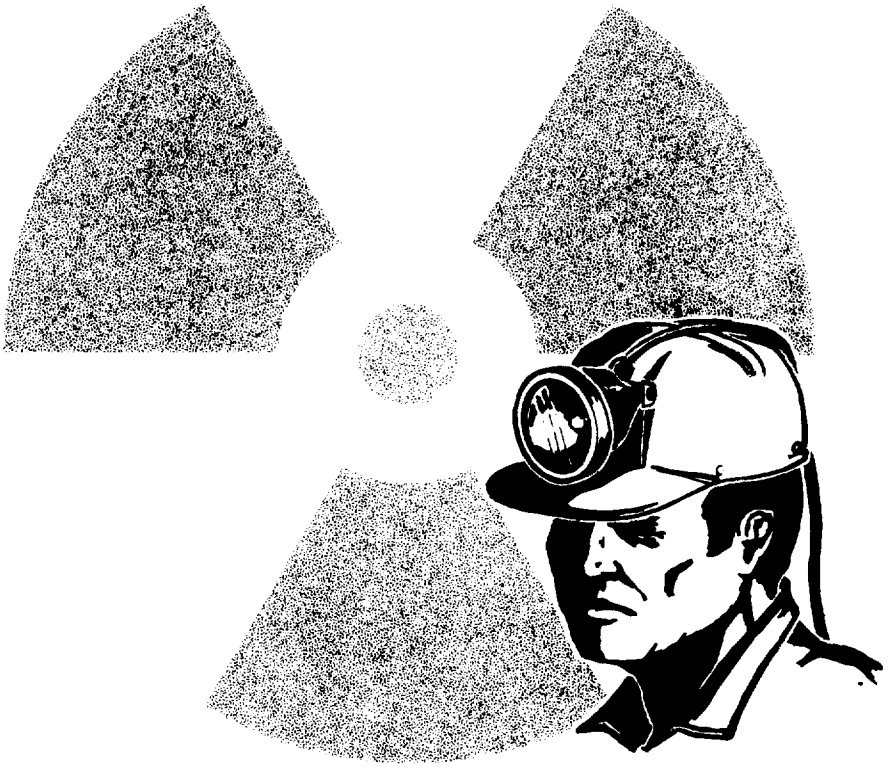
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

NIOSH

A Recommended Standard for Occupational Exposure to....

RADON PROGENY in UNDERGROUND MINES



CRITERIA FOR A RECOMMENDED STANDARD.... OCCUPATIONAL EXPOSURE TO RADON PROGENY IN UNDERGROUND MINES

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
DIVISION OF STANDARDS DEVELOPMENT AND TECHNOLOGY TRANSFER

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FOREWORD

As Director of the National Institute for Occupational Safety and Health (NIOSH), I am accustomed to making decisions on difficult issues, but few issues have presented the legislative, scientific, and public health dilemmas that accompany recommending criteria to control the exposure of workers to radon progeny in underground mines.

The development of this criteria document is subject to the provisions of two legislative mandates. First, the Occupational Safety and Health Act of 1970 [Public Law (PL) 91-596, which established NIOSH] requires safe and healthful working conditions for every working person. The Act further requires NIOSH to preserve our human resources by providing medical and other criteria that will ensure, insofar as practicable, that no worker will suffer diminished health, functional capacity, or life expectancy as a result of work experience [PL 91-596, Sections 6(b)(5)]. The Act also authorizes NIOSH to recommend new criteria to further improve working conditions [PL 91-596, Sections 22(c) and (d)]. In addition, the Federal Coal Mine Health and Safety Act of 1969 [PL 91-173] and the Federal Mine Safety and Health Amendments Act of 1977 [PL 95-164] require NIOSH to develop and revise recommended occupational safety and health standards for mine workers. Specifically, the Secretary of Health, Education, and Welfare (now the Secretary of Health and Human Services) is required to consider, "in addition to the attainment of the highest degree of health protection for the miner . . . the latest available scientific data in the field, the technical feasibility of the standards, and experience gained under this and other health statutes" [PL 91-173, Title 1, Section 101(d)]. These mandates have required NIOSH to weigh its obligation to assure the highest degree of health protection for miners against the technical feasibility of the recommended standard in the development of recommendations for controlling radon progeny exposure in underground mines.

