Radon in the Workplace, The OSHA Ionizing Radiation Regulations

Robert K. Lewis
PA DEP, Bureau of Radiation Protection, Radon Division
Harrisburg, PA USA

INTRODUCTION

The Occupational Safety and Health Administration (OSHA) is the federal agency responsible for the safety of American workers. Their overall mission is to save lives, prevent injuries, and protect the American workforce. The vast majority of American workers are covered by the Occupational Safety and Health Act of 1970. One specific part of the OSHA mission is to protect the American workforce from unnecessary exposure to ionizing radiation, and as it relates to this paper the radioactive gas Radon-222. Due to the fact that the OSHA ionizing radiation regulations have not been updated since their inception in 1970, some confusion has arisen as to what are the applicable limiting exposure values for Rn-222 in the workplace.

The Act: To assure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the Act; by assisting and encouraging the States in their efforts to assure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health; and for other purposes.

The primary duty under the Act: Each employer shall furnish to each of his employees employment and a place of employment, which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees.

What's covered under the Act: OSHA covers all radiation sources not regulated by the U.S. Atomic Energy Act of 1954. This would include X-ray equipment, accelerators, accelerator-produced materials, electron microscopes, betratrons, and some naturally occurring radioactive materials.

Who's covered under the Act: This Act shall apply with respect to employment in a workplace in a state … Section 4 Applicability of this Act. OSHA covers the private sector in States that do not have an approved OSHA plan. OSHA also covers federal workers except some Department of Defense workers. There are approximately 6.5 million workplaces covered by Act.

Who's not covered under the Act: Miners, construction workers covered under 29CFR1926, and State and local workers in the 26 states that have not entered

into an agreement with OSHA to enforce their regulations. Pennsylvania is an example of one state that has not entered into an agreement with OHSA, and therefore its state and local government employees may be covered by the Pennsylvania Department of Labor and Industry, local codes, or nothing at all.

State OSHA Programs: OSHA encourages States to develop and operate their own job safety and health programs. There are currently 22 States and jurisdictions operating complete State plans, covering both private sector and State and local government employees: Alaska, Arizona, California, Hawaii, Indiana, Iowa, Kentucky, Maryland, Michigan, Minnesota, Nevada, New Mexico, North Carolina, Oregon, Puerto Rico, South Carolina, Tennessee, Utah, Vermont, Virginia, Washington, and Wyoming. There are four States, which cover public employees only; Connecticut, New Jersey, New York, and Virgin Islands. Under these State plans OSHA relinquishes its authority to the States to cover occupational safety and health matters. If an employee finds a health and safety hazard they would bring their complaint directly to the State. In States without an OSHA Program, OSHA is the responsible agency for workplace health and safety issues.

What is an Occupational Illness: Any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to **environmental factors** associated with employment. Included are acute and chronic illnesses or diseases that may be caused by **inhalation**, absorption, ingestion, or direct contact with toxic substances or **harmful agents**.

Occupational Exposure: It should be pointed out that the term "occupational" is used to describe two different groups of workers by the Nuclear Regulatory Commission (NRC) and OSHA. NRC regulates exposures to "persons licensed", who are potentially exposed to radiation as part of their jobs, such as nuclear power plant workers or medical personnel. NRC occupational exposure is specifically from licensed material. This type of occupational exposure does not include exposure to natural background radiation. The January 27, 1987 Federal Register helps to explain this type of worker. OSHA regulates exposure to "employees." These people may be exposed to natural background as part of their jobs, with the most likely source of that natural background radiation being Rn-222.

Ionizing Radiation under the Act: The ionizing radiation standard was issued in 1971. In 1996 OSHA re-designated the standard as 29 CFR 1910.1096, which is also the current designation. OSHA references Nuclear Regulatory Commission regulations as found in 10 CFR 20. The ionizing radiation regulation can be found at www.osha.gov, under Laws and Regulations select Standards, then select Part 1910 (Occupational Safety and Health Standard), then scrool down to 1910.1096 (Ionizing Radiation).

