add/insert

9409290146 940929
PDR ADOCK 05000413
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add to Section 3/4.9

3/4.9.12 SPENT FUEL POOL BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

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

APPLICABILITY:

During storage of fuel in the spent fuel pool.

ACTION:

a. Immediately suspend movement of fuel assemblies in the spent fuel pool and initiate action to restore the spent fuel pool boron concentration to within its limit.

b. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS:

4.9.12. Verify at least once per 31 days that the spent fuel pool boron concentration is within its limit.

3/4.9.13 SPENT FUEL ASSEMBLY STORAGE

add to section 3/4.9

LIMITING CONDITION FOR OPERATION

3.9.13 New or irradiated fuel may be stored in the Spent Fuel Pool in accordance with these limits:

a. Unrestricted storage of fuel meeting the criteria of Table 3.9-1; or

b. Restricted storage in accordance with Figure 3.9-1, of fuel which does not meet the criteria of Table 3.9-1; or

c. Another configuration determined to be acceptable by means of an analysis to assure that k_{eff} is less than or equal to 0.95.

APPLICABILITY:

During storage of fuel in the spent fuel pool.

ACTION:

a. Immediately initiate action to move the noncomplying fuel assembly to the correct location.

b. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS:

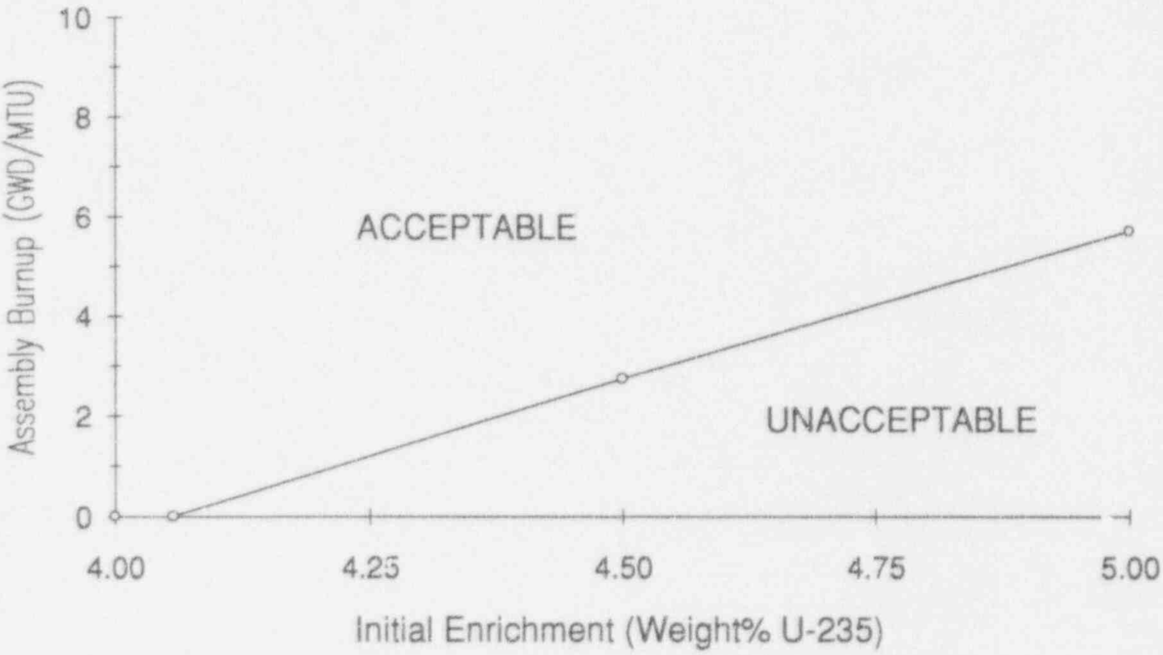
4.9.13 Prior to storing a fuel assembly in the spent fuel storage pool, verify by administrative means the initial enrichment and burnup of the fuel assembly are in accordance with Specification 3.9.13.

Table 3.9-1

Minimum Qualifying Burnup Versus Initial Enrichment for Unrestricted Storage

add to Section 3/4.9.13

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

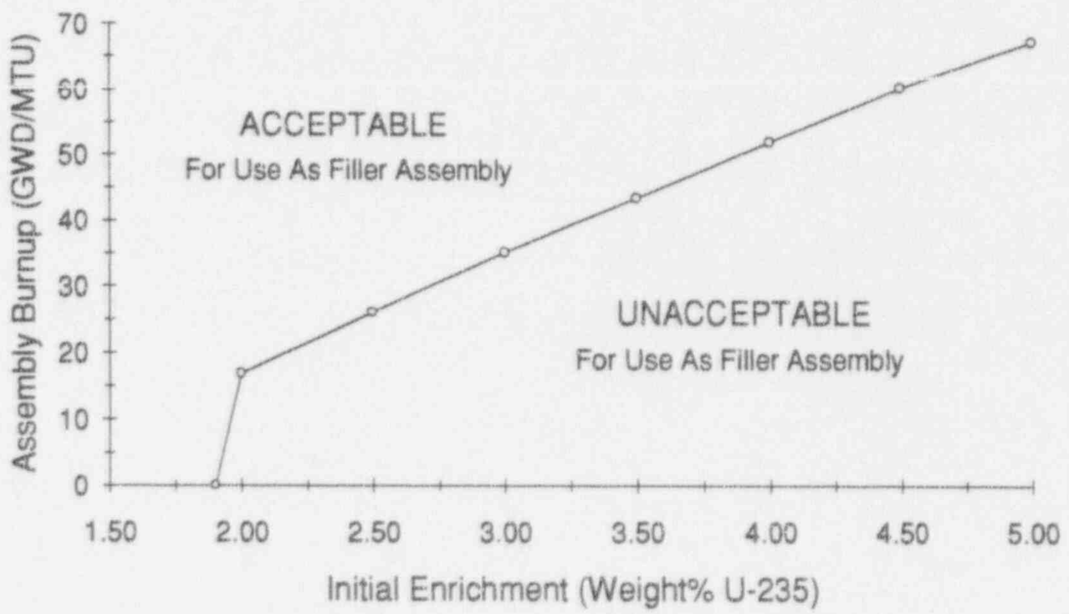


add to Section 3/4 9.13

Table 3.9-2

Minimum Qualifying Burnup Versus Initial Enrichment for Filler Assemblies

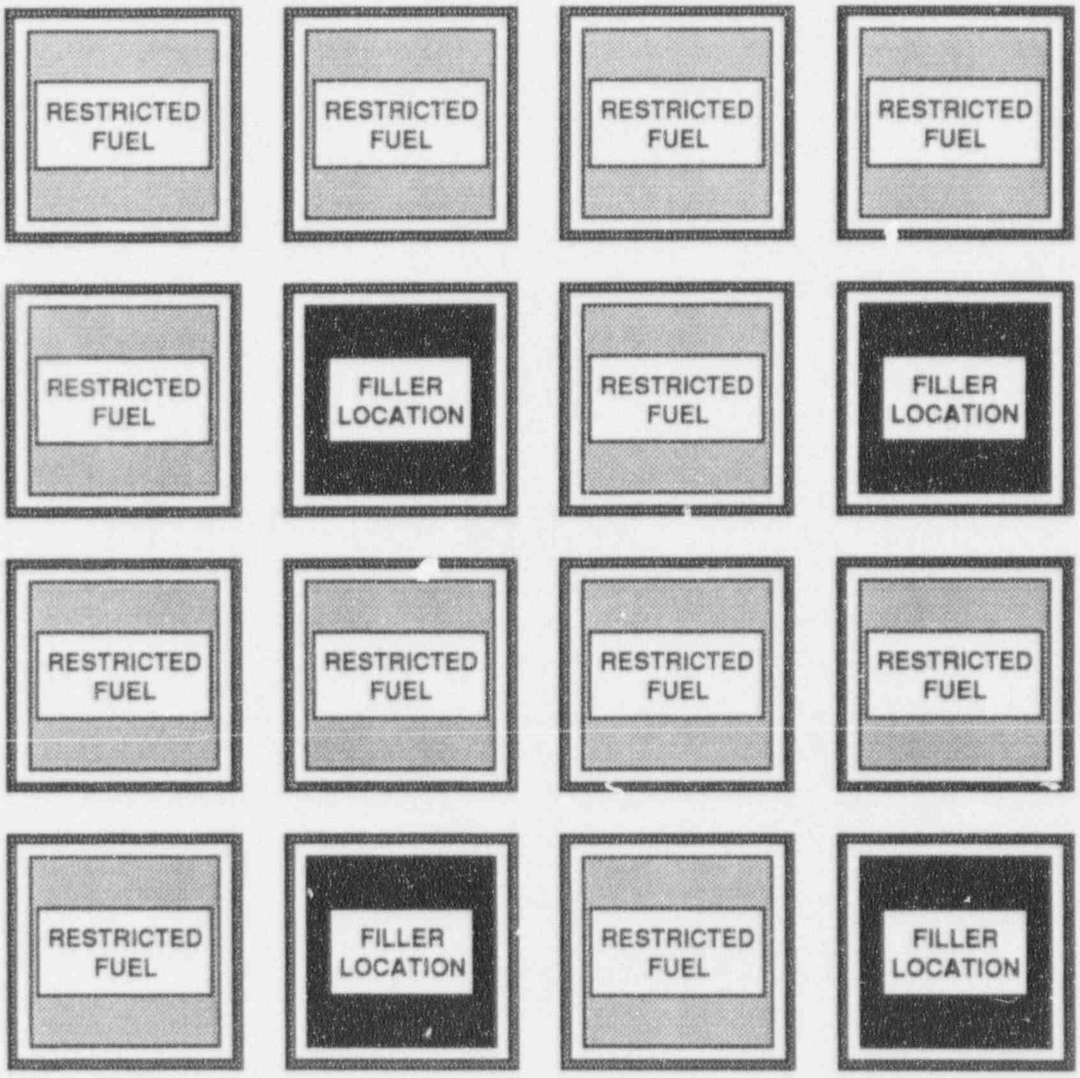
Initial Enrichment Weight% U-235	Assembly Burnup (GWD/MTU)
1.90 (or less)	0
2.00	16.83
2.50	26.05
3.00	35.11
3.50	43.48
4.00	51.99
4.50	60.36
5.00	67.28



