ICRP AND THE RADON PROBLEM

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Radon, usually represented by radon-222, has long been recognized as a source of radiation risk. Lung cancer among miners in the Schneeberg-Jachymov region in the Erzgebirge was diagnosed in 1879. This was the "Schneeberger Krankheit" that is known already from the 15th-16th century. Its association with radon was suggested in the 1920's.

Over the last few decades, there has been a growing concern about the occupational radon problem in mines; not just in uranium mines but, as was found in the 1970's, also in other mines. For the public, new types of buildings, with reduced ventilation to reduce the heating cost and spare fuel, and with directly accessable basement space, exposed to emanation from the ground, have caused increased radon concentrations in indoor air. Values exceeding 10,000 Bq/m3 have been found and the problem has now been recognized in most countries with sufficiently cold climat to make limited ventilation a practical necessity.

The 1982 UNSCEAR report, with its presentation in terms of the effective dose equivalent, made it obvious that radon exposures, even under "normal" conditions, contribute substantially to the annual effective dose equivalent. The previous value of 1 mSv per year from natural background radiation was suddenly raised to 2 mSv per year. It is against this development that the work of ICRP in relation to radon and to the natural radiation background in general should be seen. A conceptual problem is involved: Can and should natural sources of radiation be controlled? How should this be done? What is "natural"?

RISK ASSESSMENTS

The risk from radon is almost exclusively a lung cancer risk. "Exposure" in this connection is usually taken to mean either the time integral of the potential alpha energy concentration in air inhaled by the exposed individual, or the time integral of the equilibrium equivalent concentration (EEC) of radon in that air.

The radon daughter exposure of miners is often expressed in the unit WLM (working level months), which, for radon-222 relates to the time integral of the potential alpha energy concentration and the activity concentration by: 1 WLM = 0.0035 Jh/m3 = 630,000 Bqh/m3

There are two different models for risk projection. The <u>relative risk model</u> is based on the assumption that the risk per <u>unit time, after a</u> latent period, will be some fraction of the age-specific lung cancer mortality, whatever that would have been without the radon exposure. For the <u>absolute risk model</u> it is assumed that the future increment of the <u>age-specific lung</u> cancer mortality is independent of the normal lung cancer mortality and only a function of the radiation dose and the age at exposure.

Once a model has been chosen, there are also two different ways of assessing the risk. One is by epidemiological studies, the other by calculating the effective dose equivalent and applying the usual risk factor (about 2 % per sievert).

The epidemiological approach is the most direct one and has been used in assessing the lung cancer risk for miners. In ICRP Publication 50 (1987), the risk-exposure coefficient is believed to be in the range of 5 - 15 cases per million personyears and WLM on the basis of the absolute risk model, and 0.5 - 1.5 % per WLM on the basis of the relative risk model.

For members of the public, the epidemiological method has not been available directly, because of the practical difficulties. However, the epidemiological findings from the studies on miners have been used to derive indirect risk estimates, taking into account factors such as differences in the breathing rate. This derivation of the public risk from the risk of miners is subject to a number of uncertainties because of obvious differences in the exposure situations.

The alternative method, the dosimetric method, however, also involves great uncertainties. One is the identification of the relevant tissues for which the dose should be calculated. In ICRP Publication 50, it has been assumed that the cells at risk are located in the basal and mucus cell layer of the tracheobronchial epithelium and the pulmonary region.

The influence of smoking habits is of particular importance. Some epidemiological results suggest a more than additive influence of smoking which can be approximated by a semi-multiplicative model in the case of heavy smoking and high radon exposures.

The conclusion of the Task Group preparing ICRP Publication 50 was that an appropriate reference value for the life-time risk of lung cancer from chronic indoor exposure to Rn-222 daughter products would be an <u>absolute</u> risk of

$$2 \times 10^{-8} \text{ per Bqh/m}^3 \text{ for each year of exposure}$$

based on the absolute risk model, and a <u>relative</u> risk of

$$0.8 \times 10^{-6} \text{ per Bqh/m}^3 \text{ for each year of exposure}$$

based on the relative risk model. The two estimates would be equal if the mean life-time risk of lung cancer (from other causes) were 2.5%.

