LEGAL AND REGULATORY ISSUES REGARDING CLASSIFICATION AND DISPOSAL OF WASTES FROM ACTINIDE PARTITIONING AND TRANSMUTATION

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ABSTRACT

Partitioning and transmutation of actinide radioelements in spent nuclear fuel from civilian power reactors is potentially attractive because the resulting wastes might be acceptable for disposal using systems which are considerably less costly than a deep geologic repository. At present, there are no legal or regulatory prohibitions to seeking alternatives to a geologic repository for disposal of such wastes, regardless of whether they would be classified as high-level waste or greater-than-Class-C low-level waste. However, additional laws and regulations would be needed, and the Nuclear Regulatory Commission has been reluctant to alter the current framework for radioactive waste management, in which geologic repositories or near-surface facilities are the only disposal options established in law and regulations, unless a compelling need for alternatives with intermediate waste-isolation capabilities is demonstrated. There are also important technical considerations which are not encouraging with regard to the development of intermediate disposal systems for wastes from partitioning and transmutation of actinides in civilian spent fuel. First, the wastes may contain sufficient concentrations of fission products that disposal in a geologic repository would be required for protection of public health regardless of the concentrations of long-lived actinides. Second, defense reprocessing wastes may contain sufficient concentrations of fission products and long-lived actinides that disposal in a geologic repository would be required, in which case there would be little incentive for developing alternative disposal systems for civilian wastes. Thus, in developing the legal and regulatory framework for alternative disposal systems, there is a need to establish maximum concentrations of fission products and long-lived actinides that would be acceptable for intermediate disposal.

INTRODUCTION

Partitioning and transmutation of actinide radioelements in spent nuclear fuel has been studied since the mid-1960s; e.g., see ref. (1) and references therein. Actinide partitioning and transmutation using an integral fast reactor system is receiving renewed attention (2), because the concentrations of long-lived, alpha-emitting transuranic (TRU) radionuclides in the resulting wastes might be sufficiently low that intermediate disposal systems would provide acceptable long-term protection of public health. Such disposal systems would be considerably less confining than a deep geologic repository but more confining than a near-surface land disposal facility. The potential benefits of alternatives to a geologic repository for wastes from actinide partitioning and transmutation include [a] less stringent technical requirements for the disposal system, due to the lesser degree of waste isolation that would be needed, [b] increased confidence in predictive models for demonstrating compliance of the disposal system with technical requirements and general environmental radiation standards, due to the shorter time period over which waste isolation would be required, and [c] a significant reduction in the costs of disposal.

This paper discusses legal and regulatory issues regarding classification and disposal of radioactive wastes which are important to an evaluation of the potential benefits of actinide partitioning and transmutation. The actinides are assumed to be produced by burning of uranium fuel in civilian light-water-cooled nuclear power reactors, and the primary wastes requiring disposal would include [a] wastes from reprocessing of the original spent fuel and [b] reprocessing wastes from the actinide burner itself (2). Reprocessing wastes from defense activities of the Department of Energy (DOE) are assumed to be excluded from the system for actinide burning.

According to the Nuclear Waste Policy Act (NWPA) of 1982 (Public Law 97-425) and the Low-Level Radioactive Waste Policy Amendments Act (LLRWPAA) of 1985 (Public Law 99-240), the DOE would be responsible for disposal of any wastes from partitioning and transmutation of actinides in civilian spent fuel that are classified as high-level waste (HLW) or greater-than-Class-C low-level waste (LLW). Disposal of these wastes would be subject to general environmental radiation standards established by the Environmental Protection Agency (EPA), and any disposal system would be licensed according to technical criteria established by the Nuclear Regulatory Commission (NRC).