The control of exposure to radon progeny presents an unprecedented problem because of the ubiquitous yet variable nature of their presence in mines and the ambient environment. To complicate this matter further, recent reports indicate that an exposure-related health risk may exist at background exposure levels.

The full ramifications of this dilemma can easily be appreciated by considering two points. The first is that dilution ventilation (the primary engineering approach to reducing the concentration of radon progeny in mines) is accomplished by the exchange of mine air with air from the outside environment. Obviously, this approach is not a viable option for the total elimination of radon progeny in underground mines because the outside air is also contaminated with radon progeny. In addition, this approach would not be a prudent community environmental public health measure in some situations because it involves releasing an additional burden of radon progeny to the ambient environment and thereby contributing to the background level in the immediate area of the mine. Thus ventilation cannot be used to totally eliminate exposure to radon progeny in mines.

The second point to consider in this dilemma is that the variable nature of radon progeny exposure in the ambient environment precludes recommending an annual cumulative exposure limit that includes both occupational and ambient contributions. Because ambient exposure varies, such a recommendation would result in an occupational exposure limit and associated risk that would vary with the locale. This approach is obviously undesirable, for it would lead to a nightmare of confusion and complicated enforcement requirements and would probably result in unequal protection of miners.

Data from both human and animal studies clearly demonstrate a direct link between lung cancer and radon exposure. Specific epidemiological studies provide a basis for quantitatively estimating human risk at various exposure levels. Such analyses clearly show that a radon exposure of 4 WLM (4 working level months) per year over a 30-year working lifetime (the current Mine Safety and Health Administration [MSHA] standard) poses a significant and unacceptable risk of lung cancer. This risk must be substantially reduced.

In recommending an exposure limit for radon progeny, NIOSH considered not only the results of its own risk assessment and the technical feasibility of the recommended standard, but also the uncertainty of the data available on risk. Uncertainties are inherent in both the risk assessment methods and the scientific data on which the risk assessment is based. This fact must be understood and acknowledged. Some of the factors involved in these uncertainties include the choice of risk assessment method and model, the measurement methods used for data collection, and risk estimates derived from data that are heavily weighted with higher exposures.

The first of these factors in risk uncertainty involves the choice of a risk assessment method and/or model (such as the Cox proportional hazards model used in the NIOSH risk assessment study). NIOSH has attempted to develop a mathematical model that best describes the lung cancer risk in miners exposed to radon progeny. The use of a risk assessment model is merely a practical way to work with a very complex problem. There are modeling approaches other than the one chosen for this study. Each choice would result in a somewhat different description of the relationship between radon progeny exposure and lung cancer risk. NIOSH has attempted to compare the alternatives that are available and applicable. NIOSH scientists have considered the differences that might arise through a review of the available scientific literature and discussions with other scientists who have evaluated this exposure-related lung cancer risk.

Although alternative models might yield minimally different quantitative risk estimates, none of them would lead the Institute to a qualitatively different risk assessment (i.e., that exposures to radon progeny at the current standard are associated with excesses of lung cancer).

The second factor involved in risk uncertainty is the measurement method used for data collection. This study involves a follow-up period of more than 35 years, more than 3,000 miners, and thousands of measurements. The

older data are subject to greater uncertainty than the more recent data because of improvements in the entire measurement process over the course of the study.

The third factor involved in risk uncertainty is the process of generating risk estimates at lower exposure levels. One consideration is that such risk estimates are derived from data heavily weighted by higher exposures (note that the annual cumulative exposures of most miners in this study are higher than either the current MSHA standard or the proposed NIOSH recommended exposure limit [REL]). Another consideration is the desirability of placing occupational risk in the context of background exposure risk. However, the latter has not been evaluated and would have to be estimated on the basis of occupational data. We therefore do not believe that it is currently possible to contrast these two types of risks. Nonetheless, EPA has generated some initial information on background exposure risk in A Citizen's Guide to Radon. This document indicates that action should be taken to lower radon progeny levels in homes with measured concentrations of 0.02 WL or greater. NIOSH estimates that this concentration would probably result in a cumulative exposure that is less than 1 WLM but within an order of magnitude of that value. New information is clearly needed on background exposure levels and the hazards associated with such exposure before occupational and nonoccupational risks can be reliably quantified and validly contrasted. Until these data are available, the final target exposure limits cannot be identified for control of this hazard in our total environment.

