FINAL DIVISION OF SAFETY SYSTEMS INTERIM STAFF GUIDANCE
DSS-ISG-2010-01
Revision 0

STAFF GUIDANCE REGARDING THE NUCLEAR CRITICALITY SAFETY ANALYSIS FOR SPENT FUEL POOLS

I INTRODUCTION

This U.S. Nuclear Regulatory Commission (NRC) Division of Safety Systems (DSS) interim staff guidance (ISG) (NRC's Agency-wide Documents Access and Management System (ADAMS) Accession Number ML110620086) provides updated guidance to the NRC staff reviewer to address the increased complexity of recent spent fuel pool (SFP) nuclear criticality analyses and operations. The guidance is intended to reiterate existing guidance, clarify ambiguity in existing guidance, and identify lessons learned based on recent submittals. The existing guidance appears in several NRC documents; NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, "Criticality Safety of Fresh and Spent Fuel Storage and Handling," Revision 3, issued March 2007 (Reference 1, ADAMS ML070570006), NRC memorandum from L. Kopp to T. Collins, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," dated August 19, 1998 (Reference 2, ADAMS ML11088A013), Generic Letter 1978-011, "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," dated April 14, 1978, (Reference 3, ADAMS ML031280383), and Generic Letter 1979-004, "Modifications to NRC Guidance Review and Acceptance of Spent Fuel Storage and Handling Applications," dated January 18, 1979, (Reference 4, ADAMS ML031290521). The guidance in these documents remains applicable, with the exception of the guidance set forth concerning the determination of the criticality code methodology uncertainty in Reference 2; see Section 4.c for more details.

The guidance in DSS-ISG-2010-01 is to be used by NRC staff to review nuclear criticality safety analyses for the storage of new and spent nuclear fuel as they apply to: (i) future applications for construction and/or operating licenses; and (ii) future applications for license amendments and requests for exemptions from compliance with applicable requirements, that are approved after the date of this ISG.

II DISCUSSION

The applicable regulatory documents for criticality safety analysis for spent fuel pools are contained in 10 CFR 50, Appendix A, General Design Criteria (GDC) for Nuclear Power Plants (Reference 5) Criterion 62, Prevention of Criticality in Fuel Storage and Handling (or pre-GDC equivalent in the plant specific licensing basis), 10 CFR 50.68, Criticality Accident Requirements (Reference 6), and 10 CFR 70.24 Criticality Accident Requirements (Reference 7). GDC 62 provides that "criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations." 10 CFR 50.68 (b)(4) provides that "if no credit for soluble boron is taken, the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with unborated water. If credit is taken for soluble boron, the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water, and the k-effective must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated

water." SFPs are subject to the requirements in 10 CFR 50.68 or 10 CFR 70.24. Rather than specifying a limit on the estimated ratio of neutron production to neutron absorption and leakage (k-effective, k_{eff}), 10 CFR 70.24 requires controls to be in place to detect and mitigate the consequences of an inadvertent criticality event. However, licensees licensed under 10 CFR 70.24 typically have an exemption. Those exemptions were based on analysis that showed the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity did not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with unborated water. Technical specifications were created to limit k-effective of the spent fuel storage racks.

Commercial reactor licensees use SFPs to store unirradiated fresh fuel and irradiated spent nuclear fuel (SNF). The SFPs were initially intended to hold fuel assemblies to facilitate refueling operations while allowing the decay heat from SNF to dissipate before shipping the fuel assemblies off site for reprocessing or storage by the U.S. Department of Energy.

Since there is currently no means of reprocessing SNF and the U.S. Department of Energy is not accepting the SNF, licensees have increased their onsite storage capacity. Increasing the storage capacity in the existing SFP was the first step in increasing onsite storage capacity. Licensees transitioned from low-density storage, relying on flux traps caused by the large center-to-center spacing of the fuel assemblies, to high-density storage relying on installed neutron absorbers to accommodate the reduced center-to-center spacing of the fuel assemblies. However, virtually every permanently installed neutron absorber for which a history can be established has degraded in the SFP environment. If that degradation results in a reduction in the neutron absorption capability, k_{eff} will increase.

Other factors affecting reactivity in the SFP have not been static. The fuel assemblies have become more reactive. Increased uranium-235 enrichment is an example. Other changes include increased fuel pellet diameter, increased fuel pellet density, increased use of removable and integral burnable absorbers, and changes to core operating parameters because of power uprates that result in more reactive fuel assemblies to be stored in the SFP.

To accommodate these effects, the SFP NCS analyses and operation have become more complex. SFP NCS analyses are taking credit for items that previously were not part of such an analysis. For example, recent license amendment requests (LARs) have credited various combinations of the following: plutonium-241 decay, americium-241 buildup, axial blankets, integral burnable poisons on fresh fuel assemblies, increased burnup (as high as 78 gigawatt day/metric ton uranium (GWD/MTU)). The proposed storage configurations are becoming more complicated. Previously, each rack design in the SFP would have one storage configuration. Now, it is not uncommon for a rack design to have multiple sets of storage configurations. These storage configurations and the controls necessary to maintain the approved configuration are essentially parts of the SFP NCS analysis.

III APPLICABILITY

The guidance in DSS-ISG-2010-01 is to be used by NRC staff to review nuclear criticality safety analyses for the storage of new and spent nuclear fuel as they apply to: (i) future applications for construction and/or operating licenses; and (ii) future applications for license amendments and requests for exemptions from compliance with applicable requirements, that are approved after the date of this ISG.

IV TECHNICAL GUIDANCE

1. **Fuel Assembly Selection:** Licensees typically have used more than one fuel assembly design. Whether an applicant has one or many fuel assembly designs, the staff should review the submittal to verify that it demonstrates that the NCS analysis adequately bounds all designs, including variations within a design. Some of the potential variations within a design include axial blankets, cutback regions, axial enrichment zoning, radial enrichment zoning, and integral burnable neutron absorber loading. Therefore, the staff should verify each application includes a portion of the analysis that demonstrates that the fuel assembly used in the analysis is appropriate for the specific conditions.

   a. Use of a single "limiting" fuel assembly design should be assessed, as recent applications have shown that the limiting fuel assembly design can change based on the effects of other parameters in the analysis, e.g. depletion parameters, burnup credited, soluble boron present in the SFP, and permanently installed neutron absorbers.

2. **Depletion Analysis:** NCS analysis for SNF for both boiling-water reactors (BWRs) and pressurized-water reactors (PWRs) typically includes a portion that simulates the use of fuel in a reactor. These depletion simulations are used to create the isotopic number densities used in the criticality analysis.

   a. *Depletion Uncertainty:* The Kopp memorandum (Reference 2) states the following:

      > A reactivity uncertainty due to uncertainty in the fuel depletion calculations should be developed and combined with other calculational uncertainties. In the absence of any other determination of the depletion uncertainty, an uncertainty equal to 5 percent of the reactivity decrement to the burnup of interest is an acceptable assumption.

   The staff should use the Kopp memorandum as follows:

      i. "Depletion uncertainty" as cited in the Kopp memorandum should only be construed as covering the uncertainty in the isotopic number densities generated during the depletion simulations.

      ii. The "reactivity decrement" should be the decrement associated with the k_{eff} of a fresh unburned fuel assembly that has no integral burnable neutron absorbers, to the k_{eff} of the fuel assembly with the burnup of interest either with or without residual integral burnable neutron absorbers, whichever results in the larger reactivity decrement.

   b. *Reactor Parameters:* Consistent with the guidance in the Kopp memorandum for "the spent fuel storage racks loaded with fuel of the maximum permissible reactivity," the depletion simulations should be performed with parameters that maximize the reactivity of the depleted fuel assembly. Several reactor parameters, when modeled in the depletion simulations, affect the reactivity of the discharged fuel assemblies. NUREG/CR-6665, "Review and Prioritization of Technical Issues Related to Burnup Credit for LWR Fuel," issued February 2000 (Reference 8), provides some discussion on the treatment of depletion analysis

parameters for PWRs. While NUREG/CR-6665 is focused on criticality analysis in storage and transportation casks, the basic principles with respect to the depletion analysis apply generically to SFPs, since the phenomena occur in the reactor as the fuel is being used. Although a useful reference on the subject, NUREG/CR-6665 is not an exhaustive study of all of the fuel designs, core operating parameters, storage conditions, and possible synergistic effects. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates that the reactor parameters used in the depletion analysis are appropriate for the specific conditions. The staff reviewer should consider the following:

i. Bounding values should be used, and they should be traceable to other licensee documents. Bounding parameters tailored to a specific scenario will typically involve additional analysis and justification and NRC staff review effort. It would also likely require additional controls.

ii. It may be physically impossible for the fuel assembly to simultaneously experience two bounding values (i.e., the moderator temperature associated with the "hot channel" fuel assembly and the minimum specific power). In those cases, the application should maximize the dominant parameter and use the nominal value for the subordinate parameter. Where this is done, the application should describe and justify the parameters used.

iii. Use of non-bounding values may require extensive additional analysis, justification, NRC staff review, and potentially new aspects of a SFP NCS analysis not previously considered. Therefore, the use of non-bounding values is outside the scope of this ISG.

c. *Burnable Absorbers:* Removable burnable absorbers are those that are inserted into or attached to a fuel assembly for a complete reactor operating cycle, but they can be readily removed. Integral burnable absorbers refer to burnable poisons that are physically part of the as-manufactured fuel assembly. NUREG/CR-6665 provides a brief discussion on removable and integral burnable absorbers. NUREG/CR-6760, "Study of the Effect of Integral Burnable Absorbers for PWR Burnup Credit," issued March 2002 (Reference 9), and NUREG/CR-6761, "Parametric Study of the Effect of Burnable Poison Rods for PWR Burnup Credit," issued March 2002 (Reference 10), provide a more detailed discussion. Although these documents are useful references on the subject, they are not exhaustive studies of all of the fuel designs, core operating parameters, storage conditions, and possible synergistic effects. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates that the treatment of burnable absorbers in the depletion analysis is appropriate for the specific conditions. For example, the reviewer should consider the following:

i. Use of the limiting removable burnable absorber applicable to their specific conditions. The reviewer should also recognize that while removable burnable absorbers are typically used to control power shaping or peaking in the reactor, they have also been used for other purposes (e.g., flux suppressors to reduce the neutron fluence on reactor

belt welds). Applications should consider all removable burnable absorbers that have been used or are predicted to be used at their facilities.

ii. Use of the limiting integral burnable absorber applicable to their specific conditions.

iii. Burnable absorbers are modeled appropriately. For example, modeling burnable absorbers as full length when they are actually part length may lead to non-conservative conclusions about their effect on SFP reactivity.

iv. Competing effects are considered, such as the depletion of the burnable absorber and the increased rate of plutonium production from increased fast neutron capture in uranium-238.

d. *Rodded Operation:* Rodded operation would affect reactivity in a manner similar to removable burnable absorbers. Since rodded operation has the potential to affect the discharge reactivity of the fuel assemblies, it should be considered. NUREG/CR-6759, "Parametric Study of the Effect of Control Rods for PWR Burnup Credit," issued February 2002 (Reference 11), provides a more detailed discussion. Although this document is a useful reference on the subject, it is not an exhaustive study of all of the fuel designs, core operating parameters, storage conditions, and possible synergistic effects. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates its treatment of rodded operation is appropriate for its specific conditions.

i. Rodded operation would affect reactivity in a manner similar to fixed burnable absorbers. However, since control rods are much stronger neutron absorbers than the typical fixed burnable absorber, the effect could occur over a shorter time period.

ii. Rodded operation could also significantly affect the Axial Burnup Profile through partial insertion for such activities as power shaping or load follow. Rodded operation could also potentially result in a significant Radial Burnup Profile for fuel assemblies next to the rodded fuel assembly or a control blade inserted for power suppression.

3. Criticality Analysis

a. *Axial Burnup Profile:* One of the most important aspects of fuel characterization is the selection of the axial burnup profile. NUREG/CR-6801, "Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses," issued March 2003 (Reference 12), provides an insightful discussion of the "end effect" and recommendations for selecting an appropriate axial burnup profile. Although NUREG/CR-6801 is a useful reference on axial burnup profiles, it is not an exhaustive study of all of the fuel designs, core operating parameters, storage conditions, and possible synergistic effects. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates its treatment of axial burnup profile is appropriate for its specific conditions. For example, the reviewer should consider the following:

i. Use of the limiting axial burnup distributions from NUREG/CR-6801 are acceptable for existing PWRs, provided they are used in a manner consistent with NUREG/CR-6801, e.g. the profiles are used within the burnup ranges specified. The NRC staff reviewer should verify the applications for plant designs that set the limiting profiles in NUREG/CR-6801 provide a site specific justification for the axial burnup distributions.

ii. Applications using site-specific profiles should consider all past and present profiles, and include licensee controls to ensure that future profiles are not more reactive. An appropriate control for the axial profiles would be a licensee procedure that would evaluate the profile of an assembly before it is placed in the SFP storage racks and treat those with more reactive profiles than those used in the SFP NCS analysis as fresh fuel.

iii. Use of uniform profiles is conservative at low burnup levels. At some amount of burnup, the use of a uniform profile will become non-conservative. The burnup point where that occurs is dependent on the specifics of the situation. Applications that use uniform axial burnup profiles should only use them when appropriate and provide appropriate justification.

b. *Rack Model:* The rack model consists of the dimensions and materials of construction, including any installed neutron absorber. Given all the combinations that are in existence, it is impossible to predict all of the combinations that could be proposed. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates that the rack model analysis used in its submittal is appropriate for its specific conditions. For example,

i. The dimensions and materials of construction should be traceable to licensee design documents.

ii. The efficiency of the neutron absorber should be established, especially considering the potential for self-shielding and streaming.

iii. Any degradation should be modeled conservatively, consistent with the certainty with which the material condition can be established.

c. *Interfaces:* For applications that contain more than a single storage configuration, in order to ensure that the regulatory requirement for k_{eff} to be known with a 95 percent probability at a 95 percent confidence level is met the NCS analysis should consider the interface between storage configurations. Given all the combinations that are in existence, it is impossible to predict all of the combinations that could be proposed. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates that the interface analysis used is appropriate for its specific conditions.

i. Absent a determination of a set of biases and uncertainties specifically for the combined interface model, use of the maximum biases and

uncertainties from the individual storage configurations should be acceptable in determining whether the k_{eff} of the combined interface model meets the regulatory requirements.

d. *Normal Conditions:* The static condition where all fuel assemblies are in approved storage locations is not the only "normal" condition. Movement of fuel in and around the SFP is a normal operation, as are other activities such as fuel inspections and reconstitution, and should also be treated as normal conditions in the NCS analysis. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates that the NCS analysis considers all appropriate normal conditions for its specific conditions.

e. *Accident Conditions:* The Kopp memorandum states, "The criticality safety analysis should consider all credible incidents and postulated accidents." Typically analyzed accident conditions include misplacement or drop of a fuel assembly alongside the storage rack, misloading of a fuel assembly into an unapproved location, loss of SFP cooling, and boron dilution. The reviewer should verify all credible accident conditions are addressed. If an application determines that based on site specific rationale an accident condition is not credible, the submittal should include an analysis that quantitatively evaluates the probability of occurrence for that event.

   i. Accidents should be considered with respect to all normal conditions, e.g. fuel inspections and fuel reconstitution.

   ii. SFP NCS analysis crediting soluble boron should include a boron dilution analysis. However, a graded approach to that analysis may be taken depending on the amount of soluble boron being credited versus the amount required to be in the SFP.