Now we must make a major distinction that is possibly the cause of some confusion. When OSHA issued their Ionizing Radiation Standard in 1971, they referenced 10 CFR 20 (NRC Regulations). They obviously had to reference the NRC regulations in place at that time, that is the 1969 version of 10 CFR 20. The NRC revised their 10 CFR Part 20 regulations in 1991. The problem that arises is that individuals looking at the OSHA Ionizing Radiation Regulations today find no mention that OSHA is referencing NRC regulations and Tables that are over 30 years old, and in fact now are different then they were in 1969. The table 1 below shows the differences of the NRC Appendix B Tables from 1969 to 2003.

Table 1, 10 CFR 20, Appendix B, Limits for Radon-222

	1969		**2003**	
	Table I	Table II	Table 1	Table 2
	Column 1	Column 1	Column 3	Column 1
	MPC (µCi/ml)	MPC (µCi/ml)	DAC (µCi/ml)	Air (µCi/ml)
Rn-222	1E-7	3E-9	3E-8	1E-10
Rn-222 (pCi/L)	100	3	30	0.1

Note: 1970 Table I concerns occupational exposure and Table II concerns effluent releases similarly, in 2003 Table 1 concerns occupational exposure and Table 2 concerns effluent releases. The effluent columns are concerned with the assessment and control of dose to the public. The NRC updated the 100 pCi/L MPC to the 30 pCi/L DAC in 1979.

From the above Table it can be easily seen how someone would use the most current Table I value (2003) and come up with 30 pCi/L (3E-8 µCi/ml) for the Rn-222 value to use to define an “airborne radioactivity area”, or 25 percent of that value, 7.5 pCi/L, also to define an “airborne radioactivity area.” This seems to be where a 1993 Radon News Digest article on “Radon in the Workplace” misunderstood the regulations. Not only did Radon News Digest make this mistake but OSHA also made the same mistake! In a letter to Mr. Richard A. Schreiber of the Georgia Radon Program, in which they were requesting OSHA interpretation of 29 CFR 1910.1096, OSHA responds in part “an airborne radioactivity area would exist in an area where an employee worked for 40 hours per week and the radon-222 concentration in the area exceeded 7.5 picocuries per liter.” Subsequently, OSHA caught their mistake and will edit this plus two other letters and provide the correct information. The mistake continues to propagate itself in the literature. A paper in the 1996 International Radon Symposium by an author from the National Institute of Occupational Safety and Health (NIOSH) quotes the “…PEL of 0.33 wl (*30 pCi/L*) based on 8-hour per day exposure throughout the work year …” AARST was also led into believing that the workplace radon concentration of 7.5 pCi/L (*25% of 30 pCi/L)* was the value for defining an “airborne radioactivity area”. Finally, OSHA again makes the mistake in their Sampling and Analytical Methods, Method #ID 208, where they

quote "OSHA PEL of 30 pCi/L (10 CFR part 20, App. B)". Not only did the above references use the incorrect value, but some of them also seem to be using it in the wrong context. Some seem to be confusing posting requirements with exposure limits. See "Posting Requirements" and Exposure Limits" below.

In support of using the 1969 10 CFR 20 Table, Richard E. Fairfax, Director, Directorate of Enforcement Programs, OSHA writes in a December 23, 2002 letter to the Department of the Army "Case law supports the interpretation that the original version of a referenced federal regulation is the enforceable regulation. Therefore, the 1969 version of Appendix B to 10 CFR Part 20 that was referenced in the original OSHA ionizing radiation standard in 1971 is enforceable."