The uncertainties in the data and a recent study commissioned by the Bureau of Mines* on the feasibilities of controlling radon progeny levels in mines have been weighed along with the available evidence and the obligations of NIOSH. This process has resulted in an REL of 1 WLM per year. Our own quantitative risk assessment clearly shows that significant health risks are posed by an exposure level of 1 WLM per year over a 30-year working lifetime. NIOSH therefore regards this REL as an upper limit and further recommends that mine operators limit exposure to radon progeny to the lowest levels possible. In addition, NIOSH wishes to emphasize that this recommended standard contains many important provisions in addition to the annual exposure limit. These include recommendations for limited work shift concentrations of radon progeny, sampling and analytical methods, recordkeeping, medical surveillance, posting of hazardous information, respiratory protection, worker education and notification, and sanitation. All of these recommendations help minimize risk.

In summary, NIOSH has the legislative, scientific, and public health responsibility to protect the health of miners by developing recommendations

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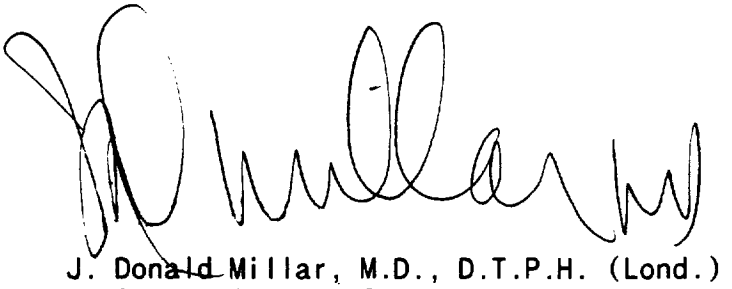
*Bloomster CH, Enderlin WI, Young JK, Dirks JA (1984). Cost survey for radon daughter control by ventilation and other control techniques. Volume 1. Richland, WA: Battelle Memorial Institute, Pacific Northwest Laboratories, NTIS PB85-152932.

that eliminate or minimize occupational risks. Although I am approving the recommended exposure limit of 1 WLM per year, I do not feel that this part of the recommended standard fully satisfies the Institute's commitment to protect the health of all of the Nation's miners. Future research may provide evidence of new and more effective methods for reducing occupational exposures to radon progeny, more reliable risk estimates at low exposure levels, and improved risk assessment methods. If new information demonstrates that a lower exposure limit constitutes both prudent public health and a feasible engineering policy, NIOSH will revise its recommended standard.



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I. RECOMMENDATIONS FOR A RADON PROGENY STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to radon progeny in underground mines be controlled by compliance with this recommended standard, which is designed to protect the health of underground miners over a working lifetime of 30 years. Mine operators should regard the recommended exposure limit for radon progeny as the upper boundary for exposure; they should make every effort to limit radon progeny to the lowest possible concentrations. This recommended standard will be reviewed and revised as necessary.

Radon progeny (also known as radon daughters) are the short-lived decay products of radon, an inert gas that is one of the natural decay products of uranium. The short-lived radon progeny (i.e., polonium-210, lead-214, bismuth-214, and polonium-214) are solids and exist in air as free ions or as ions attached to dust particles. The NIOSH recommended exposure limit (REL) is based on (1) evidence that a substantial risk of lung cancer is associated with an occupational exposure to radon progeny, and (2) the technical feasibility of reducing exposures. In this document, NIOSH presents recommendations that will protect miners employed year-round at any mine work area for as long as 30 years (the period of time used by MSHA as a miner's working lifetime). The exposure limit contained in this recommended standard is measurable by techniques that are valid, reproducible, and available to industry and government agencies. NIOSH has concluded that current technology is sufficient to achieve compliance with the recommended standard.

Because knowledge of the carcinogenic process is incomplete and no data exist to demonstrate a safe level of exposure to carcinogens, NIOSH maintains that occupational exposure to carcinogens such as radon progeny should be reduced to the lowest level technically achievable. Compliance with this standard does not relieve mine operators from complying with other applicable standards.

Section 1 - Definitions

(a) Miner

Miners include all mine personnel who are involved with any underground operation (e.g., drilling, blasting, haulage, and maintenance).

