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CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Multi-Purpose Canister Burnup Credit Technical Exchange #3
20-5702-541

DATE/PLACE: Bethesda, MD
March 29-31, 1994

AUTHORS: Emil Tschoepe, III and Prasad Nair

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PERSONS PRESENT:

CNWRA	NRC-NMSS
P. Nair	R. Carlson
E. Tschoepe	C. Haughney
	R. Weller
	C. Withee
	R. Chappell
	R. Wilson
	M. Bailey
	D. Dancer
	R. Chappell

The list of all the attendees at the workshop is presented in Attachment A.

BACKGROUND AND PURPOSE OF TRIP:

The U.S. Department of Energy (DOE) has chosen a multi-purpose canister (MPC) to be used for transportation, storage, and disposal of high-level waste (HLW). The primary motivation for this effort is to make progress toward accepting the spent fuel from the utilities by 1998. Two MPC workshops were held in July and October 1993. Two MPC technical exchange meetings (November 30–December 1, 1993, and February 10, 1994) on burnup credit preceded this one. In February 1994, DOE announced that the MPC design concept was the preferred design and that future DOE design activities would focus on the MPC. An important aspect for the implementation of the MPC concept is the timely completion of any U.S. Nuclear Regulatory Commission (NRC) licensing activities.

SUMMARY OF PERTINENT POINTS:

The technical exchange meeting was conducted in two parts. The first day focused on storage and transportation issues, particularly changes in radionuclide inventories with time. The following day was dedicated to disposal issues, limited by DOE to burnup credit and criticality issues. In addition to NRC and DOE and their M&O contractor, attendees represented utilities, vendors, affected communities, and technical journals.

Copies of viewgraphs from DOE presentations are available from the authors of this report. Most of the design information on the MPC concept that was brought out at the workshop by DOE was previously available. Highlights from DOE presentations are as follows:

Three topical reports are planned at this time for the MPC. The first, for which an outline is expected soon, covers burnup credit for the storage and transportation of pressurized water reactor (PWR) spent fuel. The second, covering burnup credit and criticality for disposal of boiling water reactor (BWR) and PWR spent fuel, is expected in the 1995-1996 time frame. The third, covering burnup credit for storage and transport of BWR spent fuel, may be deleted, since, at this time, DOE does not expect to take credit for burnup for BWR spent fuel for transport and storage.

Dr. Michaele Brady, Sandia National Laboratories (SNL), presented extensive discussions on changes in radionuclide inventories in spent PWR nuclear fuel with time. A minimum period of five years is assumed for PWR fuel prior to transportation; some PWR fuel will be much older than five years. Thirteen primary fission products are considered in calculating spent fuel reactivity, which is primarily a function of initial enrichment, burnup, and cooling time. They represent about 80% of fission product absorption; others are only marginal.

Criticality uncertainties are extrapolated outside the range of experimental data. Extrapolating to higher enrichments than those discussed in the handouts will be covered later by DOE. Cask loading curves are developed to identify the acceptable fuel region based on initial enrichment and assembly average burnup.

DOE's isotope validation strategy compares chemical assay data with criticality experiments [fresh UO_2, fresh mixed oxide (MOX), and Gadolinium]. The DOE is currently planning to use reactor restart criticals for hot zero power (HZP) and hot full power (HFP) conditions as data for benchmarking calculations.

Moderator-related characteristics, such as water temperature and density, boron concentration, fuel neutron absorbers, external absorbers, and reflector materials, were discussed with respect to isotopic validation and criticality analysis.

Twenty-four fuel nuclides are included in burnup analysis. Cs-135 is included even though it is an insignificant absorber, since data is available. Curves showing a fraction of neutrons absorbed by major actinides for various cooling times and burnup credits were shown. ENDF/B-IV and ENDF/B-V have been used to generate cross section data. Curves displaying calculated versus measured isotopic differences (calculated by ORIGEN-S, ORIGEN2) indicate calculation errors for most fission products within $\pm 25\%$.

Axial burnup distributions result from lower than average burnup at the ends of PWR assemblies, although the burnup in the central 8-10 ft of the fuel assembly is fairly flat. Axial depletion zones were modeled by five models, each with 1, 3, 7, 15, and 22 fuel zones, respectively. No significant improvement was apparent for greater than 7 zones. Curves showing normalized axial burnup vs core height indicated that 20% of each end of the core experiences less burnup, by 40-50% at ends.

The generic cask used for burnup credit calculations contains 31 assemblies, and it has a 1 cm borated aluminum basket, 33.1 cm stainless steel walls, and no flux traps.

Non-specification fuel, that which has inadequate burnup for the specified initial enrichment, may be shipped, but with special precautions.

The sequence for assigning and verifying assembly burnup takes into account the thermal energy production for each assembly and core flux mapping.

Dr. Ron Ewing (SNL) discussed burnup verification measurements to address questions from the second technical exchange and to describe the FORK hardware and technique. Results correlate within 5% of reactor records, and reactor records are considered the more accurate of the two. The FORK uses two neutron detectors and one gamma ray detector, and it could be used to correlate with reactor records on burnup and to detect anomalous assemblies. Because of errors from the grappling assembly nearby, the FORK is not well suited for routine axial scan profiling.