More confusion arises from the fact that one Federal agency (OSHA) references another Federal agencies (NRC) regulations, and the two agencies deal with different groups of people. OSHA regulates the employer for the health and safety of the employee, and NRC regulates the licensee for the health and safety of the workforce and the general public. As already noted OSHA ionizing radiation regulations point to 10 CFR 20, NRC regulations. Now, there is one major conflicting problem! The scope of 10 CFR 20 applies to persons *licensed* by the Nuclear Regulatory Commission to receive, possess, use, transfer, or dispose of byproduct, source, or special nuclear material … The limits in this part (10 CFR 20) do not apply to doses due to *background radiation* …

Based upon the above considerations, it would seem that naturally emanating Rn-222 would be excluded from Government regulation. Most general public employers do not have licenses for or posses NRC regulated material, and the agent of concern (radon) is due to natural background radiation, which (strictly interpreted) 10CFR20 does not apply to. However, all is not lost!

In 1989 Patricia Clark, Acting Director of OSHA Compliance Programs wrote a letter providing interpretation for the standard for ionizing radiation, 29 CFR 1910.1096. In that letter she wrote "An employer possesses radioactive material **and** comes under the scope of 29 CFR 1910.1096 if there are artificially enhanced concentrations of environmental radon-222 in the workplace. If environmental radon-222 concentrations have not been artificially enhanced, they are very much lower than permissible exposure limits (PEL). Accordingly, only artificially enhanced concentrations of environmental radon-222 would be sufficiently high that provisions of 29 CFR 1910.1096 would go into effect. The most common places for significant artificial enhancement of radon-222 concentrations to occur are **inside of buildings or other types of enclosures constructed on or in the ground."**

Interestingly, OSHA even considers the employer to "posses" the Rn-222 if the presence of the Rn-222 in a structure controlled by the employer exposes

employees to hazardous concentrations of airborne radiation as set forth in the standard. If that is the case then 29 CFR 1910.1096 would apply. This places a further liability on the employer.

An additional letter from Ruth McCully, OSHA Director Office of Health Compliance Assistance, dated October 6, 1992 further helps clarify the radon issue. She writes, "29 CFR 1910.1096 covers Naturally Occurring Radioactive Material (NORM). Accordingly, the definition of airborne radioactive area applies to areas that contain airborne NORM."

Thus it would appear that Rn-222 is indeed "covered" by OSHA regulations, as indeed it is.

Who does the testing: It is the responsibility of the employer to do the testing. As stated in 1910.1096 (d)(1) "*Every employer shall make such surveys as may be necessary for him to comply with the provisions in this section*. Survey means an evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment, and *measurements of levels of radiation or concentrations of radioactive material present."*

What does one say to an employer who says 'I didn't know I was supposed to test!' According to Assistant Secretary for OSHA Gerard Scannell (1991) "an employer who knows, or could have known with the exercise of reasonable diligence of the existence of artificially enhanced concentrations of environmental Rn-222 in its workplace, must conduct a survey as described above."

Mr. Scannell in a 1991 letter to Senator John McCain clarified that "an employer could know of a potential hazard with the exercise of reasonable diligence if the media has reported excessive radon exposure in the area the workplace is located."

How is the testing done: The OSHA Technical Manual, Section III, Chapter 2, Indoor Air Quality Investigation says "a rapid, easy-to-use screening method for measuring radon gas concentrations is available from the Salt Lake Technical Center." This method is listed as ID-208, and in fact is the electret ion chamber method. OSHA then goes on to quote from the EPA Citizen's Guide and says that screening samples less than 4 pCi/L probably do not require follow-up, and screening samples greater than 4 pCi/L should have follow-up measurements performed.

The standard in 29 CFR 1910.1096 defines three types of **restricted** areas that must be identified and have their boundaries demarcated with special warning signs. They are "radiation area," high radiation area," and airborne radioactive area."

Restricted area means any area access to which is controlled by the employer for purposes of protection of individuals from exposure to radiation or radioactive materials. The OSHA regulation does not define restricted area in terms of exposure to airborne radioactive materials, therefore, areas that do not qualify as "unrestricted areas" are "restricted areas."