(b) Working Level

One working level (WL) is any combination of short-lived radon progeny in 1 liter (L) of air that will ultimately release 1.3×10^5 million electron volts (MeV) of alpha energy during decay to lead-210.

(c) Working Level Month

A working level month (WLM) is the product of the radon progeny concentration in WL and the exposure duration in months. For example, if a miner is exposed at a concentration of 0.083 WL for 1 month

(170 hours [hr]),* then the cumulative exposure for the month is 0.083 WLM. If the cumulative exposure of the same miner is 0.083 WLM for each of 12 consecutive months (2,040 hr), then the cumulative exposure for the year is 1 WLM.

(d) Work Area

A work area is any stope, drift heading, travelway, haulageway, shop, station, lunchroom, or any other underground location where miners work, travel, or congregate.

(e) Average Work Shift Concentration

The average work shift concentration is the average concentration of radon progeny present during a work shift in a given area. This concentration is used to represent the miner's breathing zone exposure to radon progeny.

Section 2 - Environment (Workplace Air)

(a) Recommended Exposure Limit (REL)

Exposure to radon progeny in underground mines shall not exceed 1 WLM per year, and the average work shift concentration shall not exceed 1/12 of 1 WL (or 0.083 WL). The REL of 1 WLM per year is an upper limit of cumulative exposure, and every effort shall be made to reduce exposures to the lowest levels possible.

(b) Sampling and Analysis

Grab samples for radon progeny in the workplace shall be taken and analyzed using working level monitors, the Kusnetz method, or any other method at least equivalent in accuracy, precision, and sensitivity. Sampling and analytical methods are described in Chapter II. Details of the recommended sampling strategy are contained in Appendix IV. The recommended sampling strategy allows the use of grab samples for estimating the average work shift concentration of radon progeny.

Section 3 - Monitoring and Recording Exposures

(a) Exposure Monitoring

All operators of underground mines shall perform environmental evaluations in all work areas to determine exposures to radon progeny.

(1) An initial environmental evaluation shall be conducted in each work area to determine the average work shift concentration of radon progeny.

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*Note that Mine Safety and Health Administration (MSHA) regulations are based on 173 hr per month.

(2) Periodic environmental evaluations shall be conducted at intervals (as described in Appendix IV) in each work area. An alternative sampling strategy may be used if the mine operator can demonstrate that it effectively monitors exposure to radon progeny.

(3) If environmental monitoring in a work area indicates that the average work shift concentration of radon progeny exceeds 1/12 WL (as described in Appendix IV), the mine operator shall prepare an action plan describing the types of engineering controls and work practices that will be implemented to reduce the average work shift concentration in that area.

(b) Exposure Monitoring Records

The mine operator shall determine and record the exposure to radon progeny. Each miner's exposure shall be calculated using monitoring data obtained for the areas in which the miner worked. These records shall include (1) locations, dates, and times of measurements, (2) sampling and analytical methods used, (3) the number, duration, and results of the samples taken, and (4) all items required by Sections 3(b)(2) and (3). All records shall be retained at the mine site or nearest mine office as described in Section 10.

(1) Calculating the Miner's Daily Exposure

The average work shift concentration of radon progeny for each work area shall be used to calculate each miner's daily exposure. If no monitoring has been conducted in a work area on a particular day, the daily average work shift concentration for that area shall be determined by averaging the results obtained on the last day of monitoring with the results from the next day that monitoring is conducted.

A miner's exposure (in WLM) for a given area is calculated as follows:

$$\text{WLM} = \frac{\text{WL} \times \text{T}}{170 \text{ hr}}$$

where WL is the average work shift concentration of radon progeny, T is the total time (hours) spent in the area, and 170 is the number of hours worked per month.

A miner's total cumulative exposure for the year is the sum of the daily exposures (as calculated above) for all work areas in which time was spent during the work shift.

(2) Uranium Mines

Exposure to radon progeny shall be recorded daily for each uranium miner. These records shall include the miner's name, social security number, the time spent in each work area, estimated exposure to radon progeny for each work area as determined in

Section 3(b)(3), and (if applicable) the type of respiratory protection and duration of its use.

(3) Nonuranium Mines

Exposure to radon progeny shall be recorded daily for all miners assigned to work in areas where environmental monitoring for radon progeny is required as described in Appendix IV. These exposure monitoring records shall include the miner's name, social security number, time the miner has spent in each work area, estimated exposure to radon progeny for each work area as determined in Section 3(b)(3), and (if applicable) the type of respiratory protection used and the duration of its use.

