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September 13, 2005

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Subject: Duke Energy Corporation
Catawba Nuclear Station, Units 1 and 2
Docket Numbers 50-413 and 50-414
Proposed Technical Specification Amendment
Technical Specification 3.7.16, Spent Fuel
Assembly Storage, and 4.3, Fuel Storage

Pursuant to 10 CFR 50.90, Duke Energy Corporation is requesting an amendment to the Catawba Nuclear Station Facility Operating License and Technical Specifications (TS) Sections 3.7.16 and 4.3. This license amendment request (LAR) is being submitted to correct a nonconservative TS. An issue was identified while comparing results from spent fuel pool (SFP) criticality codes. The issue involves the use of three dimensional (3-D) codes versus two dimensional (2-D) codes in which Duke discovered that the 2-D codes were nonconservative. Axial burnup distribution of assemblies in the SFP was known to have an effect on criticality analysis, but 2-D codes were considered to be conservative. As an interim measure, restrictions were imposed on where spent fuel could be placed in the SFP. This LAR presents revised storage criteria for low-enriched uranium fuel stored at Catawba to correct this nonconservative TS. This is accomplished by taking partial credit for soluble boron in the Catawba spent fuel pools, in accordance with the regulatory requirements of 10 CFR 50.68 (b).

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Duke has performed an analysis that examined the criticality aspects of fuel storage in the Catawba new fuel storage vaults and spent fuel pools, to ensure that all pertinent regulatory subcriticality criteria are satisfied for proposed configurations of fuel stored in these areas. The attached justification supports these proposed changes.

The contents of this amendment request package are as follows:

Enclosure 1 provides a description of the proposed changes, technical justification, the determination that the amendment contains No Significant Hazards Considerations pursuant to 10 CFR 50.92, and provides the basis for the categorical exclusion from performing an Environmental Assessment/Impact Statement pursuant to 10 CFR 51.22(c)(9).

Attachment 1 provides marked copies of the affected TS pages for Catawba showing the proposed changes. Attachment 2 provides marked copies of the affected TS Bases pages for Catawba showing the proposed changes for information only. Attachment 3 provides a summary of regulatory commitments made in this submittal. Attachment 4 provides the Catawba Fuel Storage Criticality Analysis.

Implementation of this amendment to the Catawba Facility Operating License and TS will impact the Catawba Updated Final Safety Analysis Report (UFSAR). Duke is requesting a 60-day implementation period in conjunction with this amendment. Duke is requesting the 60 days to allow for completion of the associated procedure changes.

In accordance with Duke administrative procedures and the Quality Assurance Program Topical Report, this proposed amendment has been previously reviewed and approved by the Catawba Plant Operations Review Committee and the Duke Corporate Nuclear Safety Review Board.

Pursuant to 10 CFR 50.91, a copy of this proposed amendment is being sent to the appropriate state officials.

Inquiries on this matter should be directed to R. D. Hart at (803) 831-3622.

Very truly yours,

Dhiaa Jamil

RDH/s

Enclosure: 1) - EVALUATION

Attachments:
1) - MARKUP of TS PAGES FOR CATAWBA
2) - PROPOSED TS BASES CHANGES FOR CATAWBA (For information only)
3) - SUMMARY OF REGULATORY COMMITMENTS
4) - CATAWBA NUCLEAR STATION FUEL STORAGE CRITICALITY ANALYSIS

Dhiaa Jamil affirms that he is the person who subscribed his name to the foregoing statement, and that all statements and matters set forth herein are true and correct to the best of his knowledge.

Dhiaa Jamil,

Subscribed and sworn to me: 9/14/05
Date

Notary Public

My commission expires: 7/2/2014
Date

SEAL

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ENCLOSURE 1

EVALUATION

EVALUATION

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1.0 DESCRIPTION

Duke Energy proposes to modify the Catawba Nuclear Station Technical Specifications (TS) Sections 3.7.16 (Spent Fuel Assembly Storage) and 4.3 (Design Features: Fuel Storage). A markup of the specific changes is shown in Attachment 1.

This License Amendment Request (LAR) presents revised storage criteria for low-enriched uranium (LEU) fuel stored at Catawba. This is accomplished by taking partial credit for soluble boron in the Catawba spent fuel pools (SFPs), in accordance with the regulatory requirements of 10 CFR 50.68 (b). The criticality analysis in support of the revised storage criteria is described in Attachment 4.

Reference 1, which was approved by the NRC in March 2005, allows four (4) mixed-oxide (MOX) lead test assemblies to be stored in the Catawba SFPs in a Restricted configuration. Reference 1 also specifies storage limitations at the boundary between the proposed MOX storage configuration and neighboring LEU configurations. The LEU-only storage criteria and criticality analyses documented in this LAR do not affect the MOX storage configuration requirements specified in the approved Reference 1 MOX submittal.

2.0 PROPOSED CHANGES

The TS and TS Bases changes proposed in this LAR include the following:

- **LCO 3.7.16.a:** This LCO currently defines the fuel enrichment and burnup requirements for Unrestricted storage of fuel assemblies in the Catawba SFP storage racks. As the revised criticality analysis in Attachment 4 shows, partial credit for soluble boron allows Unrestricted storage of LEU fuel assemblies enriched up to an initial nominal 5 wt % U-235, with no minimum burnup requirements. Therefore, this LCO is modified to delete the reference to the table of burnup requirements for Unrestricted storage (TS Table 3.7.16-1), and to redefine Unrestricted storage requirements to allow new or spent LEU fuel assemblies at any enrichment (up to an initial nominal 5 wt % U-235) to be used in an Unrestricted storage configuration - that is, with no limitations on placement in the Catawba SFPs.

- **LCO 3.7.16.b:** This LCO currently defines the fuel enrichment and burnup requirements for Restricted storage of fuel assemblies in the Catawba SFP storage racks. Because the proposed change to LCO 3.7.16.a would eliminate the need for Restricted storage of any LEU fuel, if it were not for the presence of MOX fuel at Catawba this LCO for Restricted storage could be deleted. However, because a previously submitted LAR (Reference 1), which was approved in March 2005, allows MOX lead test assemblies (LTAs) to be stored in the Catawba SFPs in a Restricted storage configuration, this type of storage is still necessary. LCO 3.7.16.b is modified to delete the reference to Table 3.7.16-1, because that table, which currently specifies burnup requirements for Unrestricted LEU fuel storage, will be eliminated.

- **LCO 3.7.16.c:** Because the above change to LCO 3.7.16.b results in a general reference to Figure 3.7.16-1 for Restricted storage requirements, LCO 3.7.16.c is redundant, and is eliminated.

- **Table 3.7.16-1:** As discussed above, this table is deleted. The revised criticality analysis described in Attachment 4 removes any burnup requirements from Unrestricted storage of LEU fuel.

- **Table 3.7.16-2:** This table currently defines minimum burnup requirements for LEU assemblies to qualify as Filler fuel for the Restricted / Filler storage configuration shown in TS Figure 3.7.16-1. This table is retained here, for compatibility with the approved TS changes for the MOX LTAs (Reference 1), which specify that MOX LTAs must be stored as Restricted assemblies, with LEU fuel assemblies as Fillers. However, because TS Table 3.7.16-1 is eliminated, TS Table 3.7.16-2 will be renumbered as TS Table 3.7.16-1.

- **Figure 3.7.16-1:** This figure illustrates the loading configuration for Restricted / Filler fuel storage in the Catawba SFPs. The definition of Restricted fuel is revised on this figure, to remove the reference to current TS Table 3.7.16-1. As noted above, the revised Catawba SFP criticality analysis eliminates the need to store any LEU fuel as Restricted fuel.

- **TS 4.3.1.1.b:** This design feature currently defines the maximum k_{eff} limit for fuel stored in the Catawba SFPs. Due to the dual subcriticality criteria associated with partial credit for soluble boron - per 10 CFR 50.68 (b)(4) - this TS section is split into TS 4.3.1.1.b, which defines the maximum k_{eff} in unborated water (k_{eff} < 1.0), and TS 4.3.1.1.c, which specifies that the maximum k_{eff} must not exceed 0.95 in water with 200 ppm soluble boron.

- **TS 4.3.1.1.c:** This design feature is renumbered as TS 4.3.1.1.d, because of the splitting of the k_{eff} criteria in current TS 4.3.1.1.b, as described in the item above.

- **TS 4.3.3:** This design feature defines the storage capacity of the Catawba SFPs. Currently this is specified as 1418 fuel assemblies. However, as the response to RAI Question 6 in Reference 2 noted, the number of usable storage cells in each of the Catawba SFPs is actually 1421. The current TS value of 1418 was based on estimates prior to actual installation of the SFP storage racks at Catawba. This TS surveillance is therefore revised to allow the actual full capacity of 1421 storage cells to be used.

- **TS Bases B3.7.15 and B3.7.16:** These TS Bases are revised to update the description of the SFP subcriticality criteria, replacing the existing single criterion (95/95 k_{eff} must not exceed 0.95 in unborated water) with the dual criteria for partial soluble boron credit (maximum 95/95 k_{eff} is less than 1.0 in unborated water, and does not exceed 0.95 with 200 ppm soluble boron). The TS Bases for TS 3.7.15 is also revised to change the number of usable storage cells in each of the Catawba SFPs to 1421 as described above for TS 4.3.3. Both of these TS Bases are also amended to provide soluble boron requirements for the SFP accident conditions considered, and to note that there are no credible dilution events that could drop the SFP boron concentration below the amount required for normal conditions (200 ppm). In the LCO for TS B3.7.16, the current description of restrictions on storage of fuel assemblies in the SFP racks is replaced with a statement that with 200 ppm soluble boron, there are no restrictions on storage of fuel assemblies enriched up to 5 wt % U-235.

3.0 BACKGROUND

UFSAR section 9.1.2.2 provides the following description for spent fuel storage.

> Each unit of the Catawba Station has an independent spent fuel storage system. There are sufficient fuel storage racks to accommodate the number of fuel assemblies discharged from approximately 19 normal Catawba refueling cycles plus one complete Catawba core. Provisions are also made to store control rods and burnable poison rods. Major components, piping, valves and instrumentation in contact with the fuel pool water are stainless steel. The fuel pools, transfer canals, and cask pits are lined with stainless steel plate. This fuel pool liner plate is designed, fabricated, and installed as a nuclear safety related, QA Condition 1 system. The spent fuel assemblies are held in a vertical position by the spent fuel pool storage racks. The fuel assemblies are supported within the fuel storage racks by a stainless steel plate located six inches above the fuel pool floor. Openings are provided that allow coolant water to flow through the rack and up around the fuel assembly. A lead-in assembly is provided at the top of each rack to guide fuel into its proper storage location. The spent fuel is stored in canned racks. The storage cell is formed by 1/4 inch nominal thickness type 304 stainless steel that completely encloses the fuel on all four sides. The nominal internal can dimension is 9 inches and the nominal center-to-center spacing is 13.5 inches. Space between storage locations are blocked to prevent insertion of fuel in other than designated positions. The fuel racks are designed as free standing, self-supporting, independent modules which stand on the fuel pool floor. While there are 1421 accessible storage locations in each spent fuel pool, currently the maximum number of fuel assemblies that can be stored is 1418.

