Attachment 3

Guidelines for Implementation of Revised Fuel Specifications

GUIDELINES FOR THE IMPLEMENTATION OF FUEL SPECIFICATIONS STANDARD TECHNICAL SPECIFICATIONS (STS)

APPENDIX [ ] TO NEI 99-06

In order for the Fuel Specifications Standard Technical Specifications (STS) to be employed for a given Spent Fuel Management System (DCSS), the guidelines contained in this appendix define the information that must be contained and maintained in the Safety Analysis Report (SAR) in order to ensure that any changes to analytical methods for criticality calculations or to the fuel types that are to be stored in the DCSS under 10 CFR 72.48 are bounded in such a way so that the subcriticality limit of 0.95 Keff is not exceeded.

Existing SARs, for DCSS that have been certified by the NRC, may not all meet the guidelines for criticality safety determinations established in this document. The certificate holder may choose to either upgrade the SAR to be consistent with the guidelines in order to employ the STS, or maintain the current certificate and its custom Technical Specifications for fuel specifications. The SAR upgrade would likely be subject to NRC review and approval. Applications for new DCSS would employ the guidelines in full.

These guidelines have been developed based on discussions with the NRC and through review of DCSS certification documents for the latest generation of DCSS from four vendors; NAC, TN, Holtec, and FuelSolutions. It is expected that these guidelines will give the NRC sufficient assurance that all parameters important to the maintenance of criticality safety will be rigorously controlled and that changes to the DCSS, fuel parameters or the types of fuel stored in the DCSS will be conservatively controlled under the requirements of 10 CFR 72.48, and that NRC review and approval of changes that may adversely impact criticality safety will be assured.

1. Fuel Parameters

The following fuel parameters will be identified in the SAR, as applicable, for each fuel type analyzed to be stored. Applicability will be determined for the particular fuel type (for example, very few fuel types would employ partial length fuel rods in their design). These may be explicitly identified for each fuel assembly design or may be representative of a class of fuel assemblies that are grouped together for analytical purposes to define a fuel type (e.g., Westinghouse 17x17, Siemens 17x17, B&W 17x17 that was used in a particular reactor or reactor type).

a. clad material
b. initial enrichment (i.e., maximum pin enrichment, bundle average enrichment, lattice average enrichment, etc.)
c. pellet or stack UO_2 density

d. number of fuel rods, including number of partial length rods
e. clad O.D.
f. clad thickness
g. pellet diameter
h. fuel rod pitch
i. active fuel length
j. number and location of water holes (water rods)
k. number of inert (solid) rods
l. distance from bottom of the fuel assembly to start of active fuel
m. number, size, material, and location of guide and instrument tubes
n. fuel channels – material, presence and thickness
o. maximum uranium loading (total)
p. presence of burnable poison and control rod assemblies

Limitations on the type of fuel assemblies (Intact, Mixed Oxide, Partial and Damaged) that have been analyzed for storage will be identified as it pertains to its effect on cask criticality analyses.

2. Analysis and Model Design Criteria, Assumptions and Conservatisms

The design criteria, assumptions and conservatisms utilized in the development of the analytical models for the criticality safety analyses will be explicitly defined and controlled in the SAR. An example[1] of these criteria, assumptions and conservatisms are:

- The canisters are assumed to contain the most reactive fresh fuel authorized to be loaded into a specific basket design.
- No credit for fuel burnup is assumed, either in depleting the quantity of fissile nuclides or in producing fission product poisons.
- The criticality analyses assume [75%] of the manufacturer's minimum Boron-10 content for the borated neutron absorber.
- The fuel stack density is conservatively assumed to be [96%] of theoretical (10.522 g/cm^3) for all criticality analyses.
- No credit is taken for the ^{234}U and ^{236}U in the fuel.
- When flooded, the moderator is assumed to be pure, unborated water at a

[1] This example is a composite of design criteria, assumptions and conservatisms taken from several certification documents and is not meant to imply a minimum or required list for any cask vendor, but rather is provided for illustrative purposes to show the detail that is typically addressed in current DCSS criticality safety analyses.

temperature corresponding to the highest reactivity within the expected operating range (i.e., water density of 1.000 g/cc).

- When flooded with borated water (for certain DCSS designs), the optimum borated water density will be determined.

- Neutron absorption in minor structural members and heat conduction elements is neglected, i.e., spacer grids, basket supports, and heat conduction elements are replaced by water (if this is demonstrated to be conservative for the specific design).

- Evaluation of the reactivity impact for a variety of channel dimensions in the BWR most-reactive-assembly analysis to demonstrate the impact of the channel material on cask criticality.

- In compliance with NUREG-1536, the worst hypothetical combination of tolerances (most conservative values within the range of acceptable values) is assumed.

- When flooded, the fuel rod pellet-to-clad gap regions are assumed to be flooded.

- Planar-averaged enrichments are assumed for BWR fuel. (In accordance with NUREG-1536, analysis is presented to demonstrate that the use of planar-average enrichments produces conservative results.)