add to section 3/4.9.13

Figure 3.9-1

Required 3 out of 4 Loading Pattern for Restricted Storage



Restricted Fuel: Fuel which does not meet the minimum burnup requirements of Table 3.9-1. (Fuel which does meet the requirements of Table 3.9-1 may be placed in restricted fuel locations as needed)

Filler Location: Either fuel which meets the minimum burnup requirements of Table 3.9-2, or an empty cell.

Boundary Condition: Any row bounded by an Unrestricted Storage Area shall contain a combination of restricted fuel assemblies and filler locations arranged such that no 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.

add to BASES

3/4.9.12 and 3/4.9.13 SPENT FUEL POOL BORON CONCENTRATION and SPENT FUEL ASSEMBLY STORAGE

The requirements for spent fuel pool boron concentration specified in Specification 3.9.12 ensure that a minimum boron concentration is maintained in the pool. The requirements for spent fuel assembly storage specified in Specification 3.9.13 ensure that the pool remains subcritical. The water in the spent fuel storage 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 with the pool fully loaded. The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 4) 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 increase the reactivity of the spent fuel pool. To mitigate this postulated criticality related accident, boron is dissolved in the pool water.

Specification 3.9.13.c allows for specific criticality analysis for configurations other than those explicitly defined in Specifications 3.9.13. These analyses would require using NRC approved methodology to ensure that $k_{eff} \leq 0.95$ with a 95 percent probability at a 95 percent confidence level as described in Section 9.1 of the FSAR.

In verifying the design criteria of $k_{eff} \leq 0.95$, the criticality analysis assumed the most conservative conditions, i.e. fuel of the maximum permissible reactivity for a given configuration. Since the data presented in Specification 3.9.13.a and 3.9.13.b represents the maximum reactivity requirements for acceptable storage, substitutions of less reactive components would also meet the $k_{eff} \leq 0.95$ criteria. Hence an empty cell, or a non-fuel component may be substituted for any designated fuel assembly location. These, or other substitutions which will decrease the reactivity of a particular storage cell will only decrease the overall reactivity of the spent fuel storage pool.

If both restricted and unrestricted storage is used, an additional criteria has been imposed to ensure that the boundary row between these two configurations would not locally increase the reactivity above the required limit.

The action statement applicable to fuel storage in the spent fuel pool requires that 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. Prior to the resumption of fuel movement, the requirements of the LCOs must be met. This requires restoring the soluble boron concentration and the correct fuel storage configuration to within the corresponding limits. This does not preclude movement of a fuel assembly to a safe position.

add to BASES

The surveillance requirements ensure that the requirements of the two LCOs are satisfied, namely boron concentration and fuel placement. The boron concentration in the spent fuel pool is verified to be greater than or equal to the minimum limit. The fuel assemblies are verified to meet the subcriticality requirement by meeting either the initial enrichment and burnup requirements of Table 3.9-1 and 3.9-2, or by using NRC approved methodology to ensure that $k_{eff} \leq 0.95$. By meeting either of these requirements, the analyzed accidents are fully addressed.

The fuel storage requirements and restrictions discussed here and applied in specification 3.9.13 are based on a maximum allowable fuel enrichment of 5.0 weight% U-235. The enrichments listed in Tables 3.9-1 and 3.9-2 are nominal enrichments and include uncertainties to account for the tolerance on the as built enrichment. Hence the as built enrichments may exceed the enrichments listed in the tables by up to 0.05 weight% U-235. Qualifying burnups for enrichments not listed in the tables may be linearly interpolated between the enrichments provided. This is because the reactivity of an assembly varies linearly for small ranges of enrichment.

REFERENCES

1. "Regulatory Guide 1.13: Spent Fuel Storage Facility Design Basis", U.S. Nuclear Regulatory Commission, Office of Standards Development, Revision 1, December 1976.

2 "Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations", American Nuclear Society, ANSI N210-1976/ANS-57.2, April 1976.

3. FSAR, Section 9.1.

4. 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).

5.6 FUEL STORAGE

delete and replace with 5.6.1 (a) & (b) attached

CRITICALITY

5.6.1 ~~The new and spent fuel storage racks are designed and shall be maintained with:~~

a. ~~A k_{eff} equivalent to less than or equal to 0.95 when flooded with unborated water, which includes a conservative allowance for uncertainties as described in Section 9.1.2.3.1 of the FSAR, and~~

b. ~~A nominal 21-inch fc. new fuel and a nominal 13.5-inch for spent fuel center-to-center distance between fuel assemblies placed in the storage racks.~~

DRAINAGE

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

CAPACITY

5.6.3 The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1418 fuel assemblies.

5.7 COMPONENT CYCLIC OR TRANSIENT LIMIT

5.7.1 The components identified in Table 5.7-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.7-1.

5.6 Fuel Storage

CRITICALITY

5.6.1 a. The spent fuel storage racks are designed and shall be maintained with:

1) $k_{eff} \leq 0.95$ if fully flooded with unborated water as described in Section 9.1 of the FSAR; and

2) A nominal 13.5" center to center distance between fuel assemblies placed in the spent fuel storage racks.

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

1) $k_{eff} \leq 0.95$ if fully flooded with unborated water as described in Section 9.1 of the FSAR; and

2) $k_{eff} \leq 0.98$ if moderated by aqueous foam as described in Section 9.1 of the FSAR; and

3) A nominal 21" center to center distance between fuel assemblies placed in the new fuel storage racks.

DRAINAGE

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

CAPACITY

5.6.3 The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1418 fuel assemblies.

5.7 COMPONENT CYCLIC OR TRANSIENT LIMIT

5.7.1 The components identified in Table 5.7-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.7-1.

ATTACHMENT II
NO SIGNIFICANT HAZARDS ANALYSIS

Duke Power Company has reviewed the proposed changes utilizing the criteria specified in 10CFR50.92 and has determined that the proposed changes do not involve a Significant Hazards Consideration pursuant thereto, for the reasons discussed below.

1. The proposed changes do not involve a significant increase in the probability or consequences of an accident previously evaluated.

There is no increase in the probability or consequences of an accident in the new fuel vault since the only credible accidents for this area are criticality accidents and it has been shown that calculated, worst case K_{eff} for this area is ≤ 0.95 under all conditions.