The acceptance criteria for criticality for the spent fuel pools from UFSAR 9.1.2.3.1.4 is: "The neutron multiplication factor in the spent fuel pools shall be less than or equal to 0.95, including all uncertainties under all conditions". UFSAR 9.1.2.3.1.4 also states that "credit may be taken for soluble boron under accident conditions as allowed by double contingency principle in ANSI/ANS-57.2-1983, and that no credit is taken for soluble boron under normal conditions." These criteria are restated in the bases for TS 3.7.15 and 3.7.16, and section 4.3 of TS states that a design feature of the spent fuel pool is that k_{eff} is maintained less than 0.95.

During a comparison of the results from 3-Dimensional (3-D) codes to 2-Dimensional (2-D) codes for a spent fuel pool model, Duke discovered that the 2-D codes were nonconservative. The axial burnup distribution of assemblies in the spent fuel pool was known to have an effect on criticality analysis, but 2-D codes were considered to be conservative at burnups that bounded discharged fuel in spent fuel pools. Recent analyses performed by Duke indicate that the 2-D calculations become non-conservative at a lower burnup, as low as 10 GWD/MTU, than previously believed.

For Catawba, the nonconservatism in the 2-D codes is applicable to Technical Specification (TS) 3.7.16, Spent Fuel Assembly Storage. TS 3.7.16 requires new and spent fuel assemblies to be stored in certain configurations based on initial enrichment and burnup. The limiting configuration (highest k_{eff}) is for new fuel loaded in the 3 out of 4 loading pattern specified in TS Figure 3.7.16-1. For new fuel near the enrichment limit (5 weight % U-235), TS Table 3.7.16-2, Minimum Qualifying Burnup Versus Initial Enrichment for Filler Assemblies, may not be restrictive enough to prevent exceeding k_{eff} of 0.95 in the absence of soluble boron.

Catawba documented this issue in the corrective action program and developed an operability evaluation that determined that administrative restrictions were required to limit the enrichment of Filler fuel to 1.90 weight % U-235 or less. This restriction ensures that the Catawba spent fuel pools remain within their design basis. Therefore, the spent fuel pools are considered to be operable but degraded/nonconforming because administrative restrictions beyond requirements of TS 3.7.16 are required to ensure that the spent fuel pools remain within their design basis.

This license amendment request revises the Catawba TS to account for this issue and to allow the restrictions to be removed.

4.0 TECHNICAL ANALYSIS

Catawba currently complies with the following design basis for preventing criticality in the SFPs:

- The k_{eff} of the SFP 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 fully flooded with unborated water.

The objective of this TS LAR is to simplify the storage criteria for LEU fuel in the Catawba SFPs, by eliminating restrictions on the placement of these fuel assemblies in the SFP storage cells. This is accomplished by taking partial credit for soluble boron, in accordance with 10 CFR 50.68 (b) (4). This regulation specifies the following dual subcriticality requirements for normal (non-accident) conditions:

- The k_{eff} of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water.

- The k_{eff} 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.

Note that the approved Reference 1 MOX lead test assembly SFP storage configuration meets the current, more stringent subcriticality criterion of $k_{eff} \leq 0.95$ in unborated water. Relaxing the subcriticality requirements for LEU fuel storage, per 10 CFR 50.68 (b) (4), does not adversely affect the MOX analysis, which also meets these dual subcriticality criteria.

In addition to the above subcriticality criteria for partial soluble boron credit, Reference 3 states:

> "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 that can occur from the minimum technical specification boron concentration to the boron concentration

required to maintain the 0.95 k_{eff} design basis limit."

Finally, note that the criticality codes and / or versions used in the previous Catawba LEU fuel storage LAR (Reference 4) are different from the code suite used for the criticality calculations in this new LAR (SCALE 4.4 / KENO V.a - see Reference 5). Reference 4 analyzed both the new fuel storage vaults (NFVs) and the SFPs to allow the enrichment limit for fuel assemblies to be increased from 4.00 wt % U-235 to 5.00 wt % U-235. To maintain consistency in the code used for the NFV and SFP evaluations, Attachment 4 also re-evaluates the Catawba NFVs with SCALE 4.4 / KENO V.a, even though the subcriticality requirements for fuel assembly storage in the NFVs - as specified in TS 4.3.1.2 - are unchanged.

Attachment 4 provides pertinent criticality modeling information about the Catawba SFPs and NFVs, discusses the methods and assumptions employed in carrying out the criticality evaluations of these storage areas, and presents the results of these analyses. The LEU fuel assembly designs considered include all of those that have, to-date, been irradiated in the Catawba reactors and / or stored in the SFPs and NFVs.

The results of the revised NFV analysis in Attachment 4 demonstrate that all of the fuel designs evaluated continue to meet the existing requirements of TS 4.3.1.2. The NFV criticality models considered a full range of moderator density, from 0.001 g/cc to 1.00 g/cc, in order to ensure that optimum moderation conditions were considered.

The Catawba SFP criticality analysis in Attachment 4 shows that, for normal conditions, both of the boron-credit subcriticality criteria in 10 CFR 50.68 (b) (4) - described earlier in this section - can be achieved if credit is taken for 200 ppm soluble boron in the SFPs. These criteria are met with the entire SFP filled with fresh fuel enriched to 5 wt % U-235. The results of the SFP criticality analysis confirm that, when partial soluble boron credit is used, no storage restrictions need to be imposed on any LEU fuel in the Catawba SFPs.

The boron dilution analysis for the Catawba SFPs, which used a starting boron concentration of 2700 ppm (current minimum, as controlled through the COLR per TS 3.7.15), yielded the following results:

- The worst-case dilution scenario was initiated by a "continuous flow" event involving the break of a 4-inch pipe in the non-seismic fire protection (RF) system, which delivered unborated water to the Catawba SFP at a maximum flow rate of 701 gpm.

- The minimum starting volume of the Catawba SFP dilution event (374,403 gal) was determined with the cask loading pit isolated and the water at the minimum TS level.

- With this minimum starting boron concentration and water level, the worst-case dilution event required 32.4 hours to dilute the Catawba SFP to the amount credited in the criticality analysis for normal conditions (200 ppm).

This worst-case dilution scenario would involve substantial overflow of the SFP, and is deemed incredible, because numerous indicators such as level alarms, flooding in the auxiliary building, etc., would alert Operations long before 32 hours had elapsed.

Note that the above conclusion is consistent with the dilution analysis that was previously submitted for the McGuire SFPs (Attachment 7 in Reference 6, with an update in Reference 7). Reference 6 was approved by the NRC on November 27, 2000 (Reference 10) and Reference 7 was approved by the NRC on February 4, 2003 (Reference 11). The McGuire dilution evaluation identified the same worst-case continuous flow initiator, with the same maximum flow rate of unborated water into the SFP. However, the McGuire dilution event began with a lower starting boron concentration, higher ending boron concentration, and smaller SFP water volume than that used for the Catawba dilution event. As expected, these differences allow significantly more time to detect and respond to a worst-case Catawba dilution scenario (32.4 hours versus 9.5 hours for McGuire per Reference 7).

References 3 and 8 identify the pertinent accident conditions that need to be evaluated in the Catawba SFPs. These accident conditions include:

- Fuel assembly drop
- Fuel assembly misplacement on the outside of and immediately adjacent to a storage rack module
- Abnormal SFP water temperatures
- Heavy load drop onto the SFP racks

Per the double contingency principle, as noted in Reference 3, full credit for the minimum boron concentration in the Catawba SFPs (2700 ppm) is allowed for the evaluation of these accident conditions.

Attachment 4 discusses the analysis and results of these postulated accidents. The most severe of these, from a criticality vantage, is the heavy load drop (weir gate drop). As Attachment 4 shows, when 2700 ppm boron credit is taken for the worst-case weir gate drop condition in the Catawba SFP, the maximum 95/95 k_{eff} remains well below 0.95. The radiological analyses for the weir gate drop accident were reviewed. These analyses assumed a conservative set of isotopics applied to the assemblies affected by the weir gate drop. These isotopics would correspond to fuel that has burnup higher than the current threshold for Unrestricted storage (see current TS Table 3.7.16-1), and so these analyses remain valid and bounding for the proposed TS changes.

Of the remaining accident conditions listed above, a SFP soluble boron concentration of just 500 ppm is sufficient to maintain the maximum 95/95 k_{eff} below 0.95.

5.0 REGULATORY ANALYSIS

This section addresses the standards of 10 CFR 50.92 as well as the applicable regulatory requirements and acceptance criteria.

5.1 NO SIGNIFICANCE HAZARDS CONSIDERATIONS (NSHC)

The following discussion is a summary of the evaluation of the changes contained in this proposed amendment against the 10 CFR 50.92(c) requirements to demonstrate that all three standards are satisfied. A No Significant Hazards Consideration is indicated if operation of the facility in accordance with the proposed amendment would not:

1. Involve a significant increase in the probability or consequences of an accident previously evaluated, or
2. Create the possibility of a new or different kind of accident from any accident previously evaluated, or
3. Involve a significant reduction in a margin of safety.

First Standard

Does operation of the facility in accordance with the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No.

The addition of the amount of soluble boron specified by Specification 4.3 has no impact on the probability or consequences of any previously evaluated accident. This addition of soluble boron requirements is not considered to be an initiator of any accidents nor does it influence how previously evaluated accidents are mitigated.

The increase in the number of usable storage cells in each of the Catawba SFPs from 1418 to 1421 has no impact on the probability or consequences of any previously evaluated accident. This change makes the TS accurate based on the discussion in Reference 2. This correction in usable storage cells is not considered to be an initiator of any accidents nor does it influence how previously evaluated accidents are mitigated.

There is no increase in the probability of a fuel assembly drop accident in the spent fuel pools when allowing for credit to be taken for soluble boron to maintain an acceptable margin of subcriticality in the spent fuel pool. The method of handling fuel assemblies in the spent fuel pool is not affected by the changes made to the criticality analysis for the spent fuel pool or by the proposed TS changes. The handling of fuel assemblies during normal operation is unchanged, since the same equipment and procedures will be used.

