Depleted Uranium Classification - 9321

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ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) staff recently completed a technical analysis and an evaluation of regulatory options to respond to a Commission Memorandum and Order (CLI) regarding depleted uranium (DU) waste classification. This paper summarizes the results of the technical analysis and the regulatory options evaluated by the staff.

INTRODUCTION

The licensing of new uranium enrichment facilities in the United States has brought DU to the forefront of low-level waste (LLW) disposal issues. Depleted uranium is produced in the enrichment process as a waste product. The enrichment process concentrates both the U-235 and U-234 in the product, and therefore, these radionuclides are depleted in the DU waste stream. The dominant radionuclide in DU is U-238.

The most prevalent forms of DU for disposal resulting from nuclear fuel cycle activities are depleted uranium hexafluoride (UF_6) and depleted uranium oxide (UO_2 or U_3O_8), which results from deconversion of fluoride forms. Depleted uranium oxide contains approximately 85 percent uranium by mass. In comparison, a low-grade uranium ore common in the United States may contain 0.1 percent uranium by mass.

Over time, the parent radionuclides in DU decay through the uranium series decay chains producing daughter radionuclides. In natural ores, the daughter radionuclides are generally in secular equilibrium with the parent radionuclides. For uranium mill tailings, the uranium has been substantially removed, leaving the daughter products (specifically, radium) a significant portion of the total activity at the time of disposal; therefore, disposal or management decisions can focus on the radiological inventory at the time of disposal. In contrast, DU is essentially depleted in the daughter radionuclides but concentrated (compared to natural ore or uranium mill tailings) in the parent radionuclides. Over long periods of time, the uranium parent radionuclides have the potential to produce quantities of daughter radionuclides significantly in excess of natural ores or uranium mill tailings because the DU source has much higher concentrations of uranium.

The DU waste stream is unique; the relatively high concentrations and large quantities of DU that are generated by enrichment facilities were not considered in the Final Environmental Impact Statement (FEIS) supporting the development of 10 CFR Part 61 (Part 61).[1] When the FEIS was issued in 1982, the FEIS considered only the types of uranium-bearing waste streams being typically disposed of by NRC licensees at the time. There were no commercial facilities generating large amounts of DU waste and,

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[1] Part 61 FEIS, NUREG-0945, Vol. 1, (November 1982) at 5-38. The FEIS relies on extensive analysis and calculations found in the Draft Environmental Impact Statement (DEIS) that are incorporated by reference. The references in this paper to the FEIS include the supporting information found in the DEIS.

thus, the assumed inventory of uranium was relatively small.[2] The NRC concluded that those waste streams posed an insufficient hazard to warrant establishing a concentration limit for uranium in the waste classification tables in 10 CFR 61.

With the existing Department of Energy (DOE) stockpile of DU at the Paducah and Portsmouth Gaseous Diffusion Plants, and the recent licensing of Louisiana Energy Services (LES) National Enrichment Facility and the United States Enrichment Corporation American Centrifuge Plant, more than 1,000,000 metric tons of DUF_6 need a disposition path, which could be a commercial LLW disposal facility licensed by the NRC or an Agreement State. The Commission has previously indicated “under a plain reading of the regulation, depleted uranium is a Class A waste” [1]. As such, any existing disposal facility currently licensed to accept Class A waste represents a potential disposal path for the DU waste stream. However, in light of the large quantities of DU that need to be disposed, the Commission directed staff “outside of the LES adjudication, to consider whether the quantities of depleted uranium at issue in the waste stream from uranium enrichment facilities warrant amending section 61.55(a)(6) or the section 61.55(a) waste classification tables” [1].

In order to develop an informed response to the Commission direction, the staff performed a technical analysis to evaluate the impacts of near-surface disposal of large quantities of DU and to determine if amendments to § 61.55(a) are necessary to assure that large quantities of DU are disposed of in a manner that meets the performance objectives of Part 61. The results of this technical analysis are summarized in the discussion below. Following the summary of the technical analysis, this paper presents four possible regulatory approaches in response to the Commission direction. Additional detail about staff’s technical analysis and the regulatory options presented in this paper can be found in Commission Paper (SECY)-08-0147 [2].

SUMMARY OF RESULTS OF TECHNICAL ANALYSIS

Staff developed a screening model to evaluate the radiological risk and uncertainties associated with near-surface disposal of large quantities of DU at a generic LLW disposal site. The generic disposal site had a broad range of climatic (e.g., humid or arid), hydrological, and geochemical conditions. The model was used to understand the impacts of key variables such as: disposal configurations, performance periods, institutional control periods, waste forms, site conditions, exposure pathways, and receptor scenarios. Calculations were performed probabilistically to represent the impact of variability and uncertainty on the results. The analysis methodology used in the model is consistent with the technical analysis methodology found in the FEIS supporting Part 61. This approach allowed constraints to be identified for the safe disposal of large quantities of DU in near-surface disposal.