There is no increase in the probability of a fuel drop accident in the Spent Fuel Storage Pool since the mass of an assembly will not be affected by the increase in fuel enrichment. The likelihood of other accidents, previously evaluated and described in Section 9.1.2 of the FSAR, is also not affected by the proposed changes. In fact, it could be postulated that since the increase in fuel enrichment will allow for extended fuel cycles, there will be a decrease in fuel movement and the probability of an accident may likewise be decreased. There is also no increase in the consequences of a fuel drop accident in the Spent Fuel Pool since the fission product inventory of individual fuel assemblies will not change significantly as a result of increased initial enrichment. In addition, no change to safety related systems is being made. Therefore, the consequences of a fuel rupture accident remain unchanged. In addition, it has been shown that k_{eff}, is ≤ 0.95, under all conditions. Therefore, the consequences of a criticality accident in the Spent Fuel Pool remain unchanged as well.

2. The proposed changes do not create the possibility of a new or different kind of accident from any accident previously evaluated.

The proposed changes do not create the possibility of a new or different kind of accident since fuel handling accidents(fuel drop and misplacement) are not new or different kinds of accidents. Fuel handling accidents are already discussed in the FSAR for fuel with enrichments up to 4.0 weight %. As described in Section VI.9 of Attachment IV, additional analyses have been performed for fuel with enrichment up to 5.00 weight %. Worst case misloading accidents associated with the new loading patterns were evaluated. It was shown that the negative reactivity provided by soluble boron maintains $k_{eff} \leq 0.95$.

3. The proposed changes do not involve a significant reduction in the margin of safety.

The proposed change does not involve a significant reduction in the margin of safety since, in all cases, a $k_{eff} \leq 0.95$ is being maintained. Criticality analyses have been performed which show that the new fuel storage vault will remain subcritical under a variety of moderation conditions, from fully flooded to optimum moderation. As discussed above, the Spent Fuel Pool will remain sufficiently subcritical during any fuel misplacement accident.

ATTACHMENT III
ENVIRONMENTAL IMPACT ANALYSIS

Pursuant to 10CFR51.22 (b), an evaluation of the proposed amendments has been performed to determine whether or not it meets the criteria for categorical exclusion set forth in 10CFR51.22 (c)9 of the regulations. The proposed amendment does involve changes in the use of facility components located within the restricted area as defined in 10CFR20, and changes some surveillance requirements however, the proposed amendment does not involve:

1) A significant hazards consideration.

As discussed in Attachment II of this submittal, the proposed amendments do not involve an unresolved safety question since the changes do not; 1) Increase the probability or consequences of an accident previously evaluated, 2) Create a new or different kind of accident than one previously evaluated, or 3) Involve a reduction in the margin of safety.

2) A significant change in the types or significant increase in the amounts of any effluents that may be released offsite.

An increase in the fuel enrichment limit or storage configuration would not change the types of effluents created since the use of that material is not being changed. The amounts of effluents to be released offsite also, would not be changed since, the inventory of fission products contributing to offsite dose would not be increased significantly with an increase in fuel enrichment or burnup, and the mechanisms used to control offsite releases are not being changed.

3) A significant increase in the individual or cumulative occupational radiation exposure.

Increases in individual or cumulative occupational exposure would not be expected with this change since no safety systems, or related procedural controls associated with the handling or storage of fuel are being changed. These safety controls ensure that sufficient water level is maintained in the pool to provide adequate radiation shielding and that $k_{eff} \leq 0.95$ under all storage conditions.

Attachment IV

Duke Power Company
Catawba Nuclear Station

Fuel Enrichment Upgrade

License Amendment Request
and
Supporting Safety Analysis

Table of Contents

1 INTRODUCTION

This submittal represents Duke Power Company's formal request for approval of a license amendment which establishes restricted loading patterns and associated burnup criteria for placement of new and irradiated fuel into the Catawba spent fuel storage pools. Analyses performed in support of this submittal demonstrate that the use of these configurations for storing fuel with initial enrichments of up to 5.00weight% U-235 will maintain sufficient criticality safety margins. This amendment will allow for maximum utilization of the fuel storage racks and will provide additional flexibility in the area of reactor core reload analysis and design.

All enrichments in this submittal are nominal values. As built variations of up to 0.05 weight% U-235 above the nominal enrichments are acceptable. This uncertainty is accounted for in the analyses.

The methodology used to analyze the fuel loading patterns and generate the various burnup criteria discussed above is identical to that submitted for NRC approval in the request for License Amendment for the McGuire Nuclear Station dated . une 13, 1994. This methodology was specifically developed for spent fuel burnup credit applications and is based on the CASMO and SIMULATE computer codes. Formal approval of this methodology was requested in the above referenced submittal. Therefore, this License Amendment Request for the Catawba Nuclear Station relies on the approval of Duke Power Company's burnup credit methodology, and as such, references this methodology where appropriate.

II BACKGROUND INFORMATION

The spent fuel storage requirements at the Catawba Nuclear Station have remained unchanged since its initial operation in 1985. The total spent fuel storage capacity for each of the two independent spent fuel pools is 1418 fuel assemblies. Fuel is stored in 28 free standing fuel storage modules utilizing a 13½" center-to-center spacing between individual fuel storage cells. The current license includes a maximum allowable fuel enrichment of 4.0weight% U-235. Since each reactor core design is individually licensed, this limit is specifically applicable to the new fuel storage vaults and the spent fuel storage pools.

Plans are underway to utilize future reload batches which incorporate fuel assemblies with enrichments in excess of the current 4.0weight% limit. As higher enrichments are used and then discharged, it will become more important to efficiently utilize the available spent fuel storage locations. The pending increase in fuel enrichments and the need to continue utilizing 100% of the spent fuel storage locations, represents the basis for this submittal.

III JUSTIFICATION

The primary reasons for this license amendment request are to provide additional flexibility to the reload design efforts at Duke, and to maximize the efficiency of fuel storage cell utilization in the spent fuel pools.

Duke continuously performs extensive economic sensitivity studies to evaluate variations in cycle length, reload batch size, and reload batch enrichments for all of its nuclear units. Duke's ongoing goal is to develop the most efficient core designs for each operating cycle. Recent efforts in this area have indicated the desirability of a 459 EFPD cycle for both Catawba Units. Reload batches containing fuel with enrichments up to 4.75 weight% are being evaluated for these extended cycles.

From the standpoint of maximizing storage cell efficiency, the proposed loading patterns were developed to eliminate the need for empty cells, thereby making use of all storage cells. By taking advantage of low reactivity "filler" fuel, otherwise empty storage cells are available for spent fuel storage. Additionally, the increased enrichment limit will allow for reduced batch sizes, which will reduce the rate at which assemblies are discharged to the spent fuel pool. These factors will help delay the need for costly expansion of spent fuel storage capacity at the Catawba Nuclear Station.

Preliminary studies have indicated dry storage to be the most likely alternative for providing additional on-site storage capacity as the Catawba pools approach full capacity. Based on current discharge projections, Duke will be forced to install additional capacity at Catawba by the year 2006. Experience at Duke's Oconee Nuclear Station shows that expenditures of up to $12 Million would be necessary to initiate such a facility with annual costs being in the range of $2 million. Delaying these startup and annual costs by freeing up otherwise unavailable storage cells would represent significant economic savings for Duke Power Company. Additionally, once the storage facility is operational, an increased assembly discharge rate would force an accelerated annual rate of fuel movement into the storage facility, representing additional economic penalties.

IV SCHEDULE

Current plans for a transition to the 459 EFPD cycle length at the Catawba Nuclear Station are aimed at Unit 2, Cycle 8 which is currently scheduled for a December 1995 startup. Based on very limiting constraints placed on Duke's normal lead time requirements for planning, detailed design, licensing, enrichment, and fabrication of fuel batches, approval of the higher enrichment capability for the Catawba facility would be needed by June, 1995 at the latest. A delayed approval of this amendment request beyond this date would force Duke Power to delay movement to this more economic 459 EFPD cycle length.

V. GENERAL DESCRIPTION OF AMENDMENT REQUEST/SUBMITTAL

V.1 Introduction

The primary purpose of this submittal is to demonstrate sufficient analytical justification for modifying technical specifications and FSAR sections currently applicable to new and irradiated fuel storage at the Catawba Nuclear Station (CNS). Areas proposed for modification are the limitations and restrictions associated with 1) storage of unirradiated fuel in auxiliary building new fuel storage vaults, and 2) storage of irradiated and un-irradiated fuel in both spent fuel pools.

The fuel storage rack designs for the new fuel storage vaults and the spent fuel storage pools of both CNS units are identical. The spent fuel storage racks are the original storage racks designed and fabricated by Lamco Industries and installed when the plant was constructed between 1975 and 1985. Consequently all analytical methods and results discussed in this document are applicable to either unit as are the resulting procedural and technical specification modifications. Additionally, the most reactive of all fuel types currently in use, or in storage at any Duke Power nuclear facility, was used in developing the proposed requirements and limitations. Eventual approval of this amendment request should therefore apply to both units.

