high above, and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look but no one ever finds it. When a man looks for something beyond reach, his friends say he is looking for the pot of gold at the end of the rainbow.

(f) Grimace. The test subject shall smile or frown.

(g) Bending over. The test subject shall bend at the waist as if he/she were to touch his/her toes. Jogging in place shall be substituted for this exercise in those test environments such as shroud type QNFT units which prohibit bending at the waist.

(h) Normal breathing. Same as exercise 1. Each test exercise shall be performed for one minute except for the grimace exercise which shall be performed for 15 seconds.

(6) Every 30 seconds the aerosol concentration shall be replenished using one half the number of squeezes as initially.

(7) The test subject shall indicate to the test conductor if at any time during the fit test the taste of saccharin is detected.

(8) If the taste of saccharin is detected, the fit is deemed unsatisfactory and a different respirator shall be tried.

2. Isoamyl Acetate Protocol for Organic Vapor Respirators

(a) Odor Threshold Screening
The odor threshold screening test, performed **without** wearing a respirator, is intended to determine if the individual tested can detect the odor of isoamyl acetate.

(1) The screening test shall be conducted in a room separate from the room used for actual fit testing. The two rooms shall be well ventilated but shall not be connected to the same recirculating ventilation system.

(2) Two jars of similar appearance shall be prepared---one containing a cloth swab wetted with 0.5 cc of isoamyl acetate (IAA) solution and the other containing a cloth swab wetted with 0.5 cc of odor free water (e.g. distilled or spring water). Subjects will be requested to select the jar with the banana oil smell to determine whether or not the individual tested can detect the odor of isoamyl acetate.

(3) The odor test jar and blank jar containing water shall be labeled 1 and 2 for jar identification.

(4) The following instruction shall be typed on a card a placed on the table in front of the two test jars (i.e. 1 and 2): "The purpose of this test is to determine if you can smell banana oil at a low concentration. The two jars in front of you contain clear liquids. One of these jars contains a small amount of banana oil. Unscrew the lid of each bottle, one at a time, and sniff at the mouth of the bottle. Indicate to the test conductor which bottle contains banana oil."

(5) If the test subject is unable to correctly identify the jar containing the odor test solution, the IAA qualitative fit test shall not be performed.

(6) If the test subject correctly identifies the jar containing the odor test solution, the test subject may proceed to respirator selection and fit testing.

(b) Isoamyl Acetate Fit Test Procedure

(1) Each respirator used for the fitting and fit testing shall be equipped with organic vapor cartridges or offer protection against organic vapors.

(2) After selecting, donning, and properly adjusting a respirator, the test subject shall wear it to the fit testing room. This room shall be separate from the room used for odor threshold screening and respirator selection, and shall be well ventilated, as by an exhaust fan, lab hood, or open window to prevent general room contamination.

(3) Using respirator fit-test ampules (e.g., North Safety Equipment #7002 or similar product), hold the crushed swab 2 to 3 inches from where the respirator facepiece seals to the face and using a circular motion, slowly move the swab around the entire perimeter of the respirator seal.

(4) While performing this motion, the exercises previously identified in section F.1.(b)(5) shall be performed by the test subject.

(5) If at any time during the test, the subject detects the banana like odor of IAA, the test has failed. The subject shall quickly exit from the test area and leave the room to avoid olfactory fatigue.

(6) If the test has failed, the subject shall return to the selection room and remove the respirator, repeat the odor sensitivity test, select and put on another respirator, return to the test area and again begin the procedure described in (1) through (4) above. The process continues until a respirator that fits well has been tried. Should the odor sensitivity test be failed, the subject shall wait about 5 minutes before retesting. Odor sensitivity will usually have returned by this time.

(7) When a respirator is tried that passes the test, its efficiency shall be demonstrated for the subject by having the subject break the face seal and take a breath before exiting the test area.

(8) To prevent an excessive isoamyl acetate concentration build-up in the test area, used swabs shall be stored in a sealed container and general ventilation of the test room shall be maintained.

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.

1. Cleaning and Sanitizing of Respirators

(a) Cleaning and sanitizing is recommended after each use and should be the user's responsibility. Disassemble the respirator by removing the cartridges, pre-filters, headbands and other parts.
(b) Immerse the facepiece and headband in warm cleaning solution detergent if necessary or use a cleaner-sanitizer solution. Avoid using detergemts containing lanolin or other oils.
(c) Rinse in plain warm water and air dry in a non-contaminated atmosphere. Do not use excessive warm water (over 120 degrees) to avoid possible overheating and distortion of the respirator pieces.

2. Maintenance and Storage of Respirators.

(a) After the cleaned and sanitized respirator is dry, the respirator should 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
(b) When the respirator is not in use it should 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 facepiece 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. If you are in a contaminated area when any of these conditions occur, you must leave the area immediately.

1. If while wearing the respirator:
(a) you smell or taste contaminants
(b) you experience difficulty breathing
(c) irritation occurs
(d) dizziness or other distress occurs

2. Discard and replace the respirator or respirator cartridges if damaged or deformed. A respirator cannot be relied on for protection from respirable contaminants if a proper face seal cannot be achieved.

Refer to manufacturers instructions regarding limitations of respirator use which may apply to specific respirator models.

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

Employer 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 of this manual.

## III. MONITORING WORKER RADON EXPOSURE

A. Need for Monitoring Worker Radon Exposure

Those involved in radon work---whether in radon measurement services, the investigation of buildings with elevated radon levels, or the performance of radon mitigation---can be exposed to high levels of radon and radon decay products (RDP's). Because these work-related exposure to radon are much higher than the normal exposures of the occupants of problem buildings, it is imperative that measures be taken to minimize occupational exposures to radon and to keep accurate records of all occasions during which workers are exposed to radon and RDP's.

There is currently no single recommended method of monitoring radon mitigator workers for exposure to radon and RDP's. A method of monitoring employee exposure to RDP's is given in Part F of this section.

B. Units of Measurement

Health effects from radon exposure are due primarily to the radon decay products and the effect they have on lung tissue. Radon decay products (RDP's; also known as radon daughters or radon progeny) are measured in "Working Levels" (WL). This is a unit of measurement indicative of the energy eventually released during the RDP decay process. A Working Level is any combination of radon decay products in one liter of air that results in the release or emission of $1.3 \times 10^5$ or 130,000 mega electron volts (MeV) of alpha particle energy.

Radon gas is commonly measured in picoCuries per liter (pCi/L). The picoCurie is a measure of activity or rate of decay indicating 0.037 decays of radon per second (or 2.2 decays per minute). The law of radioactive decay states that the rate of decay is proportional to the number of remaining undecayed nuclei of atoms. Therefore, pCi/L represents the concentration of radon gas in the air (i.e., the number of nuclei of radon atoms in the air per volume of air).

Since radon's health effect---its dose to the lung tissue---is due mostly to the radon decay products, it would appear that the chosen detection instrument should measure these decay products directly. In practice, however, measurements of radon gas---rather than of RDP's---are often taken because there are fewer variables in radon measurement, so there is greater certainty in representative results. For instance, unlike that of RDP's, radon concentration is not affected by circulation or filtration devices. Also, for time averaging measurements, radon gas measurements are generally more practical, easier, and less expensive to make. Therefore, it is common practice to use instruments which measure radon gas only and then make conversions to RDP exposure levels for estimating risk. Measurement of radon defines the maximum concentration possible of RDP's.

C. Equilibrium Ratio

Once radon enters a building, it begins to form decay products. The amount of RDP's found at a given radon concentration varies depending on such factors as air movement, air exchange and air filtering.