The model framework is based on several key assumptions, which are detailed in SECY-08-0147 [3]. DU is assumed to be disposed of in an oxide form, either in carbon steel packages filled with a low-density powder or blended and stabilized in a cementitious grout form.[3] The waste is assumed to be buried in below ground disposal cells backfilled with native soil. The disposal cells are assumed to have an engineered cover that would limit infiltration and a clay layer that would serve as a radon barrier.

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[2] The Part 61 FEIS (NUREG-0945, November 1982) considered 17 Curies of U^{238} (6.3×10^{11} Becquerel) compared to approximately 100,000 - 200,000 Curies of U^{238} (3.7×10^{15} to 7.4×10^{15} Becquerel) that will be generated from LES during its 25-year lifespan (FEIS for the Proposed National Enrichment Facility in Lea County, New Mexico, NUREG-1790, June 2005).

[3] This assumption is consistent with the Final Programmatic EIS for Alternative Strategies for the Long-Term Management and Use of DUF_6, (DOE/EIS-0269), 1999.

Two primary receptors are evaluated in the technical analysis: the resident and the inadvertent intruder. The resident receptor is assumed to build and occupy a residence at the boundary of the disposal site, outside a buffer zone around the disposal area, and use a well for residential activities. A receptor engaging in activities on the disposal site, rather than outside the buffer zone, is regarded as the inadvertent intruder. The inadvertent intruder is assumed to excavate into the waste layer for home construction, occupy a residence on the disposal site, drink water from an onsite well, and ingest food grown in contaminated soil. For waste disposal depths greater than 3 m, a disruption and redistribution of waste was assumed to occur as a result of drilling of a well for domestic water use. Both the resident and the inadvertent intruder are expected to occupy the site after a breakdown of institutional controls; however, as noted above the resident is not located above the disposed waste. Institutional controls are assumed to be relied upon for 100 years, consistent with 10 CFR 61.59(b).

Radon was included in the total dose assessment in the technical analysis based on guidance in NRC guidance document (NUREG)/CR-4370, 'Update of Part 61 Impacts Analysis Methodology.' The impacts analysis update provides approaches to calculate radon doses, and states that the doses should be added to other impacts calculated for the intruder scenario. The resident receptor total dose received was compared to the 25 millirem (mrem)/yr (0.25 millisieverts(mSv)/yr) total dose value specified in 10 CFR 61.41, whereas the intruder total dose received was compared to a 500 mrem (5 mSv) total dose limit. [4]

The technical analysis determined that DU has unique characteristics that are dissimilar from commercial LLW. The radiological hazard from DU gradually increases over time due to the in-growth of decay products, eventually peaking after 1,000,000 years, in contrast to the radiological hazard from typical LLW, which decreases significantly over a few hundred years. Therefore, consistent with NUREG-1573, "A Performance Assessment Methodology for Low-Level Radioactive Waste Disposal Facilities", the technical analysis evaluated a period of performance of 10,000 years, yet considered longer timeframes as a basis for making judgments about the magnitude of the estimated dose relative to the performance objectives.

The technical analysis concluded that near-surface disposal (i.e., less than 30 m, as defined in Part 61) may be appropriate for large quantities of DU under certain conditions. However, unfavorable site conditions, such as shallow disposal (i.e., less than 3 m) or disposal at humid sites with a potable groundwater pathway, could exceed the performance objectives of Part 61, Subpart C. Although shallow disposal for large quantities of DU is not likely to be appropriate regardless of site conditions, small quantities (approximately 1 – 10 metric tons) of DU could be disposed of at shallow depths. Shallow disposal may also be possible for larger quantities of DU if robust intruder barriers excluding the possible excavation of DU and a robust radon barrier that can effectively limit radon fluxes over the period of performance are installed and their performance is justified. However, performance of radon or intruder barriers for long periods of time (i.e., beyond 1,000 years) is well beyond the current experience base and is highly uncertain.

EVALUATION OF REGULATORY OPTIONS

Based on the results of the technical analysis, staff believes that a change to existing regulations or a generic communication is necessary to ensure large quantities of DU are disposed of safely. Staff identified four options in SECY-08-0147 that it believes would facilitate safe disposal.

