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Blending of Low-Level Radioactive Waste for NPP Decommissioning

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1. Introduction

The purpose of this paper is to review concept of blending low-level radioactive waste for disposal as a method for enhancing disposal options for nuclear power plant (NPP) operators. The U.S. faces a significant increase in low level radioactive waste from nuclear power plant decommissioning in the near future, a fact which has been recognized by the NRC in its *2007 Strategic Assessment of the US NRCs Low-Level Radioactive Waste Regulatory Program* [1].

Radioactive wastes may are generated throughout the life cycle of a nuclear power plant. These wastes can be categorized as follows [2]:

- Operational wastes in the form of solids, liquids and gases
- Plant components resulting from maintenance, modification or life extension work (e.g. steam generators, pumps, valves, control rods, spent filters, etc.)
- Materials from the structure of the plant and equipment (e.g. metals and concrete that result in large quantities of waste upon decommissioning

Large quantities of materials will be generated during decommissioning and dismantling. A significant proportion of these materials will only be slightly contaminated with radioactivity. Due to economies of scale, recycling and reuse options are more likely to be cost effective for such large quantities of materials than for the relatively smaller quantities arising during operation [2]. These materials also present opportunities to manage waste more effectively by utilizing the approaches to blending discussed in this paper.

2. Blending LLW for Disposal

2.1 NRC Position on Blending

Blending as defined by the NRC is "the mixing of LLW with different concentrations of radionuclides, which results in a relatively homogeneous mixture that may be appropriate for disposal in a licensed facility.

The types of waste may include those that are physically and chemically similar (such as ion-exchange resins from nuclear power plant systems), but could also include different waste types that can be made into a relatively homogeneous final mixture, such as soil and ash. Blending does not include placement of discrete wastes of varying concentrations into a disposal container, or the averaging of concentrations of radioactivity of a discrete component over its volume. Blending is confined to waste types that have physical properties that result in a homogeneous final waste form."[3].

LLW blending is an approach to waste management that can give greater flexibility for disposal options for NPP waste from the entire life cycle of the plant which includes operational wastes such as ion exchange resins and filters, maintenance wastes which include replacement components (discrete items), and large quantities of decommissioning wastes.

The NRC's current position on blending is that large-scale LLW blending may be conducted when it can be demonstrated to be safe. The NRC allows blending based on risk and performance measures for public health and safety. NRC's decision-making involving blending is based on performance. Performance means that the blended waste must meet the limits on radiation exposures at the disposal facility and limits on how much the radioactivity concentration may vary (i.e., how well-mixed it must be) [3].

2.3 *Revised Branch Technical Position on Concentration Averaging and Encapsulation*

Concentration averaging is the mathematical averaging of the radionuclide activities in waste over its volume or mass. The CA BTP provides guidance on appropriate volumes and masses to use in calculating average concentrations [4].

The regulatory requirements for licensing a low-level waste disposal facility in 10 CFR 61 describe a system for classifying low-level radioactive waste for disposal. Classification is based on the concentrations of certain radionuclides, and 10 CFR 61.55(a)(8) specifically allows for averaging of concentrations in determining the waste class. The CA BTP describes acceptable averaging methods that can be used in classifying waste [4].

The NRC revised the 1995 CA BTP in February 2015. The revised version allows a risk-informed, performance-based approach to classifying low-level waste materials for disposal (as Class A, B or C) based on the radioactivity concentration of blended mixtures of waste [4]. The older 1995 version constrained the concentration of certain waste types put into a mixture (e.g., ion exchange resins) to within a factor of 10 of the average concentration of the final mixture. The revised guidance for blending makes the hazard (i.e. the radioactivity concentration) of the final mixture the primary consideration for classification [4].

3. Revised Guidance for Blending LLW

The 1995 CA BTP did not use the term "blendable waste". It addressed two categories of waste, discrete items and wastes assumed to be homogeneous. The revised CA BTP introduces the term "blendable waste" to describe waste that is not treated as discrete items, but which has unknown homogeneity. A waste stream is considered to be blendable if:

- The waste can be physically mixed to create relatively uniform radionuclide concentrations or
- The waste is not expected to contain durable items with significant activity

Examples of blendable wastes include contaminated soils, ash, ion-exchange resins, evaporator bottom concentrates, and contaminated trash [4].

Adequate blending is a requirement for the mixture of blended waste that provides assurance that the mixture of waste has a uniform concentration without hot spots. If blending is inadequate there may be volumes of relatively concentrated waste in the blended product. Demonstrating adequate blending can be based on process knowledge, reasoned conclusions, calculations, or direct measurements [4].

The revised CA BTP includes a standard for the homogeneity of blended wastes. There are two blending scenarios that are considered in the CA BTP. The first is a blended mixture from one waste stream and the second is a blend from multiple waste streams. If a waste package contains a single blendable waste stream, radionuclide concentrations for waste classification then a simple volume averaged concentration may be used [4].

If the multiple waste streams are blended and exceed the thresholds in CA BTP Table 1 then the requirements for demonstrating adequate blending must be met. Waste is adequately blended if there is reasonable assurance that there are no hot spots of waste $\geq 0.2m^3$ that have a sum of fractions >10 times the average concentration of the blended product for the specific radionuclides [4]. Concentration limits for radionuclides are found in Tables 1 and 2 of 10 CFR 61.55. A detailed explanation and example of determining the sum of fractions is provided in 10 CFR 61.55(a)(7) [3].

3. Conclusions

The NRC issued in February 2015 the revised Branch Technical Position on Concentration Averaging and Encapsulation (CA BTP), which provides a risk-informed, performance-based approach to classifying low-level radioactive waste for disposal based on the radioactivity concentration of blended waste and the risk posed to an inadvertent intruder into a waste disposal facility.

The NRC's current position on blending is that large-scale LLW blending may be conducted when it can be demonstrated to be safe. The NRC uses allows blending based on risk and performance measures for public health and safety. Performance-based regulation means that the blended waste must meet the limits on radiation exposures at the disposal facility and limits on how much the radioactivity concentration may vary or in other words, how homogeneous and well mixed it is.

LLW blending is an approach to waste management that can give greater flexibility for disposal options for NPP waste from the entire life cycle of the plant which includes operational wastes such as ion exchange resins and filters, maintenance wastes which include replacement components (discrete items), and large quantities of decommissioning wastes.

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