The radiological consequences of a fuel assembly drop accident will not be adversely impacted due to taking credit for soluble boron for criticality control in the spent fuel pool in the criticality analysis. The criticality analysis showed that the consequences of a fuel assembly drop accident in the spent fuel pools are not affected when allowing for credit to be taken for soluble boron to maintain an acceptable margin of subcriticality in the spent fuel pool.

As discussed in section 4.0, the radiological consequences of a weir gate drop accident will not be adversely impacted due to the proposed TS changes.

There is no increase in the probability or consequences of the accidental misloading of fuel assemblies into the spent fuel pool racks when allowing for credit to be taken for soluble boron to maintain an acceptable margin of subcriticality in the spent fuel pool. Fuel assembly placement and storage will continue to be controlled pursuant to approved fuel handling procedures and other approved processes to ensure compliance with the Technical Specification requirements. These procedures and processes will be revised as needed to comply with the revised requirements which would be imposed by the proposed Technical Specification changes.

Therefore, it is concluded that operation of Catawba Units 1 and 2 in accordance with these proposed changes does not involve a significant increase the probability of occurrence or consequences of an accident previously analyzed.

Second Standard

Does operation of the facility in accordance with the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

Criticality and other related accidents within the spent fuel pool are not new or different types of accidents. They have been analyzed in the Updated Final Safety Analysis Report and in criticality analysis reports associated with specific licensing amendments. Specific accidents considered and evaluated include fuel assembly drop, accidental misloading of fuel assemblies into the spent fuel pool racks, significant changes in spent fuel pool water temperature, and a heavy load (weir gate) drop onto the spent fuel racks. The accident analysis in the Updated Final Safety Analysis Report remains bounding.

For the proposed amendment, the spent fuel pool dilution evaluation demonstrates that a dilution of the boron concentration in the spent fuel pool water which could increase the rack k_{eff} to greater than 0.95 continues to be a non-credible event. The proposed amendment regarding fuel storage requirements, number of usable storage cells, and amount of soluble boron in the spent fuel pool water specified by Specification 4.3 will have no effect on normal pool operations and maintenance. There are no changes in equipment design or in plant configuration. The Technical Specification changes will not result in the installation of any new equipment or modification of any existing equipment. Therefore, the proposed amendment will not result in the possibility of a new or different kind of accident.

Third Standard

Does operation of the facility in accordance with the proposed amendment involve a significant reduction in the margin of safety?

Response: No.

The proposed Technical Specification changes and the resulting spent fuel storage operating limits will provide adequate safety margin to ensure that the stored fuel assembly array will always remain subcritical. Those limits are based on a plant specific criticality analysis (Attachment 4). This methodology takes partial credit for soluble boron in the spent fuel pool and requires conformance with the following NRC acceptance criteria for preventing criticality outside the reactor:

1. k_{eff} shall be less than 1.0 if fully flooded with unborated water, which includes an allowance for uncertainties at a 95% probability, 95% confidence (95/95) level; and

2. k_{eff} shall be less than or equal to 0.95 if flooded with borated water, which includes an allowance for uncertainties at a 95/95 level.

The criticality analysis utilized partial credit for soluble boron (200 ppm) to ensure the maximum 95/95 k_{eff} will be less than or equal to 0.95 under normal circumstances, and storage configurations have been defined using a 95/95 k_{eff} calculation to ensure that the spent fuel rack k_{eff} will be less than 1.0 with no soluble boron. The loss of substantial amounts of soluble boron from the spent fuel pool which could lead to exceeding a k_{eff} of 0.95 has been evaluated and shown to be not credible. Therefore, it is concluded that this change does not involve a significant reduction in the margin of safety.

The increase in the number of usable storage cells in each of the Catawba SFPs from 1418 to 1421 has no impact on the margin of safety. This change just makes the TS accurate based on the discussion in Reference 2. This correction in usable storage cells does not involve a significant reduction in the margin of safety.

Based upon the preceding discussion, Duke Energy has concluded that the proposed amendment does not involve a significant hazards consideration.

5.2 APPLICABLE REGULATORY REQUIREMENTS/CRITERIA

The regulatory bases and guidance documents associated with the systems discussed in this proposed TS amendment include:

GDC-2 requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without the loss of capability to perform their safety functions.

GDC-4 requires that structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.

GDC-61 requires that fuel storage and handling, radioactive waste, and other systems which may contain radioactivity shall be designed to assure adequate safety under normal and postulated accident conditions. These systems shall be designed (1) with a capability to permit appropriate periodic inspection and testing of components important to safety, (2) with suitable shielding for radiation protection, (3) with appropriate containment, confinement, and filtering systems, (4) with a residual heat removal capability having reliability and testability that reflects the importance to safety of decay heat and other residual heat removal, and (5) to prevent significant reduction in fuel storage coolant inventory under accident conditions.

GDC-62 requires that criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations.

GDC-63 requires that appropriate systems shall be provided in fuel storage and radioactive waste systems and associated handling areas (1) to detect conditions that may result in loss of residual heat removal capability and excessive radiation levels and (2) to initiate appropriate safety actions.

There will be no changes to new fuel storage or spent fuel storage such that compliance with any of the regulatory requirements and guidance documents above would come into question. The method of handling fuel assemblies in the spent fuel pool and new fuel storage vault is not affected by the changes made to the criticality analysis for the spent fuel pool or by the proposed TS changes. The handling of fuel assemblies during normal operation is unchanged, since the same equipment and procedures will be used. The above evaluations confirm that the plant will continue to comply with applicable regulatory requirements.

Based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

6.0 ENVIRONMENTAL CONSIDERATION

Pursuant to 10 CFR 51.22(b), an evaluation of this license amendment request has been performed to determine whether or not it meets the criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9) of the regulations.

Implementation of this amendment will have no adverse impact upon the Catawba units; neither will it contribute to any additional quantity or type of effluent being available for adverse environmental impact or personnel exposure.

It has been determined there is:

1. No significant hazards consideration,

2. No significant change in the types, or significant increase in the amounts, of any effluents that may be released offsite, and

3. No significant increase in individual or cumulative occupational radiation exposures involved.

Therefore, this amendment to the Catawba TS meets the criteria of 10 CFR 51.22(c)(9) for categorical exclusion from an environmental impact statement.

7.0 REFERENCES

1. "Proposed Amendments to the Facility Operating License and Technical Specifications to Allow Insertion of Mixed Oxide (MOX) Fuel Lead Assemblies and Request for Exemption from Certain Regulations in 10 CFR Part 50", Package Transmittal from M. S. Tuckman (Duke Power) to U.S. NRC Document Control Desk, February 27, 2003.
2. "Catawba Nuclear Station Units 1 & 2, Response to NRC Request for Additional Information, Fuel Enrichment Upgrade Submittal", Letter from M. S. Tuckman (Duke Power) to U.S. NRC Document Control Desk, June 19, 1995.
3. "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants", Memorandum from L. Kopp (NRC) to T. Collins (NRC), U.S. Nuclear Regulatory Commission, August 19, 1998.
4. "Catawba Nuclear Station Units 1 & 2, Proposed Technical Specification Changes", Package Transmittal

from M. S. Tuckman (Duke Power) to U.S. NRC Document Control Desk, September 19, 1994.

5. SCALE 4.4 - A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation, NUREG/CR-0200 (Rev. 5), CCC-545, Oak Ridge National Laboratory, March 1997.
6. "McGuire Nuclear Station Units 1 and 2, Proposed Technical Specification (TS) Amendments, TS 3.7.15 and TS 4.3", Package Transmittal from H. B. Barron (Duke Energy) to U.S. NRC Document Control Desk, August 1, 2000.
7. "McGuire Nuclear Station Units 1 and 2, Technical Specification (TS) Amendment Request for Additional Information (RAI), TS 3.7.15 and TS 4.3", Letter from D. M. Jamil (Duke Power) to U.S. NRC Document Control Desk, October 30, 2002.
8. NUREG-0612, Control of Heavy Loads at Nuclear Power Plants, (Resolution of Generic Technical Activity A-36), U.S. Nuclear Regulatory Commission, July 1980.
9. Letter from R. E. Martin, Project Manager - U.S. Regulatory Commission to H. B. Barron dated March 3, 2005, Issuance of License Amendments 220 and 215 for Catawba Nuclear Station concerning the use of mixed oxide fuel lead test assemblies.
10. Letter from F. Rinaldi, Project Manager - U.S. Regulatory Commission to H. B. Barron dated November 27, 2000, Issuance of License Amendments 197 and 178 for McGuire Nuclear Station to allow the use of credit for soluble boron in spent fuel pool criticality analyses.
11. Letter from R. E. Martin, Project Manager - U.S. Regulatory Commission to D. Jamil dated February 4, 2003, Issuance of License Amendments 210 and 191 for McGuire Nuclear Station concerning issuance of amendments for spent fuel pool.

ATTACHMENT 1

MARKUP of TECHNICAL SPECIFICATIONS PAGES FOR CATAWBA

FOR INFO ONLY
NO CHANGES TO THIS PAGE

3.7 PLANT SYSTEMS

3.7.15 Spent Fuel Pool Boron Concentration

LCO 3.7.15 The spent fuel pool boron concentration shall be within the limit specified in the COLR.

APPLICABILITY: When fuel assemblies are stored in the spent fuel pool.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Spent fuel pool boron concentration not within limit.	----------NOTE---------- LCO 3.0.3 is not applicable. ------------------------------	
	A.1 Suspend movement of fuel assemblies in the spent fuel pool.	Immediately
	AND	
	A.2 Initiate action to restore spent fuel pool boron concentration to within limit.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.7.15.1 Verify the spent fuel pool boron concentration is within limit.	7 days

3.7 PLANT SYSTEMS

3.7.16 Spent Fuel Assembly Storage

(new or irradiated low enriched uranium fuel enriched up to an initial nominal 5.0 wt% U-235); or

LCO 3.7.16 The combination of initial enrichment and burnup of each new or spent fuel assembly stored in the spent fuel pool storage racks shall be within the following configurations:

a. Unrestricted storage ~~of fuel meeting the criteria of Table 3.7.16-1; or~~

b. Restricted storage in accordance with Figure 3.7.16-1. ~~of fuel which does not meet the criteria of Table 3.7.16-1; or~~

~~c. Restricted storage, in accordance with Figure 3.7.16-1, of MOX fuel assemblies as Restricted Fuel.~~

APPLICABILITY: Whenever any fuel assembly is stored in the spent fuel pool.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Requirements of the LCO not met.	A.1 ---------NOTE--------- LCO 3.0.3 is not applicable. ------------------------ Initiate action to move the noncomplying fuel assembly to the correct location.	Immediately

