From: Oleg Povetko
Sent: Monday, August 14, 2006 11:54 AM
To: James Winterle
Subject: FW: Criticality Techncial Exchange
Attachments: Summary of Burnup Credit Issues for TE.wpd; Potential 2006 Crit TE topics 2006-07-17.wpd; Applicability of CRCs.wpd

Jim,

Criticality TE is tentatively agreed on to be held in November (see message below). It might be held in two different places due to split of DOE criticality program between BSC and SNL.

Oleg.

> Marissa,
>
> I have pulled together a rough outline of burnup credit issues that needs to be further developed with the staff. (1st attachment).
>
> I am also sending out the original list of criticality topics that may be discussed at a technical exchange. (2nd attachment)
>
> I have attached a rough outline of my ideas on Commerical Reactor Criticals. (3rd attachment) If they are unsuitable to be benchmarks, than DOE and the industry are going to need more data is they want credit for fission products. If they may be treated as benchmarks, though perhaps marginal, DOE may be able to live without obtaining more data, at least for disposal. I would like to work out a technically based position with SFPO that I provide to DOE. ORNL is looking at the applicability of the experiments (neutronic similarity). My argument concern the sufficiency of the material data.
>
> Jim Rubenstone and I talked to Paige Russell Thursday afternnoon about the criticality technical exchange. On October 1, the existing criticality group at BSC will be split into a Sandia based postclosure group overseen by Paige Russell and a BSC pre-closure based group overseen by a person yet to be named. Also, BSC has a bunch of preclosure deliverables due around the end of September that would be impacted by an mid-September technical exchange. Based on this information and my leave, Jim, Paige, and I agreed that an early November technical exchange may be preferable. Given that the groups are splitting, the preclosure and postclosure portion of the meeting will probably be split, but there would be no reason why they could not be held on the same trip.
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> Thanks,
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> Dennis

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Summary of Burnup Credit Issues

<u>It is not clear how the bounding parameter approach as identified by DOE can be practically implemented.</u>

- Containers need to be designed for the most reactive fuel to be placed into them
- DOE has not identified a systematic process for identifying the most reactive fuel to be placed into the containers.
- The isotopic bias and uncertainty have to be applied to the reactivity of the most reactive fuel, not “nominal” fuel. The designation of “nominal” fuel is not relevant and serves as a distraction to the relevant issues.
- DOE needs to define limiting depletion parameters when performing its analysis. These depletion parameters will need to be verified for each fuel assembly.

<u>The direct difference method used to calculate the isotopic bias and uncertainties from radiochemical assays needs additional justification.</u>

- The direct difference approach does not account for the time dependent nature of the isotopic bias and uncertainty due to the decay and build-up of radionuclides.
- Any method grouping isotopes needs to use a consistent set of isotopes. There is variability in the isotopes measured in the radiochemical assays.
- The method does not appropriate account for the uncertainty due to small number of samples measured for some isotopes, in particular most fission products.
- Justification is needed for the implied assumption that the bias determined from highly subcritical samples uniformly modeled in a waste package is applicable to a near critical fuel assemblies with axial variability.
- An analysis of any trends in the bias is required by the ANSI/ANS Standards.

Potential Criticality Technical Exchange Topics: The staff believes that both DOE and NRC are unlikely to be prepared to support a full technical exchange/management meeting in CY 2006 in the area criticality due to the ongoing changes in DOE's program and the current level of resources being applied in the NRC program. Appendix 7, planning, or some other non-management type of meetings could be supported, depending on the extent more dedicated resources can be applied. Burnup credit is the most developed issue as described below. The staff are using Regulatory Guide 3.71, which invokes consensus standards, as the primary guidance for evaluating the technical basis for DOE's approaches.

Summary List

1. Administrative Margin (Pre, Post)
2. Burnup Credit Measurements (Pre, Post)
3. Moderator Control (Pre)
4. Screening of Post-Closure Criticality Events (Post)
5. Preclosure Criticality Event Sequences
6. Burnup Credit (Isotopic Model)
7. Criticality Model (Pre, Post)
8. Qualification of Neutron Absorber Materials (Pre, Post)
9. Geochemistry Model Reports (Post)
10. Damaged Fuel (Pre, Post)
11. Naval Reactors Fuel (Pre, Post)
12. Criticality Consequences (Post)

Summary List with Brief Descriptions

1. Administrative Margin (Pre, Post)

DOE documents indicates that is planning on applying no administrative margin for postclosure criticality. DOE may also apply different administrative margins for full density and low density moderators for preclosure waste package operations.

2. Burnup Credit Measurements (Pre, Post)

DOE documents indicates that is planning on using reactors records as a basis for assigning burnup loading values. DOE has identified approaches for mitigating some deficiencies in the reactor records. DOE plans on taking exception to Regulatory Guide 3.71 since it will not verify reactor records with burnup credit measurements.

3. Moderator Control (Pre)

Some DOE design iterations relied on moderator control areas as a primary means of criticality control. While DOE has indicated it no longer plans on conducting bare fuel handling, the needs to better understand whether DOE will rely on moderator control areas for any event sequences.