It is difficult to measure levels of RDP's precisely. However, there is a relationship between the concentration of decay products compared to the parent radon. This relationship is referred to as **equilibrium:** radon is said to be at complete equilibrium with its decay products when the maximum concentration of these products has been reached. In a sealed volume of **100 pCi/L** of radon, RDP's will theoretically achieve a maximum concentration of **1 working level** in 3 to 4 hours. Equilibrium is theoretically represented by an equilibrium ratio (ER) of:

$$ER = \frac{\text{(WL value) (100)}}{\text{Radon Concentration}} = \frac{(1)\ (100)}{100}$$

However, theoretical equilibrium (i.e., ER=1) does not occur indoors because ventilation removes both radon and its decay products; also, it takes time for entering radon to produce decay products. As a result, the ER will be less than 1. Further, because RDP's have a static charge, they plate out on walls, furniture, and other solid objects; this reduces the ER without affecting the radon concentration.

Generally, then, for 100 pCi/L of radon gas in a building, there will be less than 1 WL of decay products: in most buildings, 100 pCi/L produce from 0.3 to 0.7 WL. The ER consequently ranges between 0.1 to 0.7; an ER of 0.5 is commonly assumed as an average. Based on this assumption, a building with 50 pCi/L can be expected to have about 0.25 WL; a building with 4pCi/L is likely to have about 0.02 WL.

If the ratio is unexpectedly high, indicating more decay products than anticipated, there is probably a relatively stable indoor environment with little air movement removing decay products. On the other hand, an unexpectedly low ratio suggests a high degree of air movement, exchange, or filtering and a large number of particles in the air for RDPs to attach to.

A reliable WL measurement allows for estimating radon concentration (using an assumed ER value), although it is not possible to guess the upper limits of such concentration. However, a reliable measure of radon gas concentration enables estimation of the upper limit of RDP concentration

OCCUPATIONAL EXPOSURE, ACCORDING TO OSHA AND BASED UPON THE NRC STANDARD (10 CFR 20, Table 1, footnote 3), REFLECTS AN ER OF 1 (for example, 100 pCi/L is equivalent to 1 WL). As noted later in this manual (section E), the EPA guidance based upon an ER of 0.5 and the OSHA standard based upon an ER of 1.0 are in agreement in respect to maximum worker exposure.

D. Calculating Worker Exposure to Radon and Radon Decay Products

Using the units of measurement for radon (pCi/L), for radon decay products (WL), or the concept of an equilibrium ratio (ER) (and given various levels of radon and RDP's present in a building during mitigation work) we can calculate the exposure of radon workers to these substances.

The following points review units of measurement calculations (pCi/L, WL, WLM) and the equilibrium ratio concept and apply these to monitoring worker exposure.

1. Concept of Equilibrium Ratio (ER)

(a) $ER = \frac{(\text{WL value})\ (100)}{\text{Radon Concentration}}$

(b) Radon and RDP's are in "equilibrium" when maximum RDP's concentration reached.

(c) ER = 1 does not occur indoors (explain why);
ER ranges between 0 and 1; ER usually between 0.1 or 0.2 and 0.7.

(d) ER of 0.5 is commonly assumed as a conservative average.

2. ER Calculation Exercises

(a) Question: You are about to begin mitigation work in a building with a radon measurement of 69 pCi/L and a working level measurement of 0.30. What is the equilibrium ratio?

Answer: $ER = \frac{(WL)\ (100)}{pCi/L} = \frac{(0.30)\ (100)}{69} = 0.43$

(b) Question: You are monitoring a basement crawlspace for radon and detect a level of 146 pCi/L. Assuming an ER of 0.5, what is the estimated WL measurement in the crawlspace?

Answer: $ER = \frac{(WL)\ (100)}{pCi/L}$ or $0.5 = \frac{WL\ (100)}{146}$ or $WL = \frac{0.5 \times 146}{100} = 0.73$

3. General Relationship of Units of Radon Measurement (pCi/L) to Units of RDP's Measurement (WL)

(a) 4 pCi/L = 0.02 WL
200 pCi/L = 1 WL

(b) Assumes an ER of 0.5

(c) Employees are generally monitored for radon exposure and measurements are then converted to RDP exposure level units (WL).

4. Conversion Formula $WL = \frac{pCi/L \times ER}{100}$

$$pCi/L = \frac{WL \times 100}{ER}$$

5. Working Levels (WL) and Working Level Months (WLM)

(a) Occupational exposure to RDP's is measured in working level months (WLM)

(b) One WLM is the equivalent of exposure to 1 WL for 170 hours. (This assumes 170 working hours per month).

(c) RDP's measurement levels (in WL's) are multiplied by the duration of exposure (in hours) and divided by 170 to obtain exposure levels in WLM's.

6. WLM Calculation Exercises

(a) 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

Answer: 0.053 WLM

For Example: 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) Question: Listed below are levels of employee exposures to radon and corresponding exposure times. Calculate total employee exposure in WLM's.

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 (PCI/L) | | WORKING LEVEL (WL) | | HOURS OF EXPOSURE (HR) | | WORKING LEVEL MONTHS (WLM) |
|---|---|---|---|---|---|---|
| 180 | /200 = | .9 | x | 1 | /170 = | .0053 |
| | /200 = | | x | | /170 = | |
| | /200 = | | x | | /170 = | |
| | /200 = | | x | | /170 = | |

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

E. Current Guidelines for Occupational Exposure to Radon Decay Products

Occupational exposure is measured by working level months (WLM). One WLM is the equivalent of exposure to 1 working level for 170 hours; this assumes 170 working hours per month. The MSHA standard for uranium mine workers and OSHA standard for occupational exposure is 4 WLM per year (with 100pCi/L = 1WL). The Environmental Protection Agency (EPA) uses a guideline of 2 WLM per year for employees and contractors working on radon projects (with 200 pCi/L = 1WL). Thus, the MSHA, OSHA, and EPA standards and guidelines are in essential agreement in respect to radon (about 33 pCi/L average over 2040 hours or 12 working months).

F. 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 that are 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 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 crawl spaces, sumps, floor drain, etc.

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

This manual 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 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. Guidelines and Protocols for Mitigation Work to Minimize Radiation Exposure

The ALARA (as low as reasonably achievable) principle should be followed when considering work procedures and practices during any radon related work (see section IV-A).

3. General Employee Monitoring Considerations

Methods used for monitoring employee exposure to RDP's should follow the general precautions for all measurement activities. Detectors used for monitoring employee exposure should be EPA Radon Measurement Proficiency (RMP) program listed. 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, 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.

(a) ATD - Although alpha track detectors (ATDs) do not meet all of these criteria, several features of ATD's make them a candidate for monitoring employee exposure. The following features of ATD's make them desirable for monitoring employee exposures.

* inexpensive
* small and unobtrusive
* measure radon, not RDP's (see section B)
* convenient and easy to use
* light weight
* measure integrated radon concentrations over long period---typically 3 months to a year
* yield truly integrated radon levels (not biased toward most recent exposure)

The following limitation of ATD's 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.

(b) E-PERMS - Electret-Passive Environmental Radon Monitors (E-PERMs, tradename; Electron Ion Chamber, generic name) are another option for monitoring employee exposure. E-PERMs share many of the characteristics of ATDs although, at the time this manual was written (February, 1991), the small chamber E-PERM marketed for employee monitoring was not EPA-RPM listed.

4. Monitoring Employee RDP Exposure:

(a) Each worker should be monitored with his/her own ATD or E-PERM and measurement results should be documented on his/her own Personal Radon Exposure Record (see Figure 1).

(b) In addition to separate ATDs or E-PERMs for individual employee monitoring, allowance must be made for background radiation and a monitor must be dedicated for this purpose. ATDs or E-PERMs 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.

Students should be alert to future EPA or other guidance concerning employee occupational and background monitoring.

(c) Each ATD or E-PERM should be clearly labeled 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).

(d) 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, representative background radiation measurements corresponding to each employee's personal ATD are subtracted from employee ATD measurements to estimate actual work-related exposure. E-PERM users should follow manufacturers recommendations and future EPA guidance.

(e) Radon mitigation contractors should consult with monitor suppliers concerning storage, deployment, collection, shipping, and quality assurance/quality control involving employee monitoring.