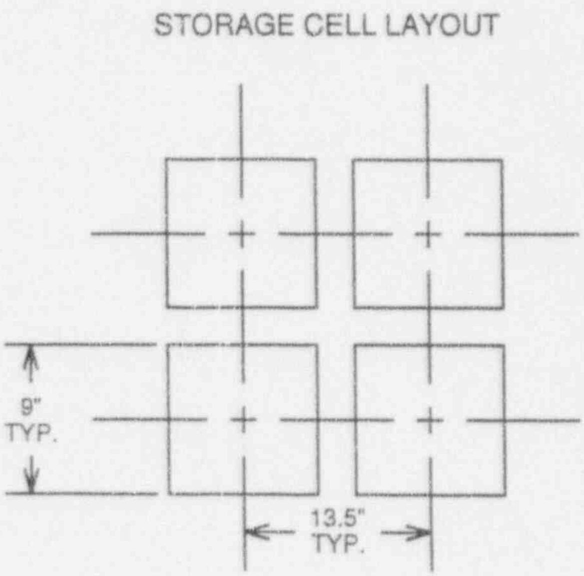
V.2 New Fuel Storage Vaults

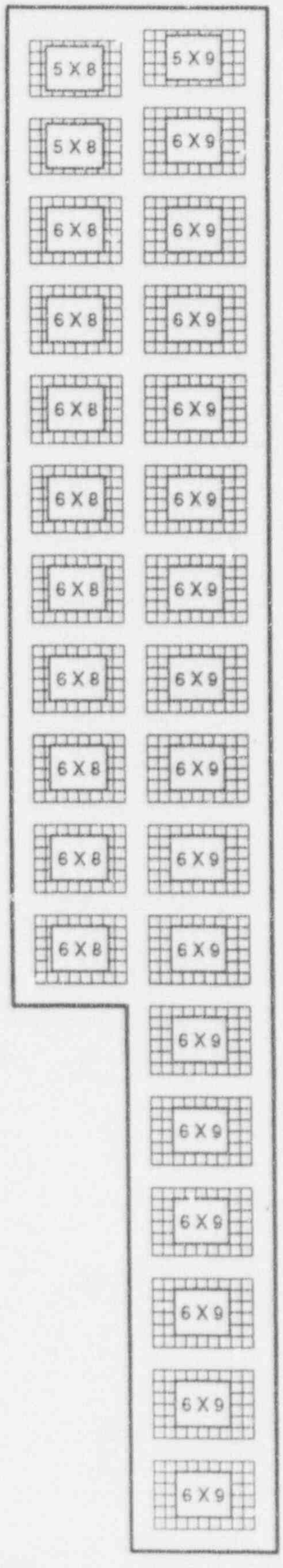
The new fuel storage vaults which are used for temporary dry storage of unirradiated reload fuel are built on 21 inch centers and are currently licensed for maximum fuel enrichments of 4.0weight% U-235. To accommodate anticipated increases in individual and/or batch average enrichments that will exceed this 4.0weight% limit, analytical methods described in Section 4.3.2.6 of the FSAR were used to demonstrate that fuel containing up to 5.00weight% U-235 can be safely stored in these fuel racks. No other restrictions beyond this enrichment limit are applicable to storage in the new fuel vaults for the fuel designs analyzed. Discussion of the methods used to justify this increased limit can be found in section VI.5 and the resulting proposed FSAR modifications can be found in section VIII.2. No technical specifications are applicable to the new fuel storage vaults.

V.3 Spent Fuel Storage Pools

The basic spent fuel storage rack arrangement for units 1 and 2 is shown in figure 5-1 on the following page. A schematic of the individual storage cell configuration is also provided.

Figure 5-1
Catawba Spent Fuel Pool Layout





The spent fuel pool is designed and used for both normal, long term storage of permanently discharged fuel as well as temporary storage of new or partially irradiated fuel stored during the core fuel off load and shuffle. The individual fuel storage cells are made of stainless steel and are spaced at 13½ inches. No explicit poison material is used in the cell design. The pool has a capacity of 1418 locations. As is the case with the new fuel vaults, the storage cells in the spent fuel pool are currently limited to fuel with a maximum initial enrichment of 4.0weight%.

Unrestricted Storage

Fuel was originally stored in the spent fuel pool with unrestricted storage for all fuel assemblies as evidenced by the lack of a Technical Specification concerning fuel storage.

To accommodate the projected as-built fuel enrichment increases discussed in section III, the spent fuel storage racks have been re-analyzed to allow for an increase in the maximum allowable initial enrichment of the stored fuel. This analysis allows for unrestricted storage (i.e. no limits on storage location or pattern) of new or irradiated fuel having initial enrichments up to 4.05weight %.

Additional analysis was performed to develop burnup criteria for restricted storage of irradiated assemblies with initial enrichments in excess of the 4.05weight% limit stated above. These criteria are summarized in section VII.2. Expressed as specific burnup vs. enrichment limits, these criteria were generated utilizing reactivity equivalencing (burnup credit) techniques. An overview of the specific methodology developed by Duke Power Company for this application is provided in section VI.6. Since this submittal references the methodology submitted in the Request for License Amendment for the McGuire Nuclear Station dated June 13, 1994, refer to Appendix B of the McGuire submittal for a more detailed discussion of this methodology. Specific changes for application of this methodology to the Catawba Nuclear Station are detailed in Appendix B of this submittal.

New or irradiated assemblies which meet the requirements for unrestricted storage will be referred to as "unrestricted" fuel throughout this submittal. New or irradiated assemblies which do not meet the above requirements for unrestricted storage must be placed in a restricted loading pattern. Restricted storage requirements are discussed below. Proposed technical specifications governing the requirements for spent fuel pool storage are included in section VIII.1.

Restricted Storage

In order to accommodate those assemblies (up to the proposed new fuel vault nominal enrichment limit of 5.00weight%) which do not qualify for unrestricted storage, criticality analysis was performed to identify a critically safe, yet simple, loading pattern restriction. While several configurations were considered, the loading pattern proposed utilizes very simple administrative control procedures and allows for maximum utilization of storage space in the spent fuel pools. Figure 5-2 illustrates the proposed storage restriction which limits storage of these unqualified assemblies to 3 of every 4 cells. Assemblies requiring

placement into this storage configuration will be referred to as "restricted" fuel throughout this submittal. Also shown is the requirement that the fourth location of this pattern contain an appropriately qualified filler assembly. The single criteria used in selecting the filler assembly is that the reactivity of the system, including three unqualified assemblies of the maximum allowable reactivity, is such that critically safety is maintained.