The discussions in this paper are presented in three parts. First, in light of current law and regulations, we discuss the classification of wastes from actinide partitioning and transmutation and requirements for their disposal. We particularly emphasize new legislation, regulations, and technical analyses that would be needed to establish intermediate disposal systems as an alternative to a geologic repository. Second, we discuss the potential impacts of current plans for disposal of defense reprocessing wastes on the disposal of civilian wastes from actinide partitioning and transmutation. Third, we summarize recommendations for actions that should be taken if the benefits of actinide

partitioning and transmutation in regard to waste disposal are to be established.

WASTE CLASSIFICATION AND REQUIREMENTS FOR DISPOSAL

The key legal and regulatory issues for evaluating the potential benefits of actinide partitioning and transmutation in regard to disposal of the wastes in intermediate facilities may be stated as follows:

- How would the wastes be classified? In particular, would the wastes be classified as HLW?
- Depending on the waste classification, what types of disposal systems would be required for long-term protection of public health? In particular, could intermediate disposal alternatives less costly than a geologic repository be acceptable?
- If intermediate disposal systems could be acceptable, what additional laws and regulations would be needed to develop these alternatives?

Waste Classification

HLW traditionally has been defined as radioactive waste from chemical reprocessing of spent nuclear fuel (3,4), and the traditional definition based on the source of the waste is embodied in current law and regulations namely, in the NWPA and the NRC's 10 CFR Part 60 (5). However, the primary wastes from partitioning and transmutation of actinides in spent fuel would not necessarily be classified as HLW.

Although current definitions of HLW are only qualitative, they clearly imply that wastes from fuel reprocessing would be classified as HLW only if they contain sufficient (but unspecified) concentrations of fission products and long-lived TRU radionuclides. For example, the NRC has suggested that primary reprocessing wastes could be classified as greater-than-Class-C LLW if the concentrations of long-lived, alpha-emitting TRU radionuclides were less than 100 nCi/g (4). This concentration is the Class-C limit for near-surface land disposal of these radionuclides established in the NRC's 10 CFR Part 61 (6). The suggestion that such reprocessing wastes could be classified as greater-than-Class-C LLW is based on the assumption that the wastes would contain concentrations of the principal fission products Sr-90 and Cs-137 greater than their Class-C limits (6).

Requirements for Waste Disposal

For wastes classified as HLW, the legal and regulatory framework for developing acceptable disposal systems is contained in the NWPA, the NRC's 10 CFR Part 60 (5), and the EPA's 40 CFR Part 191 (7).

The NWPA authorizes disposal of HLW in a geologic repository, but such a disposal system is not required. Indeed, the NWPA directs the DOE to investigate alternative disposal technologies, which presumably could include systems with waste-isolation capabilities intermediate between those for a geologic repository and a near-surface land disposal facility.

The NRC's 10 CFR Part 60 has established licensing criteria which govern DOE activities at geologic repositories. However, 10 CFR Part 60 does not require [a] that any radioactive materials, whether they are classified as HLW or not, be disposed of in a geologic repository or [b] that radioactive materials be classified as HLW in order to be eligible for disposal in a geologic repository (4). Thus, 10 CFR Part 60 is consistent with the NWPA in not precluding disposal of HLW using systems other than a geologic repository.

The EPA's 40 CFR Part 191 has established environmental radiation standards for disposal of HLW. The EPA standards also do not require disposal of HLW in a geologic repository, but a repository was the only disposal system analyzed by the EPA (8) in developing the containment requirements in the standards.

For wastes classified as LLW, which is radioactive material that is not HLW, spent fuel, or uranium and thorium mill tailings, the LLRWPAA and the NRC's 10 CFR Part 61 (6) presently govern the development of acceptable disposal systems. In addition, the EPA is developing environmental radiation standards for land disposal of LLW in 40 CFR Part 193 (9).

The LLRWPAA does not authorize particular disposal systems for LLW, although the Act assumes near-surface land disposal due to the existence of the NRC's licensing criteria for this technology (6). However, the LLRWPAA directs the NRC to identify alternative technologies for disposal of LLW and to establish licensing criteria for such facilities.