4. Criticality Code Validation: The Kopp memorandum states the following:

> The proposed analysis methods and neutron cross-section data should be benchmarked, by the analyst or organization performing the analysis, by comparison with critical experiments. This qualifies both the ability of the analyst and the computer environment. The critical experiments used for benchmarking should include, to the extent possible, configurations having neutronic and geometric characteristics as nearly comparable to those of the proposed storage facility as possible.

NUREG/CR-6698, "Guide for Validation of Nuclear Criticality Safety Calculational Methodology," issued January 2001 (Reference 13), provides a more detailed discussion. Although a useful reference on the subject, NUREG/CR-6698 focuses on nuclear fuel cycle facilities and may not be all-inclusive with respect to a validation intended for fuel stored in a SFP.

a. *Area of Applicability:* The area of applicability is where the application demonstrates that the experiments cover the range of the analyzed system's parameters. Experiments should fully cover the range of the analyzed system. If the experiments do not fully cover the analyzed system, then the results should

be extrapolated. Therefore, the staff should verify that applications demonstrate that the validation fully covers the area of applicability for their specific SFP;

i. The reviewer should verify any validation used for SNF appropriately considers actinides and fission products. NUREG/CR-6979, “Evaluation of the French Haut Taux de Combustion (HTC) Critical Experiment Data,” issued September 2008 (Reference 14) provides experiments that model the actinide content of PWR fuel. Not all experiments may be appropriate for use by every application; the NRC staff reviewer should assess the appropriateness of the experiments used. An acceptable means of including isotopes that are not explicitly represented in the critical experiments used in the validation would be to increase the bias and bias uncertainty by an amount proportional to the reactivity worth of the isotopes not explicitly validated.

ii. Experiments should be appropriate to the system being analyzed. For example, an SFP without soluble boron should not have experiments with soluble neutron absorbers, and fresh-fuel-only NCS analyses should not have mixed oxide and HTC experiments. Parameters in the experiments should bound those of the system being analyzed. Experiments with parameters significantly in excess of those of the system being analyzed should be scrutinized for possible deleterious effects on the validation.

iii. The reviewer should recognize that too few experiments may not be statistically significant to cover the parameters and may lead to invalid trend analysis conclusions, e.g., soluble boron trending analysis conclusions reached using 200 critical configurations without soluble boron together with 7 configurations with soluble boron may result in the analyst reaching an incorrect conclusion concerning bias trends as a function of soluble boron concentration.

iv. The reviewer should ensure that the experiments are not all highly correlated, e.g. critical configurations performed with the same fuel rods at the same facility.

b. *Trend Analysis:* Part of the validation is to identify whether the bias has a dependency on any of the parameters in the area of applicability. Linear regression is typically used in the trend analysis. However, it is not the only method for investigating trends, and in some cases it may not be the best method. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates that the trend analysis used in its validation is appropriate for its specific conditions. For example, the staff should consider whether:

i. A trend analysis was performed on each parameter used to define the area of applicability.

ii. The submittal states and justifies its criteria for accepting or rejecting hypothesized trends.

iii. Identified trends are fully evaluated and appropriately applied.

c. *Statistical Treatment:* The products of the validation are a methodology bias and bias uncertainty. The Kopp memorandum states the following:

> The benchmarking analyses should establish both a bias (defined as the mean difference between experiment and calculation) and an uncertainty of the mean with a one-sided tolerance factor for 95-percent probability at the 95-percent confidence level (Ref. 8).

However, this use of the "uncertainty of the mean" does not ensure that k_{eff} is known with a 95 percent probability at a 95 percent confidence level such that any single calculation that calculates as subcritical is indeed subcritical. Use of the "uncertainty of the mean" may not be consistent with other statements in the Kopp memo and does not guarantee compliance with the requirements of 10 CFR 50.68. Use of the uncertainty of the mean would be inconsistent with NUREG/CR-6698. Recent applications related to spent fuel pool criticality have used a methodology consistent with NUREG/CR-6698 regarding the development of the code bias and bias uncertainty that has been accepted by the staff. Therefore, the staff should verify that each application includes a portion of the analysis that demonstrates that the statistical treatment used in its validation is appropriate for its specific conditions. The staff should consider whether

i. Applications use the variance of the population about the mean, instead of the variance of the mean.

ii. Appropriate confidence factors are used when determining the 95 percent probability and 95 percent confidence level.

iii. Nonnormal distributions are treated using appropriate statistical methods.

d. *Lumped Fission Products:* Vintage depletion codes use lumped fission products to collectively model isotopes of lesser importance in the reactor environment. It is not clear how the lumped fission products will behave in the environmental conditions of the SFP. Therefore, the staff should verify that each application that includes lumped fission products includes a portion of the analysis that demonstrates that the lumped fission products used in its validation are appropriate for its specific conditions. For example,

i. There are no critical experiments or cross-section libraries with lumped fission products, so transferring their number densities and cross-sections into the criticality code will require an extrapolation in the validation.

ii. Replacing the lumped fission products with a quantity of a known isotope, such as boron-10, that results in an equivalent reactivity at some state point is an assumption that the substitute isotope is an adequate representation of the actual isotopes represented by the lumped fission products. This assumption will require an extrapolation in the validation.

iii. It would be acceptable remove the lumped fission products from the estimation of k-effective in the SFP NCS analysis.

e. *Code-to-Code Comparisons:* The Kopp memorandum states that "The proposed analysis methods and neutron cross-section data should be benchmarked, by the analyst or organization performing the analysis, by comparison with critical experiments." NUREG/CR-6698 reinforces this statement. As with any guidance, applicants can use alternate methods, provided those methods are technically sound. There is not an accepted standard by which a code-to-code comparison for validating a criticality code may be performed and judged. Use of code-to-code comparisons would likely require extensive additional analysis and/or justification, additional NRC staff review, and potentially new aspects of a criticality code validation not previously considered. Therefore, the use of a code-to-code comparison for validating criticality codes is outside the scope of this ISG.

5. Miscellaneous

a. *Precedents:* Consistent with LIC-109, Acceptance Review Procedures (Reference 16), the NRC staff should determine whether cited precedents are justified and used appropriately and whether any deviations from the precedent appear to be justified. A previous precedent of approval itself is not a justification for a proposed change, but can facilitate a resource savings by allowing the technical staff to make appropriate use of information from previously-approved reviews. Therefore, the staff should verify that for cited precedents, the application includes a portion of the analysis that demonstrates the commonality of the precedent to the submittal, with any differences identified and justified with respect to the use of the precedent.

b. *References:* Consistent with LIC-109, Acceptance Review Procedures he NRC staff should determine whether cited references are appropriate and used in context. References can make the NRC reviews more efficient, but they are not without limitations. An example of context is the NUREG/CR-6801 observation, "Because the axial blankets have significantly lower enrichment than the central region, the end effect for assemblies with axial blankets is typically very small or negative." Since "typically" implies "not always," and "very small" is relative, the NRC reviewer should verify that references cited in the application are used in context and within the bounds and limitations of the references. Any extrapolation outside the context or bounds of the reference should be demonstrated as appropriate.

c. *Assumptions:* Applications contain numerous assumptions, both explicit and implicit. All assumptions should be justified. The applicability of an assumption may change with different scenarios in the NCS analysis. Therefore, applications should explicitly identify and justify all assumptions used in their applications.

V CONCLUSION

DSS-ISG-2010-01 provides updated guidance to the NRC staff reviewer that is responsive to the increased complexity of recent spent fuel pool (SFP) license application analyses and operations. The guidance is intended to reiterate existing guidance, clarify ambiguity in existing guidance, and identify lessons learned based on recent submittals.

Appendix A provides the NRC resolution of public comments on the draft DSS-ISG-2010-01.

VI COMPLIANCE WITH THE BACKFIT RULE

Issuance of this DSS ISG does not constitute a backfit as defined in 10 CFR 50.109(a)(1), and the NRC staff did not prepare a backfit analysis for issuing this DSS ISG. The guidance in DSS-ISG-2010-01 is to be used by NRC staff to review nuclear criticality safety analyses for the storage of new and spent nuclear fuel as they apply to: (i) future applications for construction and/or operating licenses; and (ii) future applications for license amendments and requests for exemptions from compliance with applicable requirements, that are approved after the date of this ISG. Thus this is a “forward fit” and the NRC does not consider the issuance of “forward fit” interpretive guidance to constitute “backfitting.”

VII REFERENCES

1. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 9.1.1, “Criticality Safety of Fresh and Spent Fuel Storage and Handling,” Revision 3, March 2007. (Agencywide Documents Access and Management System (ADAMS) Accession No. ML070570006)

2. Kopp, L., NRC, memorandum to T. Collins, NRC, “Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants,” August 19, 1998. (ADAMS Accession No. ML11088A013)

3. Generic Letter 1978-011, “OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications,” dated April 14, 1978, (ADAMS ML031280383)

4. Generic Letter 1979-004, “Modifications to NRC Guidance Review and Acceptance of Spent Fuel Storage and Handling Applications,” dated January 18, 1979, (ADAMS ML031290521).

5. Title 10 of the *Code of Federal Regulations* (10 CFR) 50 Appendix A, General Design Criteria for Nuclear Power Plants (Reference 4) Criterion 62, Prevention of Criticality in Fuel Storage and Handling,

6. Title 10 of the *Code of Federal Regulations* (10 CFR) 50.68, Criticality Accident Requirements,

7. Title 10 of the *Code of Federal Regulations* (10 CFR) 70.24 Criticality Accident Requirements,

8. NUREG/CR-6665, “Review and Prioritization of Technical Issues Related to Burnup Credit for LWR Fuel,” February 2000. (ADAMS Accession No. ML003688150)

9. NUREG/CR-6760, “Study of the Effect of Integral Burnable Absorbers for PWR Burnup Credit,” March 2002. (ADAMS Accession No. ML020770436)

10. NUREG/CR-6761, “Parametric Study of the Effect of Burnable Poison Rods for PWR Burnup Credit,” March 2002. (ADAMS Accession No. ML020770329)

11. NUREG/CR-6759, “Parametric Study of the Effect of Control Rods for PWR Burnup Credit,” February 2002. (ADAMS Accession No. ML020810111)

12. NUREG/CR-6801, “Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analyses,” March 2003. (ADAMS Accession No. ML031110292)

13. NUREG/CR-6698, “Guide for Validation of Nuclear Criticality Safety Calculational Methodology,” January 2001. (ADAMS Accession No. ML050250061)

14. NUREG/CR-6979, “Evaluation of the French Haut Taux de Combustion (HTC) Critical Experiment Data,” September 2008. (ADAMS Accession No. ML082880452)

15. Title 10 of the *Code of Federal Regulations* (10 CFR) 50.109 “Backfitting” paragraph (a)(1)

16. U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation NRR Office Instruction LIC-109, Acceptance Review Procedures, Revision 1, July 20, 2009. (ADAMS Accession No. ML091810088)

Appendix A

Resolution of Public Comments on Draft DSS-ISG-2010-01
"NUCLEAR CRITICALITY SAFETY ANALYSIS FOR SPENT FUEL POOLS"

The NRC received 65 comments from 4 interested parties. The Nuclear Energy Institute (NEI), (Reference 1), the Westinghouse Electric Company (WEC), (Reference 2), Mr. Dale Lancaster (Reference 3), and Mr. Don Mueller (Reference 4), provided specific comments. Progress Energy (Reference 5), Exelon Nuclear (Reference 6), and Strategic Teaming and Resource Sharing (Reference 7) provided comments that either supported the NEI comments or restated the NEI comments.

NO.	ISG Section	COMMENT	NRC Response
NEI # 1	General	1. It would be helpful for the ISG to address the necessity of performing a boron dilution analysis if taking partial credit for soluble boron. 10 CFR 50.68 is silent on this, and the Kopp memo (reference 2 in the ISG) simply states that "If credit for soluble boron is taken ... [a] boron dilution analysis should be performed to ensure that sufficient time is available to detect and suppress the worst dilution event..." The ISG should be more definitive about whether a dilution analysis is necessary in all circumstances (such as a licensee taking only a small amount of boron credit). 2. There are several places where the NRC states that an "extrapolation" would be required. Please provide additional guidance in regards to "extrapolation."	1. The NRC staff expects licensees to perform a boron dilution analysis whenever soluble boron is credited. However, a graded approach to that analysis may be taken depending on the amount of soluble boron being credited versus the amount required to be in the SFP. A subparagraph was added to IV.3.e to provide this guidance 2. Extrapolate: to infer values of a variable in an unobserved interval from values within an already observed interval. The further an inferred value is outside the already observed interval increases the uncertainty of the inferred value. Applicants should recognize this and accommodate it in their analysis.