(f) Radon measurement results from the lab must be converted from pCi/L to WL's and entered on each employee's Personal Radon Exposure Record (see Figure One).

## IV. 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.

#### 1. Ventilation

Ventilation of work spaces suspected of having elevated radon levels should begin immediately upon arrival at the work site (ventilation should be initiated prior to commencing work whenever possible, particularly in elevated radon environments). This should be initiated even as radon or decay particle monitoring is being set up. The amount of ventilation required will be dependent upon a number of factors including: existing radon concentrations, size (air volume) of the work space and other pertinent factors (presence of friable ACM-like material; ability to temper the outside ambient air when it is very hot, cold, or damp; etc.). 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). Using an ionization filtration system (e.g. No-Rad Radon Removal System should be considered in appropriate situations. Respirator should be worn (only if following an approved respirator plan) when the measures do not sufficiently reduce radon and/or decay product concentrations.

#### 2. Logistics

Whenever possible, radon mitigation tasks should be performed in areas with low radon concentrations (outside, garage, first floor, breezeway, etc.). This would include both 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.

3. 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 will help to minimize air particulates which are a hazard in of themselves and more so when attached to radon decay products. 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 being drilled. This will direct most all of the available sub-soil radon and radon decay products 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.

4. Sequence of Installation

The installation of any active soil depressurization system should normally be installed so that any intrusive activity (floor and/or wall hole) is performed after the rest of the active system is operational. With the fan and the RVD manifold functioning, floor and wall taps can be drilled and/or cored, then connected quickly so as to remain open a minimum amount of time.

5. Miscellaneous

Certain mitigation situations may require special arrangements or procedures to minimize worker exposure.

Some crawl space and basement activities can be minimized by using a team approach in handling equipment and materials, thereby reducing the overall groups 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. Noise and Hearing Conservation

1. Noise is a Significant Health Hazard

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 whether in the course of mitigation work or elsewhere.

2. The Characteristics of Sound

Sound is nothing more than the reaction felt by a listener when minute cyclic changes in barometric pressure occur. The action of sound waves move a sound from where it is produced to the ear, where hearing takes place.

Sound waves are made up of molecules of air bumping into each other, transferring energy outward from a source, such as a clap of thunder or the chirping of a bird. This source disrupts the barometric pressure around it, and causes the air molecules to bump into each other, away from it, much like when a ripple is created in water if a pebble is dropped into it.

The following terms are **key concepts** that are important for the understanding of noise as a significant health hazard.

Intensity------------------ Intensity is described in decibels (1/10 of a "Bel") - in honor of Alexander Graham Bell. A reference must be specified or there is no meaning to decibel.

Decibel (dB)------------- Sound is measured in terms of sound levels which are expressed in decibels. Zero on the decibel scale is regarded as the lowest sound level that the healthy unimpaired human ear can detect (a sound level of 20 micronewtons per square meter). Decibels are logarithmic and not linear units like miles or pounds. Rather, they are representative points on a sharply rising curve. Thus, while 10 dB is 10 times more intense than one dB, 20 dB is 100 times more intense than 1 dB (10 x 10), 30 dB is 1,000 times more intense than 1 dB (10 x 10 x 10) and so on. One hundred dB, therefore, is 10 billion times as intense as 1 dB (that is, represents 10 billion times as much acoustic energy) as one decibel.

Sound Pressure Level- is . . . (ADD) . . . and it is sound pressure level that is measured by sound level meters.

Pure Tone---------------- Pure tone does not normally occur in nature. It is made by humans. It is the fundamental component and in its pure form is a sinusoidal oscillation of barometric pressure. The number of oscillations per second is the **"frequency"** of a pure tone and is identified as Hertz (Hz) - the greater the number, the higher the frequency. **"Pitch"** is the term used to sensation of frequency.

Hearing threshold------ is the degree of loudness at which you first begin to hear a sound.

Attenuation-------------- Attenuation is the reduction in sound pressure level (dBA) obtained by distance, barriers, hearing protection, audio booth walls, etc. **High frequencies (Hz) are attenuated, or reduced more rapidly than low frequencies.**

Figure 1

## PERSONAL RADON EXPOSURE RECORD

Name:______________________________ Month(s):______________________

Social Security #:__________________________ Year:______________________

| Date | Job Site or Number | Radon Level (PCI/L) | Working Level (WL) | Hours of Exposure (HR) | Working Level Months (WLM) | Cumulative Exposure[1] (WLM) | Type/ Model of Monitor[2] | Serial Number | Supervisor's Initials |
|---|---|---|---|---|---|---|---|---|---|
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |
| | | /200 = | x | /170 = | | | | | |

1. Based upon an annual recommended health and safety limit of 2 working level months (WLM).

2. Indicate the type of monitor
   1. Charcoal Canister
   2. Alpha Track Detector
   3. E-PERMS
   4. Continuous Monitor (Type):
   5. Other (Specify

## 3. The Harmful Effects of Excessive Noise

Excessive noise can damage parts of the human hearing (auditory) system---primarily the inner ear---and can result in the gradual loss of hearing. Excessive noise also has harmful effects on health in addition to its effect on hearing (i.e., prolonged noise exposure causes headaches and other adverse symptoms). Both the auditory and non-auditory effects of excess noise exposure are briefly reviewed in this section.

### (a) Auditory Effects of Noise

When exposed to intense sound waves for an extended period of time, temporary damage to hearing can occur. For example, after a loud concert or a long period in a noisy nightclub we experience ringing in the ears or "tinnitus". This is a temporary symptom due to damage to the hearing organ within the inner ear (the cochlea) that resolves after several hours away from noise in a quiet environment.

Another symptom of excessive noise exposure is a gradual dullness of sound as if both ears were partially blocked that occurs due to exposure to intense noise. This condition is also temporary as hearing returns to the usual clarity after its allowed to "rest" from the intense noise for several hours.

Pain can also occur as a result of sudden, very intense noise, as those of us who've experienced pain due to jet take off, explosions, and artillery fire can attest. Depending on the duration of the noise the pain can be followed by a period of tinnitus, yet both symptoms resolve after a period of time away from the noise exposure.

Permanent hearing loss may occur as a result of exposure to loud noises for extended periods of time. The hearing loss associated with exposure to work-related noise is commonly referred to as "acoustic trauma." This type of hearing loss is the result of nerve or hair cell destruction in the hearing organ and is irreversible. No form of medical care or surgery can repair the damage to hearing caused by overexposure to noise.

However, such hearing losses usually are only partial. That is, excessive noise exposure does not result in simultaneous loss of hearing at all sound frequencies. Hearing loss is first evident in the reduction of the ability to hear high frequency sounds.

The most common levels of work-related noise exposures are well below the pain threshold for noise. Pain is experienced at noise levels of 135-140 dBA and above. There is a wide range of noise levels and frequencies to which long-time exposure may cause a slowly developing impairment of hearing. The part of the inner ear that may be damaged depends on the frequency components of the noise field that are present at the levels of exposure. Individual susceptibility of the exposed worker may also be a factor. Noise-induced permanent hearing loss is first evident in a reduction in the ability to hear high frequency sounds. As the exposure continues, the reduction progresses to the lower frequency sounds in the speech range. Exposure to noise that will produce this slow damage may sometimes be accompanied by other signs, such as a sensation of tingling or ringing in the ear (tinnitus) when one moves out of the noise field. Current evidence indicates that any permanent effect on the hearing organ is unlikely unless it is preceded by a temporary threshold shift of the hearing level. This shift can be detected by an appropriate program of hearing testing, and this information can serve to warn overexposed personnel that there is a risk of permanent damage to hearing.

There is a gradual loss in hearing sensitivity that takes place as people grow older. This decrease in hearing sensitivity accompanying the aging process is known as **presbycusis.** Hearing losses due to acoustic trauma and presbycusis are both due to nerve or hair cell destruction or deterioration, and both are permanent. Hearing loss due to these causes cannot be distinguished from one another by audiometric means (i.e., hearing acuity tests).