The NRC's 10 CFR Part 61 has established licensing criteria for disposal of radioactive wastes in near-surface land disposal facilities. The standards specify maximum concentrations of radionuclides that would be generally acceptable for near-surface land disposal, i.e., the Class-C limits. Disposal of greater-than-Class-C LLW in near-surface land disposal facilities may be approved by the NRC on a case-by-case basis, but such wastes usually would require disposal in facilities with greater waste-isolation capabilities.

At the present time, 10 CFR Part 61 does not address the type of facility that would be acceptable for disposal of greater-than-Class-C LLW. However, in a proposed revision of the standards (10), the NRC would require disposal of such wastes in a geologic repository, unless the NRC approves disposal elsewhere. Thus, intermediate disposal would be acceptable for greater-than-Class-C LLW only on a case-by-case basis.

The EPA's proposed standards for land disposal of LLW in 40 CFR Part 193 will apply to greater-than-Class-C LLW as well as LLW that is generally acceptable for near-surface land disposal according to the NRC's 10 CFR Part 61. The proposed standards do not require particular disposal technologies, but near-surface land disposal systems

were the only ones analyzed by the EPA in developing the standards (9).

Summary of Current Law and Regulations

The current status of law and regulations regarding classification and disposal of wastes from partitioning and transmutation of actinides in civilian spent fuel may be summarized as follows:

- There are no legal or regulatory prohibitions to classifying the primary wastes from actinide partitioning and transmutation as non-HLW, depending on the radionuclide concentrations. Any such wastes not classified as HLW presumably would be classified as greater-than-Class-C LLW, particularly if the concentrations of Sr-90 and Cs-137 exceed their Class-C limits.
- Regardless of how the primary wastes from actinide partitioning and transmutation would be classified, there are no legal or regulatory prohibitions to seeking alternatives to a geologic repository for disposal of the wastes, including new systems with waste-isolation capabilities intermediate between those for near-surface land disposal and a geologic repository.

Thus, current definitions of waste classes are not associated with requirements for specific disposal systems, and classification of the primary wastes from actinide partitioning and transmutation would essentially be irrelevant to a determination that there are acceptable alternatives to disposal in a geologic repository.

However, there are important institutional impediments to changes in current practices regarding waste classification and disposal. In particular, the NRC has indicated [a] that a proposed quantification of the definition of HLW (4) in terms of minimum concentrations of radionuclides that would require disposal in a geologic repository (i.e., maximum concentrations that would be acceptable for intermediate disposal) will not soon be forthcoming (10) and [b] that greater-than-Class-C LLW is intended for disposal in a geologic repository, unless the NRC approves disposal elsewhere (10). Thus, unless the DOE demonstrates a compelling need for intermediate disposal facilities, the NRC does not intend to alter the current institutional framework for radioactive waste management; i.e., geologic repositories (for spent fuel, HLW, and greater-than-Class-C LLW) and near-surface facilities (for LLW less than Class-C limits) will remain the only disposal systems authorized by law for which environmental radiation standards (7,9) and licensing criteria (5,6) have been promulgated or are under development.

Needed Changes in Law and Regulations

Changes in current law and regulations would be needed to develop intermediate disposal systems as an alternative to geologic repositories for the primary wastes from actinide partitioning and transmutation.

If the wastes were classified as HLW, then new legislation would be needed to develop disposal systems other than a geologic repository (4), because the NWPA does not authorize disposal in alternative facilities. The EPA's 40 CFR Part 191 (7) would apply to alternative disposal systems for HLW. However, the existence of these standards is not necessarily advantageous, because the standards were developed with the assumption that geologic repositories would be used and the requirements for long-term waste containment may not be appropriate or reasonably achievable for intermediate disposal facilities. Thus, the EPA may need to consider new environmental radiation standards for disposal of HLW in intermediate facilities. Regardless of whether the EPA standards were revised, the NRC would need to develop new licensing criteria for disposal of HLW in alternative facilities, because the criteria in 10 CFR Part 60 apply only to geologic repositories (4).