[4] "A dose guideline of 500 mrem/year (5 mSv/yr) to the whole body would therefore appear to be acceptable for protection of an inadvertent intruder. "Part 61 DEIS, NUREG-0782, Vol. 2, (September 1981) at 4-56

Option 1

Under Option 1, staff would issue a generic communication (e.g., a regulatory issue summary) that would reiterate that the "bottom line for disposal of low-level radioactive wastes are the performance objectives of 10 C.F.R. Subpart C …" and would clarify acceptable methods for dealing with unique waste streams like large quantities of DU [4]. The generic communication would emphasize that compliance with the existing performance objectives needs to be demonstrated through analysis and that classification under § 61.55(a)(6) should not be relied upon for this purpose. After developing the generic communication, staff would revise the associated guidance documents to describe an acceptable method for conducting a site-specific analysis for nuclides or concentrations not specifically covered in the waste classification tables. The specific parameters and assumptions staff recommends for conducting the site-specific analysis would be included in the guidance documents, which would undergo public comment and stakeholder input prior to being finalized.

Through communication with the Agreement State regulators, the NRC staff has learned that DU is already being given special consideration as a unique waste stream. For the commercial LLW disposal facilities where large quantities of DU are most likely to be disposed, some site-specific evaluation has already been performed by the licensee or the Agreement State regulatory authority, or the regulatory authority plans to require the licensee to perform a site-specific evaluation prior to disposal of large quantities of DU. As such, Option 1 allows Agreement State regulators to continue with their current policies under the existing regulations, without conducting a rulemaking to revise NRC regulations.

The primary advantages of Option 1 are that it would not require rulemaking and would require fewer resources than the other options. In addition, it is staff's understanding that Agreement State regulators believe a site-specific analysis is needed for large quantities of DU, and indicated that they intend to rely heavily upon NRC staff's guidance for conducting these analyses at the facilities they regulate. A generic communication would clarify the need to demonstrate compliance with the performance objectives and the Agreement States could request that their licensees and applicants perform site-specific analyses prior to disposal of large quantities of DU or other unique waste streams. The primary disadvantage of Option 1 is that the Agreement State regulators would not be able to require licensees and applicants to perform a site-specific analysis. Licensees and applicants would be free to propose alternative methods of complying with the regulations, which the regulators would then have to evaluate to determine whether the methods proposed by the licensee or applicant comply with the performance objectives of Part 61.

Option 2

Option 2 is a limited rulemaking to revise Part 61 to reflect a requirement to perform a site-specific analysis prior to disposal of unique waste streams, including large quantities of DU. This change would be assigned a compatibility category that would require Agreement States to adopt and make conforming changes to their regulations (e.g., compatibility category B). The rule language under Option 2 would be broad enough to include other unique waste streams that may arise in the future, so that additional rulemakings may not be necessary. As currently envisioned, unique waste streams could include those that may result from spent fuel reprocessing, or other types of waste streams that could emerge in the future from new kinds of facilities that generate significantly different concentrations and quantities of waste not previously considered in the Part 61 FEIS. Similarly, staff intends to define "large quantities" of DU in the rule language as quantities similar to those being generated at uranium enrichment facilities.

In order to ensure that the site-specific analyses that would be conducted by licensees and applicants are consistent with the analysis performed in the Part 61 FEIS, and to be protective of public health and safety, staff believes certain technical requirements, such as the type of receptors used to assess protection of the general population from releases of radioactivity, the exposure scenarios evaluated to protect individuals from inadvertent intrusion, and the period of performance evaluated, will also need to be specified in the rule language. Therefore, under Option 2, the specific technical requirements associated with disposal of large quantities of DU (as well as other unique waste streams) would be developed in the notice and comment rulemaking process. Option 2 also involves developing and issuing a guidance document that would provide the Agreement State regulators, and their licensees and applicants, technical guidance to conduct these site-specific analyses.

The primary advantage of Option 2 is that it creates a legally binding requirement, which ensures a site-specific analysis is performed by licensees and applicants and reviewed and approved by the Commission or Agreement State regulators. Furthermore, several Agreement State regulators indicated that they preferred this option because it could be easily enforced. In addition, this option ensures the protection of health and safety by imposing an additional requirement for large quantities of DU in a risk-informed manner that will be consistent with the analysis performed to develop the waste classification tables in § 61.55. The primary disadvantage of Option 2 is that, unlike other radionuclides in the waste classification tables, large quantities of DU would require a site-specific analysis instead of the use of a convenient table with a specific concentration limit. This option would also be more resource intensive than Option 1.

Option 3

Option 3 involves developing a generic waste classification (e.g., A, B, C, or Greater than Class C [GTCC]) for DU and an associated concentration limit to be added to the waste classification tables. Staff would begin with the technical analysis described above, which was consistent with the Part 61 methodology but updated to include recent advances in modeling and performance assessment techniques. The result of staff's additional analysis would be a concentration limit for a generic LLW site in the United States. Consistent with the assumptions in the original Part 61 analysis, this concentration limit would likely be based conservatively on potential disposal at a "reference" humid, eastern LLW disposal site. Subsequent to completion of this analysis, staff would initiate a rulemaking to revise the waste classification tables to explicitly include DU.

