Attachment 5

Description of the Technical Specifications and Criticality Analyses in the Safety Analysis Reports for Recently Approved Cask Designs

Fuel Specifications used in Criticality Analyses – Comparison with TS and Development of Guidance for STS Application

Based on Review of FuelSolutions W21 and W74, TN-32 and TN-68, HI-STORM 100 MPC-24 and MPC-68, and NAC-UMS; Documents reviewed were SARS (where available), TS from CoCs, SERs from NRC:

Current Technical Specifications Fuel Specifications:

1. Maximum Weight per Assembly (all)
2. Heat Load Limit per Assembly (all)
3. Cladding Material/Condition (all)
4. Initial Enrichment (all)
5. Burnup (FuelSolutions, TN-68, NAC-UMS, HI-STORM 100 as part of cooling table for Zr Clad, specific limit for HI-STORM 100 SS Clad)
6. Cooling Time
   a. Cobalt Content (FuelSolutions only)
   b. Storage Cask Dose Rate (FuelSolutions only)
   c. Canister Heat Load (kW/Canister, and kW/inch-Canister) (FuelSolutions only)
   d. Post-irradiation cooling time (HI-STORM 100, NAC-UMS; TN-68 and FuelSolutions has burnup vs. enrichment cooling table)
7. Fuel Assembly Type
   a. Max. Uranium Loading (all)
   b. Linear Uranium Loading (FuelSolutions only)
   c. Number of Fuel Rods (all)
   d. Minimum Clad Thickness (FuelSolutions, NAC-UMS; Not for TN-68; HI-STORM 100 has clad OD and clad ID specs)
   e. Minimum Pellet O.D. (Not for TN-68; HI-STORM 100, NAC-UMS has max pellet diameter)
   f. Rod Pitch (Max for TN-68, HI-STORM 100, NAC-UMS)
   g. Minimum Bottom Tie Plate Height (FuelSolutions only)
   h. Maximum Active Fuel Length (FuelSolutions, HI-STORM 100, NAC-UMS only)
   i. Maximum Individual Pin Enrichment (FuelSolutions, HI-STORM 100 MPC-68)
   j. Minimum Rod OD (TN-68, HI-STORM 100, NAC-UMS only)
   k. Minimum Enrichment (NAC-UMS only)
8. Preferential fuel loading (HI-STORM 100, NAC-UMS only)
9. Fuel Assembly Width (HI-STORM 100, NAC-UMS only)
10. Total Fuel Assembly Length (HI-STORM 100, NAC-UMS only)
11. Guide Tube Number and Thickness (HI-STORM 100 MPC-24 only)
12. Minimum guide tube thickness (NAC-MPC only)
13. Number of Water Rods, Water Rod Thickness (HI-STORM 100 MPC-68 only)
14. Channel Thickness (HI-STORM 100 MPC-68 only)

15. Storage of thimble plugs and burnable poison inserts (NAC-UMS)
16. Specific restrictions on stainless steel channels, unenriched fuel assembly storage in canisters (NAC-UMS only)

Technical Specifications Design Features for Criticality Control:

1. Flux Trap Size (HI-STORM 100 MPC-24 only)
2. Fuel Cell Pitch (HI-STORM 100 MPC-68, FuelSolutions)
3. ^{10}B loading in the Boral neutron absorbers (HI-STORM 100, FuelSolutions, NAC-UMS)
4. Minimum distance from base of canister to fuel region (NAC-UMS only)*not considered in NAC criticality analysis