Noise exposure, then, can accelerate the progressive loss of hearing we all suffer as we grow older. To learn just how much, scientists visited an isolated area in Africa to examine the hearing acuity of a large number of elderly tribesmen and their youthful counterparts. Their findings: men in their 70s and 80s had hearing sensitivity nearly equal to that of the young boys and equivalent to that of Americans 30 to 40 years their junior.

(b) Non-Auditory Effects of Noise

In addition to its effect on hearing, excessive noise exposure has other harmful effects on health. At sound levels above 35-45 decibels, noise disturbs a sleeping person. At levels above 50-60, it disturbs conversation. All across this range people experience annoyance and disruption of their activities. And at levels of 85 decibels or above, stress reactions can be expected.

When the brain perceives noise, it reacts. Most of us automatically interpret unexpected noise as danger, a signal to prepare to fight or run. It may be a subconscious reaction, but it is clearly indicated by the physical changes that take place in response to noise. Even a sound of moderate volume and short duration such as a heavy truck passing on the other side of the street (rated about 80 decibels), produces a remarkable number of these physical changes. Blood vessels in the brain dilate while blood vessels in other parts of the body constrict. Blood pressure rises, and the heart rhythm changes. The pupils of the eyes dilate. The blood cholesterol level rises. Various endocrine glands pour additional hormones into the blood. Even the stomach changes its rate of acid secretion. While most of these reactions are only temporary, the modern environment presents such ever-changing noise levels that some of these "temporary" effects become chronic.

Ulcers, indigestion, "heartburn", gastro-intestinal malfunctions, heart disease, all are connected to stress in general and since noise is interpreted by the body as a stress, noise may also be a contributing factor in the rate of occurrence of these disease conditions.

4. 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 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.

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 sometime. In fact, this is one of the few instances where the knowledge of control technology exceeds the knowledge about the 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 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.

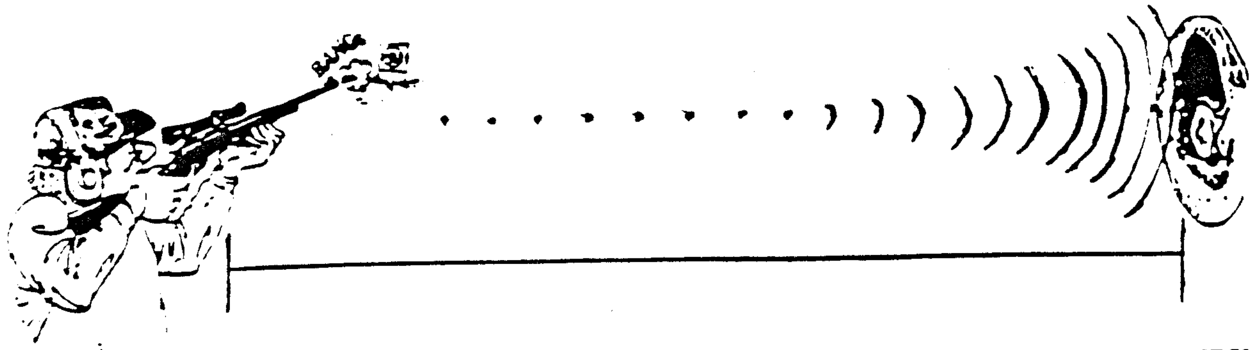


Figure 2. The 3 stages of the noise transmission pathway.

- 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 2) using various types of hearing protection. This is the most practical method of noise control for mitigation work.

5. 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 briefly described as follows.

(a) Standard Hearing Protection Devices

(1) Earmuffs

Earmuff devices cover the external ear to provide an acoustic barrier. The attenuation provided by earmuffs varies widely due to differences in earmuff size, shape, seal materials, shell mass, and type of suspension. Head size and shape also influence the attenuation characteristics of these protectors. The type of cushion used between the shell and the head has a great deal to do with attenuation efficiency. Liquid-filled cushions give better noise suppression than foam rubber types.

Of these two types, foam-filled earmuffs are lighter, less expensive, and provide a lower level of noise attenuation efficiency than liquid-filled earmuffs. Both types have adjustable headbands that accommodate various head sizes. It is important that the earmuffs be adjusted and properly seated

around the ears for both comfort and optimum noise attenuation. Examples of foam-filled earmuffs include:
*Bilsom "Universal I"
*Howard Leight "QM24"

Examples of liquid-filled earmuffs include:
*Bilsom "Viking"
*Howard Leight "QM27"
*Howard Leight "Thunder 29"

(2) Earplugs

Premolded Earplugs

Molded ear canal inserts are usually made from a soft silicone rubber or a plastic. The most important aspect of this type of hearing protection is to get a good fit. The hearing protector must fit snugly in order to be effective. For some persons, this may cause some discomfort because of the irregular shape of the external ear canal that some people possess. These earplugs must be kept clean to avoid infection; also, by cleaning them---with a mild soap and water---their life is prolonged. Examples of premolded earplugs include:
*EAR "UltraFit"
*American Optical "Hear Guard"
*North "Com-Fit"
*Howard Leight "Air Soft"
*Bilsom "Per-Fit"

Formable Earplugs

The formable type of earplug fits all ears. Most of the formable types are designed for one-time use and then thrown away. Material from which these disposable plugs are made include very fine glass fiber, wax-impregnated cotton, and expandable foam plastic. Examples of formable earplugs include:
*EAR Disposable Earplugs
*Bilsom "Ultra Soft"
*North "DeciDamp"
*Howard Leight "Quiet"

(b) Nonstandard Hearing Protection Devices

(1) Canal Caps (Superaural Hearing Protectors)

Superaural types of hearing protector depend on sealing the external edge of the ear canal in order to achieve sound reduction. A soft rubber-like material is used to make the canal caps. They are held in place against the edges of the ear canal by a spring band or a head suspension. Examples of canal caps include:
*American Optical "Sound Out"
*Howard Leight "QB2"
*EAR "Caps"

(2) Custom-molded Hearing Protection

Hearing protection of this type is custom designed for a specific individual. In designing most types of custom-molded hearing protectors, a prepared mixture is placed in the individual's outer ear with a small portion of it in the ear canal. As the material sets, it takes the shape of the individual's ear and external ear canal. These special, custom-fit devices are only available from hearing specialists (i.e. certified audiologists and otolaryngologists--ear, nose, throat physicians).

6. 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.

The following table lists selected types of hearing protectors and their corresponding NRR's.

TABLE 1.
EPA "Noise Reduction Ratings" (NRR)
for
Selected Types of Hearing Protection

| General Category | Manufacturer & Model Examples | Noise Reduction Rating |
|---|---|---|
| CANAL CAPS | American Optical "Sound Out" | 17 decibels |
| | Howard Leight "QB2" | 25 decibels |
| EARPLUGS (Formable) | Bilsom "Ultra Soft" | 26 decibels |
| | Howard Leight "Quiet" | 26 decibels |
| EARPLUGS (Premolded) | American Optical "Hear Guard" (Corded and Uncorded) | 24 decibels |
| | Howard Leight "Air Soft" | 27 decibels |
| EARMUFFS | Howard Leight "QM24" | 24 decibels |
| | Bilsom "Universal I" | 24 decibels |
| | Howard Leight "Thunder 29" | 29 decibels |
| | Bilsom "Viking" | 29 decibels |

7. 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 workplace noise level using a sound level meter or through 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 workplace 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.

8. OSHA's "Occupational Noise Exposure" Standard (29 CFR 1910.95)

In the early 1980's the Occupational Safety and Health Administration (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 workplace 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.

Other important components of a hearing conservation program as outlined in this standard include:

* Monitoring noise levels in the workplace 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 workplace noise levels, employee audiometric test results, and employee training records.