Unrestricted area means any area access to which is not controlled by the employer for purposes of protection of individuals from exposure to radiation or radioactive materials.
Patricia Clark goes on to say that an "unrestricted area for airborne radioactive materials are areas where concentrations do not exceed the limits specified in Table 2 of Appendix B to 10 CFR 20. Table 2 (1970 edition) shows a value for Rn-222 of 3E-9 µCi/ml, which equates to 3 pCi/L.

Radiation area means any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any 1 hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirem.

High radiation area means any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any one hour a dose in excess of 100 millirems.

The radiation area and the high radiation area are concerned with external exposure and will not be discussed further in this paper since we are concerned with the inhalation exposure from radon and daughters.

Posting Requirements

Airborne radioactivity area means any room, enclosure, or operating area in which airborne radioactive materials, composed wholly or partly of radioactive material, exist in concentrations in excess of the amounts specified in column 1 of Table 1 of Appendix B to 10 CFR Part 20, 1970 edition (100 pCi/L)

Or

Any room, enclosure, or operating area in which airborne radioactive materials exist in concentrations which, averaged over the number of hours in any week **during which individuals are in the area**, exceed 25 percent of the amounts specified in column 1 of Table 1 of Appendix B to 10 CFR Part 20.

Please be aware that the above two paragraphs are concerned with posting requirements for airborne radioactivity areas. If either one of the above two situations arise then the area must be posted, "Caution, Airborne Radioactivity

Area." The two paragraphs differ in that the first paragraph has no mention of individuals, and it uses the limiting value as found in Appendix B. The second paragraph introduces individuals into the work area and because of this reduces the Appendix B limiting value to 25% of the limiting value (25 pCi/L). The second paragraph has no mention of employee time in the area. Technically, if employees were in the room for one hour and the average Rn-222 concentration over that one hour was greater than 25 pCi/L, then the room must be posted.

Therefore, if one placed a continuous monitor in an area, occupied by the workforce for 40 hours per week and the average concentration for those 40 hours was greater than 25 pCi/L you would have an airborne radioactive area and all of the implications that go with it, that is, employee monitoring, restricted access by the public, and the area would also have to be posted with a sign bearing the radiation caution symbol and the words "Caution, Airborne Radioactivity Area."

Exposure Limits

There is only one OSHA Rn-222 exposure limit and that is found in 10 CFR 20, Appendix B, Table 1, Column 1, and that value is 1E-7 μCi/ml or **100 pCi/L**. This exposure limit is specified for 40 hours in any workweek of 7 consecutive days. OSHA apparently set this limit based on Federal Radiation Council guidance to the President in December 27, 1968, and U.S. Department of Labor hearings on Radiation Standards for Mining under the Walsh-Healey Public Contracts Act, November 20 and 21, 1968. This guidance said that occupational exposure to radon daughters in underground uranium mines be controlled so that no individual miner receive an exposure greater than 12 WLM per year, and that exposures should be kept as far below these values as practicable. The guidance went on to say that the uranium mining industry should continue to strive to meet the anticipated 4 WLM standard that would go into effect on January 1, 1971. Note: The 100 pCi/L OSHA maximum permissible concentration results in an exposure of 12 WLM/yr (See Appendix E).

If an employer has a work area that is occupied by their employees for 40 hours per week and the Rn-222 concentration is greater than 100 pCi/L, then the employer must either reduce the number of hours worked in the area or introduce engineering controls to reduce the concentrations. If the area is occupied it would also need to meet the posting requirements. If the number of hours worked in an area are less than 40 hours the limit specified in Appendix B may be proportionally increased, and if the number of hours worked are greater than 40 hours, the limit shall be decreased proportionally. For instance, if individuals were only in the work area for 20 hours the Rn-222 exposure limit would now be 200 pCi/L.

OSHA Permissible Exposure Limits (PEL): PELs are set to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. PELs are based on an 8-hour time weighted average exposure.

