The 2001 and 2008 Yucca Mountain Repository Standards: Errors Due to a Legal Dilemma That Needs to be Resolved – 9078

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ABSTRACT

The 2008 EPA Standards for the Yucca Mountain high-level radioactive waste repository suffer from the fact that they are *dose*-, rather than *risk*-, based. As such, they fail to reflect the scientific fundamentals of the fields of radiation biology and radiation protection and safety, the primary one being that the relationship between *dose* and *risk* will not remain constant with time. This is a key factor that distinguishes assessments of the health impacts of a nuclear facility that has the potential for long-term radionuclide releases from those, such as a commercial nuclear power plant that is designed to operate for perhaps 40 years, be decommissioned, and the site restored to its natural state. The origin of the problem lies in the Energy Policy Act of 1992, in which the U.S. Congress stipulated (a) that the Standards be expressed in terms of an "equivalent dose rate;" and (b) that EPA seek the guidance of the National Academy of Sciences (NAS) on the form and nature of the Standards. In its response, the most important recommendation of the NAS was that: "We recommend <u>the use of a standard that sets a limit on the risk to individuals of adverse health effects from releases from the repository"</u> … the reason being that "<u>a risk-based standard would not have to be revised in subsequent rulemakings if advances in scientific knowledge reveal that the dose-response relation is different than envisaged today</u>." Unfortunately, under the law EPA was compelled to follow the dictates of the U.S. Congress, namely, to express the limits in terms of a dose rate. The result is a set of Standards that is neither integrated, consistent, nor implementable.

INTRODUCTION

Through the Energy Policy Act of 1992 [1], the U.S. Congress stipulated that the Environmental Protection Agency (EPA) was assigned the responsibility for establishing "public health and safety standards" for a national high-level waste/spent nuclear fuel repository under Yucca Mountain, NV. In so doing, they called for the EPA Administrator to request that the National Academy of Sciences (NAS) provide that Agency with guidance on the form and nature of these standards.

In responding, the NAS stated [2]:

> "<u>We recommend the use of a standard that sets a limit on the risk to individuals of adverse health effects from releases from the repository</u>."

In supporting this recommendation, the NAS commented that, if the limits were expressed in terms of *dose*, it would not be possible to estimate the accompanying *risks* in the future, because "advances in scientific knowledge" could reveal "a dose-response relationship" that is "different from that envisaged today."

Concurrently, in a report on a related subject, the National Council on Radiation Protection and Measurements (NCRP) [3] stated that:

> "At some future time, it is possible that a greater proportion of somatic diseases caused by radiation will be treated successfully. If, in fact, an increased proportion of the adverse health effects of radiation prove to be either preventable or curable by advances in medical science, the estimates of the long-term detriments may need to be revised as the consequences (risks) of doses to future populations could be very different."

SCIENTIFIC BASIS FOR THE RISK APPROACH

Fundamental to this concept is that, as the baseline rates for fatal cancers in various body organs are reduced, the potential health impacts (cancer deaths) of radionuclide releases from the Yucca Mountain repository will be correspondingly reduced. This is because estimates of the risk of cancers, due to exposures to ionizing radiation, are derived using relative risk models [4]. As such, the fatal cancer risk of a dose to a specific organ is proportional to its underlying baseline rate. For this reason, as advances in methods for either the prevention or cure for a specific type of cancer are achieved, the risks of death, per unit dose to the affected organ, will be reduced.

Conflicting Guidance

Unfortunately, Congress [1] also stipulated that "such Standards shall prescribe the annual effective *dose* equivalent to individual members of the public from releases (from the repository) to the accessible environment." In so doing, they countermanded what ultimately became the primary and fundamental recommendation of the NAS. As such, both the EPA and the U.S. Nuclear Regulatory Commission (USNRC) were powerless to base the Standards and accompanying Regulations on *risk*. In essence, this also prohibited EPA from basing the Standards on the *principles of good science*. The USNRC was similarly bound in promulgating the associated Yucca Mountain Regulations [5].

JUSTIFICATION FOR RISK-BASED STANDARDS

To understand in full measure the dilemma this created, it is necessary to examine trends in the death rates from the various forms of cancer that afflict the U.S. population. For example:

- Lung cancer (the #1 cause of cancer deaths) [6] – the percentage of the members of the U.S. population who smoke cigarettes has been reduced from almost 50% in the early 1950's to 21% today. This reduction has been due to a variety of factors, the latest being the prohibition of smoking in public buildings, and in nearby outdoor areas. While there will be a lag in the response to these changes, in terms of lung cancer deaths, similar reductions in the per capita deaths will follow, especially when one recognizes that smoking causes an estimated 85% to 90% of all lung cancers [6].
- Breast cancer (the #2 cause of cancer deaths) [7] – progress is being achieved in the prevention and cure of this cancer through better diagnosis and targeted gene therapies. Another advance is the observation that physical exercise during the teen-years is beneficial because it reduces the estrogen levels in young girls.
- Colorectal Cancer (the #3 cause of cancer deaths) [6] – its annual rate of reduction is almost 5% for men, and 4.5% for women, the major reason being the development of screening tests that enable gastroenterologists to identify and remove pre-cancerous polyps so that the cancers that normally would be expected to develop do not occur. Since these reductions are being accomplished with only half of the adult population undergoing colonoscopies, it should be possible, in time, to approach a doubling of these rates.