SURVEILLANCE REQUIREMENTS

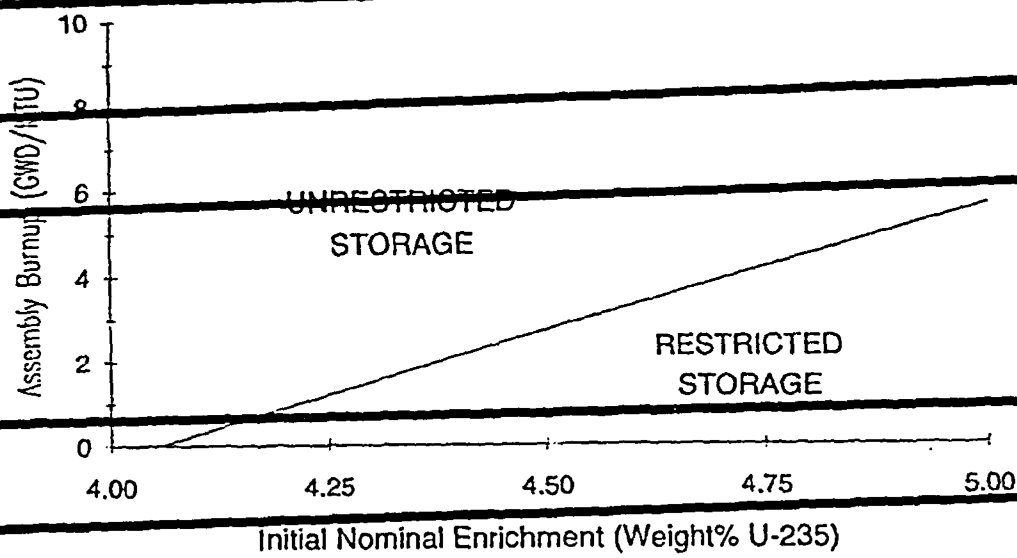
SURVEILLANCE	FREQUENCY
SR 3.7.16.1 Verify by administrative means the planned spent fuel pool location is acceptable for the fuel assembly being stored.	Prior to storing the fuel assembly in the spent fuel pool

DELETE THIS TABLE

Table 3.7.16-1

Minimum Qualifying Burnup Versus Initial Enrichment for Unrestricted Storage

Initial Nominal Enrichment (Weight% U-235)	Assembly Burnup (GWD/MTU)
4.05 (or less)	0
4.50	2.73
5.00	5.67



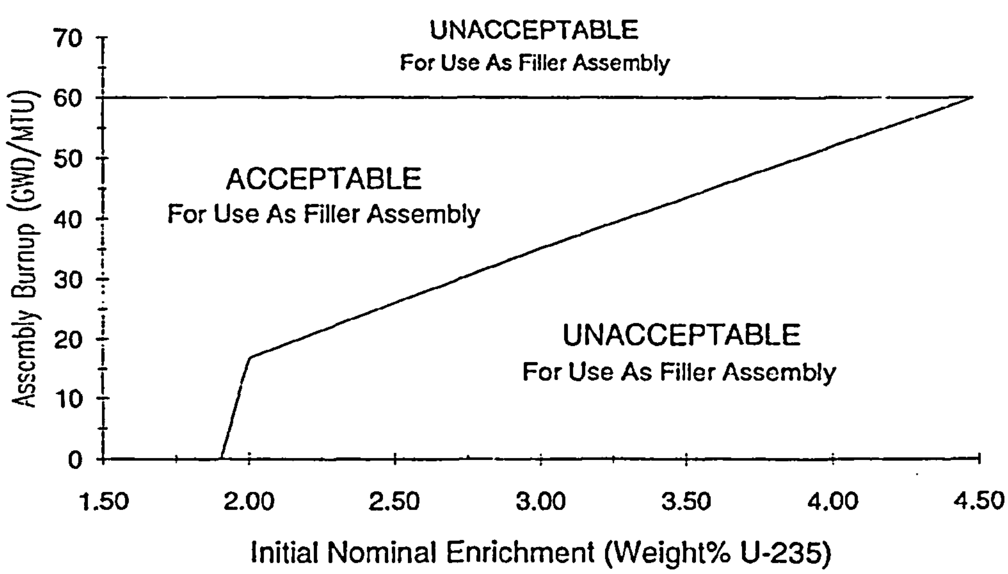
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.16-1 may be qualified for Unrestricted storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95. Likewise, previously unanalyzed fuel up to a nominal 5.0 weight% U-235 may be qualified for Restricted storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95.

Table 3.7.16-~~2~~ ← 1

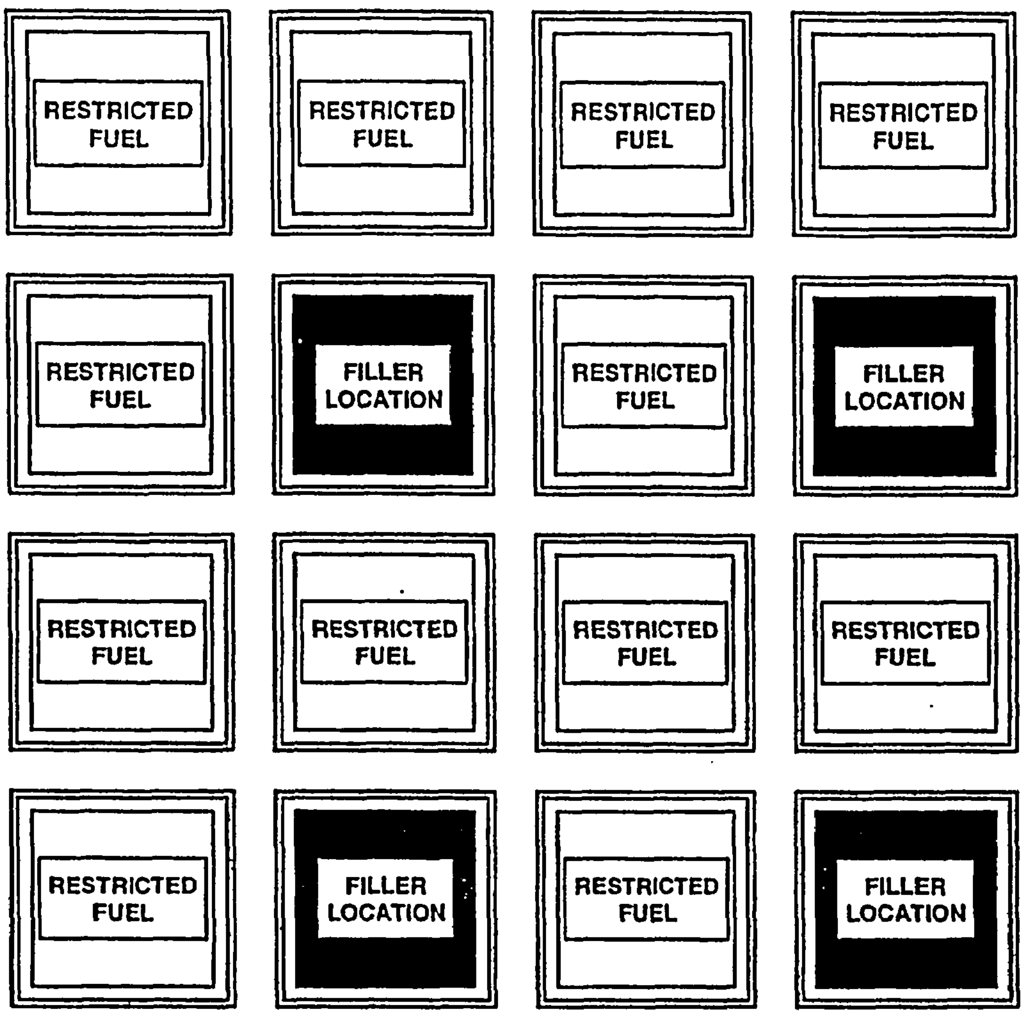
Minimum Qualifying Burnup Versus Initial Enrichment for Filler Assemblies ← Low Enriched Uranium

Initial Nominal Enrichment (Weight% U-235)	Assembly Burnup (GWD/MTU)
1.90 (or less)	0
2.00	16.83
2.50	26.05
3.00	35.11
3.50	43.48
4.00	51.99
4.48	60.00



NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.16-~~2~~ 1 must → ~~may~~ be qualified for use as a Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95.



Restricted Fuel: Fuel which ~~a) does not meet the requirements of Table 3.7.16-1 for Unrestricted Fuel; or b)~~ is a mixed oxide fuel assembly with a maximum nominal fissile plutonium concentration of 4.15 weight percent and a maximum nominal U-235 enrichment of 0.35 weight percent. (Fuel defined for Unrestricted Storage ~~in Table 3.7.16-1~~, or non-fuel components, or an empty ~~location~~ cell may be ~~placed~~ used in Restricted Fuel locations as needed)

per LCO 3.7.16.a

Filler Location: Either ~~fuel~~ low enriched uranium which meets the minimum burnup requirements of Table 3.7.16-~~2~~ 1, or an empty cell.

Boundary Condition: Any row bounded by an Unrestricted Storage Area shall contain a combination of ~~restricted fuel~~ Restricted Fuel assemblies and filler locations arranged such that no ~~restricted fuel~~ Restricted Fuel assemblies are adjacent to each other. Example: In the figure above, row 1 or column 1 can not be adjacent to an Unrestricted Storage Area, but row 4 or column 4 can be.

Figure 3.7.16-1
Required 3 out of 4 Loading Pattern for Restricted Storage

c. Keff ≤ 0.95 if fully flooded with water borated to a minimum of 200 ppm, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR; and

4.0 DESIGN FEATURES

4.3 Fuel Storage (continued)

Low enriched uranium fuel

a. ~~Fuel~~ assemblies having a maximum nominal U-235 enrichment of 5.0 weight percent or mixed oxide fuel assemblies having a maximum nominal fissile plutonium concentration up to 4.15 weight percent and a maximum nominal U-235 enrichment of 0.35 weight percent;

< 1.0

b. k_{eff} ~~≤ 0.95~~ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR~~; and~~

d ~~c~~. A nominal 13.5 inch center to center distance between fuel assemblies placed in the fuel storage racks.

4.3.1.2 The new fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum nominal U-235 enrichment of 5.0 weight percent;

b. $k_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR;

c. $k_{eff} \leq 0.98$ if moderated by aqueous foam, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR; and

d. A nominal 21 inch center to center distance between fuel assemblies placed in the storage racks.

4.3.2 Drainage

The spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below elevation 596 ft.

4.3.3 Capacity

The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 14~~18~~ fuel assemblies.