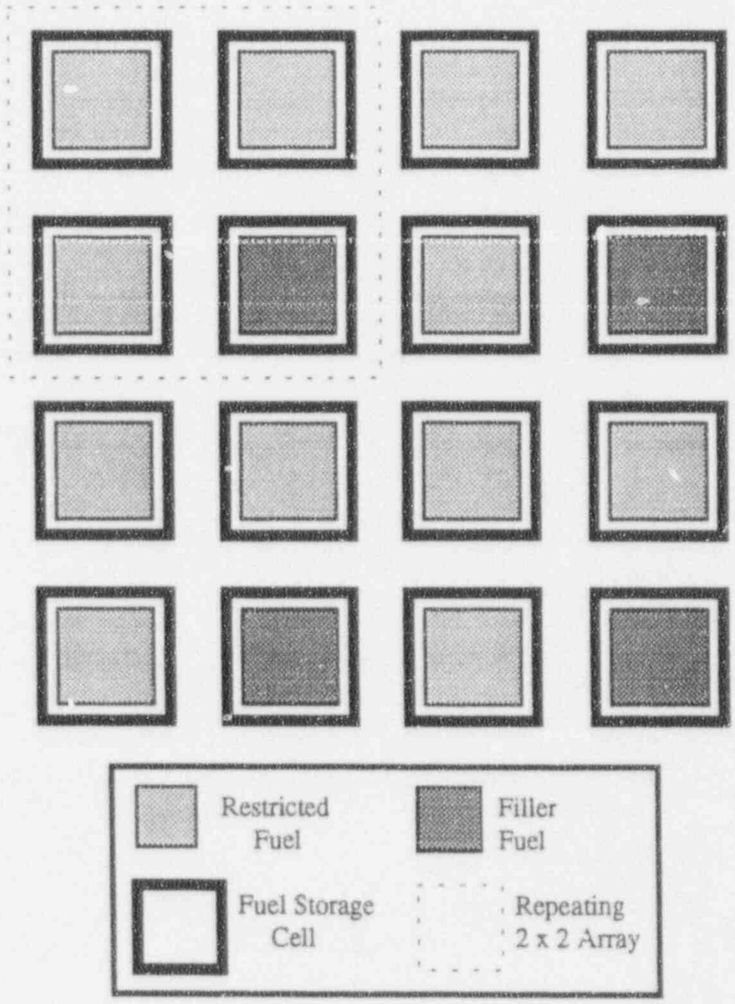


Figure 5-2
<u>Restricted Storage Loading Pattern</u>

Discussion of the analysis which justifies the above loading pattern and the specific selection criteria for the filler assemblies is included in sections VI.6 and VII.2 respectively. Expressed as specific burnup versus enrichment limits, these criteria were also generated using reactivity equivalencing (burnup credit) techniques as discussed in the previous section. Assemblies qualified for, and selected as fillers, will be referred to as "filler" fuel throughout this submittal. In the event that enough filler assemblies are not available for use, empty storage cells may be used in place of appropriately qualified filler assemblies.

To preclude a fuel misloading accident, an appropriate quantity of these filler assemblies will be in place in an area of the spent fuel pool designated for restricted/filler fuel storage prior to placement of any restricted assemblies. This and other administrative controls are discussed further in section IX. Proposed technical specifications governing this and all other requirements for restricted storage are included in section VIII.1.

A summary description of the fuel categories is provided in Table 5-1.

Table 5-1
Fuel Category Summary

Fuel Category	Fuel Category Description	Loading Restriction
Unrestricted	New or Irradiated fuel qualified for unrestricted storage	None
Restricted	New or Irradiated fuel requiring restricted storage	75% with filler assemblies or empty cells
Filler	Irradiated fuel qualified for use as filler assemblies	Use as filler assemblies with restricted fuel

To provide added flexibility for the storage of spent fuel beyond the conditions described above, additional criteria will be included in the technical specifications to allow for specific analysis, using NRC approved methodology, as an alternative method for determining storage requirements. Additionally, an empty storage cell will be allowed in place of any designated fuel location.

V.4 Region Interface Restriction

Once the unrestricted loading criteria and restricted loading pattern requirements were established, a criticality assessment at the loading pattern interface between any Unrestricted and Restricted areas of the spent fuel pool was performed. The methodology used, and the results of this assessment are summarized in sections VI.7 and VII.3 respectively. A more detailed discussion is included as Appendix A. These results were then used to determine specific interface restrictions necessary to maintain criticality safety at the interface. The specific restrictions are summarized in section VII.3 while the proposed technical specifications governing these restrictions are included in section VIII.1.

V.5 Summary

This licensing document represents a request for amendments to the Catawba technical specifications related to fuel storage under several anticipated conditions/scenarios. Figure 5-3 below illustrates in summary form the various storage configurations called for in the proposed technical specification amendments.

All current and proposed new and spent fuel storage requirements and restrictions are summarized in Table 5-2 along with a specific reference to the applicable current or proposed technical specifications. Details of the requested technical specification changes are provided in section VIII.1.

Figure 5-3
Proposed Allowable Storage Configurations

Fresh Fuel Equivalent Enrichment	Loading Pattern
4.05 - 5.00 Equivalent Weight %	Restricted Fuel, Restricted Fuel, Restricted Fuel, Filler Fuel **Restricted Loading Pattern with Fillers**
Less Than 4.05 Equivalent Weight %	Unrestricted Fuel, Unrestricted Fuel, Unrestricted Fuel, Unrestricted Fuel **Unrestricted Loading Pattern**

Table 5-2

Current and Proposed
CNS Fuel Storage Limits and Restrictions

New Fuel Storage Vault							
Fuel Category	Fuel Condition	Current Limits/Requirements	Current Load Pattern	Current Reference	Proposed Limits/Requirements	Proposed Load Pattern	Proposed Reference
New Fuel Vault	New Fuel	Max. Init. Enr. 4.0%	100%	FSAR: 9.1.1.3	Max. Init. Enr. 5.00%	100%	FSAR: 9.1.1.3

Spent Fuel Pool							
Fuel Category	Fuel Condition	Current Limits/Requirements	Current Load Pattern	Current Reference	Proposed Limits/Requirements	Proposed Load Pattern	Proposed Reference
Unrestricted	New or Irradiated Fuel	Max. Init. Enr. 4.0%	100%	FSAR: 9.1.2.3.1	Max. Init. Enr. 4.05% or Qualifying Burnup*	100%	FSAR: 9.1.2.3.1
							New T.S. 3.9.13a
Restricted	New or Irradiated Fuel (Does Not Meet Unrestricted Limits)	N/A	N/A	N/A	Max. Init. Enr. 5.00%	75% With Filler Assemblies	FSAR: 9.1.2.3.1
							New T.S. 3.9.13b
Filler	Filler Assemblies	N/A	N/A	N/A	Qualifying Burnup*	25% as Fillers	New T.S. 3.9.13b

* Qualifying Burnups

Unrestricted Fuel:	Proposed Unrestricted Curve - See Figure 7-1 or T. S. Table 3.9-1
Filler Fuel:	Proposed Filler Curve - See Figure 7-1 or T. S. Table 3.9-2

VI METHODOLOGY OVERVIEW

VI.1 General Purpose

This section provides an overview of the analytical methods and associated assumptions used to justify the proposed amendments to the Catawba Nuclear Station technical specifications and related modifications to the FSAR. The only parameters that must be reviewed and analyzed relative to previously approved requirements are the reactivity increase due to the higher enrichments, and the thermal loading increase due to the anticipated higher discharge burnups. Review or modification of currently applicable seismic, structural, radiological, or environmental analyses is not considered necessary as a result of these proposed changes. The methodologies described in Appendix B, and Section 4.3.2.6 of the FSAR, were used for performing the necessary criticality analyses to demonstrate sufficient criticality safety margins.

VI.2 Applicable Codes, Standards, and Regulations

The following listing represents those codes, standards, and regulations which are considered to be applicable to criticality safety as it relates to new and irradiated fuel storage. These were used as general guidelines in performing the necessary analyses.

- 10CFR Part 50, General Design Criterion #62 - "Prevention of Criticality in Fuel Storage and Handling"
- NUREG - 0800, USNRC Standard Review Plan, Sections 9.1.1 & 9.1.2
- ANSI/ANS - 57.2 - 1983, "Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Plants"
- ANSI/ANS - 57.3 - 1983, "Design Requirements for New LWR Fuel Storage"
- NRC Regulatory Guide 1.13 - Dec. 1975, "Spent Fuel Storage Facility Design Basis"
- NRC Letter from Brian K. Grimes to All Power Reactor Licensees, Revision 1 1/18/79, "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications"
- ANSI/ANS-8.17-1984, "Criticality Safety Criteria for the Handling, Storage and Transportation of LWR Fuel Outside Reactors"
- ANSI/ANS-8.1.1-1983, "American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors"

Additionally, NRC Regulatory Guide 1.13 and ANSI/ANS - 57.2 were used as guidance for performing spent fuel pool decay heat removal assessments.

VI.3 Design Bases and General Assumptions

Consistent with previous license applications and amendments and in compliance with the requirements of the above regulations and guides, the criticality analyses performed to support the proposed FSAR and Technical Specification changes are based on the requirement that there is a 95% probability at a 95% confidence level that the effective multiplication factor (k_{eff}) of the fuel assembly array will be less than 0.95 (0.98 for new fuel vault under optimum moderation conditions). The calculated k_{eff} value must also include all appropriate biases and uncertainties (mechanical, method, etc.).

As an additional safety margin to those included in the design bases above, several conservative assumptions related to the physical conditions, procedural controls, and neutron behavior are incorporated into the criticality analyses. These ensure that the actual degree of subcriticality provided by the resulting safety limits will always be less than the analyzed value. The generally applicable of these assumptions are listed below:

- All pool storage configurations are assumed to be flooded with pure, unborated water at the temperature within the design limits of the pool which yields the largest reactivity.