NO.	ISG Section	COMMENT	NRC Response
		3. Please clarify how this ISG will be applied to license amendment requests currently under NRC review that were submitted prior to issuance of the draft ISG or, ultimately, the final ISG. It is recommended that those applications submitted prior to the issuance of the final ISG not be subjected to the new issues identified in the draft or final ISG. In addition, please clarify NRC staff's expectations with regards to how soon license amendment requests should incorporate the new issues identified after the final ISG is issued.	3. This ISG represents how the NRC staff is currently reviewing SFP NCS analyses. This ISG is restating existing guidance, providing clarity of existing guidance, and correcting existing guidance believed to be in error. Therefore this ISG is intended to be applied to all current and future SFP NCS analyses. The NRC staff intends to issue more durable guidance in the future. At that time this ISG will be retired.
		4. Clarification is required for the use of the term "bounding" when referring to depletion parameters or axial burnup profiles or interface requirements. The regulation calls for the k-eff to be calculated "at a 95 percent probability, 95 percent confidence level." As long as the chosen parameters / profiles result in a calculation of the k-eff at the required probability and confidence level, it should be sufficient.	4. From a literal aspect the NRC staff agrees. However, the NRC staff believes identifying and justifying such parameters would be problematic. The NRC staff would require an extended period to review such parameters. Therefore, the NRC staff guidance in this ISG is for the use of bounding parameters. Also see NRC staff response to NEI comment 11.1
		5. Reviewer flexibility is appropriate in the ISG. However, flexibility can reduce the effectiveness of the guidance in predicting regulatory expectations. Please consider enhancing the specificity of the guidance.	5. The level of specificity is appropriate given the scope of analysis that this ISG aims to cover (e.g., BWR and PWR, variation in fuel designs, differences in operating characteristics, etc.)

NO.	ISG Section	COMMENT	NRC Response
		6. If the ISG endorses a portion of a NUREG (e.g., CR-6698) it should extract or narrowly refer to it (by section) and endorse it specifically.	6. In DSS-ISG-2010-01 NUREG/CRs are referenced so that the reviewer will have a reference for understanding the subject. With the exception of NUREG/CR-6698, Guide for Validation of Nuclear Criticality Safety Calculational Methodology, the NUREG/CRs referenced are not methodologies for performing an analysis and there will likely be nuances in a particular NCS analysis that were not part of the NUREG/CR. DSS-ISG-2010-01 alerts the reviewer to this possibility. The comment specifically calls out NUREG/CR-6698. While NUREG/CR-6698 provides more direct guidance than the other NUREG/CRs referenced, it focuses on nuclear fuel cycle facilities and may not be all-inclusive with respect to a validation intended for fuel stored in an SFP. DSS-ISG-2010-01 paragraph IV.4.a.i is an example of additional guidance regarding NUREG/CR-6698. Therefore, no change to DSS-ISG-2010-01 has been incorporated.

NO.	ISG Section	COMMENT	NRC Response
NEI # 2	I	1. The current licensing basis (CLB) for most plants is References 2 and 3 (Kopp memo and Brian Grimes letter), not the SRP.	1. The Kopp memorandum was an NRC internal document has become de facto guidance. The Brian Grimes letter is more than 30 years old and its guidance should be updated. The NRC staff intends to issue more durable guidance in the future in a manner more consistent with the NRC's current practices for issuing and maintaining guidance documents. At that time the Kopp memorandum, Brian Grimes letter, and DSS-ISG-2010-01 will be retired. Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 3	II	1. The ISG goes to great lengths to discuss how margins have supposedly been eroded over time due to degraded neutron absorbers, increased fuel enrichments, etc. However, the ISG needs to maintain appropriate perspective with regard to actual safety margin in spent fuel pools. In particular, for pressurized water reactors (PWRs), the regulations themselves (i.e., 10CFR50.68(b)(4)) inherently contain a significant amount of safety margin. For example, 10CFR50.68(b)(4) requires the assumption of a beyond-design-basis accident in the requirement to assume complete dilution of the spent fuel pool soluble boron. With this inherent safety margin in mind, it is requested that the Staff consider the imposition of the new criticality safety analysis requirements discussed in this document from a risk-informed standpoint. For example, it should be recognized that increasing conservatism in criticality analyses through this ISG can result in the applicant having to	1. The NRC staff reviews license amendment requests to make an independent determination as to whether or not there is reasonable assurance the appropriate regulations will be met. Analyzing the unborated condition is a 10 CFR 50.68(b)(4) requirement. Therefore, no change to DSS-ISG-2010-01 has been incorporated.

NO.	ISG Section	COMMENT	NRC Response
		impose more complicated loading patterns to manage the fuel in the spent fuel pool.	
		2. Industry notes that no significant loss of neutron absorber efficiency has been observed in modern spent fuel rack neutron absorber materials, such as BORAL or METAMIC. Any degradation of these types of absorbers has been limited to superficial corrosion or blistering which did not affect the integrity of the neutron absorber itself. Further, any such superficial degradation in these materials has been demonstrated to have no significant impact on the criticality safety analysis. Discussion of neutron absorber degradation should be more precise and directed toward the specific materials and manufacturing vintage that has demonstrated the degradation.	2. The NRC staff agrees that "…no significant loss of neutron absorber efficiency has been observed in modern spent fuel rack neutron absorber materials, such as BORAL or METAMIC..." to date. However, the BORAL blisters continue to form, and the metal matrix composites (i.e. METAMIC) have not been in use long enough to establish an operating history. Providing specificity for every neutron absorber currently in use would be extensive. Since this section of the ISG just indicates awareness, the specificity is unwarranted.
		3. Although the initial reactivity in the fuel has increased for the reasons stated in this section, the burnup has also increased so the net average reactivity in the pool has not changed much. Suggest changing the second sentence in the paragraph beginning "Other factors" to: "The initial reactivity of the fuel has increased causing more dependence on burnup credit. The increase in initial reactivity is due to higher enrichments and changes in the pellet diameter and density. Other changes have resulted in dependence on higher burnup which include increases in the use of burnable absorbers as well as higher moderator and fuel temperatures."	3. The comment is editorial in nature and does not affect the guidance. Therefore, no change to DSS-ISG-2010-01 has been incorporated. 4. #4 was skipped by the commenter.
		5. Although burnups as high as 78 GWD/MTU have shown up in	5. While a NCS analysis may calculate

NO.	ISG Section	COMMENT	NRC Response
		applications, no credit for 78 GWD/MTU has ever been taken. High burnups such as this are given to allow interpolation between data points. Operating and licensing limits prevent assembly burnups from approaching 78 GWD/MTU. Please refer to "burnups reaching operating and licensing limits" rather than 78 GWD/MTU. Other margin degradation statements in this section are not completely accurate. For example, fuel enrichments close to 5 wt% U-235 have been in use for the better part of 20 years. In addition, high density fuel storage racks have also been in use across the industry since 1990 and licensees have been using burnup credit in the 40-60 GWd/MTU range (the current operating and licensing limits for reactors is close 60 GWd/MTU) for about the last 20 years. It should also be noted that Reference 2 explicitly states that credit for Pu-241 decay may be taken to reduce burnup limits. This is a practice that has been utilized in various license amendments within the last 20 years.	burnups above the licensed limit for use in the analysis, a licensee should not propose technical specifications that include burnups above its current licensed limit. SFP enrichment/burnup loading curves with burnup above current licensed limits could be construed as some level of NRC staff acceptance of the increased burnup, which would not be the case in a SFP NCS analysis and therefore should be avoided.
NEI # 4	IV.1	As desirable as the simplicity of defining a single limiting design is, the reality is that most design parameters important to SFP criticality are interdependent and complex. It will be difficult to meet the expectation that the limiting assembly design chosen "adequately bounds" all designs (past, present and expected future) for all conditions (borated, unborated, fresh fuel, high burnup, maximum temperature, minimum temperature, blankets, no blankets, poison type, grid volume and material, etc.). There is a long list of fuel design variables within a particular general fuel design to be tested in combination with each other for each rack design and at various conditions for both fresh and burned fuel: Some key fuel design variables a. Fuel pellet diameter (max and min) b. Fuel density (max and min)	1. The ISG does not espouse that the SFP NCS analysis use a single limiting fuel assembly design. Both using a single limiting fuel assembly designs and multiple designs have pros and cons and the choice is often a business decision made by the applicant over which they prefer. The expectation is that the applicant will demonstrate the appropriateness of the fuel assembly design or designs that are used in the SFP NCS analysis. For example if the analysis demonstrates that one fuel

NO.	ISG Section	COMMENT	NRC Response
		c. Grid material d. Grid volume (max and min) e. Clad diameter (max and min) f. Clad thickness (max and min) g. Clad material h. Guide thimble diameter (max and min) i. Guide thimble thickness (max and min) j. Guide thimble material k. Integral poison type and loading l. Discrete poison type and loading m. Enrichment distribution within the assembly n. Blanket length o. Blanket enrichment From the guidance, it is not clear how many criticality cases and what set of variable combinations would be considered adequate. More clarity is needed. One possible approach would be to define bounding fuel characteristics rather than a particular bounding fuel design. Bounding values of items ‘a’ through ‘j’ above could be determined from independent sensitivity cases performed for fresh and burned fuel of two enrichments (expected low and high range of fresh fuel enrichment). The significance of each variable could be ranked by level of importance, and bounding combination cases could demonstrate that the combined effect of all bounding variables is similar to the expected effect determined from the independent sensitivity cases. Variables ‘k’ through ‘o’ could be considered separable from fuel characteristics ‘a’-‘j’ such that sensitivity cases on those variables could be performed using a base design model instead of being performed with multiple combinations of the other variables (i.e. burnable poison effects	assembly design was limiting at low burnups while another was limiting at higher burnups, the applicant should use the appropriate fuel assembly design for each scenario. The ISG guidance aims to alert the reviewer to this possibility. The number of criticality cases necessary to demonstrate the appropriateness of the design(s) used in the SFP NCS analysis will vary from application to application and cannot be limited in the ISG. Some applicants may perform a relatively limited number of cases that clearly demonstrate the appropriate design was used in each scenario; others may require a significant number of cases. It is not expected that the manufacturing tolerances within fuel assembly design parameters will have an impact on determining the appropriateness of the design. However, the range of the parameters may influence appropriateness of the fuel assembly designs for a particular scenario.

NO.	ISG Section	COMMENT	NRC Response
		could be considered to be independent of small fuel characteristic variations). Future changes in fuel design could then be compared to the bounding fuel characteristics to determine whether a new fuel type is bounded by the SFP licensing basis. 2. "NCS" should be followed by "analysis" or "analyses"	The commenter espouses a method for creating a hybrid fuel assembly design consisting of the worst case parameters from the 'a' through 'o' based on a sensitivity study. The NRC staff believes there is inadequate information in the comment to evaluate this possibility, and the sensitivity study may require a large number of cases to establish the bounding fuel characteristics. Therefore, the NRC staff cannot endorse that method at this time. 2. Comment was incorporated throughout DSS-ISG-2010-01.
NEI # 5	IV.1.a	1. If using a single limiting assembly is inappropriate, the ISG should provide more information on the expectation in regards to limiting assemblies. 2. Please elaborate on "effects of other parameters". Is this referring to parameters that are not considered in the tolerance and abnormal analyses? Is it referring to depletion parameters? Additional guidance is needed to allow for consistent interpretation by the licensees.	1. See above NRC staff response to NEI comment 4. 2. "Other parameters" includes parameters such things as the depletion parameters, the amount of burnup credited, soluble boron present in the SFP, and amount of permanently installed neutron absorber. The ISG has been edited to provide clarification on what "other parameter" should be considered.
NEI # 6	IV.2.a.i	1. The ISG suggests restricting the use of 5% of the reactivity decrement to cover only the uncertainty in the isotopic content of the burned fuel.	1. The depletion uncertainty is intended to be a reactivity

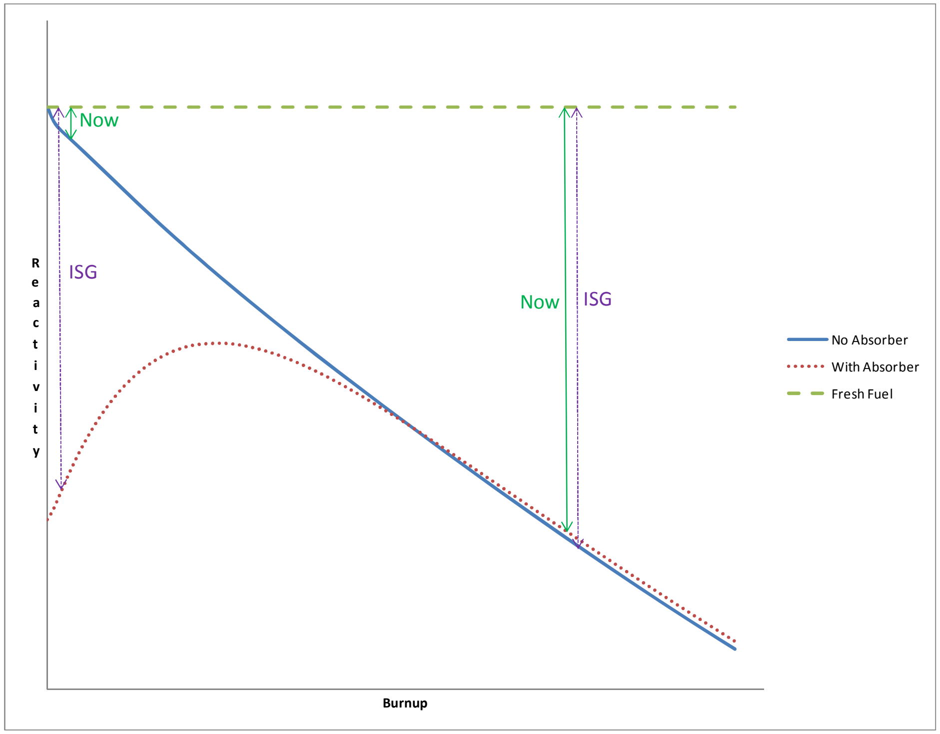
NO.	ISG Section	COMMENT	NRC Response
		This is arbitrary and not technically justified. It is the belief of Industry that the 5% of the reactivity decrement, as discussed in Reference 2, was intended to include both the isotopic uncertainty and the reactivity worth of the depletion based on reactor experience at the time. Reactor experience has only gotten better. Furthermore, if the reactivity worth uncertainty is not to be included in the 5% decrement, there is no guidance as to what to use to estimate the uncertainty in the reactivity worth due to depletion.	uncertainty due to the uncertainty in the depletion calculations. It is the change in isotopic content that provides the reactivity worth of the depletion. As the depletion calculations provide the isotopic content used in the criticality calculations it is the uncertainty in the isotopic content that is the depletion uncertainty. In accordance with the current guidance the '5% of the reactivity decrement' is being used to estimate the uncertainty in the change in reactivity worth due to depletion.
		2. There is no established basis for limiting use of the 5% uncertainty recommendation from the "Kopp memorandum" to only isotopic number densities generated during the depletion simulations. Docketed estimates of the actual reactivity uncertainties associated with depletion simulations, based on measured in-reactor critical data for reactor cores that contain the actual fuel assemblies that are being stored in the spent fuel pools, clearly indicate that the actual uncertainty associated with depletion calculations is less than the 5% value suggested in the Kopp memo. Further, these comparisons of depletion simulations with actual measured in-reactor criticals cover virtually all possible sources of uncertainty, including code methodology inaccuracies, cross section uncertainties, measured reactor critical uncertainties, impacts of time- and irradiation-induced changes in fuel geometry, and so on.	2. There is no discussion in the current guidance that would indicate it could be applied to anything else. The current guidance is based on engineering judgment. Extending the depletion uncertainty to anything else would involve extrapolating the original engineering judgment. The basis for the original engineering judgment is insufficiently known to make any extrapolation. The NRC staff is in the process of establishing a methodology for determining the depletion uncertainty that is more technically defensible. The NRC