21

ATTACHMENT 2

PROPOSED TECHNICAL SPECIFICATION BASES CHANGES FOR CATAWBA
(For information only)

B 3.7 PLANT SYSTEMS

B 3.7.15 Spent Fuel Pool Boron Concentration

BASES

1421

BACKGROUND

Insert 1

The spent fuel storage rack (Ref. 1) is limited to a capacity of ~~1418~~ fuel assemblies. The spent fuel storage rack is designed to accommodate fuel with a maximum nominal enrichment of 5.0 wt% U-235 (maximum tolerance of ± 0.05 wt%) ~~which have accumulated minimum burnups greater than or equal to the minimum qualifying burnups in Table 3.7.16-1. Fuel assemblies not meeting the criteria of Table 3.7.16-1 shall be stored in accordance with Figure 3.7.16-1~~.

INSERT 2

~~The water in the spent fuel pool normally contains soluble boron, which results in large subcriticality margins under actual operating conditions. However, the NRC guidelines, based upon the accident condition in which all soluble poison is assumed to have been lost, specify that the limiting k_{eff} of 0.95 be evaluated in the absence of soluble boron. Hence, the design of the spent fuel storage racks is based on the use of unborated water, which maintains the spent fuel pool in a subcritical condition during normal operation when fully loaded. The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 2) allows credit for soluble boron under other abnormal or accident conditions, since only a single accident need be considered at one time. For example, the most severe accident scenario is associated with the accidental misloading of a fuel assembly. This could potentially increase the reactivity of the spent fuel pool. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. Safe operation of the spent fuel pool storage rack with no movement of assemblies may therefore be achieved by controlling the location of each assembly in accordance with LCO 3.7.16, "Spent Fuel Assembly Storage."~~ Prior to movement of an assembly, it is necessary to perform SR 3.7.15.1.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in the reactivity of the spent fuel storage rack. An example of these accident conditions is the dropping of a fuel assembly on the top of the rack. However, accidents can be postulated that could increase the reactivity. ~~This increase in reactivity is unacceptable with unborated water in the storage pool. Thus, for these accident occurrences, the presence of soluble~~

INSERT 1:

The storage rack can also accommodate mixed oxide fuel assemblies with a maximum nominal fissile plutonium concentration up to 4.15 weight percent (maximum tolerance of +/- 0.075 weight percent fissile Pu) and a maximum nominal Uranium-235 enrichment of 0.35 weight percent. The mixed oxide fuel assembly design is radially zoned with fuel rods at three different plutonium concentrations. The nominal fissile plutonium concentration limit is the volume weighted average for the entire fuel assembly.

INSERT 2:

The spent fuel storage racks have been analyzed taking credit for soluble boron as allowed in Reference 2. The methodology ensures that the spent fuel rack multiplication factor, k_{eff}, is less than or equal to 0.95 as recommended in ANSI/ANS-57.2-1983 (Reference 3) and NRC guidance (Reference 4). The spent fuel storage racks are analyzed to allow storage of fuel assemblies with enrichments up to a maximum nominal value of 5.00 weight percent Uranium-235 while maintaining $k_{eff} \leq 0.95$ including uncertainties, tolerances, biases, and credit for soluble boron. Soluble boron credit is used to offset off-normal conditions and to provide subcritical margin such that the spent fuel pool k_{eff} is maintained less than or equal to 0.95. The soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 under normal conditions is 200 ppm. In addition, sub-criticality of the spent fuel pool ($k_{eff} < 1.0$) is assured on an overall 95 percent probability, at a 95 percent confidence (95/95) basis, without the presence of the soluble boron in the spent fuel pool. The criticality analysis performed shows that the regulatory subcriticality requirements are met for fuel assembly storage within an allowable storage configuration, when the criteria specified in LCO 3.7.16 are satisfied.

BASES

APPLICABLE SAFETY ANALYSES (continued)

~~boron in the storage pool prevents criticality in the spent fuel pool~~. The postulated accidents are basically of two types. A fuel assembly could be incorrectly positioned (e.g., an unirradiated fuel assembly or an insufficiently depleted fuel assembly). The second type of postulated accidents is associated with a fuel assembly which is dropped adjacent to the fully loaded storage rack. ~~This could have a small positive reactivity effect. However, the negative reactivity effect of the soluble boron compensates for the increased reactivity caused by either one of the two postulated accident scenarios. The accident analyses is provided in the UFSAR, Section 15.7.4 (Ref. 3).~~

INSERT 3

The concentration of dissolved boron in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 4). 7

LCO

The spent fuel pool boron concentration is required to be within the limits specified in the COLR. The specified concentration of dissolved boron in the spent fuel pool preserves the assumptions used in the analyses of the potential critical accident scenarios as described in Reference 3. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the spent fuel pool. 6

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the spent fuel pool.

ACTIONS

A.1 and A.2

The Required Actions are modified by a Note indicating that LCO 3.0.3 does not apply.

When the concentration of boron in the fuel storage pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored simultaneously with suspending movement of fuel assemblies.

If the LCO is not met while moving irradiated fuel assemblies in MODE 5 or 6, LCO 3.0.3 would not be applicable. If moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the fuel movement is

INSERT 3:

For an occurrence of these postulated accidents, the double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Reference 5) can be applied. This states that one is not required to assume two unlikely, independent, concurrent events to ensure protection against a criticality accident. Thus, for these postulated accident conditions, the presence of additional soluble boron in the spent fuel pool water (above the 200 ppm required to maintain k_{eff} less than or equal to 0.95 under normal conditions) can be assumed as a realistic initial condition since not assuming its presence would be a second unlikely event.

Calculations show that the soluble boron concentrations needed to maintain the spent fuel pool k_{eff} below 0.95 for the postulated accidents related to fuel assembly movement are far less than the minimum amount available in the spent fuel pools (per the LCO for TS 3.7.15).

Specification 4.3.1.1 c. requires that the spent fuel rack k_{eff} be less than or equal to 0.95 when flooded with water borated to 200 ppm. A spent fuel pool boron dilution analysis was performed which confirmed that sufficient time is available to detect and mitigate a dilution of the spent fuel pool before the 0.95 k_{eff} design basis is exceeded. The spent fuel pool boron dilution analysis concluded that an unplanned or inadvertent event which could result in the dilution of the spent fuel pool boron concentration to 200 ppm is not a credible event.

NUREG-0612,"Control of Heavy Loads at Nuclear Power Plants," requires that the criticality consequences of dropping a load heavier than a fuel assembly on the spent fuel pool rack be considered. This accident condition allows full credit for the minimum required boron concentration in the spent fuel pools. That minimum boron concentration is controlled though the COLR as described in the LCO for TS 3.7.15.

The largest loads that may be moved over the spent fuel pool storage racks are the weir gates. An analysis of the criticality consequences of a worst-case weir gate drop on these racks demonstrates that even with up to six (6) fuel assemblies crushed by the weir gate into an optimum-reactivity configuration, the maximum achievable 95/95 k_{eff} is well below the 0.95 subcriticality criterion, when full credit is taken for the minimum soluble boron concentration in the spent fuel pools as required by the LCO for TS 3.7.15.

BASES

ACTIONS (continued)

independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.7.15.1

This SR verifies that the concentration of boron in the spent fuel pool is within the required limit. As long as this SR is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no major replenishment of pool water is expected to take place over such a short period of time.

REFERENCES

1. UFSAR, Section 9.1.2.

5 ~~2~~. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).

6 ~~3~~. UFSAR, Section 15.7.4.

7 ~~4~~. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).

2. 10 CFR 50.68, "Criticality Accident Requirements"

3. American Nuclear Society, "American National Standard Design Requirements for Light Water Reactor Fuel Storage Facilities at Nuclear Power Plants," ANSI/ANS-57.2-1983, October 7, 1983.

4. Nuclear Regulatory Commission, Memorandum to Timothy Collins from Laurence Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants," August 19, 1998.

B 3.7 PLANT SYSTEMS

B 3.7.16 Spent Fuel Assembly Storage

BASES

BACKGROUND

The spent fuel storage rack (Ref. 1) is limited to a capacity of 1418 21 fuel assemblies. The spent fuel storage rack is designed to accommodate fuel with a maximum nominal enrichment of 5.0 wt% U-235 (maximum tolerance of ± 0.05 wt%) ~~which have accumulated minimum burnups greater than or equal to the minimum qualifying burnups in Table 3.7.16-1.~~ The storage rack can also accommodate mixed oxide fuel assemblies with a maximum nominal fissile plutonium concentration up to 4.15 weight percent (maximum tolerance of +/- 0.075 weight percent fissile Pu) and a maximum nominal Uranium-235 enrichment of 0.35 weight percent. The mixed oxide fuel assembly design is radially zoned with fuel rods at three different plutonium concentrations. The nominal fissile plutonium concentration limit is the weighted average for the entire fuel assembly. ~~Fuel assemblies not meeting the criteria of Table 3.7.16-1 shall be stored in accordance with Figure 3.7.16-1.~~

INSERT 4 →

The water in the spent fuel pool normally contains soluble boron, which results in large subcriticality margins under actual operating conditions. However, the NRC guidelines, based upon the accident condition in which all soluble poison is assumed to have been lost, specify that the limiting k_{eff} of 0.95 be evaluated in the absence of soluble boron. Hence, the design of the spent fuel storage racks is based on the use of unborated water, which maintains the spent fuel pool in a subcritical condition during normal operation when fully loaded. The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 2) allows credit for soluble boron under other abnormal or accident conditions, since only a single accident need be considered at one time. For example, the most severe accident scenario is associated with the accidental misloading of a fuel assembly. This could potentially increase the reactivity of the spent fuel pool. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. Safe operation of the spent fuel pool storage rack with no movement of assemblies may therefore be achieved by controlling the location of each assembly in accordance with the accompanying LCO. Prior to movement of an assembly, it is necessary to perform SR 3.7.15.1.

INSERT 4:

The spent fuel storage racks have been analyzed taking credit for soluble boron as allowed in Reference 2. The methodology ensures that the spent fuel rack multiplication factor, k_{eff}, is less than or equal to 0.95 as recommended in ANSI/ANS-57.2-1983 (Reference 3) and NRC guidance (Reference 4). The spent fuel storage racks are analyzed to allow storage of fuel assemblies with enrichments up to a maximum nominal value of 5.00 weight percent Uranium-235 while maintaining $k_{eff} \leq 0.95$ including uncertainties, tolerances, biases, and credit for soluble boron. Soluble boron credit is used to offset off-normal conditions and to provide subcritical margin such that the spent fuel pool k_{eff} is maintained less than or equal to 0.95. The soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 under normal conditions is 200 ppm. In addition, sub-criticality of the spent fuel pool ($k_{eff} < 1.0$) is assured on an overall 95 percent probability, at a 95 percent confidence (95/95) basis, without the presence of the soluble boron in the spent fuel pool. The criticality analysis performed shows that the regulatory subcriticality requirements are met for fuel assembly storage within an allowable storage configuration, when the criteria specified in the accompanying LCO are satisfied.

or movement of heavy loads in the spent fuel pool

BASES

APPLICABLE SAFETY ANALYSES

The hypothetical accidents can only take place during or as a result of the movement of an assembly (Ref. 6). For these accident occurrences, the presence of soluble boron in the spent fuel pool (controlled by LCO 3.7.15, "Spent Fuel Pool Boron Concentration") prevents criticality in the spent fuel pool storage racks. By closely controlling the movement of each assembly and by checking the location of each assembly after movement, the time period for potential accidents may be limited to a small fraction of the total operating time. During the remaining time period with no potential for accidents, the operation may be under the auspices of the accompanying LCO.