- Each storage configuration analyzed is assumed to be a 2 dimensional infinite array with no axial or radial leakage,

- Fuel assemblies are assumed to be the most reactive of all fuel types stored at any Duke Power facility,

- No credit is taken for burnable poisons, control rods, or other fuel assembly control components

The above assumption concerning the 2 dimensional infinite array is consistent with assumptions used by the vendor for other burnup credit analyses. The vendor studied the differences between a detailed 3-D model which included the effects of axial burnup, and an infinite 2-D model which did not. The conclusion reached by the vendor was that the reactivity differences were relatively small and that the infinite 2-D model conservatively bounded the results of the 3-D model with axial burnup effects for the typical range of minimum burnup requirements.

Additional assumptions specifically applicable to the new fuel storage vaults are as follows:

- Water density is varied to determine optimum flooding condition

- No supplemental neutron poisons are assumed to be present.
- All assemblies are assumed to be un-irradiated with a maximum enrichment value of 5.10weight% U-235.

VI.4 Computer Code / Methodology Description

The SCALE system of computer codes was used to perform new fuel vault reactivity calculations and to model the boundary conditions that will exist at the fuel storage region interface in the spent fuel pool. This methodology utilizes three dimensional Monte Carlo theory and is particularly applicable to the widely-spaced fresh fuel lattices which are typical of new fuel storage vaults. Specifically, this analysis method used the CSAS25 sequence contained in Criticality Analysis Sequence No. 4 (CSAS4). CSAS4 is a control module contained in the SCALE-3 system of codes. The CSAS25 sequence utilizes two cross section processing codes (NITAWL and BONAMI) and a 3-D Monte Carlo code (KENO V.a) for calculating the effective multiplication factor for the system. The 123 Group GMTH cross section library was used exclusively for this analysis.

The SCALE-3 System of Codes is certified for use and incorporated into the QA-certified library on Duke mainframe node PRDB. CSAS4 and the 123 Group GMTH library have been further benchmarked for criticality analysis via comparison with critical experiments to determine the applicable biases and uncertainties.

The burnup credit approach to fuel rack criticality analysis requires calculation and comparison of reactivity values over a range of burnup and initial enrichment conditions. In order to accurately model characteristics of irradiated fuel which impact reactivity, a criticality analysis method capable of evaluating arrays of these irradiated assemblies is needed. In this license submittal, the advanced nodal method combining CASMO-3/TABLES-3/SIMULATE-3 is used for this purpose. CASMO-3 is an integral transport theory code, SIMULATE-3 is a nodal diffusion theory code, and TABLES-3 is a linking code which reformats CASMO-3 data for use in SIMULATE-3. This methodology permits direct coupling of in-core depletion calculations and resulting fuel isotopics with out-of-core storage array criticality analysis. While the CASMO-3/SIMULATE-3 methodology has been approved for use in nuclear design analysis (DPC-NE-1004A, November 1992), the License Amendment Request for the McGuire Nuclear Station date June 13, 1994 extends this methodology to criticality analysis for spent fuel pools. Similar application of this methodology to spent fuel pool analysis has been previously approved by the NRC. A detailed description of the benchmarking and analysis of Duke Power's application of this burnup credit methodology is provided in Appendix B of the McGuire License Amendment Request. Appendix B of this submittal details the components of the methodology specific to the Catawba Nuclear Station.

VI.5 Fuel Storage Vault Methodology

The new fuel vaults at the Catawba Nuclear Station are designed exclusively for temporary storage of fresh unirradiated fuel. ANSI/ANS - 57.3 - 1983, Design Requirements for New LWR Fuel Storage, simply requires that k_{eff} be maintained at less than or equal to 0.98 under optimum moderation conditions. Analysis used to determine k_{eff} in these storage racks must therefore assume maximum allowable fuel enrichments. Criticality control relies strictly on the wide spacing between individual storage locations and a specified upper limit for as-built fuel assembly enrichment. This upper limit is specified in the Catawba FSAR Section 9.1.1.3. The absence of other factors such as soluble boron, fixed poisons, burnup effects, and fission products makes for a relatively straightforward analysis. The normally dry condition of the fuel vaults introduces the possibility of water intrusion. Consequently, full density water flooding was conservatively modeled as a normal condition in this analysis. Other less likely events which could create low density moderator conditions (i.e. foaming, misting, etc.) dictated analysis of optimum moderator conditions as an accident condition. Vault criticality analysis is therefore performed as a function of both enrichment and moderator density.

As discussed in section VI.4, the KENO Va model was used to determine the acceptability of the proposed 5.00weight% upper fuel enrichment limit for vault storage. The analysis assumed a 100% cell loading pattern and, consequently, no loading pattern restrictions are needed or applicable in the new fuel storage vault. Results of this analysis are summarized in section VII.1.

VI.6 Burnup Credit Methodology

In order to justify storage of fuel at or near the proposed upper enrichment limit established for the new fuel vaults, the concept of burnup credit was utilized in the spent fuel pools. As discussed in section VI.4 above, the variable effects of fission product poisoning, fissile material production and utilization and other related effects are accurately modeled with the CASMO-3/TABLES-3/SIMULATE-3 methodology. Applicable biases and uncertainties are developed and become inputs to the methodology.

The basic approach is to use reactivity equivalencing techniques to construct burnup versus enrichment curves which represent equivalent and acceptable reactivity conditions over an applicable range of burnups and initial enrichments. The first curve establishes the burnup requirements for unrestricted storage or 100% cell utilization. Assemblies which fall short of these burnup requirements will require storage restrictions. A second curve is then generated to reflect the minimum requirements of a restricted storage pattern for the more reactive fuel assemblies which do not qualify for unrestricted storage.

To maximize the utilization of the storage locations while accommodating these higher enriched assemblies, the analysis also focuses on determining a loading pattern which mixes the storage of projected restricted assemblies with appropriately selected filler

assemblies. Reactivity limits placed on these filler assemblies are driven by the maximum reactivity of the restricted assemblies that will be stored with them such that the reactivity of the combined loading pattern meets the design criteria. Once the reactivity requirements of these fillers is determined, the second burnup curve which represents this reactivity level is constructed. This curve is then used for qualification of the filler assemblies.

Generation of the applicable burnup credit curves requires a two part calculation process. The first part is to create two types of reactivity versus burnup curves. The first type of curve defines the maximum reactivity for the spent fuel pool such that the appropriate design criteria are met including allowances for both calculational uncertainties and manufacturing tolerances. The second type of curve represents the reactivity versus burnup for a particular enrichment, and is generated for the range of enrichments. The intersection of the maximum design reactivity curve with the multiple enrichment curves provides data points for the second part of the process.

The second part of the process generates the burnup versus initial enrichment curves by plotting the burnup where the maximum design reactivity equals the reactivity of a particular enrichment for each enrichment. Two curves are generated which represent the qualification criteria for a particular storage configuration. Each burnup versus enrichment curve shows the minimum amount of burnup required to qualify fuel for storage in the applicable loading pattern as a function of the fuel's initial enrichment. As discussed in section V, there are two storage configurations, normal 100% storage of unrestricted fuel and 75% storage of unrestricted fuel with 25% filler fuel (See figure 5-2). The fresh fuel has an enrichment limit of 5.00weight%. These curves and supporting data are provided in section VII.2 while additional details of the methods used to generate these curves are provided in Appendix B of the McGuire License Amendment Request, June 13, 1994.

VI.7 Region Interface Methodology

As was the case for the new fuel vault criticality analysis, the KENO Va code was used to analyze the boundary condition that is created between the restricted and unrestricted storage configurations to assure that the storage configurations at the boundary do not cause an increase in the nominal k_{eff} for the individual regions. This analysis was performed to determine if there was a need for new administrative restrictions at the boundaries.

Other related assumptions and more detailed discussions are contained in appendix A. The results of the boundary condition analyses are summarized in section VII.3.

VI.8 Spent Fuel Pool Cooling Considerations

Initial fuel enrichment can cause slight differences in decay heat due to the variation in fission product yield fractions for the various actinides. Also, an expected and desirable result of an increase in allowable fuel enrichments for the Catawba Nuclear Station would be a corresponding increase in the discharge burnups. Therefore, the effects of both increased enrichment values and increased discharge burnups were evaluated on the spent fuel pool.

Decay heat was evaluated with two methods. First, the certified Duke Power Company computer code, PANTHER, was used to calculate decay heat based on estimates of initial enrichments and discharge burnups. This computer code uses the calculational methodology outlined in ANSI/ANS-5.1-1979. The code automatically varies the fission power fraction associated with each actinide throughout burnup. Second, the computer code ORIGEN2 was used to calculate decay heat.