NO.	ISG Section	COMMENT	NRC Response
			staff intends to issue more durable guidance in the future in a manner more consistent with the NRC's current practices for issuing and maintaining guidance documents. At that time the Kopp memorandum, Brian Grimes letter, and DSS-ISG-2010-01 will be retired. Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 7	IV.2.a.ii	1. The "reactivity decrement" was intended to be the change in reactivity from the initial condition to the storage condition. It is not appropriate to take the initial condition from an assembly without a Burnable Absorber (BA) and then use a BA assembly for the final condition. Note that by using the method proposed in the draft ISG for a burnup of 1 MWD/MTU, there would be a very large reactivity decrement since the reactivity decrement would actually be the worth of the burnable absorber. Although burnup credit is never sought for burnups this low, burnup credit is sometimes sought for burnups less than that which would have complete burnout of the BA. There is no technical justification for the reactivity decrement to include the worth of the BA. For removable BAs and ZrB_2 BAs and normal discharge burnups, this provision is no change from common practice since both the initial and final conditions will come from assemblies without BAs. For gadolinia or erbia, the residual absorption from the even isotopes makes it conservative to ignore these BAs. Following the proposed section of the ISG, one would have to analyze with Gd or Er. This is inappropriate and unnecessary.	1. This comment while requesting no specific action with regard to the ISG hits on a key point with the current guidance for determining the depletion uncertainty. Application of the current guidance is straight forward for cases where burnable absorbers are not present, but not so for cases where burnable absorbers are present. Cases where a large amount of burnable absorbers are present may initially actually show an increase in reactivity with depletion, as depicted in the commenter's Figure 1. As there is a 'reactivity increment' a reviewer or applicant may falsely conclude that no depletion uncertainty is required. In cases with a more moderate amount of burnable absorber there may initially

NO.	ISG Section	COMMENT	NRC Response
			be essentially no change in reactivity, thereby rendering the reactivity change ineffective in estimating the depletion uncertainty.
		2. The wording "with or without residual neutron absorber" in this section creates an inconsistent application of conservatisms in two cases as described below. Please consider revising this section. Case 1: The first inconsistency impacts the application of the depletion uncertainty at low burnups with burnable neutron absorbers (IFBA, Gd, erbia, WABA, BPRA, Pyrex, etc). As shown on the left side in Figure 1 (provided at the end of this attachment), the difference in reactivity between an assembly that contains burnable absorbers versus an assembly that does not contain burnable absorbers is significant at low burnups. Applying 5% of the reactivity difference between the fresh assembly and the assembly with burnable absorbers would suggest that a significant conservative uncertainty be applied even in the case where the residual neutron absorber is not credited in the low burnup assembly. This would also create a large discontinuity in the maximum k_{eff} (which includes all biases and uncertainties) between the fresh fuel assembly where integral absorber is not credited in the spent fuel pool and the slightly burned fuel assembly, where the large "depletion uncertainty" would be applied according to the prescription in the draft ISG. Neglecting the residual burnable absorber is a much more significant conservatism than applying the 5% depletion uncertainty and therefore it is not necessary to apply both of these conservatisms. Case 2: The guidance as written would recommend a double application of conservatisms from two separate configurations. To illustrate this point, Figure 1 shows the reactivity of two fuel assemblies in a representative spent fuel storage rack as a function of burnup. The first	2. In Case 1 the commenter presents a scenario with the fuel assembly having a large initial BA loading. The commenter's figure appears to show that for fuel assemblies with large initial BA loadings the DSS-ISG guidance on determining the depletion uncertainty will be unnecessarily conservative at lower burnups. The NRC staff agrees that there will be cases at low burnups where following the ISG guidance could be unnecessarily conservative. However, as pointed out in NEI comment 7.1 burnups in this range are rarely credited. The NRC staff does not believe it is productive to provide guidance for something that may not occur during the life of the DSS-ISG. Additionally, the NRC staff believes that more moderate BA loadings will result in less dramatic conservatisms, and the NRC staff guidance should consider those scenarios as well.

NO.	ISG Section	COMMENT	NRC Response
		assembly (dotted line) includes burnable absorbers, while the second assembly (solid line) is identical to the first, only without the burnable absorber. The reactivity of the fresh fuel assembly is also shown as the horizontal (dashed) line. If the draft guidance were followed verbatim, the depletion uncertainty would have to be calculated based on the difference in reactivity of the fresh fuel assembly and the assembly that contained no neutron absorber, because it has the lower reactivity at higher burnups as shown in the left of Figure 1. However, as suggested by ISG Section IV.2.c, burnable absorbers must be considered in their effect of hardening the spectrum and providing a more reactive fuel assembly at the same burnup and enrichment. As a result, the NRC has specified in the draft ISG the application of conservatisms from two different physical configurations.	In Case 2 the comment indicates that there is a double application of conservatisms. Consideration of the burnable absorber effect on the final reactivity of a depleted fuel assembly is not a conservatism. The delta shown in the figure is small. 5% of the delta would likely have a negligible impact on the total final estimated keff and therefore does not warrant separate guidance. Therefore, no change was made to the guidance and as with any guidance, applicants can use alternate methods, provided those methods are technically sound.
		3. The definition of reactivity decrement suggested here is arbitrary and inconsistent with physical reality as discussed above. To be consistent, the guidance should read that the reactivity decrement should be the largest of the following three scenarios (noting that all might not be applicable to a specific criticality analysis application): (1) the difference in the k_{eff} of a fresh unburned assembly with no burnable poison to the k_{eff} of the same assembly with the credited amount of burnup; (2) the difference in the k_{eff} of a fresh unburned assembly with no burnable poison to the k_{eff} of the same assembly with the credited amount of burnup, depleted with a fixed burnable absorber to the maximum burnup permitted with the fixed burnable absorber present, but with the fixed burnable absorber removed at the credited burnup; or (3) the difference in the k_{eff} of a fresh unburned assembly with an integral poison present to the k_{eff} of the same assembly with the credited amount of burnup,	3. The DSS-ISG guidance does contain a bit of artificiality. However, the guidance continues the Kopp Letter guidance of using a reactivity decrement to estimate the depletion uncertainty. The DSS-ISG guidance on how to determine the reactivity decrement includes scenarios the Kopp Letter does not, as noted in the NRC staff response to NEI comment 7.1. The DSS-ISG guidance is simple and should be conservative over all scenarios. The commenter's suggestions would not be

NO.	ISG Section	COMMENT	NRC Response
		depleted to that credited amount of burnup with the integral absorber present, and with the residual integral burnable absorber present.	conservative over all scenarios. As with any guidance, applicants can use alternate methods, provided those methods are technically sound. Therefore these recommendations were not incorporated into the DSS-ISG.
		4. This section narrowly discusses single assemblies, while sometimes cell combinations are analyzed. For example, if a 2x2 array in the pool is analyzed and qualified to have 3 spent fuel assemblies and one empty cell, then the reactivity change associated with a single assembly (i.e. infinite array of assemblies) would be overly conservative as the basis for the depletion uncertainty, and the reactivity change associated with changing the three assemblies in the array to three fresh assemblies would be more appropriate. The text should be changed to consider such conditions.	4. The comment notes that as storage configurations change the burnup of interest can change. DSS-ISG-2010-01 states the reactivity change will be based on the "…burnup of interest…" Therefore, these scenarios are already covered and no change to DSS-ISG-2010-01 has been incorporated.

NO.	ISG Section	COMMENT	NRC Response
		 Figure 1 Representative Reactivity Effect of Burnable Absorbers	
NEI # 8	IV.2.b	1. This section is silent on the possible variations for BWRs. Justification should be provided to demonstrate the validity of applying this section's guidance to BWRs, or additional clarification should be provided.	1. The analysis should use depletion parameters that maximize the reactivity of depleted fuel and justify the parameters used. The guidance is equally applicable to BWRs. One

NO.	ISG Section	COMMENT	NRC Response
		2. See Comment 7.4 above.	PWR example is provided in IV.2.b.ii. The NRC staff believes one example is sufficient to demonstrate the point of IV.2.b.ii. NUREG/CR-6665 is cited as a reference that highlights the importance of selecting appropriate depletion parameters. 2. See NRC staff Response to NEI Comment 9.1
NEI # 9	IV.2.b and IV.2.c	The ISG assumes that bounding, worst-case parameters must be used for the depletion parameters. The licensee should be allowed to select certain depletion parameters for some assemblies and other depletion parameters for other assemblies. The fuel inventory can be categorized accordingly to use the appropriate loading curves.	1. Two sentences have been added to IV.2.b.i to acknowledge this possibility, "Bounding parameters tailored to a specific scenario will typically involve extensive additional analysis and/or justification, and NRC staff review effort. It would also likely require additional controls."
NEI # 10	IV.2.b.i	1. Bounding reactor depletion parameters should not automatically be required to be used. In many cases, such as in an explicit 3-D analysis, it is appropriate to use a realistic "nominal" irradiation model, and then determine the maximum deviations from that nominal model. 2. It may not always be possible to trace all bounding parameter values	1. While it may be defensible to "use a realistic "nominal" irradiation model, and then determine the maximum deviations from that nominal model," that has not been the practice. To do so would involve extensive additional analysis and/or justification, and NRC staff review effort. It would also likely require additional controls. 2. The ISG does not state "other

NO.	ISG Section	COMMENT	NRC Response
		to “other licensing documents”. For example, maximum operating fuel temperature values or limitations are not typically present in licensing documents. This sentence should be reworded to state, “Bounding parameters should be used, and these should be consistent with the operating history and licensing basis of the plant.”	licensing documents.” It states “other licensee documents.” Other licensee documents include licensing documents as well as plant operating records. Therefore the NRC staff believes the wording is appropriate.
		3. Using bounding values of reactor parameters may sometimes be unnecessarily conservative. For example, is it really necessary to use the highest fuel assembly exit temperature over all operating cycles (instead of the core average exit temperature) if this temperature will be assumed for all of the axial nodes, including the low burnup ends of the core with relatively small reactivity effects due to temperature history?	3. The guidance is to use limiting parameters. The guidance does not stipulate that the highest fuel assembly exit temperature be used at all axial nodes. Rather an appropriate use of the guidance would be to develop a temperature profile that is anchored by the highest fuel assembly exit temperature. Therefore, each node can reasonably be considered to be at its maximum. Tailoring the limiting parameters to specific scenarios while possibly defensible, would involve extensive additional analysis and/or justification and NRC staff review effort. It would also likely require additional controls. A sentence to reflect this possibility has been added to IV 2.b.i to reflect this possibility.
		4. There are several apparently contradictory statements: “It may not be acceptable …” implies that it could actually be acceptable under certain conditions, but then the second sentence clearly states “Bounding values	4. To remove the confusion the first sentence of ISG paragraph IV 2.b.i

NO.	ISG Section	COMMENT	NRC Response
		should be used ….” Also, if it really would result in 10CFR50.68 not being met, then it would not be acceptable (no “may”). 5. The entire implication of this section does not appear to be correct. It is not clear why compliance with 10CFR50.68’s 95/95 confidence level is specifically stated here as opposed to other sections. Only the final result needs to meet that criterion, and it is affected by a large number of parameters, each of them with some uncertainty. Using nominal parameters in one area and more conservative or bounding values in other areas can also ensure the requirement is met. 6. This section discusses the use of bounding core parameters as opposed to nominal or typical ones. “Bounding” is vague and should be better defined. The NRC’s definition of bounding has been evolving. For example, fuel temperatures have moved from average to core planar maximum to fuel assembly maximum. There have been recent discussions that this may change to maximum fuel pin (peak node). Applying the peak pin max temperature as the standard fuel temperature for ALL pins/assemblies is overly conservative. The ISG should better define “bounding” so Industry knows how to address this for all applicable input parameters.	has been deleted. 5. To remove the confusion the first sentence of ISG paragraph IV 2.b.i has been deleted. 6. The NRC staff’s position on what constitutes the bounding moderator and fuel temperature has been consistent. What has changed is the NRC staff’s realization that applicant’s claims to have used a ‘conservative’ temperature were actually nominal temperatures without any attempt to “... determine the maximum deviations from that nominal model.” The NRC staff is unaware of discussions regarding applying the peak pin temperature to all pins. The NRC staff believes that the concept of ‘bounding values’ is well established in the nuclear industry and its use is consistent with that in this ISG. The NRC staff believes no further definition is needed.