(4) Respirator Credit

The type of respirator worn and the credit given for wearing it (see Section 7) shall be recorded for each miner. Mine operators shall record both the average work shift concentration of radon progeny and the adjusted exposure concentration calculated by using the respirator credit. The adjusted exposure concentration shall be used to determine the miner's cumulative exposure for compliance with the REL of 1.0 WLM/year.

Section 4 - Medical Surveillance

(a) General

(1) The mine operator shall institute a medical surveillance program for all miners.

(2) The mine operator shall ensure that all medical examinations and procedures are performed by or under the direction of a licensed physician.

(3) The mine operator shall provide the required medical surveillance at a reasonable time and place without loss of pay or cost to the miners.

(4) The mine operator shall provide the following information to the physician performing or responsible for the medical surveillance program: a copy of the radon progeny standard, the miner's duration of employment, the miner's cumulative exposure to radon progeny (or an estimate of potential exposure to radon progeny if the miner is a new employee), a description of the miner's duties as they relate to his exposure, and a description of any protective equipment the miner has used or may be required to use.

(5) The mine operator or physician shall counsel tobacco-smoking miners about their increased risk of developing lung cancer from the combined exposure to tobacco smoke and radon progeny. The mine operator or physician shall encourage the miner to participate in a

smoking cessation program. The mine operator shall enforce a policy prohibiting smoking at the mine site.

(6) The physician shall provide the mine operator and the miner with a written statement describing any medical conditions found during the preplacement or periodic medical examinations that may increase the miner's health risk when exposed to radon progeny. This written statement shall not reveal specific findings, but shall include any recommended limitations on the miner's exposure to radon progeny or ability to use respirators and other personal protective equipment.

(b) Preplacement Medical Examination

The preplacement medical examination of each miner shall include the following:

(1) A comprehensive medical and work history (including smoking history) that emphasizes the identification of existing medical conditions and attempts to elicit information about previous occupational exposure to radon progeny.

(2) A thorough examination of the miner's respiratory system, including pulmonary function tests. The initial and subsequent pulmonary function tests shall include determination of forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) using the current American Thoracic Society (ATS) recommendations on instrumentation, technician training, and interpretation. A prospective miner with symptomatic, spirometric, or radiographic evidence of pulmonary impairment should be counseled about the risks of continued exposure.

(3) A posterio-anterior chest X-ray using the current ATS recommendations on instrumentation, technician training, and interpretation.

(4) Other tests deemed appropriate by the physician.

(c) Periodic Medical Examination

The periodic medical examination for each miner shall include the following:

(1) An annual update of medical and work histories (including smoking history).

(2) An evaluation of the miner's respiratory system. Because of the potential for chronic respiratory disease, this evaluation shall include spirometry at intervals determined by the physician. Miners that have spirometric or radiographic evidence or symptoms of pulmonary impairment should be counseled by the physician regarding the risks of continued exposure.

(3) A posterio-anterior chest X-ray at intervals determined by the physician using the current ATS recommendations on instrumentation, technician training, and interpretation. Periodic chest X-rays are recommended for monitoring miners exposed to fibrogenic respiratory hazards (e.g., quartz). Ordinarily, chest X-rays may be obtained every 5 years for the first 15 years of employment and every 2 years thereafter, depending on the nature and intensity of exposures and their related health risks. A recent X-ray obtained for other purposes (e.g., upon hospitalization) may be substituted for the periodic X-ray if it is of acceptable quality.

(4) Other tests deemed appropriate by the physician.

Section 5 - Posting

All warning signs shall be printed in both English and the predominant language of non-English-reading miners. Miners unable to read the posted signs shall be informed verbally about the hazardous areas of the mine and the instructions printed on the signs.

(a) Readily visible signs containing the following information shall be posted at mine entrances or in work areas that require environmental monitoring for radon progeny as described in Appendix IV:

AUTHORIZED PERSONNEL ONLY
DANGER!
POTENTIAL RADIATION HAZARD
RADON PROGENY

(b) If respiratory protection is required, the following statement shall be added in large letters to the sign required in Section 5(a):

RESPIRATORY PROTECTION REQUIRED IN THIS AREA

Section 6 - Work Practices and Engineering Controls

Effective work practices and engineering controls shall be instituted by the mine operator to reduce the concentration of radon progeny to the lowest technically achievable limit. Since there is no typical mine and each operation has some unique features, the work practices and engineering controls in this section may need to be adapted for use in particular situations.

