Calculated risks

One of the main problems with permanent geological disposal of radioactive wastes is that the peak risks associated with some radionuclides will occur hundreds of thousands of years in the future. Virtually all nations (planning or operating repositories) follow standards for radiation exposure; nevertheless, burying nuclear wastes amounts to mortgaging the welfare of future generations and the future environment. Current disposal standards can have questionable consequences because following a uniform annual dose limit for thousands of years will result in intergenerational inequities: as time increases, the risk will also increase, because radiation effects are cumulative and because there is no safe level of exposure, no threshold. Uniform dose standards alone eventually lead to nonuniform environmental effects.

To counteract the intergenerational inequities associated with a uniform annual *dose* limit for radiation exposure from nuclear repositories, a landmark August 1995 report of the US National Academy of Sciences (NAS) recommended using a uniform annual *risk* limit instead, that is, a standard based on the expected value of the probabilistic distribution of health effects of radiation. The report also recommended that compliance with standards for radioactive wastes be measured at the time of peak risk, whenever it occurs. It affirmed that geological processes are sufficiently boundable to allow million-year performance assessment (PA) of a potential repository, but warned that it is not possible to assess the frequency of intrusion into a permanent repository for a million years into the future[1].

Although the NAS proposal – to move from standards based on radiation dose to those based on risk – appears reasonable on grounds of intergenerational equity, in reality it could weaken current protection against radioactive pollution. Contrary to the International Commission on Radiological Protection (ICRP)[2], the most influential body in the area of radiation standards, the US report rejected the ICRP dose standard and proposed one based on risk alone.

According to the ICRP, 'ideally' standards should include both dose and risk limits. Using only a risk-based standard can be dangerous. The ICRP warns that assessing risk is more difficult than assessing dose, because in the former case 'it is necessary to depend on an examination of the procedures for estimating the probability of the exposures. The probabilities cannot be directly determined'. Also, the dose standard is useful for 'its original function of applying controls on each individual's accumulation of dose'[2].

Obviously, it is much easier to apply controls to an individual's radiation exposure if one has a measurable dose standard, than if one has a risk standard that is subject to potentially arbitrary assumptions about populations and distributions. A dose standard clearly specifies that, independent of any assumptions or arbitrary calculations about populations or their distributions, radiation controls should prevent any individual from receiving exposures above a certain limit. Moreover, individuals can 'count on' these controls in a way that they cannot count on risk standards. Risk-based standards (1) may require using arbitrary risk models and assumptions about unknowable future situations, (2) may be vulnerable to manipulation, (3) may remove the public's guarantee that exposures will be below a given dose, and (4) may generate public controversy because of their complexity and susceptibility to manipulation[3]. Also, one cannot adhere to a risk standard if one has to perform calculations (after measuring exposure) in order to determine exactly what the standard requires. At least the dose standard is clear and dependable, a fact of no small merit in health or environmental standards.

Of course, a risk standard is clear and dependable in situations in which the relevant probabilities and consequences can be known precisely. Radiation exposures, relevant populations, distributions and probabilities, however, cannot be known precisely over the million-year lifetime of a nuclear repository[4]. And if not, then the US committee's choice – of risk, rather than dose, standards for a radioactive waste facility – appears least desirable in the very situations for which the committee proposes it: million-year disposal. Present doses usually can be *measured*, whereas future risks always must be *calculated*, often on the basis of subjective judgments. The longer the time period of calculation, the more subjective is the PA. For risks a million years in the future, the devil you know (measurable dose) may sometimes be better than the devil you don't know (calculated risk).

Members of the public may believe that they are being asked to sign a blank check if they are asked to give up the protection of current dose limits and instead to rely on risk standards based on assumptions about what will happen in a million years. This blank check may become all the more onerous to the degree that radiation protection relies on expert judgment about exposure models and scenarios, rather than firm guidelines about dose. Citizens might reasonably fear the following consequences: (1) a future exposure to high levels of radiation; (2) resulting public outcries; (3) after-the-fact government assessment of whether the risk standards were actually violated; and then (4) the official 'conclusion' that the high exposure was really associated with a very low risk.

What is the solution to the risk-versus-dose dilemma that pits intergenerational equity against reliable radiation protection? One possibility might be to retain the dose limits on releases from a nuclear repository – for example, to allow $0.25\,mSv\,yr^{-1}$, as the French do – and to add the proposed risk standard to the dose limit. (Given the cumulative effects of radiation, this proposal obviously would require periodically reducing the dose limit, so as to keep risk – probability of harm – constant among generations. The ICRP, however, has not recommended such a continual dose reduction, although intergenerational equity seems to require it.)

If the Academy's proposed risk standard is as protective as dose limits, then adopting both would give the public no cause for alarm, and it would promote intergenerational equity. If the risk standard is not as protective as dose limits, then adopting both would promote reliable pollution-control in the present. In either case, the National Academy report would have done better to propose a dual standard if it wants present generations to trust repository regulation. The ICRP would do well to spell out the dose-reduction requirements if it wants to protect future generations.

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