NO.	ISG Section	COMMENT	NRC Response
NEI # 11	IV.2.b.ii	1. The ISG states “Bounding values should be used, and they should be traceable to other licensee documents”. In the event it is physically impossible to simultaneously use bounding values for important depletion conditions, “the application should maximize the dominate parameter and use the nominal value for the subordinate parameter”. Sensitivity studies are required to determine which parameters are dominant and to demonstrate “the synergistic effects of other variables”. Combinations of variables will need to be used in the sensitivity studies. It would be helpful to have as many of these depletion variables as possible identified in the ISG and to have additional guidance on the scope of combinations expected. 2. “dominate” should be “dominant” 3. Please clarify what is meant by the “hot channel fuel assembly.” Is this meant to be the hot channel temperature of the bounding fuel assembly? It is not credible for any fuel assembly to operate at the hot channel temperature for the entire life of the fuel assembly in the core.	1. Use of non-bounding values will likely require extensive additional analysis, justification, NRC staff review, and due to potentially new aspects of a SFP NCS analysis not previously considered. Therefore, the use of non-bounding values is outside the scope of this ISG. DSS-ISG paragraph V.2.b.iii has been replaced accordingly. However, applicants can use alternate methods, provided those methods are technically sound. 2. Change has been made. 3. See the NRC staff response to NEI Comment 10.3 above.
NEI # 12	IV.2.b.iii	1. The ISG does not state what code or combination of codes may be used for the sensitivity studies. For example, can the sensitivity studies be performed using the depletion code used to determine spent fuel isotopic content at reactor conditions, or is it necessary to run SFP condition calculations using the generated isotopic content? Is it acceptable to perform the depletion sensitivity studies in 2D or is full 3D modeling including bounding axial burnup shapes required? Is it necessary to perform these studies at bounding high and low fuel enrichments and with or without burnable poisons? More guidance is needed regarding the scope of the sensitivity studies required.	1. See NRC staff Response to NEI Comment 11.1 above.

NO.	ISG Section	COMMENT	NRC Response
		2. Reactor parameters are 1) Moderator temperature and density (Higher temperatures result in less depletion reactivity decrement), 2) Fuel temperature (Higher fuel temperatures result in less depletion reactivity decrement), 3) Specific power (very little effect), 4) Operating history (very little effect). Sensitivity studies on these parameters has already been performed, accepted, and documented by ORNL and others. Therefore, this section should be removed. 3. The phrase "…include the synergistic effects of other variables" in this particular section is vague. It would be helpful if the NRC identified specific variables to be considered here or list some examples.	2. See NRC staff Response to NEI Comment 11.1 above. 3. See NRC staff Response to NEI Comment 11.1 above.
NEI # 13	IV.2.c	The term "fixed burnable absorbers" is not standard. Please change to "removable burnable absorbers." Fixed burnable absorbers was a term used for burnable absorber rods, which displaced fuel rods in the assembly lattice. These rods were used in the first cores in CE reactor designs. The NUREGs listed in this section did not utilize the term "fixed burnable absorbers" when referring to removable burnable absorbers.	1. The change has been made throughout the ISG.
NEI # 14	IV.2.c.i	In the last sentence, delete "predicted."	1. The NRC staff believes that it is important for the SFP NCS analyses to consider past, current, and within reason future conditions. For business reasons licensees can predict future energy needs including burnable absorbers. Since the use of removable burnable absorbers can increase the reactivity of a discharged fuel assembly it is important that the SFP NCS analysis covers a full

NO.	ISG Section	COMMENT	NRC Response
			range of removable burnable absorbers that the applicant “predicts” it may use.
NEI # 15	IV.2.c.ii	It is not clear how “use of limiting burnable absorbers” should be interpreted for BWRs. Please include guidance within the ISG for BWRs with integral absorbers which are evaluated at peak reactivity conditions.	1. What constitutes “limiting burnable absorbers” may be different for different scenarios, whether it is a BWR or PWR. Whether “limiting burnable absorbers” is a maximum or minimum will depend on the specifics of the scenario as indicated by DSS-ISG paragraph IV.2.c.iv, (See also NRC staff Response to NEI comment 17.1 below.) BWR fuel evaluated at peak reactivity would be a specific case where the intention of the DSS-ISG is broader. The NRC staff believes that if the full guidance in DSS-ISG section IV.2.c is considered the reviewer will be able to determine if the appropriate “limiting burnable absorbers” were used for “BWRs with integral absorbers which are evaluated at peak reactivity.” Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 16	IV.2.c.iii	1. The guidance in this section needs to be more specific. The situation where part-length burnable absorbers appear to bound full length absorbers only occurs in situations where three-dimensional depletion modeling is employed, with a realistic axial power shape, thus resulting in a significant residual burnable poison effect at the top and bottom of the model, due to the low fluxes in those regions. Since burnable absorbers	1. The comment describes the basis for the guidance. If burnable absorbers are modeled as described in the comment there are two non-conservatisms (1) including burnable absorbers that are in fact

NO.	ISG Section	COMMENT	NRC Response
		effects are typically computed with two-dimensional models, effectively making the burnable poison full length but without incurring the "end effects", this statement will not be true for most, if not all, applications. Much confusion could be averted in future licensing submittals if this section was modified accordingly. 2. The statement "modeling burnable absorbers as full length when they are actually part length may lead to non-conservative conclusions about their effect on SFP reactivity," is an incorrect statement unless the residual burnable absorber is credited at the low burnup ends of the active fuel length. Is it the intent of the NRC to allow credit for the residual burnable absorber?	not present and (2) ignoring the end effect. Therefore the guidance is appropriate and no change to DSS-ISG-2010-01 has been incorporated. 2. The NRC staff has never indicated that credit for the residual integral burnable absorber would not be accepted for a SFP NCS analysis.
NEI # 17	IV.2.c.iv	1. This is not a "competing effect". This is the primary effect of performing depletions with burnable absorbers present, and this is the main reason for performing such calculations. Restating this here simply creates confusing guidance, and will have analysts searching for additional effects that are already accounted for in the basic depletion calculations.	1. The competing effects in the example are the negative reactivity effects of the residual burnable absorber and the positive reactivity effects of the increased plutonium caused by the burnable absorber. The NRC staff believes that it is inappropriate to always assume the negative reactivity effects of the residual burnable absorber would outweigh the positive reactivity effects of the increased plutonium without considering the specifics of the particular scenario being analyzed.
NEI # 18	IV.2.d	Justification should be provided to demonstrate the validity of applying this section's guidance to BWR control rod blades, or additional clarification should be provided.	1. BWRs may operate with control rods inserted for power control or power suppression of leaking fuel assemblies. Therefore, the NRC

NO.	ISG Section	COMMENT	NRC Response
			staff considers it more likely that BWRs will need to address rodded operation than PWRs, and that it is incumbent upon the applicant to demonstrate rodded operation need not be considered for their application. Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 19	IV.3.a	1. The ISG says that use of the limiting axial profiles in NUREG/CR-6801 are acceptable for PWRs provided they are used in a manner "consistent with NUREG/CR-6801" and that a "site specific justification" is provided. It is not clear what the burden of proof is that would be required to demonstrate consistent usage, nor what type of justification is needed. Please clarify the ISG accordingly. If site-specific profiles are used, the ISG requires "licensee controls to ensure that future profiles are not more reactive". It is difficult to design cores that limit axial burnup shapes as a function of burnup. Therefore, the use of site-specific profiles should be avoided. 2. It would be helpful to note that in addition to the axial burnup profile, secondary contributors to the "end effect" are also important to consider, including axial histories for moderator temperature, fuel temperature, boron concentration, and burnable poison content. 3. This section is only applicable to PWR operation. Please revise this section to recognize that axial burnup profiles and end effects are not applicable to BWR analysis based on peak reactivity.	1. An example was added to IV.3.a.i to demonstrate what the NRC staff would consider 'consistent with NUREG/CR-6801'. Guidance for 'site specific justification' is provided in IV.3.a.ii. 2. The DSS-ISG section IV.2.b provides guidance on the reactor parameters used in the depletion analysis. 3. BWR SFP NCS analyses perform a depletion analysis to determine the fuel's peak reactivity. The burnup where that occurs may be beyond the burnup where a uniform profile is limiting, and therefore axial profiles should be considered. Additionally,

NO.	ISG Section	COMMENT	NRC Response
			the NRC staff has received a LAR requesting burnup credit for BWR fuel beyond the point of peak reactivity. In such cases the axial profile would need to be addressed for the same reasons it is addressed in a PWR SFP NCS analysis. Therefore the guidance is applicable to BWRs and no change to DSS-ISG-2010-01 has been incorporated.
NEI # 20	IV.3.a.i	1. Please remove the requirement to provide a site-specific justification for use of the axial burnup profiles from NUREG/CR-6801. This statement is inconsistent with the previous statement in this section that, "Use of the limiting axial burnup distributions from NUREG/CR-6801 are acceptable for existing PWRs..." 2. Please clarify the meaning of "set the limiting profiles"?	1. See NRC staff response to NEI comment 19.1 2. See NRC staff response to NEI comment 19.1

NO.	ISG Section	COMMENT	NRC Response
NEI # 21	IV.3.a.ii	1. Please provide an example of an acceptable licensee control. Without such guidance each applicant could propose a different licensee control, which will cause considerable discrepancies and inconsistencies within the industry. 2. This section includes text "…to ensure that future profiles are not more reactive…" than the ones used in the analysis. This reads like a commitment and licensees would not be able to use more reactive axial burnup profiles in future cores. Industry can and should be able to utilize more reactive profiles, provided they are addressed in criticality analysis space beforehand. Suggest rewording.	1. The appropriate controls could range from technical specifications to control storage configurations and burnup/enrichment loading curves to procedures that ensure current plant operating parameters continue to bound those used in the NCS analysis. An example of a control for this paragraph has been added to DSS-ISG-2010-01. 2. More reactive profiles add reactivity. While small increases may be accommodated within the NRC staff reviewed and approved analysis of record (AOR) with its approved methodology, large increases may not. Such increases would require either an adjustment of the TS controlled burnup/enrichment loading curves or a change to the NRC staff approved methodology. Either should prompt the licensee to submit a LAR. Therefore the comment is correct licensees would not be able to use more reactive profiles and no change to DSS-ISG-2010-01 has been incorporated.
NEI # 22	IV.3.a.iii	1. Change "will" to "may" in the second sentence. The ability of a non-uniform axial burnup distribution to be more conservative than a uniform distribution is highly dependent on the application and, in particular, on	1. While the NRC staff agrees, and recognizes in the DSS-ISS, that the burnup at which the use of a uniform

NO.	ISG Section	COMMENT	NRC Response
		the loading pattern assumed in the criticality analysis. 2. Please remove the statement “Applications that use uniform axial burnup profiles should clearly demonstrate where that [cross-over point] occurs.” Identification of the cross-over point between where a uniform versus axially distributed profile is conservative is not necessary to be identified if analyses are performed with both a uniform and distributed profile modeled. This statement as written could be construed as a requirement for approval with no technical basis for this information to be provided.	distribution becomes non-conservative is highly dependent on the particular scenario, the NRC staff also believes that there is always a burnup at which the uniform distribution will become non-conservative. Therefore, no change to DSS-ISG-2010-01 has been incorporated. 2. The sentence was revised as follows: “Applications that use uniform axial burnup profiles should only use them when appropriate and provide appropriate justification. “
NEI # 23	IV.3.b.ii	1. Please clarify what is meant by “efficiency?” It is unclear how this might be accomplished except through some kind of literature review. Since there are a relatively small number and type of neutron poisons in use, it would be helpful to have more guidance on what the staff considers to be sufficiently conservative modeling for each major category of absorber. Without such guidance, submittals will not be uniform with regard to absorber efficiency.	1. It is clear from NEI comment 3.2 that the commenter actually already has a clear understanding of what is meant by “efficiency” as applied to neutron absorbers. The “efficiency” of a neutron absorber may be affected by the system that surrounds it. B^{10} in a system that does not thermalize the neutrons before they reach the B^{10} will not be a very efficient neutron absorber. This issue can become more significant as systems age and possibly degrade such that the

NO.	ISG Section	COMMENT	NRC Response
		2. This section states that the rack model used must be appropriate, "especially considering the potential for self-shielding and streaming." Neutron absorbers such as Boral and Metamic have been manufactured with sufficient homogeneity that self-shielding and streaming does not occur in the environment of the spent fuel pool, where there is a continuous neutron spectrum (primarily at thermal energies) and neutrons are travelling in all directions. No additional guidance is provided on how these items should be considered. This will result in variable approaches across submittals for similar material, as no generally accepted approach has been demonstrated as "appropriate". Additional guidance on how to treat these items should be provided.	'efficiency' of the neutron absorber may be reduced, even though it is still physically present. 2. While the commenter believes a couple materials may have sufficient homogeneity that self-shielding and streaming does not occur, those materials are not the only materials currently in use or potential materials for future use. Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 24	IV.3.c	1. "NCS" should be followed by "analysis" or "analyses" 2. In the last sentence: "… interface analysis used is appropriate for its specific condition." Please clarify what the meaning of "specific condition" is in this context.	1. Comment incorporated throughout DSS-ISG-2010-01. 2. Interfaces occur between areas with different storage requirements such as differing enrichment/burnup loading curves. Within the different storage requirements there may be different requirements. The DSS-ISG guidance is intended to alert the reviewer to the possibility of multiple 'specific conditions' for these interfaces.
NEI # 25	IV.3.c.i	1. Use of the word "could" in the ISG statement introduces uncertainty as to whether the suggested approach is acceptable to the staff or not. What is required to make this approach acceptable?	1. The word was changed to "should."

<table>
<tr><th>NO.</th><th>ISG Section</th><th>COMMENT</th><th>NRC Response</th></tr>
<tr><td></td><td></td><td>2. This statement should be removed. The use of the maximum biases and uncertainties from either of the individual storage configurations would make it impossible to analytically qualify the interfaces between either distinct rack designs within a pool or to qualify different storage patterns within a rack module. Table 1 (provided at the end of this attachment) shows an example of the application of this requirement to an interface between a rack module with flux traps intended for fresh fuel and a high-density rack module without flux-traps intended for spent fuel, that were both qualified to the same maximum k_{eff}.