If the wastes were classified as greater-than-Class-C LLW, then new legislation would not be needed to develop intermediate disposal systems, because the LLRWPAA specifically requires that the NRC identify alternatives to near-surface land disposal and establish licensing criteria for alternative facilities. Thus, there would be an immediate advantage if the wastes were not classified as HLW. However, the NRC would need to develop licensing criteria for intermediate disposal systems, and the EPA may need to consider whether its proposed standards in 40 CFR Part 193 (9) are appropriate and reasonably achievable for intermediate disposal of greater-than-Class-C LLW.

Regardless of how the primary wastes from actinide partitioning and transmutation were classified, an important task in developing licensing criteria for intermediate disposal facilities presumably will be a definitive technical analysis to establish maximum concentrations of radionuclides that would be generally acceptable for disposal in such facilities. The analysis would be similar to that performed by the NRC in establishing maximum concentrations of radionuclides that are generally acceptable for near-surface land disposal (6).

A preliminary analysis of the type described above recently was performed as part of a study to develop a new system for classifying radioactive wastes (11). The analysis assumed intermediate-depth burial as the disposal technology, and the maximum concentrations of radionuclides that would be acceptable for disposal were estimated by assuming a particular scenario for exposure of an inadvertent intruder at 500 years after disposal and a limit on annual effective dose equivalent for the intruder of 5 mSv (0.5 rem).

The results of the analysis suggest that the maximum concentrations of important radionuclides in spent fuel that would be acceptable for intermediate-depth burial may exceed their respective Class-C limits for near-surface land disposal (6) by about the following amounts (11):

- two orders of magnitude for the long-lived, alpha-emitting TRU radionuclides Pu-238, Pu-239, Pu-240, and Pu-242;
- less than an order of magnitude for the long-lived, alpha-emitting TRU radionuclides Np-237, Am-241, and Am-243;

- from less than an order of magnitude to two orders of magnitude for the long-lived fission products Tc-99, Sn-126, and I-129; and
- one or two orders of magnitude for the shorter-lived fission products Cs-137 and Sr-90, respectively.

The Class-C limit for Sn-126, which is not given in 10 CFR Part 61 (6), was calculated (11) using the NRC's revised impacts analysis methodology for near-surface land disposal (12,13).

On the basis of these results and expected concentrations of fission products and TRU radionuclides in civilian spent fuel (14,15), a high percentage of some of the radionuclides listed above probably would need to be removed from the original spent fuel and transmuted in an actinide burner in order for the wastes to be acceptable for intermediate disposal. In particular, the analysis suggests (11) that concentrations may need to be reduced by [a] one-to-two orders of magnitude for Tc-99, Sn-126, Cs-137, Np-237, and Pu-238, [b] two-to-three orders of magnitude for Pu-239, Pu-240, and Am-243, and [c] more than four orders of magnitude for Am-241.

The results described above do not represent a definitive analysis. However, they clearly indicate that the concentrations of fission products, including the shorter-lived Cs-137 (and perhaps Sr-90), as well as long-lived TRU radionuclides will be of concern in determining wastes that would be acceptable for intermediate disposal.

Finally, additional legislation and regulations probably will be needed to establish a system for partitioning and transmutation of actinides in civilian spent fuel and to provide financial support for disposal of the wastes in intermediate facilities.

Although there are no legal prohibitions to reprocessing of civilian spent fuel, new legislation may be needed to develop an actinide burner system, including facilities for reprocessing of spent fuel, particularly if development of the system is the DOE's responsibility. The EPA's environmental radiation standards for operations of the uranium fuel cycle in 40 CFR Part 190 (16) would apply to the actinide burner system, including fuel reprocessing, and all facilities would be licensed according to procedures established in the NRC's 10 CFR Part 50 (17). However, the NRC probably would develop detailed technical requirements for construction and operation of new facilities, particularly those for reprocessing, similar to existing requirements for civilian power reactors in Appendix A of 10 CFR Part 50.

