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General Comment

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Attachments

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July 30, 2012

Comments on Proposed Revisions to Part 61

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Introduction

I was asked to participate on the panel discussing Time of Compliance in the public meeting on July 19, 2012. However, health issues prevented my direct participation, except by listening to the webinar. I have about 30 years experience in risk analysis and performance assessment of waste facilities; at one time I served as the Senior Advisor for Performance Assessment in NMSS. For the last 12 years I have taught graduate courses in the Clark School of Engineering of the University of Maryland. One such course is "Environmental Risk Analysis", ENPM627, which uses the textbook, Quantitative Environmental Risk Analysis for Human Health, of which I am a coauthor. I believe my academic activities have provided me with a broader perspective, which may be helpful to the NRC in its deliberations on this matter. Because of my other commitments, I have not been able to provide as much information as I would have liked; if granted more time, I could expand on these limited comments.

Analysis

Much of my input is based on the staff's White Paper, "Technical Analysis Supporting Definition of Period of Performance for Low-Level Waste Disposal", the June 1997 report by the National Academy of Public Administration (NAPA), and the comments made at the public meeting on July 19, 2012. One of the issues common to all three sources is surprisingly loose terminology used to discuss this important issue. Both the staff's white paper and the NAPA report seem to shift language among terms such as "hazard", "risk", and "estimated dose". This is more than an academic distinction. "Hazard" denotes the potential for harm. An electrical outlet is a hazard; however, it is seldom dangerous because most adults know not to insert un-insulated metal objects into an electrical outlet. "Risk" is the magnitude of harm weighted by its probability of occurrence. Finally "estimated dose" is a measure of radiological harm to a future individual, which may be converted to a risk of cancer. However, for high doses, somatic health effects may occur, which could cause severe, prompt health impacts, including death. Depleted uranium, which appears to be the main focus of the proposed rulemaking, is an odd substance, because the present hazard from depleted uranium is small per unit mass, while the hazard from it is predictable, with little uncertainty, to be much larger, because of the ingrowth of progeny radionuclides, especially radium, radon, and lead-210. Although the hazard of depleted uranium in time may be predicted with almost perfect certainty, the risk and dose from disposing of this substance in shallow land burial is fraught with enormous uncertainty, especially for the long time periods over which the inventory of hazardous progeny becomes large. What the staff does not discuss fully is the relationship among hazard, dose, and risk, although it should.

Another bewildering facet of the staff's white paper and the panel discussion is the focus on "radioactivity", as if it were a good measure of hazard, dose, and/or risk. In fact,

Figure 1 of the staff's white paper plots "Activity Ratios of Depleted Uranium and Commercial Low-Level Waste". Following Figure 1, the staff states: "Because different elements can have different mobility and radiotoxicity, total activity may not directly translate to risk (dose)." This appears to be a substantial understatement of the facts. The staff knows (or should know) very well that some of the progeny of uranium-238 are substantially more radiotoxic than the parent radionuclide. Radionuclides with short half-lives are very radioactive and may pose a substantial risk from direct exposure or from internal exposure (if the radionuclide enters the body through inhalation, ingestion, or dermal sorption). Some long half-life radionuclides (especially alpha emitters, such as radium) pose small risks from external exposure, but are powerful carcinogens if they enter the body. If radioactivity were the key to radiotoxicity, then tritium would be as dangerous for internal exposure as plutonium; it is not. One of the panelists at the July 19 meeting said that depleted uranium had 1/5 the radioactivity of natural uranium, as if to emphasize how harmless the substance is (however, perhaps, he should be excused since