In reality the reactivity of the spent fuel pool with different storage configurations will be dominated by the most reactive configuration within the spent fuel pool, and the biases and uncertainties from that configuration would be the most applicable to be applied. The application of the maximum biases and uncertainties from any other configuration is not a technically valid application of the biases and uncertainties.

Table 1: Reactivity Effect of Interfaces per ISG-DSS-2001-01
<table>
<tr><th></th><th>Fresh Fuel Racks</th><th>Spent Fuel Racks</th><th>Interface Analysis</th></tr>
<tr><td>Calculated k_{eff}</td><td>0.980</td><td>0.965</td><td>0.980</td></tr>
<tr><td>Biases + Uncertainties</td><td>0.015</td><td>0.030</td><td>0.030</td></tr>
<tr><td>Maximum k_{eff}</td><td>0.995</td><td>0.995</td><td>1.100</td></tr>
</table>
</td><td>2. The DSS-ISG provides two alternatives. If an applicant believes one alternative is too restrictive, they may use the other, or an alternate method, provided that method is technically sound. Therefore, no change to DSS-ISG-2010-01 has been incorporated.</td></tr>
<tr><td>NEI # 26</td><td>IV.3.d</td><td>1. It appears that this paragraph is requesting an additional section be added to the license application. There is nothing in this paragraph to suggest any condition not already covered in a standard license application. Fuel inspections and reconstitution are maintenance/modification activities that are not always planned at the time the license is amended. Maintenance and modification activities</td><td>1. The DSS-ISG guidance is meant to alert the reviewer that there may be normal conditions other than a simple monolithic storage module or rack, such as fuel inspections and fuel reconstitution. If licensees have</td></tr>
</table>

NO.	ISG Section	COMMENT	NRC Response
		must always meet the plant technical specifications in effect at the time and, if required, pass a 50.59 review to be implemented. 2. "NCS" should be followed by "analysis" or "analyses"	the capability for these other normal conditions at the time of the review they should be included in the review, whether they are currently ‘planned’ or not. Should licensee add these or other capabilities after the review, the licensee should then use the appropriate change process. 2. Incorporated.
NEI # 27	IV.3.e	1. If the ISG intends to have licensees go into a risk-informed evaluation mode for this type of analysis, the guidance should provide what constitutes an acceptable level of risk (probability times consequences) for use in determining when an accident does not need to be considered. In other words, in risk-informed space, if an “accident” has no consequences (i.e., cannot result in inadvertent criticality), then it does not need to be considered. 3. Please add the discussion on the double contingency principle from the Kopp memo to this section to provide clarity with regard to the analysis of multiple accidents.	1. The guidance in the Kopp Letter is to “…consider all credible incidents and postulated accidents.” Several recent LARs have claimed a fuel assembly misloading is not credible at that site. However, fuel assembly misloadings have occurred in the industry. The guidance is to use a probability of occurrence analysis to determine whether or not an event is credible. The NRC staff believes using a probability of occurrence analysis will increase rather than decrease the objectivity of the determination. 2. #2 was skipped by the commenter. 3. The Kopp Letter is not being superseded by this DSS-ISG, and there is no intention to repeat all of

NO.	ISG Section	COMMENT	NRC Response
		4. It is not clear why loss of SFP cooling is included. Is this due to the potential for boiling? Please provide an explicit reason for loss of SFP cooling. 5. The statement opens up a totally new area of NCS licensing that has no precedent or demonstrated technical basis to support it by requiring the applicant to quantitatively evaluate the probability of occurrence of an accident condition that is not considered credible. First, there is no agreed upon measure for the credibility of spent fuel accidents which is not necessarily the same as that for core accidents viz. $< 10^{-6}$. Second, this leaves the subject open to an individual reviewer's interpretation as to what is not credible.	the Kopp Letter in this DSS-ISG. Therefore, no change to DSS-ISG-2010-01 has been incorporated. 4. Some SFPs have a positive moderator temperature coefficient. 5. See NRC staff response to NEI comment 27.1.
NEI # 28	IV.3.e.i	1. This section states that "Accidents should be considered with respect to all normal conditions". It is unclear what this is meant to convey. It could be interpreted to mean that every accident condition should be analyzed against any credible normal condition, which would require an exhaustive study with limited impact on final results. It could also be interpreted to mean that a limiting normal configuration should be determined and all accident scenarios be considered with respect to this limiting normal case. The sentence also could be meant solely to suggest that each accident should be defined as only 1 departure from a normal condition, not 2 or more, consistent with the double contingency principle. Additional clarification should be provided to make interpretation of this guidance more uniform across applications.	1. It is meant to convey that there may be other normal conditions such as fuel inspections and fuel reconstitution that happen in the SFP that may be a starting point for an accident other than a simple monolithic storage module or rack. The sentence has been revised as follows, "Accidents should be considered with respect to all normal conditions, e.g. fuel inspections and fuel reconstitution."
NEI # 29	IV.4	This section seems to primarily focus on the use of the statistical treatment from NUREG/CR-6698 and the inclusion of the HTC Critical	1. NUREG/CR-6698, Guide for Validation of Nuclear Criticality

NO.	ISG Section	COMMENT	NRC Response
		Experiment data. However, no mention is made of appropriate selection of UO_2 critical experiments, either from the OECD manual or other sources, which are much more important in terms of reactivity than the HTC Critical Experiment data.	Safety Calculational Methodology, is referenced to provide the reviewer with an NRC document that discusses the validation of criticality codes. It is referenced so that the reviewer will have a standard by which to determine whether a validation in a SFP NCS LAR has the key elements. Most of the comments dealing with DSS-ISG paragraph IV.4 can be resolved by reviewing NUREG/CR-6698. In particular the selection of experiments for use in the validation is addressed in NUREG/CR-6698 section 2.2 "Select Critical Experiment Data" which explicitly references the OECD manual (International Handbook of Evaluated Criticality Safety Experiments). Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 30	IV.4.a	The ISG does not provide guidance with regard to NRC's expectations for inclusion of critical experiments that may become available prior to a license amendment request. After the issuance of the NUREG/CR-6979, the NRC stated their expectation that these criticals be included in the criticality analysis through RAIs and acceptance reviews. The ISG should be modified to include guidance in the area in order to prevent a similar situation from occurring in the future as new experiments become available.	1. Applications should use appropriate experiments for validation. The 'newness' of an experiment doesn't affect its 'appropriateness'. The primary source of available new experiments is OECD International Handbook of Evaluated Criticality Safety Experiments. The 'Handbook' is published annually in September. Applicants should have ample time to

NO.	ISG Section	COMMENT	NRC Response
			plan their submittals. Experiments becoming available outside the Handbook are rare and will be addressed on a case by case basis. None are expected during the expected lifetime of the DSS-ISG. Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 31	IV.4.a.i	1. A specific requirement for the inclusion of the so-called HTC critical experiments is not warranted, nor is it supported by fact. In at least two cases, significant time, effort, and expense has been incurred to include the HTC experiments in the suite of critical benchmarks for criticality analysis codes, with the result that the methodology bias and bias uncertainty did not change significantly. Therefore, there is no basis to specify that the HTC critical experiments must be a part of the benchmark experiment portfolio when actinides and fission products are credited. Numerous other experiments were performed with plutonium-239 and other actinides present in the fuel, and these should be equally acceptable. 2. The statement “The reviewer should verify that any validation that [is] used for SNF appropriately considers actinides and fission products.” should be modified. This statement does not provide clear guidance on what the NRC finds acceptable for validation of fission products. Given that there are currently only two critical experiments that include fission products (Sm-149 and Rh-103), this requirement may be impossible to meet as written. Please revise to specify a requirement that is possible to be met. Recommendation is to remove the discussion on lumped	1. The ISG does not establish a "specific requirement for the inclusion of the so-called HTC critical experiments." However, there is a need for the validation to be sufficiently thorough. The HTC critical experiments are the only readily available experiments that include actinides. Any validation that includes the modeling of spent nuclear fuel, but does not include some set of the HTC critical experiments is potentially remiss and would warrant additional scrutiny during the review. 2. The NRC staff is developing a method that will allow a validation to be completed with due consideration for the fission products. Until that method is finalized any consideration of the fission products will be based on engineering judgment. As discussed in NUREG/CR-6698 the

NO.	ISG Section	COMMENT	NRC Response
		fission products, and provide instead reasonable and practicably applicable guidance on all fission products. It should be noted that the Industry has referred to the uncertainty associated with actinides and fission products in spent fuel as the "depletion uncertainty" and this portion of the validation uncertainty would be conservatively covered by the 5% of the reactivity decrement (i.e., the depletion uncertainty). The validation using fresh fuel critical experiments establishes the bias and uncertainty for fresh fuel and the uncertainty associated with the difference between the fresh fuel condition and the burned fuel condition is appropriately covered by the "depletion uncertainty."	lack of fission product data in the critical experiments would constitute a material outside the area of applicability of the validation. NUREG/CR-6698 provides guidance on extending the area of applicability of the valuation.
NEI # 32	IV.4.a.ii	1. No critical experiments will match exactly the SNF in the pool environment. Since SFPs typically depend on boron in absorber plates, it is appropriate to use as many boron containing experiments as possible. Use of soluble boron experiments for the SFP with 0 ppm is still valuable for confirmation of the boron that is in the absorber plates. Trends on boron should be sought and if found, care should be given to the use of boron containing experiments. No trend on boron has been found in recent analyses, so separate sets for no soluble boron and for soluble boron conditions are not needed. Since there is no trend with boron content, a single set of experiments that cover the range of racks is acceptable. For example, it is appropriate to use the same set of experiments for the new fuel racks which do not contain any absorber plates.	1. There is a difference between absorber plates and soluble absorber. If there were no experiments with absorber plates then one might need to use experiments with soluble boron to approximate the absorber plates, but the NRC staff believes there is a sufficient number of experiments with absorber plates and no soluble boron so that approximation does not need to be made. It is inappropriate to assume that since a small number of analyses have not identified a trend in parameter X that all future analysis will also not identify a trend in parameter X. Separate sets of

NO.	ISG Section	COMMENT	NRC Response
			experiments with separate biases and bias uncertainties would be one way to accommodate a trend. Whether there is a trend needs to be determined by analysis.
		2. Inclusion of critical experiments in the benchmarking suites for criticality analysis codes that go beyond the scope of the specific application is not unacceptable and, in fact, helps to demonstrate the robustness of the methodology. Any "deleterious effects" caused by inclusion of experiments that are supposedly inappropriate would manifest themselves in the methodology bias and bias uncertainty.	2. The NRC staff disagrees with the comment. In general the industry disagrees with the comment as shown in ANSI/ANS-8.24-2007, Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations, Section 7.2 which states, "The validation applicability should not be so large that a subset of the data with a high degree of similarity to the system or process would produce an upper subcritical limit that is lower than that determined for the entire set. This criterion is recommended to ensure that a subset of data that is closely related to the system or process is not non-conservatively masked by benchmarks that do not match the system as well."
		3. How does this affect new neutron poison materials? Can criticals with a different material type be used?	3. As with any first of kind material use or methodology, an applicant intending to use a neutron absorber that has never been used before should engage the NRC staff well

NO.	ISG Section	COMMENT	NRC Response
			before submitting an application.
NEI # 33	IV.4.a.iii	Please provide guidance for definition of what is considered statistically significant for a valid trend analysis.	1. NUREG/CR-6698 provides guidance on instances when there may be an insufficient number of critical experiments.
NEI # 34	IV.4.b	1. Linear Regression will result in higher uncertainties if the trend is not linear. Since the higher uncertainties will result in a lower target k, the use of linear regression would be conservative and acceptable. Unless there is a sound theoretical reason for a non-linear trend, a higher order fit may be misleading. Suggest that the sentence regarding linear regression be removed. 2. It is unclear what is meant by the statement "Part of the validation is to identify whether the bias or bias uncertainty or both have a dependency on any of the parameters in the area of applicability." From the way this is phrased, it could be interpreted that the bias uncertainty should be studied on its own to determine if it is characterized by any trends. There is no clear guidance on studying bias uncertainty trends independent of trends in the bias. This section should either be clarified to provide guidance on bias uncertainty trend analyses or rephrased to be more clear.	1. This comment is evidently referring to 2nd and 3rd sentences of DSS-ISG paragraph IV.4 which are "Linear regression is typically used in the trend analysis. However, it is not the only method for investigating trends, and in some cases it may not be the best method." These two sentences are paraphrasing the 3rd and 4th sentences in the 3rd paragraph on page nine of NUREG/CR-6698. NUREG/CR-6698 is referenced in DSS-ISG paragraph IV. Therefore, no change to DSS-ISG-2010-01 has been incorporated. 2. The sentence has been changed to read as, "Part of the validation is to identify whether the bias has a dependency on any of the parameters in the area of applicability."