(a) Work Practices

(1) Ore Extraction and Handling

Examples of effective ore extraction and handling procedures include the following: minimizing the number of ore faces simultaneously exposed, performing retreat mining toward intake air, limiting the underground storage and handling of ore, locating ore transfer points away from ventilation intakes, removing dust

spilled from ore cars, minimizing ore spillage by maintaining roadways and carefully loading haulage vehicles, and covering ore until it is moved to the surface.

(2) Blasting

Blasting should be performed at the end of the work shift whenever possible. Miners shall be evacuated from exhaust drifts until environmental sampling confirms that the average work shift concentration of radon progeny does not exceed 1/12 WL. Refer to Section 7 if respiratory protection is required for subsequent reentry.

(3) Worker Rotation

The mine operator shall not use the planned rotation of miners to maintain an individual's exposure below the REL of 1.0 WLM per year. NIOSH acknowledges, however, that some miners may inadvertently be exposed to short-term high concentrations of radon progeny. For example, such exposures may occur when engineering controls fail. To ensure that the miners' cumulative exposure remains below the REL in such circumstances, it may be necessary to transfer them to other jobs or work areas that have lower concentrations of radon progeny. Miners transferred under these circumstances shall retain their pay as prescribed for coal miners under Section 203(b) of the Federal Coal Mine Safety and Health Act of 1977.

(b) Engineering Controls

Mechanical exhaust ventilation used alone or in combination with other engineering controls and work practices can effectively reduce exposures to radon progeny. Ventilation systems discharging outside the mine shall conform with applicable local, State, and Federal [40 CFR*61, Subpart B] air pollution regulations and shall not constitute a hazard to miners or to the general population.

(1) Ductwork shall be kept in good repair to maintain designed airflows. The effectiveness of mechanical ventilation systems shall be determined periodically and as soon as possible after any significant changes have been made in production or control. A log shall be kept showing designed airflow and the results of all airflow measurements.

(2) Fans shall be operated continuously in the work areas of an active mine and before the opening of a previously inactive mine or inactive section until environmental sampling confirms that the average work shift concentrations of radon progeny do not exceed 1/12 WL. Refer to Section 7 if respiratory protection is required.

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*Code of Federal Regulations. See CFR in references.

(3) Fresh air shall be provided to miners in dead end areas near the working faces.

(4) Bulkheads, backfill, and sealants shall be used to control exposures as appropriate.

Appendix III provides a general discussion of engineering control methods.

Section 7 - Respirator Selection and Credit for Respirator Use

(a) General Considerations

NIOSH has determined that a radon progeny exposure limit of 1.0 WLM per year is technically achievable in mines through the use of effective work practices and engineering controls. Over a 30-year working lifetime, this exposure limit will reduce but not eliminate the risk of lung cancer associated with exposure to radon progeny. NIOSH considers respirators to be one of the last options for worker protection. Work practices and engineering controls are more effective means for limiting exposures and providing a safe environment for all workers. Respirator use in underground mines is not always practical for a number of reasons, including the additional physiological burden and safety hazards they pose. NIOSH therefore recommends that engineering controls and work practices be used where technically achievable to control the exposure of miners to radon progeny.

Compliance with an exposure limit of 1.0 WLM per year requires an average exposure of 1/12 WL throughout the year to ensure that the miner can work for an entire year (i.e., 2,040 hr). For average work shift concentrations above 1/12 WL, NIOSH recommends mandatory respirator use as well as the implementation of engineering controls and work practices to reduce exposure to radon progeny.

Occupational exposure to radon progeny above background concentrations has been associated with excess lung cancer risk. Therefore, regardless of the exposure concentration, NIOSH advises the use of respirators to further reduce exposure and decrease the risk of lung cancer.

Respiratory protection shall be used by miners (1) when work practices and engineering controls are not adequate to limit average work shift concentrations of radon progeny to 1/12 WL, (2) when entering a mine area where concentrations of radon progeny are unknown, or (3) during emergencies. Use only those respirators approved by NIOSH or the Mine Safety and Health Administration (MSHA).