<u>Review of Cask Vendor Criticality Analyses</u>

Key Criticality Analyses Features

1. Case studies to establish most reactive fuel type and average enrichment – Canister (W74) or Assembly Class (W21, TN, HI-STORM, NAC-UMS) – considers bounding values, as appropriate, from sensitivity studies for the following:
   a. clad material
   b. initial enrichment
   c. pellet stack UO_2 density
   d. number of fuel rods, including TN-68, HI-STORM 100 MPC-68) number of partial length rods
   e. clad O.D.
   f. clad thickness
   g. clad inner diameter
   h. pellet diameter
   i. fuel rod pitch
   j. active fuel length
   k. number of water holes
   l. number of non-corner water holes (W74 partial)
   m. number of inert rods (W74)
   n. bottom nozzle/tie plate height
   o. instrument tube and guide tube sj ecifications (TN-32, FuelSolutions, HI-STORM 100)
   p. Fuel channels – presence and .h ckness/limiting thickness (HI-STORM 100 MPC-68, TN-68, NAC-UMS)
   q. Maximum loading in MTU (NAC-UMS)
2. Varying design conditions involving loading, closure, on-site transfer, and dry storage.
3. Treatment of special assembly classes (MOX, damaged in damaged fuel cans, partial, fuel debris). (FuelSolutions, HI-STORM 100 MPC-68F)

4. Analysis of mixed loadings of design basis fuel types and special assembly classes.
5. Full loading and partial loading analyses.
6. Demonstration that average enrichment is more conservative than multiple pin enrichments (BWRs) (FuelSolutions and TN-68). Also treatment of variable axial enrichment and partial length fuel rods (TN-68 only).
7. No credit for pellet dishing, fuel burnup, or fuel-related burnable neutron absorbers. (pellet dishing not mentioned for TN-32)
8. Conservatisms on borated neutron absorber plate material characteristics.
9. Shifting of fuel assembly positions radially to maximize system reactivity. (FuelSolutions, TN-32 and TN-68, NAC-UMS)
10. Loading of a single or multiple fuel assemblies with higher than design basis enrichment (FuelSolutions W21, TN-32 and TN-68)
11. Postulated reduction of pin pitch due to fuel grid crushing in a tipover accident. (TN-32 and TN-68)

Key Criticality Model Features

1. Normal (complete flooding with water [including pellet/clad gap] at a density providing optimum moderation, worst case [bounding] asymmetric assembly placement within basket guide tubes, application of worst case [bounding] material and fabrication tolerances) and Postulated Accident Conditions (normal plus bounding permanent deformation of guide tubes from hypothetical cask drop accident, axial detachment of guide tubes from basket structure, removal of transportation cask neutron shield assembly).
2. Sensitivity to basket design features (e.g., spacer plate axial spacing, spacer plate thickness, spacer plate hole location tolerances).
3. Worst case (bounding) configuration for canister mode (transfer, storage, transportation).
4. Bounding canister design for different basket configurations.
5. Bounding array – single package model vs. multiple package array.
6. Worst case multiple package array for maximum acceptable enrichment and design basis k_{eff} value.
7. Determination of most reactive configuration of fuel material in damaged fuel can and effect on loaded canister criticality.
8. Optimum, bounding array for most reactive partial fuel assembly. (FuelSolutions W74)
9. Bounding condition for criticality – normal vs. hypothetical accident
10. Use of an accepted code package (e.g., MCNP 4a, SCALE 4.3 CSAS, CASMO-3).
11. List of assumptions for development of analytical models (derived from FuelSolutions W21 SAR, HI-STORM 100, NAC-UMS lists for example).
12. Detailed description of analytical models (e.g., axial and radial models for normal and hypothetical accident conditions).

13. Use of reflected planes axially to prohibit neutron leakage. (FuelSolutions, TN-68, NAC-UMS)
14. Maximized conditions for fuel exposure in axial plane (W74 only).
15. Optimum pure water moderator density. (TN-32 in clad/pellet gap).
16. Optimum water density for borated (2300 ppm) water (TN-32 only).
17. Borated water draindown (TN-32 only).
18. Bounding fuel rod enrichment pattern.
19. Limiting USL value over range of parameter values, based on consideration of:
    a. assembly pin pitch
    b. enrichment
    c. water-to-fuel volume ratio
    d. H-to-^{235}U ratio
    e. B-10 concentration in separator plates (TN 32 and 68 only)
    f. Percentage of fissile material that is Pu (as opposed to U) (FuelSolutions only, for MOX fuel storage)
20. Accounting for differences between model and design (TN-32 and 68).
21. Determination of most reactive lattice (TN-68)
22. Preferential flooding/draining of fuel assemblies (FuelSolutions W74, TN-68)
23. Neutron source location, covergence (FuelSolutions, TN-68)
24. Water density sensitivity analyses – fuel array/canister array (FuelSolutions, NAC-UMS)