B. Asbestos and Radon Mitigation Work

1. Products Containing Asbestos

Despite the health hazards associated with exposure to asbestos, it is currently found in a wide variety of products including:

* friction products such as clutch facings; brake linings for railroad cars and airplanes; and industrial friction materials.
* asbestos cement sheet and pipe products used for water supply and sewage piping, roofing and siding, casings for electric wires, fire protection material, chemical tanks, electrical switchboards and components, residential and industrial building materials.
* floor tile; gaskets and packings; paints, coatings, and sealants; caulking and patching tape; ceiling tile; and plastics.
* asbestos paper for table pads and heat-protective mats, insulation products, filters for beverages, electric wire insulation and small appliance components.
* asbestos textiles for packing components, roofing materials, heat-and fire-protective clothing, electrical wire and pipe insulation, and theater curtains and fireproof draperies.

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; underlayment for sheet flooring; textured ceiling finishes; gaskets and packings; equipment and storage tank insulation.

2. Health Hazards Associated with Asbestos

Exposure to asbestos may increase the risk of these serious diseases:

a. Asbestosis---a chronic lung ailment that can produce shortness of breath, permanent lung damage, and increased risk of dangerous lung infections.
b. Lung cancer
c. Mesothelioma---a relatively rare cancer of the thin membranes lining the chest and abdomen.
d. Certain other cancers such as cancers of the larynx, stomach, colon and rectum, and esophagus.

While asbestos exposure itself can increase the risk of developing lung cancer, asbestos and cigarette smoking together may increase lung cancer risk over the already high risk due to smoking alone. Cigarette smokers, on the average, are 10 times as likely to develop lung cancer as nonsmokers. Smokers who are also heavily exposed to asbestos has been shown to be up to **90 times more likely to develop lung cancer** than nonexposed individuals who do not smoke.

There is evidence that quitting smoking will reduce risk among asbestos-exposed workers, perhaps by as much as half or more. Workers who were exposed to asbestos on the job at any time during their lives or who suspect they may have been exposed should not smoke.

3. Occupational Exposure Limits for Asbestos

As a results of the serious health risks associated with asbestos, regulatory control over occupational and environmental exposure to asbestos has become increasingly stringent. OSHA's health standard for occupational exposure to asbestos currently limits workers to an airborne asbestos concentration of no more than 0.2 fibers per cubic centimeter (cc) of air as the average 8-hour workday exposure (8-hour Time-Weighted-Average). In addition, no employee may be exposed to a concentration in excess of 1.0 fiber per cc of air as averaged over a sampling period of thirty (30) minutes. (This is a so-called short term "excursion limit". Generally the most toxic substances are given these exposure restrictions by OSHA).

NOTE - State standards may vary from OSHA standards.

4. Precautions When Suspecting the Presence of Asbestos

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 as 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 can not 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.

The OSHA standard on asbestos was amended in 1986 and requires that asbestos control or removal projects be undertaken only by personnel who have special training and competence in performing such work. Radon mitigation contractors should be aware that revised rules concerning the OSHA standard are anticipated in 1992 (see proposed rules in July 20, 1990 <u>Federal Register</u>). The proposal rules:

-lower the permissible exposure limit to 0.1 f/cc.
-clarify the definition of small-scale, short-duration operations
-clarify that negative pressure enclosures are required, except in small-scale jobs, roofing and tile removal, in all demolition, renovation and removal work.
-require a specifically trained competent person in all construction operations including small-scale short-duration jobs.
-require notification of OSHA ten (10) days prior to beginning removal, demolition or renovation except small-scale, short-duration jobs.

5. Small-Scale, Short-Duration Renovation and Maintenance Jobs Involving Asbestos ("Exception" Provided by 29 CFR 1926.58, Appendix G)

The 1986 amended OSHA standard (but not the 1990 proposed rules) has specifically exempted employers in the interior construction trades (i.e., electrical, carpentry, utility, plumbing, etc.) who may perform such small-scale, short-duration renovation and maintenance jobs as pipe repair, valve replacement, installing electrical conduits, installing or removing drywall, roofing, and other general building maintenance or renovation from several provisions of the asbestos standard. In making this exception available to these employers, OSHA recognizes the asbestos health risks from small-scale, short-duration jobs do not warrant the erection of a full negative pressure enclosure in the exempted provisions.

Notwithstanding, Appendix G of the asbestos standard provides specific work practice guidelines to be followed when performing small-scale, short-duration jobs involving asbestos. Consult the asbestos standard with particular attention to Appendix G for specific guidance on when and how this exception may be used.

6. Respiratory Protection For Asbestos Exposure

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 RDP's 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 <u>radon mitigation work not be undertaken in such an environment</u> 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 fiber per cc of air).

7. Additional Sources of Information on Asbestos

Further information regarding occupational exposure to asbestos and specific precautions for protecting employee health are given in the OSHA health standard on asbestos (Federal Register, 29 CFR 1926.58). Additional information on the health and safety aspects of asbestos is provided in the REFERENCE section at the end of this manual.

## C. Electrical Safety

1. Electrical Hazards in Radon Mitigation Work

Because 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 done improperly. Radon mitigators should comply with local electrical codes.

2. The Health Effects of Electrical Hazards

(a) Electric Shock

Shock is the most common health effect associated with electrical hazards. Electricity travels in closed circuits, and its normal route is through a conductor. Shock occurs when the body becomes a part of the electric circuit. The current must enter the body at one point and leave at another. Shock normally occurs in one of three ways. The person must come in contact with both wires of the electric circuit; one wire of an energized circuit and the ground; or a metallic part that has become "hot" by being in contact with an energized wire, while the person is also in contact with the ground.

The metal parts of electric tools and machines may become "hot" if there is a break in the insulation of the tool or machine wiring. The worker using these tools and machines is made less vulnerable to electric shock when a low-resistance path from the metallic case of the tool or machine to the ground is established. This is done through the use of an equipment grounding conductor---a low-resistance wire that causes the unwanted current to pass directly to the ground, thereby greatly reducing the amount of current passing through the body of the person in contact with the tool or machine. If the equipment grounding conductor has been properly installed, it has a low resistance to ground, and the worker is being protected.

(b) Severity of the Shock

The severity of the shock received when a person becomes a part of an electric circuit is affected by three primary factors: the amount of current flowing through the body (measured in amperes); the path of the current through the body; and the length of time the body is in the circuit. Other factors which may affect the severity of shock are the frequency of the current, the phase of the heart cycle when shock occurs, and the general health of the person prior to shock. Table 2 shows the effects of electric current at various amperage levels in the human body.

The effects from electric shock depend upon the type of circuit, its voltage, resistance, amperage, pathway through the body, and duration of the contact. Effects can range from a barely perceptible tingle to immediate cardiac arrest. Although there are no absolute limits or even known values that show the exact injury from any given amperage, the table shows the general relationship between the degree of injury and amount of amperage for a 60-cycle hand-to-foot path of one second's duration of shock.

TABLE 2

Effects of Electric Current in the Human Body

| Current | Reaction |
|---|---|
| 1 Milliampere | Perception level. Just a faint tingle. |
| 5 Milliamperes | Slight shock felt; not painful but disturbing. Average individual can let go. However, strong involuntary reactions to shocks in this range *can* lead to injuries. |
| 6-25 Milliamperes (women)<br>9-30 Milliamperes (men) | Painful shock, muscular control is lost.<br>This is called the freezing current or "let-go" range. |
| 50-150 Milliamperes | Extreme pain, respiratory arrest, severe muscular contractions. If the extensor muscles are excited by the shock, the person may be thrown away from the circuit.<br>Individual cannot let go. Death is possible. |
| 1,000-4.300 Milliamperes | Ventricular fibrillation (The rhythmic pumping action of the heart ceases.) Muscular contraction and nerve damage occur. Death is most likely. |
| 10,000-Milliamperes | Cardiac arrest, severe burns and probable death. |

Source W.B. Kouwenhoven, "Human Safety and Electric Shock," **Electrical Safety Practices,** Monograph, 112, Instrument Society of America, p. 93. (Papers delivered at the third presentation of the Electrical Safety course given in Wilmington, DE, in November 1968.)