(b) Respirator Protection Program

Whenever respirators are used, a complete respiratory protection program shall be instituted. This program must follow the recommendations contained in ANSI Z88.2-1969 (published by the American National Standards Institute) and the respirator-use criteria in 30 CFR 57.5005.

The respiratory protection program described in ANSI Z88.2-1969 requires the following:

(1) A written program for respiratory protection that contains standard operating procedures governing the selection and use of respirators.

(2) Periodic worker training in the proper use and limitations of respirators.

(3) Evaluation of working conditions in the mine.

(4) An estimate of anticipated exposure.

(5) An estimate of the physical stress that will be placed on the miner. A detailed medical examination of each miner shall be conducted according to the guidelines set forth in Appendix V.

(6) Routine inspection, maintenance, disinfection, proper storage, and evaluation of respirators.

(7) Information concerning the manufacturers' instructions for respirator fit-testing and proper use.

(c) Respirator Selection

NIOSH makes the following recommendations for respirator selection:

(1) A respirator is not required for exposure to average work shift concentrations less than or equal to 1/12 WL.

(2) For exposure to average work shift concentrations greater than 1/12 WL, NIOSH recommends those respirators listed in Table I-1.

(3) For entry into areas where radon progeny concentrations are unknown or exceed 166 WL, or for emergency entry, NIOSH recommends only the most protective respirators (any full-facepiece, positive-pressure, self-contained breathing apparatus [SCBA] or full-facepiece, positive-pressure, supplied-air respirator and SCBA combination).

These recommendations are based on the fact that radon progeny exist as particulates and that miners are not exposed to hazardous concentrations of nonparticulate contaminants. If protection against nonparticulate contaminants is required, different types of respirators must be selected.

(d) Credit for Respirator Use

When respirators are worn properly, the miner's average work shift exposure can be reduced by a factor that depends on the class of respirator worn. Table I-1 provides the credit factors for the various classes of respirators. For example, if a miner wears a helmet-type,

Table I-1.--Respirator recommendations for radon progeny

Average work shift concentration of radon progeny* (WL)	Respirator recommendations	Credit factor for respirator use	
		65% utilization	90% utilization
0 to 0.083 (1/12)	No respirator required	NA+	NA
>0.083 to ≤ 0.42	Any disposable respirator equipped with a HEPA§ filter	2.1	3.6
	Any more protective respirator	#	#
>0.42 to ≤ 0.83	Any air-purifying half-mask respirator equipped with a HEPA filter	2.4	5.3
	Any SAR** equipped with a half-mask and operated in a demand (negative-pressure) mode	2.4	5.3
	Any more protective respirator	#	#
>0.83 to ≤ 2.08	Any powered PAPR†† equipped with a hood or helmet and a HEPA filter	2.7	7.4
	Any SAR equipped with a hood or helmet and operated in a continuous flow mode	2.7	7.4
	Any more protective respirator	#	#

See footnotes at end of table.

Table I-1 (Continued).--Respirator recommendations for radon progeny

Average work shift concentration of radon progeny*	Respirator recommendations	Credit factor for respirator use	
		65% utilization	90% utilization
>2.08 to ≤ 4.15	Any air-purifying, full facepiece respirator equipped with a HEPA filter	2.8	8.5
	Any PAPR equipped with a tight-fitting facepiece and a HEPA filter	2.8	8.5
	Any SAR equipped with a full facepiece and operated in a demand (negative-pressure) mode	2.8	8.5
	Any SAR equipped with a tight-fitting facepiece and operated in a continuous-flow mode	2.8	8.5
	Any self-contained breathing apparatus (SCBA) equipped with a full facepiece and operated in a demand (negative-pressure) mode	2.8	8.5
	Any more protective respirator	#	#
>4.15 to ≤ 83.0	Any SAR equipped with a half-mask and operated in a pressure-demand or other positive-pressure mode	2.9	9.9
	Any more protective respirator	#	#

See footnotes at end of table.