NO.	ISG Section	COMMENT	NRC Response
NEI # 35	IV.4.b.i	Can a bounding trend analysis be used instead of a trend analysis on each parameter?	1. The DSS-ISG provides guidance as to one acceptable approach. It does not preclude applicants from proposing and justifying other approaches. No change to DSS-ISG-2010-01 has been incorporated.
36	IV.4.c	1. The "uncertainty in the bias" for a code/cross-section set is correctly defined to be the uncertainty of the mean which is the standard deviation of the population times the appropriate confidence factor divided by the square root of N where N is the number of experiments. The more experiments there are, the more confidence we have that we know what the bias is. This is not the same thing as the uncertainty in the population. Although it is conservative to use the uncertainty in the population as a code uncertainty, it should be noted that the uncertainty in the population will always be greater than the code uncertainty since the population error includes experimental error as well as code error. Assuming that the code uncertainty is the uncertainty of the population is always very conservative. 2. The statistical treatment in NUREG-6698 includes two elements of the statistical treatment that are not appropriate. The first element from NUREG/CR-6698 is the recommendation to statistically combine the experimental measurement uncertainty with the calculational uncertainty	1. The NRC staff disagrees with the comment. If the bias uncertainty were covering only the uncertainty in the bias value, the comment would be correct. However, the bias uncertainty includes the population variance to support the 95/95 confidence interval for a single future calculation. While it is appropriate to include the bias uncertainty as defined by the comment, additional uncertainty is needed to cover the 95/95 confidence interval for the safety analysis limiting cases. While the language in NUREG/CR-6698 could have more clearly defined what was meant by bias uncertainty, the statistical methods described in NUREG/CR-6698 are appropriate. 2. The NRC staff disagrees with the comment. The experimental uncertainties described in the experiment benchmark sources do

NO.	ISG Section	COMMENT	NRC Response
		to determine the total uncertainty. Statistically combining the uncertainties would result in a double counting of the experimental uncertainty that is already accounted for in the statistical determination of the bias and uncertainty. Second, the "experimental uncertainty" identified in the OECD manual and other sources of critical experiments is not a measurement uncertainty in the traditional sense (i.e., uncertainty in the measurement of the neutron multiplication factor, electronic equipment, experimental setup, etc.) Rather, the "experimental uncertainty" identified in the descriptions of the critical experiments is a calculation of the reactivity effect associated with the various tolerances or uncertainties in the experiment (fuel rod diameter, fuel density, temperature of the moderator boron content, water level, etc.). Therefore, the "experimental uncertainty" identified in the sources of critical experiments is an overly conservative estimation of the experimental uncertainty based on certain parameters important to the reactivity of the system and not an experimental uncertainty as indentified in NUREG/CR-6698. Therefore it is not appropriate to apply this experimental uncertainty described in the critical experiment benchmark sources as an experimental uncertainty.	translate directly into uncertainty in the value of keff that one would expect to calculate for the physical critical experiment. Frequently, analysts assume that the expected value for a critical experiment model is exactly unity, even though the physical experimentalist likely extrapolated to critical and did not know the materials and dimensions exactly. The uncertainties in determination of the keff value for the experiment and in the descriptions of the materials and dimensions of the system do need to be considered in the validation process. Additionally, numerous approximations and simplifications are made in describing and modeling critical experiments. The impact of these simplifications and approximations on the expected keff value and its uncertainty should be quantified and included in the validation. There is additional uncertainty, such as Monte Carlo or convergence uncertainty, associated with the calculational method. This uncertainty is independent of the experimental uncertainties and should also be included in determination of the

NO.	ISG Section	COMMENT	NRC Response
			overall computational method bias and bias uncertainty.
NEI # 37	IV.4.c.i	The validation is an attempt to correct for inadequacies in the computer model. The computer model has no random characteristics and will give the same result every time. In that light it is desired to find the variance of the mean. The variance of the population includes the experimental error, which is independent of the computer model and therefore is not needed for validation of the computer model.	1. The computer codes used to estimate k-effective in the SFP are Monte Carlo codes, which do have random characteristics. Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 38	IV.4.c.ii	Non-normal distributions are common in criticality validation. No applications have attempted a trended bias and uncertainty using non-normal statistical methods. Additional guidance with regard to trend analysis for non-normal distributions should be provided.	1. NUREG/CR-6698, which is referenced in DSS-ISG paragraph IV.4.c, provides guidance on non-parametric means to address non-normal distributions. Therefore, no change to DSS-ISG-2010-01 has been incorporated.
NEI # 39	IV.4.d	1. The statement that, “It is not clear how the lumped fission products will behave in the environment of the SFP.” has no basis and is factually inaccurate. NRC has licensed the usage of depletion codes with lumped fission products for in-reactor analysis since the early 1980’s. The various applications of these in-reactor analysis models include determination of reactor shutdown margin at cold conditions with most, if not all, control rods fully inserted. The neutron spectrum that exists in a reactor at such cold, subcritical conditions is not significantly different from that in a spent fuel pool. Given this, along with the fact that, in the particular case of the CASMO code, the lumped fission products represent nuclides of very low neutron importance, no basis exists for any requirement to specifically address the usage of lumped fission products in this manner, and the uncertainties associated with usage of lumped fission products are bounded by, and should be included in, the 5% depletion uncertainty suggested by the Kopp memo.	1. Lumped fission products are not part of any of the Evaluated Nuclear Data (ENDF/B) libraries used in SFP NCS analyses submitted to the NRC staff. Therefore they are not subject to the same level of scrutiny and revision as real isotopes. While the nuclear data for real isotopes continues to evolve the cross section data for the lumped fission products has apparently remained constant. Perhaps a correlation can be made between reactor cold shutdown conditions and SFP conditions, however that correlation

NO.	ISG Section	COMMENT	NRC Response
		2. There is no guidance at all on the validation of fission products, while there is an excessively detailed discussion on the lumped fission products, which are only a small subset of the fission products. Recommendation is to remove the discussion on lumped fission products, and provide instead reasonable and practicably applicable guidance on all fission products.	has not yet been made in any appreciable detail. Therefore, the NRC staff considers there to be a lack of clarity with respect to how lumped fission products will behave in the SFP. The lumped fission products are of sufficient worth that applicants continue to credit them in SFP NCS analyses. So long as the lumped fission products are credited in SFP NCS analyses, they need to be considered in the validation of the criticality code. 2. The NRC staff believes that the guidance on fission products is also applicable to lumped fission products. Also, see NRC staff response to NEI Comment 31.2.
NEI # 40	IV.4.e.iii	What defines a sufficient number of comparisons? Please provide additional guidance.	1. See NRC staff response to WEC comment 17.
NEI # 41	IV.5.a	Defining "substantially similar" in terms of precedent is recommended. Does this term mean that the application in whole needs to be similar, or can portions be cited as similar with justification for citing it as precedent? Do only similarities in precedent need to be justified to show there is commonality? If so, why would differences to the precedent need to be justified? If different than the precedent, it should be technically supported and "demonstrated as appropriate."	1. Applicants may use precedents in many ways. They may use them in whole or in part. They may use them in a broad or specific manner. The concept of "substantially similar" will change depending on how applicants use a precedent. An application's similarities and

NO.	ISG Section	COMMENT	NRC Response
			differences to a precedent must be known and understood. Similarities show why a precedent may be applicable and differences show why it may not be applicable. The differences should be justified to demonstrate they do not preclude the use of the precedent. The last sentence of the comment is the point the ISG is trying to make.
NEI # 42	IV.5.c	In some cases, use of engineering judgment is justifiable, particularly when the “absolute margin” of the calculation (again, including the non-credible assumption of a complete dilution accident) is considered. For example, the Staff has stated on occasion that neglecting spacer grids, a customary assumption with an enormous amount of precedent, could be a non-conservative assumption. However, neglecting spacer grids has not resulted in a significant non-conservatism at the boron concentrations credited in spent fuel pool applications. In fact, the Staff continues to overlook the fact that the calculations that showed any non-conservative reactivity impact from neglecting spacer grids were, in and of themselves, overly conservative, often making the assumption that the spacer grid, as modeled, extended the entire length of the fuel assembly, instead of occupying only a few percent of the active fuel length.	1. The ISG is not precluding the use of engineering judgment. The NRC staff agrees that the use of engineering judgment can be a valuable tool. However, the reviewer must understand the basis for the engineering judgment when it is applied. With respect to the spacer grids the NRC staff attempted to establish that basis through requests for additional information. When reviewing the responses the NRC staff concluded that the assumption that it is ‘always conservative to ignore the spacer grids' was flawed. This highlights the need for the reviewer to understand the technical basis behind the engineering judgment. Also, see NRC staff response to NEI Comment 3.1

NO.	ISG Section	COMMENT	NRC Response
NEI # 43	VI	This section discusses the "forward fit" nature of this guidance and states that this guidance is only applicable to future license applications, license amendment requests, and requests for exemptions. Even though it was not explicitly stated, it is assumed that the NRC is referring to voluntary license amendment requests and not requests that are expected by NRC staff to address an operability issue (e.g., temporary non-compliance with technical specifications). Specifically, the letter referenced in the draft ISG (reference 15) states that application of updated guidance to a voluntary request by a licensee seeking to modify its licensing basis will not be considered backfitting, so long as (i) the new or revised guidance relates directly to the licensees voluntary request; and (ii) the specific subject matter of the new or revised guidance is an essential consideration in the NRC's consideration of the acceptability of the licensee's voluntary request. The distinction between license amendment requests that are submitted voluntarily by a licensee and requests that a licensee is compelled or expected to submit in order to address an operability issue is not addressed in the ISG. NEI believes that some licensing actions to which the ISG could be applied would not be voluntary and, thus, could be backfits rather than "forward-fits." Therefore, it is requested that NRC address the applicability of this ISG to license amendment requests (or other licensing/regulatory actions) that the staff expects will be submitted to address operability issues, as opposed to licensing actions that are undertaken voluntarily by the licensee.	1. In reviewing license amendment requests the NRC staff does not make the distinction made in the comment. DSS-ISG-2010-01 will be used to review all SFP NCS analyses.
WEC # 1		New issues are identified in the draft ISG that have not been previously discussed as areas of NRC staff concern in either public meetings or RAIs for plant specific license amendment requests regarding spent fuel criticality analyses. These new issues promote an ongoing uncertainty as to the scope of issues that must be addressed in a spent fuel pool criticality analysis.	1. See NRC staff response to NEI comment 1.3.

NO.	ISG Section	COMMENT	NRC Response
WEC # 2		In several cases the recommended resolution of the on-going technical uncertainties in spent fuel criticality analyses are either impossible or prohibitively conservative. The most extreme example of this is the requirement to include a validation of fission products. Given that there are limited critical experiments with fission product isotopes available for inclusion in a validation this is a requirement that is not possible to be met.	1. NUREG/CR-6698 provides guidance on extrapolating the validation if there are insufficient critical experiments. Also see NRC staff response to NEI comments 31.2 and 39.2.
WEC # 3		The wording in the draft guidance is sufficiently vague or misleading as to preclude the level of guidance that was expected. The wording leads to more confusion and uncertainty versus providing necessary guidance as to the proper way to address the technical details in spent fuel criticality analyses that the NRC staff would find acceptable.	1. The DSS-ISG is guidance to the reviewer; it is not a SFP NCS analysis methodology.
WEC # 4		General Comment: Please clarify how this ISG will be applied to license amendment requests currently under NRC review that were submitted prior to issuance of the draft ISG or ultimately the final ISG. It is recommended that those applications submitted prior to the issuance of the final ISG not be subjected to the new issues identified in the draft or final ISG.	1. See NRC staff response to NEI comment 1.3.
WEC # 5	IV.1.a.i	Clarify what is meant by "other parameters" when assessing the limiting fuel assembly.	1. See NRC staff response to NEI comment 5.2.

NO.	ISG Section	COMMENT	NRC Response
WEC # 6	IV.2.a.i	Application of the depletion uncertainty to the isotopic number density is not technically defensible. There is no technical data to defend the appropriateness of this value for isotopic number densities. The 5% depletion uncertainty has traditionally been applied to cover the uncertainty in the depletion computer code and the lack of critical experiments with fission products. There is no indication in the public literature that this is still not the case. In fact, in the May 1", 2009 NRC meeting the industry provided technical information as to why the 5% depletion uncertainty was sufficient to cover these issues. Additionally, the NRC has reviewed and approved recent applications with the 5% depletion uncertainty used as intended in the Kopp memo. It is respectfully requested that this statement be removed and the 5% depiction uncertainty be identified as sufficient.	1. See NRC staff response to NEI comments 6.1 and 6.2.
WEC # 7	IV.2.a.ii	Remove the requirement "with or without residual neutron absorber". This recommendation would require an inconsistent application of conservatisms in two cases. Issue 1: The first inconsistency impacts the application of the depletion uncertainty at low burnups with burnable neutron absorbers (IFBA, Gd, Erbia, WABA, BPRA, Pyrex, etc). As shown on the left side in Figure 1, the difference in reactivity between an assembly that contains burnable absorbers versus an assembly that does not contain burnable absorbers is significant at low burnups. Applying 5% of the reactivity difference between the fresh assembly and the assembly with burnable absorbers would suggest that a significant conservative uncertainty be applied even in the case where the residual neutron absorber is not credited in the low burnup assembly. This would also create a large discontinuity in the maximum k_{eff} (which includes all biases and uncertainties) between the fresh fuel assembly where integral absorber is not credited in the spent fuel pool and the slightly burned fuel assembly, where the large "depletion uncertainty" would be applied according to the prescription in the draft ISG. Neglecting the residual burnable absorber is a much	1. See NRC staff response to NEI comment 7.2, both issues are addressed therein.