As this table illustrates, a difference of less than 100 milliamperes exists between a current that is barely perceptible and one that can kill. Muscular contraction caused by stimulation may not allow the victim to free himself/herself from the circuit, and the increased duration of exposure increases the danger to the shock victim. For example, a current of 100 milliamperes for 3 seconds is equivalent to a current of 900 milliamperes applied for .03 seconds in causing fibrillation. The so called low voltages can be extremely dangerous because, all other factors being equal, the degree of injury is proportional to the length of time the body is in the circuit. LOW VOLTAGE DOES NOT IMPLY LOW HAZARD!

(c) Burns and Other Injuries

A severe shock can cause considerable more damage to the body than is visible. For example, a person may suffer internal hemorrhages and destruction of tissues, nerves, and muscles. In addition, shock is often only the beginning in a chain of events. The final injury may well be from a fall, cuts, burns, or broken bones.

The most common shock-related injury is a burn. Burns suffered in electrical accidents may be of three types; electrical burns, arc burns, and thermal contact burns.

Electrical Burns are the result of the electric current flowing through tissues or bone. Tissue damage is caused by the heat generated by the current flow through the body. Electrical burns are one of the most serious injuries you can receive and should be given immediate attention.

Arc or flash burns, on the other hand, are the result of high temperatures near the body and are produced by an electric arc or explosion. They should also be attended to promptly.

Finally, thermal contact burns are those normally experienced when the skin comes in contact with hot surfaces of overheated electric conductors, conduits, or other energized equipment. Additionally, clothing may be ignited in an electrical accident and a thermal burn will result. All three types of burns may be produced simultaneously.

Electric shock can also cause injuries of an indirect or secondary nature in which involuntary muscle reaction from the electric shock can cause bruises, bone fractures, and even death resulting from collisions or falls. In some cases, injuries caused by electric shock can be a contributory cause of delayed fatalities.

In addition to shock and burn hazards, electricity poses other dangers. For example, when a short circuit occurs, hazards are created from the resulting arcs. If high current is involved, these arcs can cause injury or start a fire. Extremely high-energy arcs can damage equipment, causing fragmented metal to fly in all directions. Even low-energy arcs can cause violent explosions in atmospheres that contain flammable gases, vapors, or combustible dusts.

3. Correcting Electrical Hazards and Preventing Injuries

Electrical accidents appear to be caused by a combination of three possible factors - unsafe equipment and/or installation, workplaces made unsafe by the environment, and unsafe work practices. There are various ways of protecting people from the hazards caused by electricity. These include: insulation, guarding, grounding, mechanical devices, and safe work practices.

(a) Insulation

One way to safeguard individuals from electrically energized wires and parts is through insulation. An insulator is any material with high resistance to electric current. Insulators - such as glass, mica, rubber, and plastic - are put on conductors to prevent shock, fires, and short circuits. Before employees prepare to work with electric equipment, it is always a good idea for them to check the insulation before making a connection to a power source to be sure there are no exposed wires. The insulation of flexible cords, such as extension cords, is particularly vulnerable to damage.

The National Electrical Code (NEC) generally requires that circuit conductors, the material through which current flows, be insulated to prevent people from coming into accidental contact with the current. Also, the insulation should be suitable for the voltage and existing conditions, such as temperature, moisture, oil, gasoline, or corrosive fumes.

Conductors and cables are marked by the manufacturer to show the maximum voltage and American Wire Gage size, the type letter of the insulation, and the manufacturer's name or trademark.

Insulation is often color coded. In general, insulated wires used as equipment grounding conductors are either continuous green or green with yellow stripes. The grounded conductors that complete a circuit are generally covered with continuous white or natural gray-colored insulation. The ungrounded conductors, or "hot wires," may be any color other than green, white, or gray. They are often colored black or red.

Most large capacity power tools, such as the heavy-duty drills and saws needed for renovation and mitigation projects, provide the user protection from electric shock through "double insulation." Double insulated tools with metal housings have an internal layer of protecting insulation completely isolating the electrical components from the outer metal housing. This is in addition to the functional insulation found in conventional tools. Preferably, theses tools contain a nonconductive handle, an insulated armature shaft, and a completely insulated motor. Brushes, commutators, and built-in switches are designed and used under the concept of reinforces insulation. This means that in addition to the functional insulation, a reinforced or protecting insulation is also incorporated into the tool.

This extra or reinforced insulation is physically separated from the functional insulation and is arranged so that deteriorating influences such as temperature, contaminants, and wear will not affect both insulations at the same time. Unless subject to immersion or extensive moisture which might nullify the double insulation, a double insulated or all-insulated tool does not require separate ground connections; the third wire or ground wire is not needed.

The condition of the insulation and casing of power cords, extension cords, and drop lights should be inspected regularly. Flexible cords from power tools, fans, blowers, radon monitors and diagnostic equipment, and other electrically-powered equipment should be periodically checked for cracked or peeled insulation and frayed, overstressed plug connection points.

(b) Grounding

Grounding is another method of protecting employees from electric shock; however, it is normally a secondary protective measure. The term "ground" refers to a conductive body, usually the earth. The term also means a conductive connection, whether intentional or accidental, by which an electric circuit or equipment is connected to earth or ground plane.

By "grounding" a tool or electrical system, a low-resistance path to the earth is intentionally created. When properly done, this path offers sufficiently low resistance and has sufficient current-carrying capacity to prevent the buildup of voltages that may result in a personnel hazard. This does not guarantee that no one will receive a shock, be injured, or be killed. It will, however, substantially reduce the possibility of such accidents - especially when used in combination with the other safety measures discussed in this booklet.

There are two kinds of grounds required by the NEC. One of these is called the "service or system ground." In this instance, one wire - called "the neutral conductor" or "grounded conductor" - is grounded. In an ordinary low-voltage circuit, the white (or gray) wire is grounded at the generator or transformer and again at the service entrance of the building. This type of ground is primarily designed to protect machines, tools, and insulation against damage.

To offer enhanced protection to the workers themselves, an additional ground, called the "equipment ground," must be furnished by providing another path from the tool or machine through which the current can flow to the ground. This additional ground safe-guards the electric equipment operator in the event that a malfunction causes the metal frame of the tool to become accidentally energized. The resulting heavy surge of current will then activate the circuit protection devices and open the circuit.

Grounding of portable electric tools and the use of proper ground-fault interrupters (GFIs) provide the most convenient way of safeguarding the operator. If there is any defect or short circuit inside the tool, the current is drained from the metal frame through a ground wire and does not pass through the operator's body; or, where a ground fault interrupter is used, the current is shut off before a serious shock can occur. All electric power tools should be effectively grounded except the double insulated and cordless types. Correctly grounded tools are as safe as double insulated or low voltage tools, especially when used with a proper ground fault interruption. The continuity of the ground should be checked so there will not be a false sense of security.

(c) Circuit Protection Devices

Circuit protection devices are designed to automatically limit or shut off the flow of electricity in the event of a ground-fault, overload, or short circuit in the wiring system. Fuses, circuit breakers, and ground-fault interrupters are three well-known examples of such devices.

Fuses and circuit-breakers are over-current devices that are placed in circuits to monitor the amount of current that the circuit will carry. They automatically open or break the circuit when the amount of current flow becomes excessive and unsafe. Fuses are designed to melt when too much current flows through them. Circuit breakers, on the other hand, are designed to trip open the circuit by electro-mechanical means.

Fuses and circuit breakers are intended primarily for the protection of conductors and equipment. They prevent overheating of wires and components that might otherwise create hazards for operators. They also open the circuit under certain hazardous ground-fault conditions.

The ground-fault interrupter or GFI is designed to shut off electric power within as little as 1/40 of a second. It works by comparing the amount of current going to an electric device against the amount of current returning from the device along the circuit conductors. A GFI should be used in high-risk areas such as wet basements, bathrooms, laundries, kitchens, and garages as well as construction sites.