INSERT 5

The configuration of fuel assemblies in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 7).

LCO

INSERT 6

~~The restrictions on the placement of fuel assemblies within the spent fuel pool, in accordance with Table 3.7.16-1, in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain < 0.95, assuming the pool to be flooded with unborated water. Fuel assemblies not meeting the criteria of Table 3.7.16-1 shall be stored in accordance with Figure 3.7.16-1 and Table 3.7.16-2.~~

APPLICABILITY

This LCO applies whenever any fuel assembly is stored in the spent fuel pool.

ACTIONS

A.1

Required Action A.1 is modified by a Note indicating that LCO 3.0.3 does not apply.

When the configuration of fuel assemblies stored in the spent fuel pool is not in accordance with the LCO, the immediate action is to initiate action to make the necessary fuel assembly movement(s) to bring the configuration into compliance.

If unable to move irradiated fuel assemblies while in MODE 5 or 6, LCO 3.0.3 would not be applicable. If unable to move irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the action is independent of reactor operation. Therefore, inability to move fuel assemblies is not sufficient reason to require a reactor shutdown.

INSERT 5:

For an occurrence of these postulated accidents, the double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Reference 5) can be applied. This states that one is not required to assume two unlikely, independent, concurrent events to ensure protection against a criticality accident. Thus, for these postulated accident conditions, the presence of additional soluble boron in the spent fuel pool water (above the 200 ppm required to maintain k_{eff} less than or equal to 0.95 under normal conditions) can be assumed as a realistic initial condition since not assuming its presence would be a second unlikely event.

Calculations show that the soluble boron concentrations needed to maintain the spent fuel pool k_{eff} below 0.95 for the postulated accidents related to fuel assembly movement are far less than the minimum amount available in the spent fuel pools (per the LCO for TS 3.7.15).

Specification 4.3.1.1.c requires that the spent fuel rack k_{eff} be less than or equal to 0.95 when flooded with water borated to 200 ppm. A spent fuel pool boron dilution analysis was performed which confirmed that sufficient time is available to detect and mitigate a dilution of the spent fuel pool before the 0.95 k_{eff} design basis is exceeded. The spent fuel pool boron dilution analysis concluded that an unplanned or inadvertent event which could result in the dilution of the spent fuel pool boron concentration to 200 ppm is not a credible event.

NUREG-0612,"Control of Heavy Loads at Nuclear Power Plants," requires that the criticality consequences of dropping a load heavier than a fuel assembly on the spent fuel pool rack be considered. This accident condition allows full credit for the minimum required boron concentration in the spent fuel pools. That minimum boron concentration is controlled though the COLR as described in the LCO for TS 3.7.15.

The largest loads that may be moved over the spent fuel pool storage racks are the weir gates. An analysis of the criticality consequences of a worst-case weir gate drop on these racks demonstrates that even with up to six (6) fuel assemblies crushed by the weir gate into an optimum-reactivity configuration, the maximum achievable 95/95 k_{eff} is well below the 0.95 subcriticality criterion, when full credit is taken for the minimum soluble boron concentration in the spent fuel pools as required by the LCO for TS 3.7.15.

INSERT 6:

Unrestricted storage of fuel assemblies within the spent fuel pool is allowed provided that the maximum nominal Uranium-235 enrichment is equal to or less than 5.00 weight percent. This ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool is flooded with water borated to 200 ppm. Restricted storage of fuel assemblies is also allowed, in accordance with the configuration and definitions provided in TS Figure 3.7.16-1.

BASES

SURVEILLANCE REQUIREMENTS

SR 3.7.16.1

This SR verifies by administrative means that the fuel assembly is in accordance with the configurations specified in the accompanying LCO.

REFERENCES

1. UFSAR, Section 9.1.2.

2. 10 CFR 50.68, "Criticality Accident Requirements".

3. American Nuclear Society, "American National Standard Design Requirements for Light Water Reactor Fuel Storage Facilities at Nuclear Power Plants," ANSI/ANS-57.2-1983, October 7, 1983.

4. Nuclear Regulatory Commission, Memorandum to Timothy Collins from Laurence Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants," August 19, 1998.

5 ~~2.~~ Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).

6 ~~3.~~ UFSAR, Section 15.7.4.

7 ~~4.~~ 10 CFR 50.36, Technical Specifications, (c)(2)(ii).

ATTACHMENT 3

SUMMARY OF REGULATORY COMMITMENTS

SUMMARY OF REGULATORY COMMITMENTS

The following table identifies those actions committed to by Duke Energy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be commitments. Please direct questions regarding these commitments to Mr. Randall D. Hart, Regulatory Compliance, Catawba Nuclear Station (803) 831-3622.

COMMITMENT	Due Date/Event
The proposed changes to the Catawba Nuclear Station TS will be implemented within 60 days of NRC approval.	Within 60 days of NRC approval.

ATTACHMENT 4

CATAWBA NUCLEAR STATION FUEL STORAGE CRITICALITY ANALYSIS

1: Introduction

This analysis examines the criticality aspects of fuel storage in the Catawba new fuel storage vaults (NFVs) and spent fuel pools (SFPs), to ensure that all pertinent regulatory subcriticality criteria are satisfied for proposed configurations of fuel stored in these areas. The objective of this criticality evaluation is to demonstrate that:

- Fresh fuel up to 5.0 wt % U-235 may be stored in the Catawba NFVs without restriction.
- Fresh or irradiated fuel up to 5.0 wt % U-235 may be stored in the Catawba SFPs without restriction.

The NFV criticality evaluation looks at the most reactive fresh fuel assembly designs used at Catawba, to determine whether these assemblies meet the requirements of 10 CFR 50.68 (b) (2,3) when stored in the normally-dry NFVs.

The SFP criticality analysis examines fresh fuel assembly storage in the Catawba SFP racks, to show that fresh or irradiated fuel assemblies stored in these racks comply with the requirements of 10 CFR 50.68 (b) (4). In accordance with that regulation, the Catawba SFP criticality evaluation takes partial credit for soluble boron in the SFP water during normal conditions.

This analysis is concerned with low-enriched uranium (LEU) fuel assembly storage in the Catawba NFVs and SFPs. Reference 1, which was approved by the NRC in March 2005, allows four (4) mixed-oxide (MOX) lead test assemblies to be stored in the Catawba SFPs in a Restricted configuration. Reference 1 also specifies storage limitations at the boundary between the proposed MOX storage configuration and neighboring LEU configurations. The results of the analysis performed here to allow Unrestricted LEU fuel storage in the Catawba SFPs do not affect the Technical Specification changes for MOX fuel in Reference 1.

2: Fuel Storage Facilities at Catawba

Figure 1 shows an overhead view of the pertinent fuel storage areas in one of the Catawba fuel buildings. This layout is typical of the two (2) fuel buildings at Catawba. Fresh fuel is first received in the new fuel receiving area and stored temporarily, prior to being removed from its shipping container. Upon removal from the shipping container fuel assemblies are placed in a new fuel storage vault location for inspection and then are either kept in the NFV or transferred to the spent fuel pool for storage prior to reactor irradiation. Fresh fuel and irradiated reload fuel assemblies are transported to the reactor via the water-filled Fuel Transfer Area. Discharged fuel assemblies from the reactor are also returned to the SFP through the Fuel Transfer Area.

The Catawba NFVs are intended for storage - as necessary - of unirradiated fuel assemblies in a dry condition. Each NFV comprises three columns of paired storage cells, as shown in Figure 1. Table 1 provides the Catawba NFV storage rack data pertinent to criticality modeling. The NFV criticality analysis is described in Section 6.

The Catawba SFPs are designed to store fresh and irradiated fuel assemblies in a wet, borated environment. The SFPs contain several fuel storage modules, as Figure 1 indicates. Each of these modules is made up of a rectangular array of stainless steel storage cells arranged in a "flux trap" design. There are no added neutron poisons (such as Boraflex or Boral) in the SFP storage cells - sufficient subcriticality is achieved through separation of the storage cells and partial soluble boron credit. Figure 2 depicts the layout of the storage cells in the Catawba SFPs.

Table 2 shows the rack design information needed to analyze the Catawba SFPs. The criticality evaluation of the SFPs is discussed in Section 7.

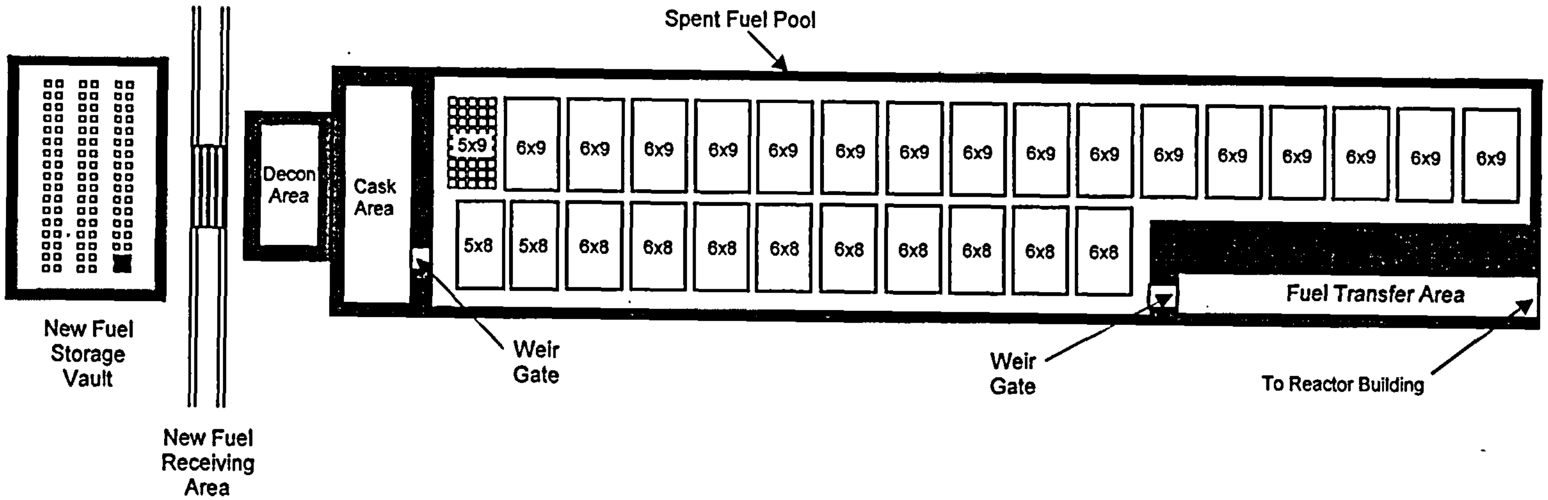


Figure 1: Overhead View of the Catawba Fuel Building (Typical of Each Unit)