NO.	ISG Section	COMMENT	NRC Response
		more significant conservatism than applying the 5% depletion uncertainty and therefore it is not necessary to apply both of these conservatisms. Issue 2: The guidance as written would recommend a double application of conservatisms from two separate configurations- To illustrate this point, Figure 1 shows the reactivity of two fuel assemblies in a representative spent fuel storage rack as a function of burnup. The first assembly (dotted line) includes burnable absorbers, while the second assembly (solid line) is identical to the first, only without the burnable absorber. The reactivity of the fresh fuel assembly is also shown as the horizontal (dashed) line. If the draft guidance were followed verbatim, the depletion uncertainty would have to be calculated based on the difference in reactivity of the fresh fuel assembly and the assembly that contained no neutron absorber, because it has the lower reactivity at higher burnups as shown in the left of Figure 1. However, as required by Section 2.c, burnable absorbers must be considered in their effect of hardening the spectrum and providing a more reactive fuel assembly at the same burnup and enrichment. The NRC has specified in the draft ISO the application of conservatisms from two different configurations; the depletion uncertainty from the assembly with no burnable absorbers and the burnable absorber bias from the assembly that does contain burnable absorbers. Table 1 below shows a representation of the burnable absorber bias and depletion uncertainty for assemblies with and without burnable absorbers. Recent analyses have been approved by the NRC with the depletion uncertainty and burnable absorber bias applied from the assembly with integral absorbers. This statement in the ISG essentially requires that the difference in reactivity between a fuel assembly with and without burnable absorbers to be applied as both a bias and an uncertainty as shown in Table 1. Table 1: Reactivity Effect of Integral Burnable Absorbers	

<table>
<tr><th>NO.</th><th>ISG Section</th><th>COMMENT</th><th>NRC Response</th></tr>
<tr><td></td><td></td><td><table><tr><td></td><td>Depletion Uncertainty</td><td>Burnable Absorber Bias</td></tr><tr><td>With Integral Absorbers</td><td>0.0250</td><td>0.0100</td></tr><tr><td>Without Integral Absorbers</td><td>0.0260</td><td>0.0000</td></tr></table></td><td></td></tr>
<tr><td>WEC # 8</td><td>IV.2.b.ii</td><td>Please clarify what is meant by the "hot channel fuel assembly"? Is this meant to be the hot channel temperature of the bounding fuel assembly? It is not credible for any fuel assembly to operate at the hot channel temperature for the entire life of the fuel assembly in the core.</td><td>1. See NRC staff response to NEI comment 10.3.</td></tr>
<tr><td>WEC # 9</td><td>IV.2.e.iii</td><td>The statement "modeling burnable absorbers as full length when they are actually part length may lead to non-conservative conclusions about their effect on SFP reactivity," is an incorrect statement unless the residual burnable absorber is credited at the low burnup ends of the active fuel length. Is it the intent of the NRC to allow credit for the residual burnable absorber?</td><td>1. See NRC staff response to NEI comment 16.</td></tr>
<tr><td>WEC # 10</td><td>IV.3.a.i</td><td>Please remove the requirement to provide a site-specific justification for use of the axial burnup profiles from NUREG/CR-6801. This statement is inconsistent with the previous statement in this section that, "Use of the limiting axial burnup distribution from NUREG/CR-6801 are acceptable for existing PWRs..."</td><td>1. See NRC staff response to NEI comment 20.</td></tr>
<tr><td>WEC # 11</td><td>IV.3.a.ii</td><td>Please provide an example of an acceptable licensee control. Without such guidance each applicant could propose a different licensee control, which will cause considerable discrepancies and non-consistencies within the industry.</td><td>1. See NRC staff response to NEI comment 21.1.</td></tr>
</table>

NO.	ISG Section	COMMENT	NRC Response
WEC # 12	IV.3.a.iii	Please remove the statement "Applications that use uniform axial burnup profiles should clearly demonstrate where that [cross-over point] occurs." Identification of the cross-over point between where a uniform versus axially distributed profile is conservative is not necessary to be identified if analyses are performed with both a uniform and distributed profile modeled. This statement as written could be construed as a requirement for approval with no technical basis for this information to be provided.	1. See NRC staff response to NEI comment 22.2.
WEC # 13	IV.3.b.ii	Please clarify what is meant with regard to "efficiency of the neutron absorber". Neutron absorbers such as BORAL and METAMIC have been manufactured with sufficiently homogeneity that self shielding and streaming does not occur in the environment of the spent fuel pool, where there is a continuous neutron spectrum (primarily at thermal energies) and neutrons are travelling in all directions.	1. See NRC staff response to NEI comment 23.1.

<table>
<tr><th>NO.</th><th>ISG Section</th><th>COMMENT</th><th>NRC Response</th></tr>
<tr><td>WEC # 14</td><td>IV.3.c.i</td><td>This statement should be removed. The use of the maximum biases and uncertainties from either of the individual storage configurations would make it impossible to analytically qualify the interfaces between either distinct rack designs within a pool or to qualify different storage patterns within a rack module. Table 2 shows an example of the application of this requirement to an interface between a rack module with flux- traps intended for fresh fuel and a high-density rack module without flux-traps intended for spent fuel, that were both qualified to the same maximum k_{eff}.

Table 2: Reactivity Effect of Interfaces per ISG-DSS-2001-01
<table>
<tr><th></th><th>Fresh Fuel Racks</th><th>Spent Fuel Racks</th><th>Interface Analysis</th></tr>
<tr><td>Calculated k_{eff}</td><td>0.980</td><td>0.965</td><td>0.980</td></tr>
<tr><td>Biases + Uncertainties</td><td>0.015</td><td>0.030</td><td>0.030</td></tr>
<tr><td>Maximum k_{eff}</td><td>0.995</td><td>0.995</td><td>1.100</td></tr>
</table>

In reality the reactivity of the spent fuel pool with different storage configurations will be dominated by the most reactive configuration within the spent fuel pool, and the biases and uncertainties from that configuration would be the most applicable to be applied. The application of the maximum biases and uncertainties from any other configuration is not a technically valid application of the biases and uncertainties.</td><td>1. See NRC staff response to NEI comment 25.2.</td></tr>
</table>

NO.	ISG Section	COMMENT	NRC Response
WEC # 15	IV.4	This section seems to primarily focus on the use of the statistical treatment from NUREG/CR-6698 and the inclusion of the HTC Critical Experiment data. However, no mention is made of appropriate selection of UO_2 critical experiments, either from the OECD manual or other sources.	1. See NRC staff response to NEI comment 29.
WEC # 16	IV.4.a.i	The statement "The reviewer should verify that any validation that [is] used for SNF appropriately considers actinides and fission products." should be modified. This statement does not provide clear guidance on what the NRC finds acceptable for validation of fission products. Given that there are currently no publicly available critical experiments that include all fission products, this requirement may be impossible to meet as written. Please revise to specify a requirement that is possible to be met.	1. See NRC staff response to NEI comment 31.2.

NO.	ISG Section	COMMENT	NRC Response
WEC # 17	IV.4.c	The statistical treatment in NUREG-6698 includes two elements of the statistical treatment that are not appropriate. The first element from NUREG/CR-6698 is the recommendation to statistically combine the experimental measurement uncertainty with the calculational uncertainty to determine the total uncertainty. Statistically combining the uncertainties would result in a double counting of the experimental uncertainty that is already accounted for in the statistical determination of the bias and uncertainty. Second, the "experimental uncertainty" identified in the OECD manual and other sources of critical experiments is not a measurement uncertainty in the traditional sense (i.e., uncertainty in the measurement of the neutron multiplication factor, electronic equipment, experimental setup, etc.) Rather, the "experimental uncertainty" identified in the descriptions of the critical experiments is a calculation of the reactivity effect associated with the various tolerances or uncertainties in the experiment (fuel rod diameter, fuel density, temperature of the moderator boron content, water level, etc.). Therefore, the "experimental uncertainty" identified in the sources of critical experiments is an overly conservative estimation of the experimental uncertainty based on certain parameters important to the reactivity of the system and not an experimental uncertainty as indentified in NUREG/CR-6698. Therefore it is not appropriate to apply this pseudo "experimental uncertainty" described in the critical experiment benchmark sources as an experimental uncertainty.	1. See NRC staff response to NEI comment 36.2.

NO.	ISG Section	COMMENT	NRC Response
WEC # 18	IV.4.e	This section describes the level of detail an applicant must provide to allow for code-to-code validation of the criticality code. Previously, the NRC has made it clear that code-to-code validations arc not accepted; i.e., computer codes must be validated against data, not other codes. By allowing a code-to-code validation the NRC is setting a precedent for the allowance of code-to-code validations.	1. The NRC staff has not previously accepted a code-to-code comparison for a criticality code validation. The draft DSS-ISG only lists very basic expectations, where as a code-to-code comparisons would likely require extensive justification, additional NRC staff review, and potentially new aspects of a criticality code validation not previously considered. Therefore, the following sentences have replaced the previous last two sentences of IV.4.e and all three subparagraphs have been deleted, "Use of code-to-code comparisons would likely require extensive additional analysis and/or justification, additional NRC staff review, and potentially new aspects of a criticality code validation not previously considered. Therefore, the use of a code-to-code comparison for validating criticality codes is outside the scope of this ISG"

NO.	ISG Section	COMMENT	NRC Response
NC # 1		The current writing of the draft ISG assumes that a reactivity decrement of depletion (isotopic content and worths together) is not utilized. EPRI has an active program to support the reactivity decrement of depletion, which should culminate in a solid well documented approach sometime in 2011. Historically, the industry has used a reactivity decrement of depletion approach that was based on engineering judgment. It is agreed that this approach should be replaced with an approach that can be backed up with measured data and the EPRI program will accomplish this. This ISG was generated at the request of the industry and it is deeply appreciated that the NRC is responsive to the industry request. However, it is respectfully requested that the NRC withhold this draft ISG until 2011 when more information is available from both EPRI and ORNL. Preliminary analysis from EPRI suggests that the old 5% of the reactivity decrement, which was used in past applications, is conservative. It is therefore appropriate to utilize the historical uncertainty of 5% reactivity decrement (which includes the uncertainty in both the isotopic content and the reactivity worth) until the issue is resolved, which is expected in 2011. The ISG has covered other issues. The issuing of the draft ISG has helped with these other issues but finalizing the ISG is not needed at this time.	1. The NRC staff believes these results are more than a year away from when they would be usable in a licensing action. The DSS-ISG should provide value in the interim. Therefore, the NRC staff will issue DSS-ISG-2010-01.
ORNL # 1	IV.2.d	Section 2.d on "Rodded Operation" points out that such operation affects the final reactivity of the fuel. The guidance provided could lead to an incomplete review because rodded operations affect the analysis in two ways. First, rodded operations affect fuel composition calculations. Second, the integrated affects of rodded operations could affect the axial and radial burnup distributions that are used in the criticality analysis. Staff should verify that either the control rods have not been and will not be used at power for any significant amount of time or that past and future rodded operations have been adequately	1. Paragraphs IV.2.d.i and IV.2.d.ii were added to ensure that reviewers are aware of the multiple ways rodded operation can affect the SFP NCS analysis.

NO.	ISG Section	COMMENT	NRC Response
		considered in the criticality analysis. The proposed ISG should be revised to highlight both impacts of rodded operations to ensure a complete review of the issue.	
ORNL # 2	IV.4.a.iii	Section 4.a.iii points out that using too few experiments for validation may lead to invalid trend analysis conclusions. This guidance should be expanded to cover two more review issues. First, the reviewer should ensure that the experiments used are not all highly correlated. For example, if all critical configurations are performed with the same fuel rods at the same facility, they may have a common experimental bias that will flow into the computational method bias. The experimental bias does not reflect how well the computational tools calculate keff. Use of critical configurations from multiple independent sources reduces the impact of experimental biases. The second issue is that the reviewer should ensure that trending analysis is performed using only appropriately selected critical configurations. For example, soluble boron trending analysis conclusions reached using 200 critical configurations without soluble boron together with 7 configurations with soluble boron may result in the analyst reaching an incorrect conclusion concerning bias trends as a function of soluble boron concentration.	1. Paragraph IV.4.a.iv was added to include the correlation aspect. The trending aspect of the comment was incorporated as an example to IV.4.a.iii.
ORNL # 3	IV.4.d	The guidance provided in Section 4.d on "Lumped Fission Products" should be expanded to point out that it is conservative and acceptable to simple remove all lumped fission products from the keff calculations.	1. Paragraph IV.4.d.iii was added to include this option.

REFERENCES

1. Nuclear Energy Institute, letter from Everett L. Redmond II, Senior Project Manager Used Fuel Storage and Transportation, to Ms. Cindy K. Bladey, Chief, Rules, Announcements and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, re: " Nuclear Energy Institute Comments on Draft Division of Safety Systems Interim Staff Guidance DSS-ISG-2010-01, "Staff Guidance Regarding the Nuclear Criticality Safety Analysis for Spent Fuel Pools," 75 *Federal Register53724,* September 1, 2010, Docket ID NRC-2010-0289," October 1, 2010. (ADAMS ML102800269)

2. Westinghouse Electric Company, Nuclear Fuel, letter LTR-NRC-10-63, from Kristopher Cummings, Manager, Fuel Engineering Licensing, to Ms. Cindy K. Bladey, Chief, Rules, Announcements and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, re: "Westinghouse Comments to NRC on DSS-ISG-2010-01, "Staff Guidance Regarding the Nuclear Criticality Safety Analysis for Spent Fuel Pools," Docket ID NRC-2010-0289," September 28, 2010. (ADAMS ML102770416)

3. Dale Lancaster re: "Comment On The Draft Interim Staff Guidance on Spent Fuel Criticality Analysis (DSS-ISG-2010-01, Docket ID: NRC-2010-XXXX)," October 4, 2010. (ADAMS ML102800268)

4. Don Mueller re: "Comment On NRC-2010-0289-0001," October 4, 2010. (ADAMS ML102800266)

5. Progress Energy, letter RA-10-027, from Brian McCabe, Manager – Nuclear Regulatory Affairs, Office of Administration, U.S. Nuclear Regulatory Commission, re: " Draft Division of Safety Systems Interim Staff Guidance DSS-ISG-2010-01, "Staff Guidance Regarding the Nuclear Criticality Safety Analysis for Spent Fuel Pools," (75 *Federal Register53724,* September 1, 2010, Docket ID NRC-2010-0289)," October 1, 2010. (ADAMS ML102800267)

6. Exelon Nuclear, letter from D. P. Helker, Manager - Licensing, to Ms. Cindy K. Bladey, Chief, Rules, Announcements and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, re: " Draft Division of Safety Systems Interim Staff Guidance DSS-ISG-2010-01, "Staff Guidance Regarding the Nuclear Criticality Safety Analysis for Spent Fuel Pools," 75 *Federal Register53724,* September 1, 2010, Docket ID NRC-2010-0289)," September 28, 2010. (ADAMS ML102770416)

7. Strategic Teaming and Resource Sharing, letter STARS-10009, from Carl B. Corbin, Chairman, STARS Integrated Regulatory Affairs Group, to Ms. Cindy K. Bladey, Chief, Rules, Announcements and Directives Branch, Office of Administration, U.S. Nuclear Regulatory Commission, re: " Strategic Teaming and Resource Sharing (STARS) Comments on Draft Division of Safety Systems Interim Staff Guidance DSS-ISG-2010-01: Staff Guidance Regarding the Nuclear Criticality Safety Analysis for Spent Fuel Pools," October 5, 2010. (ADAMS ML102871139).