There are permissible exposure limits for about 500 substances. These lists are found in 29CFR1910.1000, Tables Z-1, Z-2, and Z-3, "Limits for Air Contaminants". Radon-222 is not found in these tables. The OSHA, Radon-222 PEL is actually the NRC Maximum Permissible Concentration (MPC), which is found in 10CFR20, part 20, appendix B, 1970 ed. This value as listed in Appendix B is 1E-7 µCi/ml or **100 pCi/L** for 40 hours per week.

Understanding 10CFR20, Appendix B: Appendix B, Table 1 lists activities (µCi) and concentrations (µCi/ml) of radionuclides necessary to keep worker radiation doses below the occupational exposure limits of 5 rem whole body or 50 rem to an organ or tissue. Values are listed for both ingestion and inhalation. We will concern ourselves with the inhalation values. Column 2 lists the inhalation annual limit of intake (ALI), which is the annual intake of a given radionuclide that would result in a committed effective dose equivalent of 5 rem or a committed does equivalent of 50 rems to an organ or tissue. For Rn-222 with its daughters present the current NRC ALI is 4 WLM. Column 3 lists the inhalation derived air concentration (DAC), which are limits intended to control chronic occupational exposures. The DAC for Rn-222 with its daughters present is 0.33 WL or at 100% equilibrium 30 pCi/L (10 CFR 20, 2003 edition). The DAC value is based on a 2000-hour work year.

The DAC and the ALI are related. The DAC (in µCi/ml) = ALI(in µCi)/2.4E9 ml , or put another way the DAC is the concentration of radionuclide in air, which if breathed for a work-year (2000 hrs) would result in the intake of one ALI. In terms of Rn-222 this would mean that in an environment with 30 pCi/L (DAC) for 2000-hours per year, one would accumulate 4 WLM (ALI) of exposure, which would produce a 5 rem whole body or 50 rem lung dose. For comparison purposes, if exposed to the average environmental radon concentration (~0.3 pCi/L) one would accumulate 0.2 WLM of exposure per year. See Appendix D.

Over the years a very broad range of occupational dose limits for radon exposure have been presented, values have ranged from less than 1 WLM/yr to greater than 20 WLM/yr. In 1967 the Environmental Protection Agency (EPA) used a value of 12 WLM/yr. In 1969 they put forth 4 WLM/yr on a trail basis, and then on July 1, 1971 they made the 4 WLM/yr final for miners. This reduction in exposure limits was based on earlier studies of uranium miners showing increased lung cancer incidence. This recommendation by EPA was also extended to other Federal agencies in 1971.

The EPA recommends 4.0 pCi/L of radon-222 as its action level for mitigation in residences and schools; EPA has no guidance that applies directly to the

workplace. The EPA guideline is not an occupational safety and health standard and does not carry the weight of law.

OSHA is considering revising its radiation protection standards in the near future. OSHA has also entered into an agreement with the Health Physics Society to provide consultation services regarding radiation safety matters. It would certainly appear that the OSHA ionizing radiation regulations require an update. In particular as they relate to Rn-222 exposure in the workplace, these standards need to clearly cover occupational exposure to naturally emanating Rn-222 and be brought more in line with current radiation safety regulations and guidelines.

Conclusions

The OSHA ionizing radiation regulations, 29 CFR 1910.1096 are in need of revision to bring them in line with the most current information on radiation health effects and exposures in the workplace.

If normalized to 100% equilibrium and continuous exposure in the workplace (2000 hrs/yr) and the home environment (6570 hrs/yr) the current OSHA Rn-222 limit results in an exposure over six times greater (12 WLM Vs. 1.5 WLM) than the current EPA guideline of 4.0 pCi/L. See Appendix F.

President Ronald Reagan in a 1987 memorandum gave recommendations for numerous federal agencies, including OSHA to update previous regulations for the protection of workers exposed to ionizing radiation. This has yet to be accomplished.

Many authors and agencies over the past 10 years or so have mistakenly used the incorrect, although more conservative, limiting value for Rn-222 as found in 10 CFR 20, Appendix B, and have confused Posting Requirements with Exposure Limits.