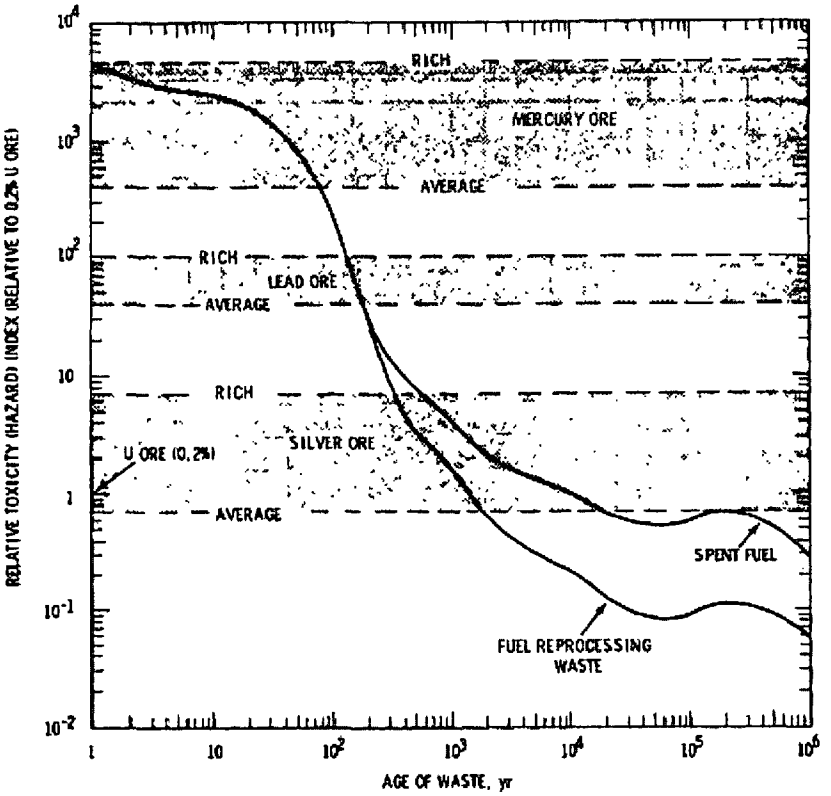

FIGURE 3.4.1 Toxicity of Spent Fuel and Reprocessing Waste from Uranium-Plutonium Recycle Relative to 0.2% Uranium Ore Necessary to Produce 1 MT of Reactor Fuel

his stated background is geochemistry, not risk analysis or health physics). If the staff wants to address the hazard of depleted uranium over long periods of time, it should employ a concept, such as the "hazard index" used in the document, *FEIS Management of Commercially Generated Radioactive Waste*[1]. Figure 3.4.1 from the cited report is

[1] ENVIRONMENTAL IMPACT STATEMENT - Management of Commercially Generated Radioactive Waste, Volume 1, U.S. Department of Energy, October 1980. DOE/EIS-0046F

reproduced here. The hazard index defined in this document is 'based on the amount of water required to bring the concentration of a substance to allowable drinking water standards". In other words, it is the quantity of a particular radionuclide divided by the concentration limit for that radionuclide established for drinking water. As such, this "hazard index"[2] has the unit of volume, often stated as m^3. Note that in Figure 3.4.1, the ingrowth of progeny in the "natural ore body" is not considered, but the ore body is presumed to remain at the same concentration of natural uranium for all time, even though it will not.

Environmental contaminants have three general temporal behaviors in the environment. Environmental contaminants may: (1) decrease in toxicity in the environment; (2) maintain their toxicity relatively constant in the environment; or (3) increase their toxicity in the environment. Many organic contaminants decrease in toxicity, because of the action of aerobic and/or anaerobic bacteria. For example, the biological oxygen demand caused by sewage outfalls into rivers is substantially reduced by the action of aerobic bacteria and may be quantified by the Streeter-Phelps model. Contrary to the staff's statement on page 19 of the White Paper, heavy metals generally do not undergo biodegradation in the environment. After all elements, unless they are radioactive, are forever! However, the bioavailability of heavy metals may be modified in the environment. Whether a particular metal may become more or less bioavailable depends very much on the chemical environment it is in. However, some toxins such as lead and arsenic may be good examples of contaminants that tend to remain at constant toxicity in the environment. Depleted uranium is a good example of the rather rare class of contaminants that will surely increase in toxicity in the environment, because of the ingrowth of more radiotoxic progeny.

As discussed in both the staff's White Paper and at the Public Meeting, virtually everyone agrees that quantitative predictions of the risk or dose of depleted uranium (DU) (or anything else for that matter) disposed by shallow land burial is extremely uncertain for very long times ($10^3 - 10^7$ years). This then is the dilemma: depleted uranium becomes much more hazardous at long times, but the ability to predict its risk to the public becomes extremely uncertain. So then, should we merely do what is convenient for society now and dispose of the DU by shallow land burial or does generational equity require us to take a more prudent course of action. I believe a practical, pragmatic, more prudent approach should be taken, rather than shallow land burial.

Unfortunately, the five options described on pages 10-19 of the White Paper all relate to adapting regulatory decision criteria contained in 10 CFR 61, so they may be applied to the shallow land burial of large quantities of depleted uranium. This may be an expedient approach, but it confines the solutions for this problem to only one possibility – shallow land burial. Given the substantial hazard that a large quantity of depleted uranium will

[2] Hazard index is placed in quotes, because this definition departs from the usual definition of hazard index used by EPA for remediation decisions. That definition is: $HI = \sum HQ_i$, where HQ_i is the ratio of the estimated dose to the reference dose for a given contaminant. See Quantitative Environmental Risk Analysis for Human Health, Chapter 11, cited above for a more complete discussion.

pose at some time in the future, other options should be explored. It should be noted that most of the residual hazard of spent fuel comes from the progeny of the initial content of uranium and, to a lesser extent, transuranium elements. Therefore, in the long term depleted uranium and spent fuel will have approximately the same hazard. If a 300,000 to 1 million year performance period is appropriate for spent fuel, based on the peak hazard (as mandated by a court), why shouldn't the same hold true for depleted uranium? The only difference is that spent fuel starts out being extremely hazardous and decreases in hazard. Depleted uranium starts out being not very hazardous and increases in hazard. Except for the extra burden of progeny of neptunium, plutonium, americium, and other activation products, the spent fuel and depleted uranium will pose similar hazards, given long periods of time.