4. Screening of Post-Closure Criticality Events (Post)

DOE has provided a screening analysis for post-closure criticality features, events, and processes (FEPs). Informally DOE has indicated that this analysis will be reconfigured to be more consistent with other FEP analyses.

5. Preclosure Criticality Event Sequences

In June 2006, the NRC clarified that it expects to see reliability estimates for all important to safety structures, systems, and components (reliability would be estimated at the highest system level that could be defended.) It is anticipated that DOE will also be identifying a new conceptual design (CD-1) for surface facilities. Informally DOE has indicated that it is updating its preclosure analyses to be consistent with the NRC clarifications. This includes the important topic of misloaded waste packages.

6. Burnup Credit (Isotopic Model)

On June 20-21, 2006, the staff conducted an onsite representative (OR) visit with the DOE on the issue of burnup credit on primarily publicly available materials. This was the first opportunity for the staff to identify its potential concerns with DOE's burnup credit model. Some of these concerns could be developed into key messages. The NRC was not aware of all relevant documents so DOE took an action to develop a comprehensive list. Some criticality documents have not been finalized because of the design control stand-down. DOE indicated that it was useful to hear NRC concerns with its methodology and would consider these concerns in the focus and scheduling of its analyses

7. Criticality Model (Pre, Post)

DOE's criticality model, which is publicly available, identifies how DOE plans on validating MCNP for performing criticality calculations. NRC has performed only a very preliminary review of the model. This model is important since the lack of relevant experimental data for validating fission product and minor actinides cross sections has limited the amount of burnup credit that may be used. DOE has identified a number of approaches to address this deficiency in the available data.

8. Qualification of Neutron Absorber Materials (Pre, Post)

DOE has indicated it may use Ni-Cr-Mo-Gd or other developmental materials as the neutron absorber material in the waste and/or the transport, aging, and disposal canister. These materials have not been previously qualified for use in spent fuel applications.

9. Geochemistry Model Reports (Post)

NRC has an open agreement for DOE to provide criticality related geochemistry model reports. The geochemistry models may provide the technical basis for the potential degraded criticality configurations DOE evaluates during the post closure period.

10. Damaged Fuel (Pre, Post)

Damaged fuel has the potential to achieve more reactive criticality configurations than intact fuel. Thus, damaged fuel is an important design consideration for transportation and storages packages. However, the staff is not aware of DOE doing any criticality calculations with damaged fuel.

11. Naval Reactors Fuel (Pre, Post)

DOE has indicated that naval reactors fuel will be evaluated with the same overall post-closure criticality methodology. However, different depletion and criticality codes will be used for the criticality calculations using a different set criticality experiments. It is probable that the navy spent fuel baskets will have a different design basis and rely on different poisons. While any detailed technical discussions would be classified, it would be useful to initiate plans for having these discussions.

12.Criticality Consequences (Post)

DOE new post-closure lead, Sandia National Laboratory, has staff that has performed criticality consequence calculations. It may be useful to engage DOE on what experimental data is available and what types of calculations NRC would expect DOE to perform if DOE were to evaluate criticality consequences. This topic is probably more suitable for an appendix 7 meeting than a technical exchange.

Use of Commercial Reactor Criticals (CRCs) as Benchmark Experiments

In deciding whether a particular set of experiments should be used as benchmarks in validating a calculational method, one has to determine their applicability and whether they are of benchmark quality.

Applicability

As discuss in section C.3 in Appendix C attached to ANSI/ANS-8.1-1998, Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors, benchmark experiments should be similar to the systems being evaluated. The similarities that should be evaluated include material compositions (fissionable materials, neutron absorbers, and moderators), geometric configurations, neutron energy spectra, and nuclear characteristics (including reflectors). While there are significant material and geometric differences between CRCs and storage and transportation casks, Holtec in a proprietary analyses indicates that CRCs show much greater neutronic similarity to storage and transportation than other experiments once the temperature differences in the two systems are accounted. This seems reasonable intuitively since similar fuel is being used in each application. (CRCs may have a lower effective burnup than cask applications). While DOE and Energy Solutions presentations are not persuasive in this regard, the proprietary Holtec approach indicates some technical basis for applicability exists.

Benchmark Quality

As stated in C.2 in Appendix C attached to ANSI/ANS-8.1-1998, a benchmark is a well characterized experiment at the critical state that may be used to establish the reliability of a calculational method. CRCs might not be considered benchmark for several reasons:

- The material composition of benchmarks have not been measured. The material composition must be calculated, many times using the same calculational method being characterized.

- The a primary parameter used to calculate the material compositions is the burnup. However, the burnup is also a calculated parameter based on correlations with their own uncertainties.

- Since the material compositions are not measured, it is not obvious that biases and uncertainties in critical calculations with CRCs are due to biases and uncertainties in determining the material compositions or in the calculation method or both.

- The previous problem is compounded by the change in compositions with time. There may be compensating effects where radionuclides that have a positive bias decay away. However, this positive bias when combined with a negative bias may result in underpredicting the actual bias of a calculational method when the radionuclide responsible for the positive bias decays.