If the employer, with the exercise of reasonable diligence, knows or could have known about the existence of artificially enhanced concentrations of environmental Rn-222 they must conduct a survey.

References:

Abel, Scott. Radon in the Workplace. Radon News Digest, Vol. 7 No. 1, Winter 1993.

Code of Federal Regulations. Title 10, Parts 1 to 50. Revised as of January 1, 2003.

Federal Register. Tuesday January 27, 1987, Part II, The President. Radiation Protection Guidance to Federal Agencies for Occupational Exposure; Approval of Environmental Protection Agency Recommendations.

Federal Register. Tuesday May 25, 1971. Environmental Protection Agency. Underground Mining of Uranium Ore. Radiation Protection Guidance for Federal Agencies. Volume 36, No. 101.

Federal Register. Wednesday January 15, 1969. Federal Radiation Council. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, December 27, 1968. Volume 34, No. 10.

Health Physics News, Volume 32, No. 6, June 2004.

Krueger, Jim. Results of Enforcing OSHA 1910.96. The 1993 International Radon Conference.

US Department of Labor, Occupational Safety and Health Administration. Occupational Safety and Health Act of 1970. Public Law 91-596. December 29, 1970.

US Department of Labor, Occupational Safety and Health Administration. Standard Interpretations. Occupational exposure limits, access restrictions, and posting requirements for airborne radioactive materials. December 23, 2002

US Department of Labor, Occupational Safety and Health Administration. Standard Interpretations. Definition of an airborne radioactivity area. October 6, 1992.

US Department of Labor, Occupational Safety and Health Administration. Standard Interpretations. Definition of Reasonable Diligence as stated in 1910.1096 (d) (1). April 17, 1991.

US Department of Labor, Occupational Safety and Health Administration. Standard Interpretations. Ionizing radiation hazards in the workplace. September 27, 1990.

US Department of Labor, Occupational safety and Health Administration. Standard Interpretations. The Ionizing Radiation Standard, 29 CFR 1910.1096. August 16, 1989.

Appendix A, OSHA Rn-222 Limit

Appendix B, Table1, Column 1	1E-7 μCi/ml (100 pCi/L)

Appendix B, OSHA Posting Requirements

Airborne Radioactivity Area	
Unoccupied Room or Area	100 pCi/L
Occupied Room or Area	25 pCi/L

Appendix C, Radiation Areas

Unrestricted Area	< 3 pCi/L
Radiation Area	> 5 mrem/hr External >3.6 pCi/L
High Radiation Area	>100 mrem/hr External >150 pCi/L

Note: The picocurie/liter values for radiation area, and high radiation area are derived values and not specifically applicable to these areas.

Appendix D

DAC to ALI

Rn-222 DAC equals 0.33 wl or at ER of 1.0 30 pCi/L

Rn-222 ALI equals 4 WLM per year

Therefore: {(0.33 wl) (2000 hrs/yr)}/170 hrs per month = 3.88 wlm or ~ 4 wlm

ALI to Committed Dose Equivalent (CDE)

Therefore: (4 wlm) (0.6 rad/wlm) = 2.4 rad

(2.4 rad) (20) = 48 rem or ~ 50 rem to TB region of lung

Appendix E

Maximum Permissible Concentration to WLM

Assume 100% equilibrium ratio and 2000 hours/year exposure.

OSHA MPC equals 100 pCi/L or 1WL, therefore

{(1 WL) (2000 hrs/yr)}/ 170 working hours per month = 11.76 or ~ 12 WLM/yr

Appendix F

Work Exposure verse Home Exposure

Work: Assume (OSHA Limit) 100 pCi/L = 1WL, and 2000 hours/yr worked

{(1 WL) (2000 hrs/yr)}/ 170 hrs/month = 11.76 WLM ~ 12 WLM

Home: Assume (EPA Guideline) 4 pCi/L = 0.04 WL, and 6570 hours/ yr at home

{(0.04 WL) (6570 hrs/yr)}/ 170 hrs/month = 1.54 WLM