Following the guidelines in the Standard Review Plan, Section 9.1.3, decay heat was calculated for "maximum" and "normal" conditions using the methodologies stated above. With the PANTHER computer code, decay heat f : the maximum case was calculated to be $4.7 \cdot 10^7$ BTU/Hr, and for the normal case was calculated to be $1.85 \cdot 10^7$ BTU/Hr. Of course, the normal spent fuel pool decay heat is not nearly this high; in this calculation, both the Standard Review Plan definitions of "maximum" and "normal" are being used, as well as the criteria for evaluation. With the ORIGEN2 computer code, decay heat for the maximum case was calculated to be $4.33 \cdot 10^7$ BTU/Hr.

Again using the Standard Review Plan criteria for allowable number of Spent Fuel Cooling trains in service in the evaluation of pool temperature, the spent fuel pool equilibrium temperature was evaluated for both the maximum and normal cases. In this evaluation, tested values for Spent Fuel Pool Cooling System heat exchanger UAF were used. The equilibrium spent fuel pool temperature for both the maximum and normal decay heat cases was calculated to be below 140 ^{O}F. The maximum decay heat case assumed two trains of cooling in service, while the normal decay heat case assumed only one train of cooling in service. ANSI/ANS-57.2 provides a guideline value of 140 ^{O}F for all cases, whereas the Standard Review Plan provides a guideline value of 140 °F for the normal decay heat case, and a value of below boiling for the maximum decay heat case. The Catawba Safety Evaluation Report, NUREG-0954, notes that 150 ^{O}F is acceptable for conditions of maximum decay heat, while the value of 140 ^{O}F is applied to conditions of normal decay heat. The calculated results for Catawba Nuclear Station spent fuel pool temperature are below all of the above stated guideline values with the initial enrichment upgrade and the extended burnup values.

Catawba Nuclear Station was also licensed to be capable of maintaining water inventory above the fuel assemblies for 72 hours in a Standby Shutdown Facility event with required flow from the spent fuel pool to the Reactor Coolant System pump seals. A calculation was performed which modeled the depletion flow from the spent fuel pool to the RCS pumps, decay heat, heatup rate, boiloff rate after boiling begins, minimum spent fuel pool water inventory based on a maximum number of assemblies residing in the spent fuel pool,

etc. With the increased initial enrichments and extended burnups, boiloff to the top of the fuel assemblies will not occur in this event until well after the allowable 72 hours.

The computer code PANTHER is used frequently at Catawba and McGuire Nuclear Stations to predict shutdown decay heat. This computer code has always yielded accurate but conservative results. Hence, experience demonstrates that the calculations performed for this analysis are conservative and reliable. Hence, the enrichment upgrade and extended burnups will not adversely affect the licensing commitments of Catawba Nuclear Station.

VI.9 Accident Conditions

In addition to the several abnormal conditions considered as part of the original safety assessment for the spent fuel storage rack, this proposed enrichment upgrade also considered a fuel misloading accident condition. In this case, the excess negative reactivity provided by the soluble boron in the spent fuel pool water is sufficient to maintain the pool configuration at or below an acceptable k_{eff} of 0.95. The only type of accident necessary of consideration was the failure to provide appropriate filler assemblies for fuel above 4.05weight% actual or equivalent enrichment. The analysis performed to evaluate this misloading accident was based on misloading unirradiated, 5.00weight% fuel assemblies into the filler locations required by the technical specifications. Results of this analysis are provided in section VII.4.

VII GENERAL RESULTS OF ANALYSES

This section provides the basic results of the various analyses performed in support of the proposed FSAR and Technical Specification changes. Additional discussion of the supporting analytical techniques can be found in the appendices of the McGuire License Amendment Request, June 13, 1994.

VII.1 New Fuel Vaults

The calculated worst case k_{eff} for a fuel assembly with the maximum enrichment of 5.00weight% U-235 under optimum moderation conditions in the Catawba new fuel vault is shown below.

$$k_{eff} = 0.95861$$

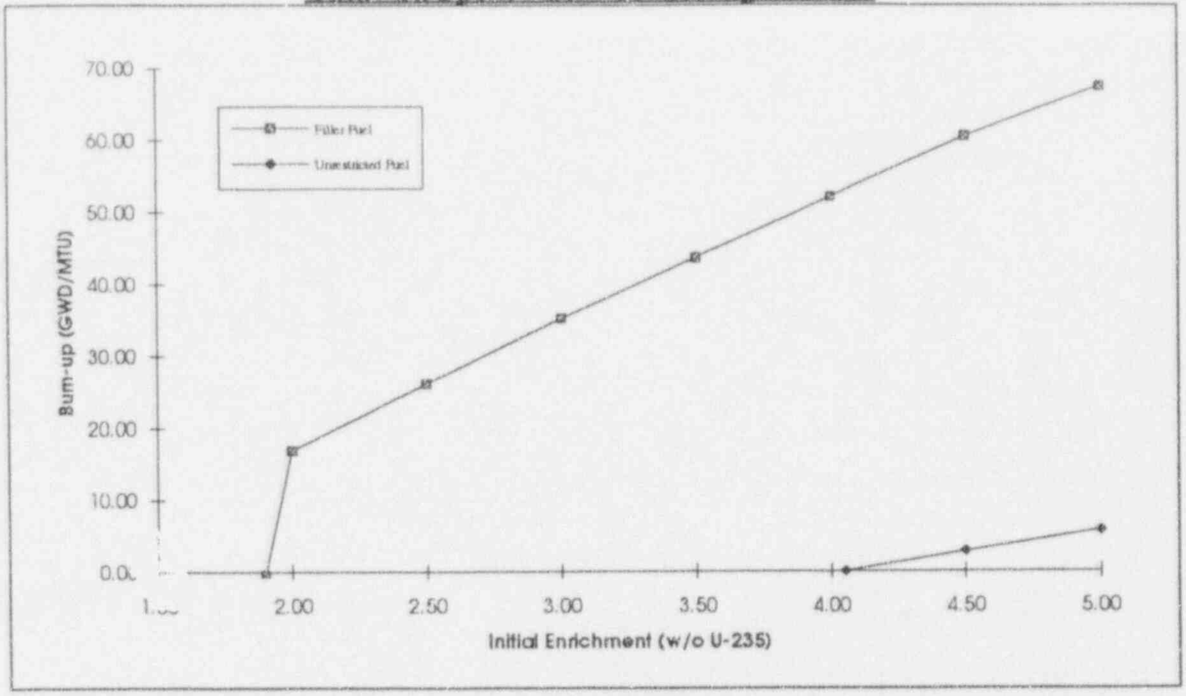
This value was specifically calculated for the Westinghouse Optimized Fuel Assembly (OFA) design which has been shown to be the most reactive fresh fuel of all fuel types stored at any Duke Power facility. This value also includes geometrical and material biases and uncertainties at a 95 percent probability and a 95 percent confidence level as required to demonstrate criticality safety. Fuel cage tolerances are included in the geometrical uncertainty.

As specified in ANSI/ANS 57.3, the maximum k_{eff} value in LWR new fuel storage vaults shall be less than or equal to 0.98 under optimum moderator conditions. The analytical result shown above indicates that this criteria has been met.

VII.2 Fuel Assembly Burnup Requirements

The burnup credit criticality analysis results are summarized by the two burnup curves shown in figure 7-1. These curves define the burnup requirements for the two fuel loading configurations allowed in the Catawba spent fuel pools. Specific data points generated by the criticality analysis and used to create these burnup curves are shown in Table 7-1.

Figure 7-1
Catawba Spent Fuel Pool Storage Curves



Unrestricted Fuel	Minimum requirements for unrestricted (100%) fuel storage. Assemblies not meeting 100% storage requirements must be stored in a 75% loading pattern with qualified filler assemblies or empty cells
Filler Fuel	Minimum requirements for filler assemblies

Table 7-1
Catawba Spent Fuel Pool
Storage Qualification Requirements

Enrichment (w/o) ->	1.90	2.00	2.50	3.00	3.50	4.00	4.05	4.50
Unrestricted Burnup (GWD/MTU) ->	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.73
Filler Burnup (GWD/MTU) ->	0.00	16.83	26.05	35.11	43.48	51.99	52.83	60.36

VII.3 Region Interface Restrictions

As discussed earlier in section V and summarized in table 5-1, fuel will be stored in the spent fuel pools according to two different loading configurations to accommodate fuel above and below the 4.05weight% equivalent enrichment value. The boundary conditions between these configurations was analyzed to determine the worst geometry configuration for neutronic coupling between the cells of differing enrichments. In this process it was determined that provided that the border between regions is a row of alternating filler assemblies and restricted assemblies, the boundary between the two storage configurations

Loading Configuration Interface Restriction	
Unrestricted and Restricted w/ Filler	Row of separation between restricted/filler and unrestricted storage must be a row which contains alternating restricted and filler assemblies

VII.4 Fuel Misloading Accident Analysis

A specific analysis was performed to verify that sufficient margin is provided by the soluble boron to maintain the pool configuration at or below k_{eff} of 0.95 following the misloading of a fresh 5.00weight% assembly in place of a required filler assembly. The results of this analysis showed that the allowed soluble boron provided sufficient criticality safety margin.