(d) Guarding

Live parts of electric equipment operating at 50 volts or more must be guarded against accidental contact. Guarding of live parts may be accomplished by:

* location in a room, vault, or similar enclosure accessible only to qualified persons;
* use of permanent, substantial partitions or screens to exclude unqualified persons;
* location on a suitable balcony, gallery, or platform elevated and arranged to exclude unqualified persons; or
* elevation of 8 feet or more above the floor.

When working outside a building, such as when installing the roof cap on a ventilation system, care must be taken in positioning an aluminum ladder if one is used to access the roof or other elevated area. Avoid contact between metal ladders and the power line to the building.

(e) Safe Work Practices

Mitigators and others working with electric equipment need to use safe work practices. These include: de-energizing electric equipment before inspecting or making repairs, using electric tools that are in good repair, using good judgment when working near energized lines, and using appropriate protective equipment.

*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 mitigation job being done. When work is performed around energized lines, for example, some basic procedures are:

1. Have the line de-energized.
2. Ensure that the line remains de-energized by using some type of lockout and tagging procedure.
3. Use insulated protective equipment.
4. 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. 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, moving acid-battery back-up power sources for sump pumps.

The amount of money spent to acquire and fit eye protective devices for employees is small when measured against the savings afforded by the protection given. For example, the purchase and fitting of a pair or impact-resistant safety glasses may cost upward from 20 to 25 dollars; compensation costs for a lost eye or lost vision may range from 20,000 to 1,000,000 dollars.

In addition to safety eye wear, an eye wash kit should be available at all mitigation job sites.

1. Selecting Safety Eyewear for Mitigation Work

Factors that should be considered in the selection of protective eyewear include the type of protection afforded, the comfort with which they can be worn, and the ease of keeping them in good repair.

(a) Safety Glasses

Safety glasses are constructed of lenses made of impact-resistant plastic with a thickness of 3 mm. The lens bezel (flanged edge) which fits into the groove of the safety frame is ground to a 113 angle (as opposed to the 80 angle of ordinary lenses) for additional protection in the event of impact with a foreign object.

Depending on whether or not the wearer requires corrective lenses, the types of safety glasses available for employees are non-corrective safety glasses (commonly called "planos"--because they have plain lenses) or corrective (prescription) safety glasses. Both types of glasses should be equipped with side shields permanently molded into the temple portion of the frame. For safety prescription eyewear without side shields and non-prescription glasses without permanently attached side shields, snap-on or slide-on side shield are available. These should be self-locking or fit securely enough on the frames to prevent accidental slippage or removal.

Prescription safety glasses should be prescribed and fitted only by ophthalmologists (eye physicians) or optometrists (Doctors of Optometry). Non-prescription safety glasses, however, should be made available by employers to all employees engaged in radon mitigation work.

(b) Safety Goggles

Safety goggles generally have a rigid plastic frame with a cushioned or pliable edge for secure and comfortable contact with the wearer's face. Safety goggles usually have a single plastic lens. These goggles are designed to give the eyes frontal and side protection from splashing or flying material. Safety goggles are also available with flexible plastic frames. Flexible types of goggles are preferred by many because of their light weight and convenience, however, they generally have a shorter wear-life than the more sturdier frame and glass lens type.

Oversize safety goggles are available that fit over prescription glasses. These provide a high level of eye protection and can be worn by prescription glass wearers who don't normally need safety eyewear, such as visitors to a job site undergoing mitigation work.

To prevent fogging of the inner surface of the goggles, vents are provided which are shielded so that foreign material, especially liquid chemicals, cannot penetrate the goggles if splashed on the outside.

(c) Face Shields

Face shields are available in a wide variety of types to protect the face and neck from flying particles, sprays of hazardous liquids, and from hot solutions. As a general rule, face shields should be worn over basic eye protection, such as safety glasses. Three basic styles of face shields include headgear without crown protectors, with crown protectors, and with crown and chin protectors.

The materials used in face shields should combine mechanical strength, light weight, nonirritation to skin, and the capability of withstanding frequent cleanings. Only optical grade (clear or tinted) plastic, which is free from flaws or distortions, should be used for the windows.

Again, face shields are not recommended as a basic type of eye protection against the impact of foreign material. Although they do provide protection for the face, they must be used in combination with safety eyewear for adequate eye protection.

2. Wearing Contact Lenses On-The-Job

Contact lenses should never be considered as a substitute for protective equipment for the eyes. However, some workers, of necessity, must wear contact lenses to perform their jobs. Those that do must consequently exercise extra care. When the work environment entails exposure to chemical vapors, fumes, or splashes; intense heat, metal chips or fragments, or an atmosphere with a high particulate concentration, contact lens use should be restricted. Workers have had their eyesight permanently impaired and have even been blinded by corrosive chemicals or small particles getting between the contact lens and the eye.

Depending on the nature of the foreign body hazard, safety glasses or safety goggles must be worn over contact lenses to provide the necessary level of protection.

3. Supervision of a Workplace Eye Safety Program

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

Reasons given for non-compliance with the wearing of personal protective equipment include employees feeling that the equipment is uncomfortable or seems to interfere with work, a low awareness level on the part of employees of the extent of the safety hazard present, temporary unavailability of equipment ("I forgot it" or "I left it in the truck"), and other reasons (or excuses!).

A workplace 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. Safety glasses serve no purpose folded in a worker's pocket, especially if a serious eye injury could have been prevented by wearing them.

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 where there is a 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."

In addition to a humanistic obligation to provide employees with a safe working environment, the above passage from OSHA standards provides employers with additional incentive to promote eye safety: failure to provide employees with proper eye protection is against federal health and safety regulations.

## VI. HAZARD COMMUNICATION AND CHEMICAL SAFETY

The Occupational Safety and Health Administration (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 workplace 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. But 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 comply with specific provisions to ensure a safe workplace, 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.

### A. What the Hazard Communication Standard Addresses

The Hazard Communication Standard establishes uniform requirements to assure that the hazards of all chemicals imported into, produced, or used in U.S. workplaces are evaluated, and that the resultant hazard information and associated protective measures are transmitted to employers and potentially exposed employees.

Chemical manufacturers and importers must convey the hazard information they learn from their evaluations to downstream employers by means of labels on containers and material safety data sheets

(MSDSs). In addition, all employers must have a hazard communication program to get this information to their employees through labels on containers, MSDS's, and training.

This program ensures that all employers receive the information they need to inform and train their employees properly and to design and put in place employee protection programs. It also provides necessary hazard information to employees, so they can participate in, and support, the protective measures in place at their workplaces.

B. What is a Contractor Required To Do?

All employees who may be exposed to hazardous chemicals will need to be trained in the dangers associated with those chemicals and the protective measures they need to take. There are four major elements of compliance required by the Hazard Communication Standard:

1. Material Safety Data Sheets (MSDSs)
2. Labels
3. Employee Training
4. A Written Hazard Communication Program

The following sections will describe these elements of HazCom and provide examples of each.

C. Material Safety Data Sheets (MSDSs)

The Material Safety data Sheet (MSDS) is a detailed information bulletin prepared by the manufacturer or importer of a chemical that describes the physical and chemical properties, physical and health hazards, routes of exposure, precautions for safe handling and use, emergency and first-aid procedures, and control measures. Information on an MSDS aids in the selection of safe products and helps prepare employers and employees to respond effectively to daily exposure situations as well as to emergency situations.

The MSDS's are a comprehensive source of information for all types of employers. There may be information on the MSDS that is not useful to you or not important to the safety and health in your particular operation. Concentrate on the information that is applicable to your situation. Generally, hazard information and protective measures should be the focus of concern.

The first thing to do is to make sure you have an MSDS for every hazardous substance you use. It is the responsibility of suppliers/distributors to provide MSDSs with the products they are selling. You should have been receiving MSDSs with every shipment of hazardous substances.
Nonetheless, you still may have trouble getting the MSDSs from suppliers who are unaware of their responsibilities. If you don't receive an MSDS with a shipment, it's your responsibility to request one.