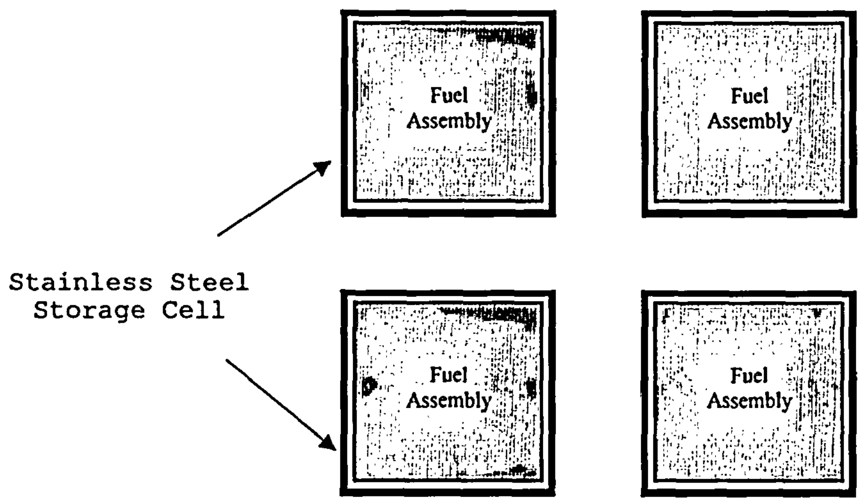


Figure 2: Catawba Spent Fuel Pool Storage Cell Arrangement

Table 1: General Design Information for the Catawba NFV Storage Racks

Design Parameter	Value
# of storage locations in each NFV	98
Storage cell pitch - narrow gap sides (cm)	53.3
Storage cell pitch - wide gap side (cm)	104.1
Storage cell inner distance between box walls (cm)	22.9
Stainless steel storage cell wall thickness (cm)	0.32

Table 2: General Design Information for the Catawba SFP Storage Racks

Design Parameter	Value
# of storage locations in each SFP	1421
Storage cell pitch (cm)	34.3
Storage cell inner distance between box walls (cm)	22.9
Stainless steel storage cell wall thickness (cm)	0.64
Normal SFP water temperature range (°F)	68 - 150
Minimum required SFP boron concentration (ppm)	2700

3: Fuel Assembly Designs Considered

The following fuel types are considered for the Catawba criticality analyses:

- **W-STD** - this is the original "standard" 17x17 Westinghouse fuel design. It has not actually been used in the Catawba reactors or SFPs, but was employed in the initial cycles (batches 1-3) of both of the McGuire reactors. It has been included in the Catawba criticality evaluations due to its similarity to the W-RFA design.

- **W-OFA** - this is the 17x17 Westinghouse "Optimized Fuel Assembly" design, which had thin fuel rods and a low total uranium loading. This design was deployed for the early cycles of both Catawba units.

- **MkBW** - this is the standard 17x17 Framatome (B&W) fuel design. This fuel type was used for several fuel batches in both Catawba reactors.

- **W-RFA** - this is the current 17x17 Westinghouse fuel design being used at Catawba. It is similar to the MkBW and W-STD assembly designs. Note that this design is neutronically equivalent to the W-NGF for the parameters important to the Catawba SFP and NFV criticality analyses. Eight (8) W-NGF lead test assemblies are currently operating in the Catawba Unit 1 reactor.

Pertinent design data for these fuel types are provided in Table 3.

Table 3: Design Data for Fuel Types Considered in the Catawba Criticality Analysis

	W-STD	**W-OFA**	**MkBW**	**W-RFA/ W-NGF**
Average UO_2 fuel density (g/cc)	10.29	10.30	10.36	10.34
Fuel pellet OR (cm)	0.4096	0.3922	0.4058	0.4096
Cladding IR (cm)	0.4178	0.4001	0.4140	0.4178
Cladding OR (cm)	0.4750	0.4572	0.4750	0.4750
Pin pitch (cm)	1.26	1.26	1.26	1.26
Pin array size	17x17	17x17	17x17	17x17
Guide tube IR (cm)	0.572	0.561	0.572	0.561
Guide tube OR (cm)	0.612	0.602	0.612	0.612

4: Criticality Computer Code Validation

The neutronics code employed in the Catawba criticality analyses is SCALE 4.4/KENO V.a. This code is well-suited to criticality modeling of the Catawba SFP and NFV, and has been extensively benchmarked to critical experiments. KENO V.a is a 3-D Monte Carlo criticality module in the SCALE (Reference 2) package.

Duke Power has performed a SCALE 4.4/KENO V.a benchmark analysis of critical experiments to determine calculational biases and uncertainties for both the 44-group and 238-group cross-section libraries included with the SCALE 4.4 package.

For Catawba criticality applications, the SCALE 4.4/KENO V.a method biases and uncertainties are based on analysis of 41 LEU critical experiments performed by Pacific Northwest Laboratories (see Reference 3). These critical experiments model various square-pitch arrangements of fuel rods, and include both over- and under-moderated lattices.

Because the NFV and SFP analyses model fresh fuel at only the highest permissible enrichment (5.00 ± 0.05 wt % U-235), each of the 41 critical experiments selected was at the highest enrichment available in Reference 3 (4.31 wt % U-235).

The results from the benchmark analyses indicated that the 238-group cross-section library yields the more consistent results (i.e., smaller variations in reactivity bias) across the range of moderation in the selected critical experiments. Therefore, the 238-group cross-section library is used for all the SCALE 4.4/KENO V.a computations performed in the Catawba NFV and SFP criticality analyses.

SCALE 4.4/KENO V.a modeling of these 41 critical experiments with the 238-group library yielded a benchmark calculational bias of +0.0061 Δk (average under-prediction of k_{eff}) and an uncertainty of ±0.0071 Δk. This bias and uncertainty are used in determining the total bounding 95/95 system k_{eff}s for each NFV or SFP storage configuration analyzed with SCALE 4.4/KENO V.a. Sections 6 and 7 provide the results of the Catawba NFV and SFP criticality evaluations, respectively.

5: Computation of the Maximum 95/95 k_{eff}

For every fuel assembly design that is considered in the scope of the Catawba SFP and NFV criticality analyses, a nominal k_{eff} is calculated. This k_{eff} is only the base value, however. A total k_{eff} is determined by adding several pertinent reactivity biases and uncertainties, to provide an overall 95 percent probability, at a 95 percent confidence level (95/95), that the true system k_{eff} does not exceed the 95/95 k_{eff} for that particular storage condition.

The total 95/95 k_{eff} equation has the following form:

$$k_{eff} = k_{nominal} + \sum B_x + \sqrt{\sum ks_x^2}$$

where:

$k_{nominal}$ is the k_{eff} computed for the nominal case being considered.

B_x is a pertinent bias, as indicated in Table 4.

ks_x is the pertinent 95/95 independent uncertainty on $k_{nominal}$, as indicated in Table 4.

Table 4 lists the various biases and uncertainties that are considered in the Catawba NFV and SFP criticality analyses. Each of these biases and uncertainties is discussed in more detail below:

- **Benchmark Method Bias**

  This bias is determined from the benchmarking of the code system used (SCALE 4.4/KENO V.a here), and represents how much the code system is expected to overpredict (negative bias) or underpredict (positive bias) the "true k_{eff}" of the physical system being modeled. The critical experiment benchmarks for this code are discussed in Section 4. The bias for SCALE 4.4/KENO V.a with its 238-group cross-section library is +0.0061 Δk.

- **Benchmark Method Uncertainty**

  This uncertainty is determined from the benchmarking of the code system used, and is a measure of the expected variance (95/95 one-sided uncertainty) of predicted reactivity from the "true k_{eff}" of the physical system being modeled. As discussed in Section 4, the method uncertainty for SCALE 4.4/KENO V.a, with its 238-group cross-section library, is ±0.0071 Δk.

- **Monte Carlo Computational Uncertainty**

  For all the nominal SCALE 4.4/KENO V.a computations performed in this analysis to determine 95/95 k_{eff}s, the Monte Carlo computational uncertainty is equal to $1.727*\sigma_{nominal}$. The $\sigma_{nominal}$ factor is the calculated standard deviation of $k_{nominal}$ (the nominal k_{eff} for that particular case). The 1.727 multiplier is the one-sided 95/95 tolerance factor for 1000 neutron generations. Each of the SCALE 4.4/KENO V.a cases in the SFP and NFV calculations counted 1000 neutron generations.

- **Mechanical Uncertainties**

  The "mechanical uncertainty" represents the total reactivity uncertainty contributions of various independent storage rack-related and fuel manufacturing-related mechanical uncertainty factors. These factors include reactivity effects for possible variations in fuel enrichment, fuel pellet diameter, fuel density, cladding dimensions, storage rack dimensions and material thickness tolerances, fuel assembly positioning within the storage cell, etc. The following bounding total mechanical uncertainties have been determined for the Catawba SFP criticality analyses:

  - ±0.0151 Δk (no boron in SFP water)
  - ±0.0133 Δk (200 ppm boron in SFP water)

  As discussed in Section 6, worst-case reactivity conditions are used for the nominal models in the Catawba NFV evaluation, and so no mechanical uncertainty factor needs to be applied in the 95/95 k_{eff} calculations for the NFV cases.

Table 4: Pertinent 95/95 Biases and Uncertainties to be Considered in the Catawba NFV and SFP Criticality Analysis

Bias	Include for NFV Analyses?	Include for SFP Analyses?
Benchmark Method Bias	✓	✓
Uncertainties		
Benchmark Method Uncertainty	✓	✓
Monte Carlo Computational Uncertainty	✓	✓
Mechanical Uncertainties		✓

6: Catawba New Fuel Storage Vault Criticality Analysis

To allow storage of fuel in the normally-dry environment of the NFV, the following requirements of 10 CFR 50.68 (b) (2) and (3) must be satisfied:

> "The estimated ratio of neutron production to neutron absorption and leakage (k-effective) of the fresh fuel in the fresh fuel storage racks shall be calculated assuming the racks are loaded with fuel of the maximum fuel assembly reactivity and flooded with unborated water and must not exceed 0.95, at a 95 percent probability, 95 percent confidence level. …
>
> If optimum moderation of fresh fuel in the fresh fuel storage racks occurs when the racks are assumed to be loaded with fuel of the maximum fuel assembly reactivity and filled with low-density hydrogenous fluid, the k-effective corresponding to this optimum moderation must not exceed 0.98, at a 95 percent probability, 95 percent confidence level."