The NWPA currently specifies that a fee of 1 mill per kW-h shall be assessed on electricity generated by civilian nuclear power reactors to offset costs related to disposal of civilian spent fuel and HLW in geologic repositories. If an actinide burner system would obviate the need for disposal of these materials in a geologic repository and considerably less costly disposal alternatives were acceptable, then the Congress probably would reexamine the question of an appropriate fee on electricity generated in civilian power reactors.

DISPOSAL OF DEFENSE HLW

We have assumed that the primary reprocessing wastes from the DOE's defense production activities will be excluded from a system for partitioning and transmutation of actinides in spent fuel from civilian power reactors. However, current plans for disposal of defense HLW could greatly influence the cost-effectiveness of alternatives to a geologic repository for disposal of the civilian wastes.

Following a directive in the NWPA and a study by the DOE (18), the President has recommended that defense HLW be placed in the same repository with civilian spent fuel and HLW. This decision was based primarily on considerations of cost efficiency.

Partitioning and transmutation of actinides in civilian spent fuel probably will be cost-effective only if a disposal system considerably less costly than a geologic repository can be used for the primary wastes. Thus, development of an intermediate disposal facility for these wastes probably can be justified only if a similar disposal system could be used for defense HLW; i.e., it would not be cost-effective to develop an alternative disposal system for civilian wastes while maintaining the present repository program for defense HLW only.

Therefore, in conjunction with investigations into the acceptability of alternatives to a geologic repository for disposal of the primary wastes from actinide partitioning and transmutation, similar investigations are needed for disposal of defense HLW. A preliminary analysis of the acceptability of intermediate-depth burial for defense HLW was presented in the study (11) discussed in the previous section. The results are not encouraging for an actinide burner system, because they suggest that the concentrations of fission products (i.e., Sn-126 and Cs-137) and long-lived TRU radionuclides (i.e., Pu-238, Pu-239, Pu-240, and Am-241) in defense HLW could be sufficiently high that disposal in a geologic repository would be required. Again, however, a more definitive analysis is needed which also takes into account the wide variety of defense HLW (19).

RECOMMENDATIONS

In light of the discussions in this paper, we offer several recommendations for actions that are needed to establish the benefits of actinide partitioning and transmutation in regard to waste disposal.

- Expected isotopic compositions of the primary wastes from partitioning and
- transmutation of actinides in civilian spent fuel must be estimated. Important constituents include [a] long-lived TRU radionuclides and [b] particular fission products including the shorter-lived Sr-90 and Cs-137 and long-lived Tc-99 and Sn-126.
- If the concentrations of fission products or long-lived TRU radionuclides in the wastes are greater than their Class-C limits (6), then a more definitive analysis than presented previously (11) is needed to estimate

maximum concentrations of radionuclides that would be acceptable for intermediate disposal (i.e., minimum concentrations of radionuclides that would require disposal in a geologic repository according to current law and regulations).

- On the basis of the analysis described in the second recommendation, the potential acceptability of intermediate disposal for the DOE's defense reprocessing wastes should be evaluated.
- Assuming a favorable outcome of the analysis described in the third recommendation, the NRC should proceed with a rulemaking on classification of radioactive wastes on the basis of radionuclide concentrations, regardless of their source. Such a rulemaking would increase public acceptance of actinide partitioning and transmutation and alternatives to a geologic repository for disposal of relatively dilute wastes containing concentrations of fission products or long-lived TRU radionuclides greater than their Class-C limits (6).
- Assuming favorable outcomes regarding the acceptability of intermediate disposal facilities for the primary wastes from partitioning and transmutation of actinides in civilian spent fuel and for defense reprocessing wastes, the EPA and the NRC should proceed with rulemakings on environmental radiation standards and licensing criteria for such facilities.

Finally, perhaps the most important recommendation is that the DOE will need to be aggressive in promoting any benefits of actinide partitioning and transmutation if the required changes in the current legal and regulatory framework for waste disposal are to be considered by the Congress, the NRC, and the EPA.

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