Tom Doering [Babcock & Wilcox Fuel Company (BWFC)] presented a discussion on DOE's time-phased approach for criticality control, covering the operations, containment, and isolation phases of repository life. During operations, emplacement drifts will be blocked in phased operations.

DOE's reference waste package design now is a two-component system (MPC with disposal overpack), although there may be additional overpacks.

Analyses during the substantially complete containment period will be deterministic, with key probabilistic fault trees. The criticality fault tree now includes water inflow, although other moderators (e.g., oils) should be considered. For isolation, a probabilistic approach will be used. Uniform degradation is expected during the isolation phase.

Daniel Thomas (BWFC) discussed criticality evaluations for disposal, for which one year of activity has been spent to date. Burnup credit is needed to represent the reduced reactivity due to the depletion of fissile materials and the buildup of neutron absorbers from fission reactions. The approach is conservative in that water is assumed to be present. ORIGEN2 and MCNP [a Monte Carlo code using point-wise cross sections developed at Los Alamos National Laboratory (LANL)] are used in analyses. Point-wise (continuous energy) cross sections are used for disposal calculations, while group-wise (discrete energy) cross sections are used for transportation, and the results from the two provide a check of results.

The familiar "two-hump" long-term criticality potential vs time curve was developed assuming an intact basket. Rationale was given for selecting the design basis fuel, with a k_{eff} of 0.95. Color scatter plots for a PWR fraction of all 86,000 MTU did not translate well into black and white handouts. The color/black-and-white problem was also evident in a number of curves depicting changes in nuclide concentrations with time, so color versions of both types of curves are expected to be delivered to NRC later. Thirty principal isotopes most important in final evaluations may be reduced, pending decisions within the next two years.

Tom Doering (BWFC) discussed MPC and overpack materials. Ceramic overpacks are discounted since they allow cladding temperatures to get high enough to cause early cladding degradation.

Examples given as potential barrier materials were alloy 825, 70-30 cupronickel, and carbon steel such as 1020. Other example materials were given for the basket structure (316L SS, Alloy 825) and basket neutron absorber materials (copper-boron, 316 SS-boron). A filler material may be used to displace any moderator (such as water) upon MPC intrusion. Also, surrogate control rods (B_4C) may be used. DOE's analyses include life prediction for cladding, although cladding may not be credited toward performance. Materials will be chosen by the contractor (bids are now out), and discussion of materials was limited during the meeting because of procurement sensitivity until May. While DOE acknowledged that corrosion tests were needed for various materials being considered, it was unclear when they would start.

Hugh Benton (BWFC) presented a summary of disposal issues. Potential shut-down mechanisms for criticality (episodal water transport) have been considered.

R. Weller (NRC) and P. Nair [Center for Nuclear Waste Regulatory Analyses (CNWRA)] offered suggestions during and after the DOE presentations. The DOE should consider other disposal issues beyond burnup and criticality, such as the long-term behavior of criticality control materials and the integrity of the MPC throughout its application. In future technical exchanges, the NRC should provide input to the scope of DOE's planned topical report on disposal issues. The DOE currently plans to limit the topical report on disposal issues to criticality, but criticality is only of concern with regard to how it affects performance. There were general discussions on treating criticality as an unanticipated event, since the site is unsaturated. This subject would need further discussion among the NRC/CNWRA staff to clarify the assumptions/definitions of anticipated vs. unanticipated event for the criticality issue. The NRC/CNWRA staff emphasized the importance of the initial conditions of the MPC at the repository, including fabrication effects, loads incurred during transportation, and inspection results.

The schedule calls for the license application design to be complete in mid-1996, with license application submittal in 2001.

IMPRESSIONS AND CONCLUSIONS:

The DOE's approach for disposal issues seemed quite limited toward criticality and burnup, and future technical exchanges will provide NRC with opportunities to explore other issues of importance to disposal. Evaluation of materials after the design contractor chose materials for the MPC seemed out of place, and the limited time available within the planned schedule may exacerbate the situation. A systems approach to MPC design, including choice of materials, was not evident, since the responsibility for design appears to be delegated by DOE to the design contractor.

PENDING ACTIONS:

The CNWRA will develop an outline for the MPC review plan, and the outline will include a number of technical considerations beyond burnup credit and criticality. The outline will be faxed to NRC for use during a telecon meeting, expected in about two weeks.

The DOE will be developing outlines for the proposed topical reports. The NRC will use future technical exchanges to provide input to the scope for the topical report on burnup credit for disposal (as well as any other topical reports related to disposal).

RECOMMENDATIONS:

The CNWRA should plan to be represented at any future MPC technical exchanges with DOE, as developments are expected to be rapid and may be guided successfully by input during those meetings.

PROBLEMS:

None.

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Senior Research Engineer

Date

4/8/94

Prasad K. Nair
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Date

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Budhi Sagar
Technical Director

Date 4/8/94

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