The Catawba NFVs are described in Section 2. The following assumptions and simplifications are made in performing the criticality analysis of the NFVs:

1) All LEU fuel designs that have been used in the Catawba reactors are evaluated. This includes the W-STD, W-OFA, MkBW, and W-RFA/W-NGF fuel assembly types described in Section 3.

2) A simplified 3-D axial model of the fuel assemblies within the NFV storage cells is employed. Only the active fuel region is modeled - the top and bottom nozzles are ignored. The NFV concrete floor and walls are modeled, and reflective boundary conditions are applied in all directions.

3) All fuel is unirradiated. All fuel assemblies considered are enriched to 5.05 wt % U-235. This is the maximum nominal U-235 enrichment per 10 CFR 50.68 (b) (7) plus a standard 0.05 wt % U-235 as-built tolerance.

4) In the nominal SCALE 4.4/KENO V.a models for the NFV evaluations, "worst-case" values are specified for NFV storage rack cell pitch, cell ID, cell thickness, and fuel assembly position within the storage cell, as well as fuel-related parameters such as enrichment, fuel pellet diameter, and fuel pellet density. The worst-case values are the pertinent Table 1 and Table 3 nominal design data with tolerances applied that yield maximum calculated k_{eff}s. The worst-case model avoids separate calculation of a mechanical uncertainty for the NFV evaluation.

5) The fuel assemblies are stored without any location restrictions in the NFV.

6) No credit is taken for spacer grid material in the active fuel regions of the fuel assemblies.

7) No burnable poison assemblies (BPRAs), control rods, or other neutron poisons are inserted in the fuel assemblies analyzed.

Using the relevant reactivity biases and uncertainties described in Section 5, the SCALE 4.4/KENO V.a analyses for fuel storage in the NFVs yield a maximum 95/95 k_{eff} of 0.9324 within the range of moderation considered (0.001 g/cc to 1.00 g/cc). The maximum k_{eff} occurred at a moderator density of ~ 0.038 g/cc. This k_{eff} value is well below both of the NFV regulatory subcriticality criteria described at the beginning of this section.

Table 5 presents the bias and uncertainties that contribute to the NFV maximum 95/95 k_{eff}.

Table 5: Maximum 95/95 k_{eff} for Fuel Storage in the Catawba NFVs (No Boron in "water" flooding NFV)

Parameter	Value
Maximum Nominal k_{eff}	0.9190
Benchmark Method Bias	0.0061
Benchmark Method Uncertainty	0.0071
Monte Carlo Computational Uncertainty	0.0019
Mechanical Uncertainties	--
Maximum 95/95 k_{eff}	0.9324

7: Catawba Spent Fuel Pool Criticality Analysis

For storage of fuel in the Catawba SFPs, the following requirements of 10 CFR 50.68 (b) (4) must be satisfied:

> "... 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."

The following assumptions and bases are employed for the Catawba SFP criticality evaluations:

1) Partial soluble boron credit is used for the normal-condition criticality evaluations. These analyses adhere to the regulatory subcriticality criteria defined in 10 CFR 50.68 (b) (4), as well as the guidance provided in Reference 4.

2) All Catawba SFP criticality calculations are performed in 2-D, with perfect axial reflection. This is acceptable, because only fresh fuel is considered in the criticality evaluation for the SFP racks. It is also conservative, because it ignores axial leakage.

3) For accident conditions, the Catawba SFP is fully-flooded (full-density water) at the minimum Catawba SFP boron concentration as specified in the Core Operating Limits Report (2700 ppm). Per the double contingency principle (see Reference 4), it is allowable to assume that the minimum boron concentration is present in the event of an accident condition such as a weir gate drop on the SFP racks.

Section 5 documented the biases and uncertainties pertinent to the Catawba SFP storage racks. Each of the Catawba SFP criticality computations for normal (non-accident) conditions considers the SFP water temperature at both 32 °F (maximum water density of 1.0 g/cc used) and 212 °F. This ensures the reactivity conditions are properly bounded. According to the Catawba UFSAR Section 9.1.3.1.1, SFP water temperatures will not exceed 150 °F under normal conditions.

The normal-condition criticality calculations are performed with no boron in the SFP water [to satisfy the 95/95 k_{eff} < 1.0 criterion of 10 CFR 50.68 (b) (4)], and with 200 ppm of soluble boron credit (to satisfy the 95/95 k_{eff} < 0.95 criterion of the same regulation).

Since the normal-condition calculations are already performed at the conceivable extremes of SFP water temperature, the only Reference 4 accident conditions that need to be considered are the fuel assembly drop, misload, and placement immediately adjacent to the rack module. In addition, per NUREG-0612 (Reference 5), the criticality consequences of dropping a load heavier than a fuel assembly on the SFP racks are considered. All of these accident conditions are allowed to take full credit for the minimum required boron concentration in the Catawba SFPs. That minimum boron concentration controlled though the COLR per Catawba TS 3.7.15 is currently 2700 ppm.

As discussed in Section 3, SFP criticality calculations are performed for the W-STD, W-OFA, W-RFA, and MkBW fuel types, using SCALE 4.4/KENO V.a. These cases consider fresh 5.0 wt % U-235 fuel, stored without restriction in the SFP racks. The maximum nominal k_{eff} in unborated SFP water is computed to be 0.9452. The maximum 95/95 k_{eff} from this case, as shown in Table 6, is 0.9680. This includes the pertinent bias and uncertainties identified in Section 5. In unborated SFP conditions, then, the maximum 95/95 k_{eff} remains below 1.0.

If credit is taken for 200 ppm soluble boron in the Catawba SFPs, the SCALE 4.4/KENO V.a computational results summarized in Table 6 show that the maximum 95/95 k_{eff} is reduced to 0.9294, meeting the SFP boron-credit subcriticality requirement quoted at the beginning of this section.

These results demonstrate that, in the Catawba SFP racks, Unrestricted storage of fresh Catawba LEU reactor fuel up to 5.0 wt % U-235 meets the boron credit subcriticality criteria of 10 CFR 50.68 (b) (4) for normal storage conditions.

Several accident conditions were identified earlier in this section, including fuel assembly misload, assembly drop, and heavy load drop events. Because any type of Catawba LEU reactor fuel, with any enrichment and burnup, can be stored without restriction in the SFP racks, there is no possibility of a misloaded assembly within the regular array of SFP storage cells. However, another type of misplacement is feasible, in which a fuel assembly is improperly placed in between the outside of a storage module and the SFP wall - see Figure 1. The worst-case SCALE 4.4/KENO V.a modeling of such a misplacement requires 500 ppm soluble boron to bring the maximum 95/95 k_{eff} (0.9456) below 0.95.

The fuel assembly drop accident, from a criticality perspective, may be considered in the same category as a single isolated fuel assembly stored in water. That is because a fuel assembly dropped onto the Catawba storage racks will rest far enough above the active fuel zones of the normally stored fuel assemblies that it is effectively isolated. SCALE 4.4/KENO V.a was used to model a single, fresh, 5.0 wt % U-235 assembly of the most reactive type (W-OFA), surrounded by 30 cm of water in all directions. Calculations with this model demonstrate that 200 ppm of soluble boron is more than enough to keep the maximum 95/95 k_{eff} (0.9145) well below the 0.95 subcriticality criterion.

As far as anything heavier than a fuel assembly is concerned, the largest loads that may be moved over the Catawba SFP storage racks are the weir gates (see Figure 1). An analysis of the criticality consequences of a worst-case weir gate drop on these racks demonstrates that even with up to six (6) fuel assemblies crushed by the weir gate into an optimum-reactivity configuration, the maximum achievable 95/95 k_{eff} (0.9382) is well below the 0.95 subcriticality criterion, when full credit is taken for the minimum soluble boron concentration (2700 ppm) in the Catawba SFPs.

Table 6: Maximum 95/95 k_{eff}s for LEU Fuel Storage in the Catawba SFPs (Normal Conditions)

	0 ppm	**200 ppm**
Maximum Nominal k_{eff}	0.9452	0.9082
Benchmark Method Bias	0.0061	0.0061
Benchmark Method Uncertainty	0.0071	0.0071
Monte Carlo Computational Uncertainty	0.0014	0.0014
Mechanical Uncertainties	0.0151	0.0133
Maximum 95/95 k_{eff}	0.9680	0.9294

8: Conclusions

The criticality analysis for the Catawba NFVs and SFPs has been performed in accordance with the requirements of 10 CFR 50.68 (b). This evaluation takes partial credit for soluble boron in the SFPs.

The analysis determined that the Catawba NFVs and SFPs can store unirradiated LEU fuel up to 5 wt % U-235, with no location restrictions.

The maximum 95/95 k_{eff} for the NFV analysis was calculated to be 0.9324, meeting the requirements of 10 CFR 50.68 (b) (2,3).

For the Catawba SFP criticality analyses, the maximum 95/95 k_{eff} with no boron in the SFP was calculated to be 0.9680. This meets the no-boron 95/95 k_{eff} < 1.0 criterion in 10 CFR 50.68 (b) (4). The SFP evaluation also confirmed that with 200 ppm of partial soluble boron credit, the maximum 95/95 k_{eff} of 0.9294 remains well below the regulatory requirement that the maximum 95/95 k_{eff} be less than 0.95 for all normal conditions.

The current minimum boron concentration required in the Catawba SFPs (2700 ppm) is adequate to maintain the maximum

95/95 k_{eff} below 0.95 for all credible accident scenarios in the Catawba SFPs.

9: References

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2. SCALE 4.4 - A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation, NUREG/CR-0200 (Rev. 5), CCC-545, Oak Ridge National Laboratory, March 1997.

3. Criticality Experiments with Subcritical Clusters of 2.35 and 4.31 wt % U-235 Enriched UO2 Rods in Water at a Water to Fuel Volume Ratio of 1.6, PNL-3314, July 1980.

4. "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants", Memorandum from L. Kopp (NRC) to T. Collins (NRC), U.S. Nuclear Regulatory Commission, August 19, 1998.

5. NUREG-0612, Control of Heavy Loads at Nuclear Power Plants, (Resolution of Generic Technical Activity A-36), U.S. Nuclear Regulatory Commission, July 1980.

6. Letter from R. E. Martin, Project Manager - U.S. Regulatory Commission to H. B. Barron dated March 3, 2005, Issuance of License Amendments 220 and 215 for Catawba Nuclear Station concerning the use of mixed oxide fuel lead test assemblies.