OCCUPATIONAL LIMITS

Various exposure limits and "maximum permissible concentrations" of radon in air inhaled by miners have been recommended by ICRP since 1954. In ICRP Publication 24 (1977), the Commission made clear that it is not the radon equilibrium equivalent concentration (EEC) at any given time, but the average concentration over a year, that must not exceed the MPC-value. In ICRP Publication 32 (1981) new limits for radon concentrations and exposures were recommended, namely, for radon concentration (EEC):

$1500\ Bq/m^3$ or 0.4 WL

and for annual exposure to radon daughters:

$3 \times 10^6\ Bqh/m^3$ or 4.8 WLM

ICRP Publication 26 put the emphasis on optimization of radiation protection. In ICRP Publication 37 (1983) an Appendix dealt with variables associated with radon contamination and their influence on the optimization process, and algebraic examples were given of optimization procedures, e.g. the design of ventilation.

ICRP Publication 47 (1986) is a revision of Publication 24 on the basis of information in Publications 26 and 32. The annual limit of intake (ALI) is expressed as 0.02 joule or 3.6 MBq. The annual limit of exposure and the derived air concentration (DAC) are the same as in Publication 32.

RECOMMENDATIONS WITH REGARD TO RADON IN DWELLINGS

Since ICRP Publication 1 (1958), the Commission has assumed that the risk resulting from exposures received from natural background radiation should not affect the justification of an additional risk from man-made exposures, because, as long as the probability of stochastic harm is proportional to the dose, the risks due to different sources of exposure are simply additive.

It was thought at the time that it was possible to define a "normal" natural background and that the limits only referred to doses resulting "from technical practices that add to the natural background radiation", such as mining and flight at high altitudes.

However, evidence of very high indoor concentrations of radon in dwellings accumulated rapidly. It was found that, in many cases, people received, in their homes, lung doses that would not have been accepted even for uranium miners. Something had to be done, but if the background dose were to be included under the normal dose limit the problem was obvious; if not, there was no other recommendation on dose limitation.

In its Publication 39 (1983), the Commission concluded that the distinction between normal and enhanced levels of exposure is not helpful and decided to base its new advice on a different approach. A more useful distinction, the Commission said, is between existing exposure situations, where any action would have to be remedial, and future situations, which can be subject to control at the stages of decision and planning.

For existing situations the Commission recommended the use of an action level specific to the initiation of the remedial action being considered. The concept of "existing situation" would also be valid for emergency situations after any accident that causes environmental contamination, where, for example, remedial actions against food-stuffs may be appropriate.

"A well chosen action level", the Commission said, "will take account of the likely effectiveness of the action to which it will

lead and of the total detrimental consequences of the action, which may not be limited to financial costs. The persons at risk should also be put in a better position by the action.

The Commission found it impossible to suggest a generally applicable value of an action level, even one limited to the specific case of radon in houses. However, if the remedial action considered is fairly simple, the Commission said, an action level "in the region of 200 Bq/m3" for the radon-222 concentration (EEC) might be considered. The Commission estimated that the corresponding annual effective dose equivalent would be about 20 mSv (which may now be considered an overestimate since the recommended dose coefficient is 0.06 mSv/year per Bq/m3).

For future situations involving exposure to natural sources of radiation, "the position is closer to that recommended by the Commission for artificial sources of exposure" says the Commission in paragraph 24 of Publication 39. The basic principles of justification of practice and optimization of protection should therefore apply. The main question was whether the normal dose limits should apply or not.

In the case of workers, the dose limit applies to occupational exposures irrespective of source, although exposure from "normal" natural background is at present not included under the occupational dose limit. A current problem for the Commission is to decide whether such exposures should be included in the future if it becomes increasingly more difficult to identify what is "normal". At present, doses from natural sources in mines are included, but not doses from high indoor radon concentrations at other work places.

For members of the public, the limitation principle is different. Their exposures are not controlled individually but by requirements related to the sources. The primary dose limit may be seen as a limit of the contribution from a particular selection of sources, explicitly excluding natural sources and medical irradiation of patients.

Since the normal dose limits were not intended to cover the doses from natural sources, the Commission decided to introduce special constraints for the optimization of protection in the case of future sources, and recommended that competent national authorities should establish an appropriate upper bound of individual dose in optimization assessments. The need of this constraint was obvious. Indoor radon concentrations (EEC) of more than 10,000 Bq/m3 had been measured in dwellings in some countries, implying annual effective dose equivalents of more than 10 times the Commission's dose limit for workers.

The Commission believed that 100 Bq/m3 would be a reasonable upper bound for the radon concentration (EEC) in new buildings, and that in many countries, it would prevent radon from becoming a dominating source of risk in dwellings. It was expected that the use of this upper bound in the optimization assessment of radiation protection in new houses would influence building standards for constructure, manufacture, ventilation, etc.