- In accordance with NUREG-1536, fuel-related burnable neutron absorbers, such as the Gadolinia normally used in BWR fuel and IFBA normally used in PWR fuel, are neglected.

- For evaluation of the bias, all benchmark calculations that result in a k_{eff} greater than 1.0 are conservatively truncated to 1.0000, in accordance with NUREG-1536.

- For fuel assemblies that contain low-enriched axial blankets, the governing enrichment is that of the highest planar average, and the blankets are not included in determining the average enrichment.

- For intact fuel assemblies, missing fuel rods must be replaced with dummy rods that displace a volume of water that is equal to, or larger than, that displaced by the original rods.

- Full and partial loading configurations for the canister are analyzed.

- The radial boundary can be defined as either the transport cask body outer shell (normal conditions) or the transfer cask shell with the appropriate neutron shielding for normal and accident conditions. The single package model is surrounded by [ ] inches of water for reflection. The multiple package array model consists of an infinite number of canisters/casks in a close packed arrangement (triangular pitch array) with the adjacent casks in contact with one another.

- Modeling of the canister axially from the top of the bottom end inner closure plate to a point just below the top shield plug support ring. Reflected planes are inserted at these points to prohibit neutron leakage thus maximizing K_{eff}.

- Both normal conditions and hypothetical accident conditions are evaluated. The normal condition models of the DCSS include consideration of: a) complete flooding with water at a density sufficient for optimum moderation; b) worst case asymmetric assembly placement within the guide/fuel tubes; and c) application of worst case material and fabrication tolerances. The hypothetical accident condition models include all the normal conditions as well as the addition of a permanent deformation of guide/fuel tubes between support plates, the axial detachment of the guide/fuel tubes from the basket structure, and the loss of the transportation cask neutron shield assembly.

3. Studies will be performed to determine bounding values of parameters or modeling assumptions to be used in criticality safety analyses and will be presented and maintained in the SAR in sufficient detail to document and detail the effect of the analyzed variations on K_{eff}. The bounding value or assumption derived from the studies will be identified, as well as the fuel assembly or canister arrays which are used, as appropriate, to define the bounding effects. Examples of the parameters and modeling assumptions that are typically subjected to these studies are:

   - Enrichment – lattice, pin (BWR), pellet (damaged fuel can analyses)
   - Clad OD
   - Clad thickness (or clad ID)
   - Pellet diameter
   - Fuel rod pitch
   - Active fuel length
   - Fuel channel thickness
   - Borated water draindown (if soluble boron concentration is required in loading)
   - Bounding configuration (storage, transfer, transportation)
   - Single vs. multiple cask package array analyses to determine most reactive configuration
   - Limiting canister design
   - Preferential flooding/draining of fuel assemblies in overall canister vs. fuel assemblies stored in damaged fuel cans
   - Interspersed and interior moderator density analyses to determine optimum moderator density

- Effects of loading one or more higher enrichment fuel assemblies than is allowed for the canister maximum enrichment
- Treatment of special fuel types, such as mixed-oxide, partial (fuel rods missing from the lattice), or damaged fuel assemblies, including mixed loading analyses for the canister
- Treatment of partial-length fuel rods and axially-blanketed fuel rods

These studies are present, as necessary, to support the following process that is typically followed in demonstrating the criticality safety of the cask contents:

- Evaluation of each of the proposed contents to determine the most reactive (bounding) fuel, to be used in all subsequent analyses;
- Evaluation of the most reactive configuration of the fuel and basket, with variables considered such as location of fuel in the compartment, the dimensions of the basket components, and the presence of moderator;
- Evaluation of special contents, such as damaged or partial fuel assemblies.

4. The methodology employed for performing criticality safety analyses will be defined in sufficient detail and maintained in the SAR. This includes the following:

   - Use of an accepted calculational methodology, such as MCNP-4a, SCALE 4.3 CSAS, or other. This will include definition of any cross-section libraries and other features that must be controlled to ensure that the calculational methodology will be consistently maintained over time. Additionally, the calculational platform (computer system) must be maintained as part of the certificate holder's software QA program. Any deviations or changes to any aspect of the calculational methodology must be analyzed in accordance with 10 CFR 72.48 to determine if a methodology change requires NRC review and approval, if applied to criticality safety analyses performed subsequent to those approved for the certified DCSS.
   - Description of the analyses performed to benchmark the calculational methodology to critical experiments to arrive at the bias to be applied to K_{eff} analyses.
   - Definition and description of the radial and axial criticality models used for analyzing the normal and hypothetical accident conditions.
   - Description of how the limiting Upper Subcritical Limit (or an alternative approach) for a range of parameter values is determined, based on consideration of the following parameters, as appropriate to the DCSS design and the fuel to be stored:

     a. assembly pin pitch
     b. enrichment
     c. water-to-fuel volume ratio
     d. H-to-^{235}U ratio

e. B-10 concentration in any neutron poison
f. Percentage of fissile material that is Pu (as opposed to U) for MOX fuel storage

- Demonstration of source convergence considering source location and number of histories.
- Description of differences between the calculational model and the physical design of the DCSS.