- Skin cancers, such as melanomas [9] – (the leading cause of cancer (not deaths) in men – prostate cancer is #1) [10] – as in the case of breast cancer, targeted gene-therapies are proving beneficial in curing these types of cancers.
- Cervical Cancers [11] – these can now be prevented through the vaccination of young women.
- All cancers – studies have documented that obesity leads to an increase in the death rates from all types of cancer. This provides opportunities for universal reductions in the baseline rates from this disease.
- In fact, the latest data indicate that the overall U.S. death rate from cancers of all types is being reduced at a rate of more than 2% per year. This represents almost a doubling from the rate of 1.1% just a few years ago [12].

Of particular relevance in this regard is that a 1997 poll, conducted by the author, of leading U.S. cancer specialists, including the Director of the National Cancer Institute, and cancer specialists at several leading universities revealed that they concurred that methods for either the prevention or cure of essentially all of the common cancers that inflict human populations today would be available within the next 50 to 100 years. A more recent assessment shows that this goal could be achieved no later than 2030, and perhaps as early as in 2020 [13]. Even if these goals are not reached for several hundred years, it would still essentially remove the health risks associated with long-term radionuclide releases from the Yucca Mountain repository.

OTHER POTENTIAL PROBLEMS WITH THE EPA STANDARDS

Although the problems cited above are important, EPA was also constrained by other Congressional mandates and related factors. For example, the primary pathway through which radionuclide releases from the repository can expose population groups will be through the consumption of contaminated groundwater (which serves as essentially the sole source of drinking water in that region), and its use to irrigate agricultural crops. For this reason, the radionuclide limits in the existing EPA Drinking Water Standards, promulgated in 1976) [14], served as a basis for the groundwater limits. This led to a situation in which the limits for some radionuclides were expressed in terms of concentrations, and others were expressed in terms of dose rates. In still other cases (such as for Ra-226), some limits mandated the inclusion of dose contributions from naturally occurring radium, others did not. In addition, the dose limit for each radionuclide had to be met on an individual basis, regardless of whether the total dose rate limit was not being exceeded. Exacerbating the situation, there were separate limits for the dose due to direct consumption of the ground water, and the consumption of the water plus agricultural products irrigated with it.

Also of note is that analyses have documented that the dose estimates [base on extremely conservative (high) release rates], coupled with physical and biological information, show that five of the eight radionuclides listed in the EPA Standards, would be so low as not to represent a problem. These include:

- C-14: The average daily consumption of stable carbon by an adult is 300 g. This would dilute the maximum estimated daily intake of C-14 by a factor of 25 trillion to 1. This places an upper bound on its potential dose rate [15, 16].
- Tc-99: This element did not exist until the nuclear era. Because it is foreign to the human organism, it is rapidly rejected, yielding a biological half-life of only 3 days. This places a limit on its dose [15]. In addition, due to the chemical nature of the underlying ground water, it will be precipitated as soon as it leaves the repository (Turcotte, 1982) [17].
- I-129: This radionuclide has a biological half-life of 12 days, and a physical half-life of 15.7 million years. For this reason, it has an extremely a low specific activity. In fact, studies have revealed that it quickly saturates the thyroid, thus limiting its dose [15, 16]. As a result, the NCRP has concluded that this evidence, in conjunction with the results of animal studies, “suggest that I-129 does not pose a meaningful threat of thyroid carcinogenesis in people” [18].

- Ra-226: Extensive studies by Evans [19] of radium dial painters documented that this radionuclide has a threshold for health effects in humans. The data supporting the threshold, which is a factor of thousands higher than any quantities that members of the public could receive from releases from Yucca Mountain, has been reviewed in detail, and fully supported by the staff of the Los Alamos National Laboratory (LANL) [20]. In the conclusions, they stated that “no symptoms were ever observed for persons with body burdens of 0.1 microgram or less. That conclusion still holds today."
- Ra-228: This radionuclide has a physical half-life of 5.75 years. It will have essentially decayed within 100 years (>17 half-lives) after closure of the repository [15].

REALITY CHECK ON THE EPA UPDATED STANDARDS

In developing its Final Rule [21], it would have been interesting to know if the EPA staff had considered the following ramifications:

- At 500,000 years, Pu-239 will have decayed through more than 21 half-lives, reducing its original activity by a factor of more than one million (10^6)
- At 1,000,000 years, its activity will have been reduced by a factor of more than one billion (10^{12}).

RESOLVING THE DILEMMA

Based on the discussions above, one could logically ask: “What can be done?” One approach would be for the waste management community, in concert with the support of organizations, such as the American Nuclear Society, the Nuclear Energy Institute, and related organizations, to join in a concerted effort to bring this dilemma to the attention of key members of Congress and request their support in resolving it as soon as possible. Also to be considered, by the Health Physics Society, for example, would to be to request that the ICRP and the NCRP clarify and strengthened their recommendations on the critical importance of expressing the limits, associated with nuclear facilities that have the potential for long-term radionuclide releases, in terms of *risk*, not *dose*.

The success of such actions would not only provide a service to our nation and the public, but also to society as a whole. Unless action is taken soon, this situation will lead to a continued unnecessary expenditure of billions of dollars, years of additional associated delays, and an erroneously based lack of confidence on the part of the public in the security and safety of the Yucca Mountain repository. In fact, assessments and preliminary analyses indicate that the probable time of maximum risk in the life of the repository will be during the emplacement of the wastes, and that the risk will fall almost entirely on facility staffers, not the public [15]. Through successfully pursuing the recommended action, the waste management community can not only provide support to EPA, but also facilitate the development of safe and effective high-level radioactive disposal facilities in other countries of the world.

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