Given these facts, the some of the principles articulated by the NAPA cannot be met, if shallow land burial for large quantities of depleted uranium is undertaken. Using the staff's modifications to the NAPA principles, two in particular cannot be met:

> (4) Actions that pose irreversible harm or catastrophic consequences should not be pursued.
>
> (5) Actions today should not prevent future generations from making independent decisions.

If large quantities of depleted uranium are emplaced in a shallow land burial site, the anticipated fate of that uranium will be to disperse in the surrounding subsurface environment, contaminating subsurface soil and groundwater and perhaps contaminating surface soil. Although this may take place over a long period of time, this environmental fate of this material is virtually certain. If one considers the basics of the contaminant transport equation[3] (also termed the advective-dispersion transport equations), it is clear that advection and dispersion will cause the high concentration of uranium in the groundwater (which will almost certainly occur and which is assumed in the staff's analysis) to be reduced by migration in the groundwater. This will spread the contaminant over a potentially large portion of the subsurface, where it may ultimately cause human exposure. Although this is not technically "irreversible", practically it is. Both spent fuel and depleted uranium are manmade materials; they do not occur in nature. Billions of dollars, (if not much more), were spent to mine natural uranium ore, concentrate it into uranium oxide, and then enrich natural uranium in the fissile U-235 isotope. This process let to enriched uranium, used for nuclear weapons and reactor fuel, and depleted uranium. Disposal of spent fuel and/or depleted uranium in the subsurface (shallow or mined facility) will ultimately undue the mining, refining, and enrichment process. So if a future generation decides to remove the result of depleted uranium disposal from the contaminated ground and groundwater, that generation will face a major remediation effort, at a cost paralleling the production of the original material. This constitutes irreversible harm! Similarly for much the same reasons, this precludes the future generations from making a large class of independent decisions, in particular to use depleted uranium for some beneficial purpose. Finally disposal of a large quantity of

[3] Because the contaminant transport equation is a parabolic partial differential equation, it causes entropy to increase. To reverse the effects of dispersion, a large amount of energy must be used to decrease the entropy of the resulting mixture and separate the uranium from the subsurface media.

depleted uranium by shallow land burial is likely to lead to a superfund site (or its future equivalent); this may occur much sooner than expected.

A good insight into the hazards and risks of uranium in the environment may be found in the dose reconstruction for the Fernald Feed Materials Production Center[4], sponsored by the Centers for Disease Control. Beginning in 1951 Uranium ore was transported to the site and processed in foundries to produce high-purity uranium. The site stored uranium ore in silos on the site. There are stark differences between the Fernald facility and shallow land burial of large quantities of depleted uranium; nevertheless, when large quantities of uranium-238 are considered, the production of radiotoxic progeny, such as radium and radon, can be significant, even over relatively short times. The staff should consider this aspect. An increase of cancers in the area surrounding the Fernald facility due to operations there was estimated to be 1-12% for lung cancers and 23 additional cases (upper bound) of leukemia in a population of approximately 46,000. The cost of remediating this site was at least $4.4 billion.

Given that we are entering a time of diminished financial resources, a more practical solution would be to store the stocks of depleted uranium in a stable chemical form in a monitored, retrievable storage facility. (Likewise, spent fuel could similarly be stored) The storage facility could be on the surface or underground. It should be noted that the EPA[5] lists the following uses for depleted uranium:

1. Shielding to protect Army tanks
2. Used in parts of bullets and missiles to promote armor piercing
3. Used in helicopters and airplanes as counter weights on certain wing parts

Since depleted uranium has several current uses and may have many more in the future, this material should be placed in a state where it may be easily recycled in the future.

Recommendations

1. Delete the graph of radioactivity vs. time (Figure 1) from the White Paper and replace it with a graph depicting the time-varying nature of the hazard of depleted uranium; e.g. use the "hazard index" defined in DOE's EIS on Commercially-Generated Radioactive Waste.
2. Although the results of hypothetical dose calculations are useful, the staff should compile tables of projected initial emplacement inventories and the anticipated long term doses from those inventories.
3. The technical analyses supporting the staff's White Paper should be made public and should be peer-reviewed both internally and externally.
4. The NRC staff should not submerge issues surrounding the disposal of depleted uranium and the hazard to future generations it represents, by parsing the issues into narrow technical questions about time of compliance and waste acceptance criteria. Instead it should address these issues head-on by being fully open about these issues with both the Commission and public.

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[4] See: http://www.cdc.gov/nceh/radiation/fernald/default.htm for a link to several documents related to this risk assessment.

[5] http://www.epa.gov/radiation/radionuclides/uranium.html#use

5. Since the statement of considerations for 10 CFR 61 explicitly excluded large quantities of long-lived radionuclides (such as depleted uranium) from shallow land disposal, this issue should only be addressed by a full scale rulemaking, perhaps leading to a separate Part of the NRC regulations related to depleted uranium and similar material.
6. The NRC staff and the Commission should consider monitored retrievable storage of depleted uranium rather than "disposal". Since this is a national problem, cooperation on a better alternative should be undertaken with DOE, even though the DOE Programmatic EIS has led to a "disposal" option.

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