The primary advantage of Option 3 is that DU would be given a specific concentration limit, similar to the other radionuclides currently listed in § 61.55, and a specific waste classification that would apply to any LLW disposal site in the United States. The development of such a generic classification could prove useful if the current LLW environment were to change drastically in the future (e.g., if several new LLW disposal facilities are proposed) because it would eliminate the need for a site-specific analysis for large quantities of DU. The primary disadvantage of Option 3 is that the concentration limit developed could be so low for a reference site that it would unnecessarily constrain disposal options at sites with significantly different characteristics (e.g., humid vs. arid). As such, this approach would be prescriptive rather than a risk-informed approach, which would take into account the performance of the waste in a specific disposal environment. Another drawback to Option 3 is that it propagates the existing waste classification system, which was developed using often conservative assumptions based on the environment for LLW at the time the Part 61 FEIS was developed; some of these assumptions are not necessarily applicable in today's environment of limited disposal options and improved performance assessment capabilities.

Option 4

A final option staff considered is to risk-inform the entire waste classification framework by using updated modeling and performance assessment techniques to evaluate and revise the existing waste classification tables for all radionuclides, if necessary, not just for DU. This revision would likely involve different methodologies and assumptions than the original Part 61 methodology. The existing Part 61 waste classification framework is well accepted by the LLW disposal industry, and has been used successfully for more than two decades. However, as mentioned above, some of the assumptions built into the framework could be considered conservative and inconsistent with today's movement towards risk-informed regulation.

Staff could also consider, for example, the International Atomic Energy Agency's waste classification system to determine if it would be appropriate for use in the United States. Subsequent to completion of this analysis, staff would initiate a rulemaking to revise the waste classification tables.

The primary advantage of Option 4 is that the waste classification framework would reflect current knowledge of the performance of LLW disposal facilities and would present risk-informed concentration limits for all radionuclides, not selectively for DU. An update of the methodology used to develop the concentration limits could result in higher or lower concentration limits than currently used, which could actually increase or decrease disposal options for some types of wastes (e.g., current Class B/C waste could become Class A waste). However, some stakeholders may view this to be "deregulation" of LLW. A disadvantage of Option 4 is that the efficiency that could be gained from updating the existing waste classification framework may not be the most effective use of agency resources, given the relatively low increase in health and safety achieved and the small number of currently operating LLW disposal facilities. Option 4 is also well beyond the scope of what the Commission directed the staff to consider, and would require a large amount of time and resources.

Additional Options Evaluated

In addition to the options discussed above, staff evaluated the possible use of 10 CFR 61.58 "Alternate requirements for waste classification and characteristics" to require that a site-specific analysis be performed prior to disposal of large quantities of DU. Staff concluded that because § 61.58 is an exception provision, if the staff intended to use § 61.58 in order to develop an alternate waste classification or alternate characteristics for a Class A waste stream such as DU, *and to require licensees to conform to the alternate classification or characteristics as the sole method of compliance in place of (as opposed to as an alternative to) the existing regulations*, a rule change would be necessary.[5] A complete discussion of the staff's evaluation of the use of § 61.58 is presented in SECY-08-0147 [5].

REFERENCES

1 NRC, "Memorandum and Order CLI-05-20, In the Matter of Louisiana Energy Services", October 19, 2005.

2 NRC, "SECY-08-0147, Response to Commission Order CLI-05-20 Regarding Depleted Uranium", October 7, 2008.

3 NRC, Enclosure 1 to "SECY-08-0147, Response to Commission Order CLI-05-20 Regarding Depleted Uranium", October 7, 2008.

4 NRC, "Memorandum and Order CLI-05-05, In the Matter of Louisiana Energy Services", January 18, 2005.

[5] This is consistent with the discussion of § 61.58 in NUREG-1854, "NRC Staff Guidance for Activities Related to U.S. Department of Energy Waste Determinations: Draft Final Report for Interim Use." Specifically, NUREG-1854 states:

> "10 CFR 61.58 was intended to allow the NRC the flexibility of establishing alternate waste classification schemes when justified by site-specific conditions *and does not affect the generic waste classifications established in 10 CFR 61.55"*

Id. at 3-36 (emphasis added).

5 NRC, Enclosure 3 to "SECY-08-0147, Response to Commission Order CLI-05-20 Regarding Depleted Uranium", October 7, 2008.