If a product is tagged or labeled with any key words such as "danger", "caution", "flammable", "warning", etc., that is a signal to you to get an MSDS from the supplier. Put any requests to a supplier for an MSDS in writing.

To simplify this process, you may want to designate one employee to coordinate your compliance efforts. That person should set up a system to collect all incoming MSDSs and set up an easily understood filing and retrieval system. Without an organized system, you could easily be overwhelmed with paper. The MSDSs will vary in length from two to twenty pages, depending on the make-up of the substance. These documents should give you a complete breakdown on the hazards associated with the products you are using and will be a key to effective employee training.

If your supplier tends to be a retail outlet, such as a hardware store or a building products supplier, be aware that retailers only have to supply MSDSs to customers who have commercial accounts. For all other customers, the retailer must supply the address and telephone number of the manufacturer from which an MSDS can be obtained. It will be wise to automatically ask for MSDSs with your purchases if you have a commercial account or the address and telephone number if you don't have an account. Once you have an MSDS on a product, though, it's not necessary to get one with every shipment of that product. You only need to obtain another one if the chemical make-up of the product changes. All employers having difficulty obtaining MSDSs from product suppliers and/or manufacturers are advised to contact their local OSHA office for assistance.

Once MSDSs for products have been obtained, they should be made available to employees at each job site. This is most easily done by maintaining a binder of all MSDSs in trucks or trailers at each work location. All employees must be informed of the locations of MSDSs and give access to them upon request. As MSDSs are intended as standardized sources of health and safety information on chemicals used in the workplace, and must be made readily available to employees while they are in the workplace.

SUMMARY OF REQUIRED ACTIVITIES: MSDSs

* Request MSDSs for hazardous substances from suppliers/manufacturers
* Maintain MSDSs at each job site within easy access of employees
* Inform employees about what MSDSs are and where they are located
* Although not a requirement of the standards, review each MSDS to be sure it is clear and understandable to employees

D. Labeling of Hazardous Chemicals

The most immediate source of safety information for both the prevention of and response to accidents with hazardous substances are the labels on product containers. In case of a mishap at the job site involving a hazardous substance, the label is the most immediate source of information on a product's dangers and emergency response, with the MSDS serving as a backup.

Employers must ensure that all containers of hazardous substances in the workplace are labeled with the name of the substance, the appropriate hazard warning, and the name and address of its manufacturer. The labels must be in English, legible, prominently displayed, easily understandable, and not defaced. For any hazardous substance containers not so labeled, the employer must ensure that a label or labeling information is obtained from the chemical manufacturer or other responsible party.

Although the label on a hazardous substance is a brief summary of the information provided on the substance's MSDS, labels and MSDSs are not substitutes for one another. Each substance must be in a properly labeled container and have a corresponding MSDS. However, you can use one to check the other. If a product has a warning label, but no MSDS or vice versa, you will need to request either the label or MSDS from the supplier.

Portable containers into which hazardous substances have been transferred from their original containers must also be properly labeled with the name of the substance, the appropriate hazard warning, and its manufacturers name and address. For example, if a coating or sealant is transferred from its original drum into smaller containers which are not labeled, then the smaller containers must be labeled with the hazard warning from the drum. The only exception to this requirement is when the person making the transfer is going to use all of the substance in the course of the present task at hand. In such cases of immediate use of the substance, no labeling is required on the portable container.

As for MSDSs, employees must be trained about this system for product labelling and the importance of heeding product instructions and warnings. Employers are required to provide instruction for employees on the meaning of warnings and the interpretation of warning symbols and hazard rating systems if used on labels. If an accident with a hazardous substance occurs, its container will be the first thing sought for information on the product. Products must be properly labelled, and labels must be clear and understandable.

SUMMARY OF REQUIRED ACTIVITIES: LABELS

* Ensure that all containers of hazardous substances are appropriately labeled
* If not, obtain labels or labeling information from product suppliers
* Instruct employees on the meaning of the terminology and symbols used in warning labels

E. Employee Training

Even though you may use several types of potentially hazardous substances (i.e., caulks, sealants, paints, etc.) at many different job sites, training all employees on these hazards need not be a monumental project. Once MSDSs and a labeling system is in place, training is largely a process of transmitting this information to employees.

Employers or their designated representatives must convey to employees the potential health risks and precautions associated with hazardous substances used on-the-job. This means employees should be trained in the following areas:

1. How to recognize hazards at work;
2. What the harmful physical and health effects are from hazardous substances sued on-the-job;
3. How employees can protect themselves from these hazards;
4. And what actions to take in the event of a hazardous substance emergency.

All employees potentially exposed to hazardous substances must be trained in these areas. In deciding who should receive this training, the term "potentially exposed" is to be interpreted broadly. Not only should training include employees actually exposed to hazardous substances during their routine job duties, but also employees who may be exposed through unexpected releases of hazardous substances or in accident or emergency situations. In this sense, office personnel who routinely come to job sites in the course of their work could potentially become exposed to hazardous substances and should receive training.

Training must be provided at the time employees are initially assigned to work and whenever a new hazardous substance is introduced into the workplace. Even though an employee may already have received training on a substance from another employer in the past, the training should be given to the employee because (s)he is now your employee and your responsibility. It may be best to offer HazCom training right after employees have completed their tax and immigration forms. In this way, several administrative and training tasks related to employment can be "signed-off" on by the employee at once.

Training on hazardous substances isn't a one-time occurrence. A number of employees pass through the construction industry and new hazardous substances are introduced into the workplace periodically. Each new employee and newly-introduced hazard indicates the need for training. Training may be done for each category of hazard rather than each chemical and thus, additional training is not required when new chemicals are used that present the same hazard. If more than one contracting company is working on the same job site, information on hazardous substances for the employees of all participating contractors must be shared among companies. Training on new hazardous substances need not repeat training in other areas that employees have already received. And additional training is not necessary when you substitute one brand of a product for another.

SUMMARY OF REQUIRED ACTIVITIES: EMPLOYEE TRAINING

* Plan the training with information from the MSDSs and labels of all hazardous substances used on-the-job;
* Select an employee or outside contractor to conduct the training;
* Provide training to employees in content areas listed above during normal work hours;
* Document all training provided to each employee.

F. Written Hazard Communication Program

The final part of putting together a program for complying with HazCom is preparing the Written Hazard Communication Program. Basically, this written program is a description of all the activities described in the three preceding sections that are being done to comply with HazCom. It should begin with a current list of all hazardous substances used on-the-job and include descriptions of systems you have developed for hazard substance labeling, MSDSs, and employee training.

Once completed, the written program must be available to employees and employee representatives if they request to see it. It is also one of the first things OSHA requests to see, should you undergo an OSHA inspection. Since a copy of the written program must be maintained at each job site, it is advisable to keep a written program with product MSDSs in a trailer or truck at each work location, as copies of MSDSs must also be readily available to employees.

SUMMARY OF REQUIRED ACTIVITIES: WRITTEN HAZCOM PROGRAM

* Prepare a list of all hazardous substances used on-the-job;
* Outline all steps taken to comply with HazCom requirements for labels, MSDSs, and employee training;
* Make the written program available to employees, employee representatives, and OSHA upon request.

## VI. REFERENCES

(to be listed)

## VII. APPENDICES

(copies of relevant OSHA standards)

A. 29 CFR 1926, Occupational Safety and Health Standards
B. 29 CFR 1910, Construction Health and Safety Standards
C. 29 CFR 1910.1200, Right to Know
D. EPA order 1440.3
E. Health and Safety Training Record

## E. HEALTH AND SAFETY TRAINING RECORD

Project:________________________________________

Client:________________________________________

Project Site/Location:________________________________

Date:____________ Conducted by:________________________

| Full Name | Organization | Soc. Sec. No. |
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Training conducted by:________________ Signature:____________________

Remarks:________________________________________

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