Table I-1 (Continued).--Respirator recommendations for radon progeny

Average work shift concentration of radon progeny*	Respirator recommendations	Credit factor for respirator use	
		65% utilization	90% utilization
>83.0 to ≤ 166.0	Any SAR equipped with a full facepiece and operated in a pressure demand or other positive pressure mode	2.9	10.0
	Any more protective respirator	#	#
>166.0 or unknown concentration or emergency entry	Any SCBA equipped with a full facepiece and operated in a pressure demand or other positive pressure mode	2.9	10.0
	Any SAR equipped with a full facepiece operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode	2.9	10.0
Emergency escape	Any self-contained self-rescuer (SCSR)	NA	NA

*As estimated using the sampling techniques described in Appendix IV.
†NA=Not applicable.
§HEPA = high-efficiency particulate air.
#See appropriated credit factors below.
**SAR = supplied-air respirator.
††PAPR = powered air-purifying respirator.

powered, air-purifying respirator (PAPR) for 65% of the work shift and the radon progeny concentration in the work area is 0.3 WL, then the miner's exposure can be adjusted by dividing 0.3 WL by 2.7, the credit factor for this class of respirator. This results in an adjusted exposure of 0.11 WL for that miner. Respirator credit is discused in detail in Chapter II.

Section 8 - Informing Workers of the Hazards of Radon Progeny

(a) Notification of Hazards

The mine operator shall provide all miners with information about workplace hazards before job assignment and at least annually thereafter.

(b) Training

(1) The mine operator shall institute a continuing education program conducted by persons with expertise in occupational safety and health. The purpose of this program is to ensure that all miners have current knowledge of workplace hazards, effective work practices, engineering controls, and the proper use of respirators and other personal protective equipment. This program shall also include a description of the general nature of the environmental and medical surveillance programs and the advantages of participating in them. This information shall be kept on file and be readily available to miners for examination and copying. The mine operator shall maintain a written plan of these training and surveillance programs.

(2) Miners shall be instructed about their responsibilities for following proper work practices and sanitation procedures necessary to protect their health and safety.

Section 9 - Sanitation

(a) Eating and Drinking

The preparation, storage, dispensing (including vending machines), or consumption of food shall be prohibited in any area where a toxic material is present. The mine operator shall provide facilities so that miners can wash their hands and faces thoroughly with soap or mild detergent and water before eating or drinking.

(b) Smoking

Smoking shall be prohibited in underground work areas.

(c) Toilet Facilities

The mine operator shall provide an adequate number of toilet facilities and encourage the miners to wash their hands thoroughly with soap or mild detergent and water before and after using these facilities.

(d) Change Rooms

(1) The mine operator shall provide clean change rooms for the miners.

(2) The mine operator shall provide storage facilities such as lockers to permit the miners to store street clothing and personal items.

(e) Showers

The mine operator shall provide showers and encourage the miners to shower at the end of the work shift.

(f) Laundering

(1) The mine operator shall provide for the cleaning, laundering, or disposal of contaminated work clothing and equipment.

(2) The mine operator shall ensure that contaminated work clothing or equipment that is to be cleaned, laundered, or disposed of is placed in a closed container to prevent dispersion of dust.

(3) Any person who cleans or launders this contaminated work clothing or equipment must be informed by the operator that it may be contaminated with radioactive materials.

Section 10 - Recordkeeping Requirements

(a) Record Retention

(1) The mine operator shall retain all records of the monitoring required in Section 3(b).

(2) All monitoring records shall be retained for at least 40 years after termination of employment.

(3) The mine operator shall retain the medical records required by Section 4. These records shall be retained for at least 40 years after termination of employment.

(b) Availability of Records

The miner shall have access to his medical records and be permitted to obtain copies of them. Records shall also be made available to former miners, or their representative and to the designated representatives of the Secretary of Labor and the Secretary of Health and Human Services.

(c) Transfer of Records

(1) Upon termination of employment, the mine operator shall provide the miner with a copy of his records specified in Section 10(a).

(2) Whenever the mine operator transfers ownership of the mine, all records described in this section shall be transferred to the new operator, who shall maintain them as required by this standard.

(3) Whenever a mine operator ceases to do business and there is no successor, the mine operator shall notify the miners of their rights of access to those records at least 3 months before cessation of business.

(4) The Director of NIOSH shall be notified in writing before (a) a mine operator ceases to do business and there is no successor to maintain records, and (b) the mine operator intends to dispose of those records.

(5) No records shall be destroyed until the Director of NIOSH responds in writing to the mine operator.