VIII PROPOSED TECHNICAL SPECIFICATION / FSAR MODIFICATIONS

This section contains the proposed modifications to the CNS Technical Specifications being requested with this submittal as well as a discussion of the resulting necessary changes that will be made in the Catawba Nuclear Station FSAR either upon approval of this amendment request or in the very first annual update which follows NRC's approval.

VIII.1 Technical Specification Changes

The following changes are those necessary to raise the maximum fuel enrichment allowed for use at the Catawba Nuclear Station to 5.00weight%. Specific spent fuel pool loading restrictions necessary to maintain acceptable criticality safety margins for all new and irradiated fuel with initial enrichments at or below this new value are ensured by these changes. Administrative controls necessary to ensure compliance with these revised technical specifications are discussed in section IX.

The new fuel storage vaults were specifically analyzed and determined to provide acceptable criticality safety margins for fuel enrichments at or below the new 5.00weight% limit. Consequently no loading pattern restrictions or related technical specifications are necessary for the new fuel storage vaults.

Current Requirements:

Technical Specification Reference: **3/4.9 Refueling Operations**

REFUELING OPERATIONS

None.

Currently, there are no restrictions in the technical specifications with regard to fuel storage in the spent fuel pool. Technical Specifications 3/4.9.12 (Spent Fuel Pool Boron Concentration) and 3/4.9.13 (Spent Fuel Assembly Storage) will be added to the current technical specifications.

Proposed Requirements:

Technical Specification Reference: 3/4.9 Refueling Operations

REFUELING OPERATIONS

3/4.9.12 SPENT FUEL POOL BORON CONCENTRATION

LIMITING CONDITION FOR OPERATION

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

APPLICABILITY:

During storage of fuel in the spent fuel pool.

ACTION:

a. Immediately suspend movement of fuel assemblies in the spent fuel pool and initiate action to restore the spent fuel pool boron concentration to within its limit.

b. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS:

4.9.12. Verify at least once per 31 days that the spent fuel pool boron concentration is within its limit.

Proposed Requirements:

Technical Specification Reference: 3/4.9 Refueling Operations

3/4.9.13 SPENT FUEL ASSEMBLY STORAGE

LIMITING CONDITION FOR OPERATION

3.9.13 New or irradiated fuel may be stored in the Spent Fuel Pool in accordance with these limits:

a. Unrestricted storage of fuel meeting the criteria of Table 3.9-1; or

b. Restricted storage in accordance with Figure 3.9-1, of fuel which does not meet the criteria of Table 3.9-1; or

c. Another configuration determined to be acceptable by means of an analysis to ass[illegible] that k_{eff} is less than or equal to 0.95.

APPLICABILITY:

During storage of fuel in the spent fuel pool.

ACTION:

a. Immediately initiate action to move the noncomplying fuel assembly to the correct location.

b. The provisions of Specification 3.0.3 are not applicable.

SURVEILLANCE REQUIREMENTS:

4.9.13 Prior to storing a fuel assembly in the spent fuel storage pool, verify by administrative means the initial enrichment and burnup of the fuel assembly are in accordance with Specification 3.9.13.

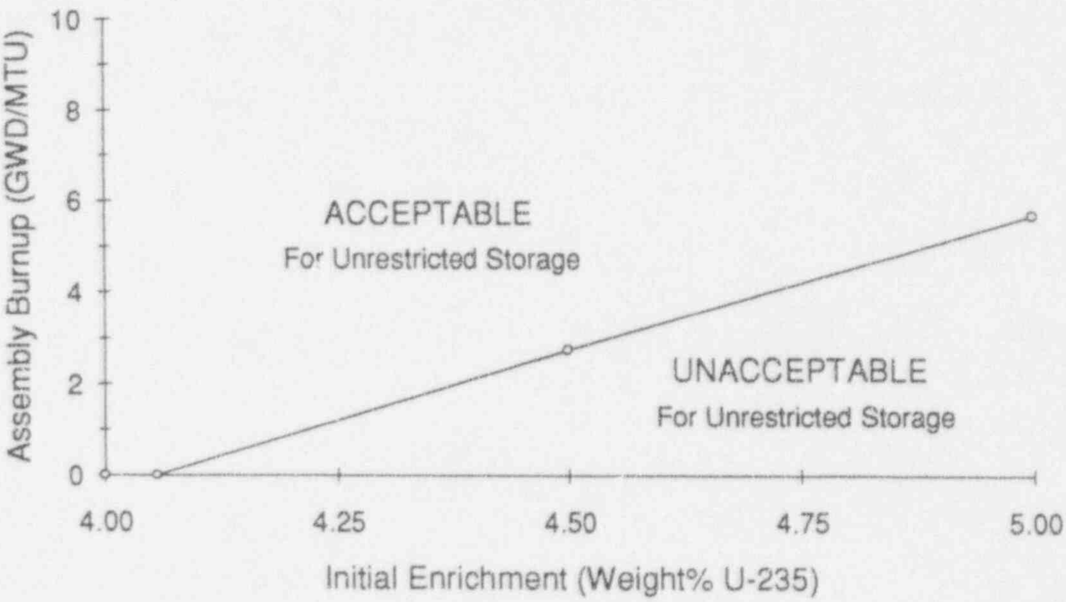
Proposed Requirements:

Technical Specification Reference: **3/4.9 Refueling Operations**

Table 3.9-1

Minimum Qualifying Burnup Versus Initial Enrichment for Unrestricted Storage

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



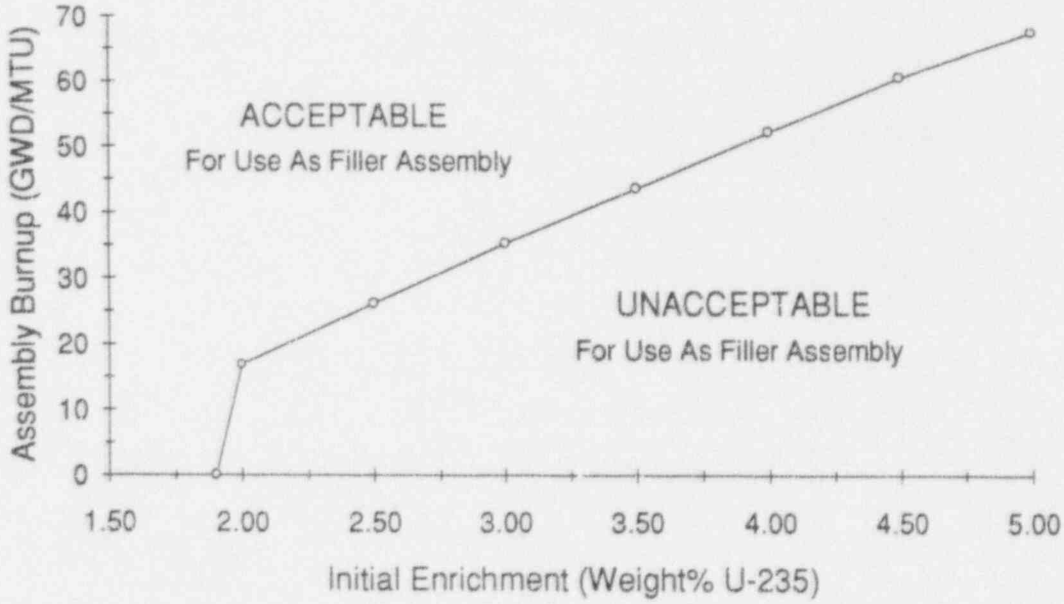
Proposed Requirements:

Technical Specification Reference: 3/4.9 Refueling Operations

Table 3.9-2

Minimum Qualifying Burnup Versus Initial Enrichment for Filler Assemblies

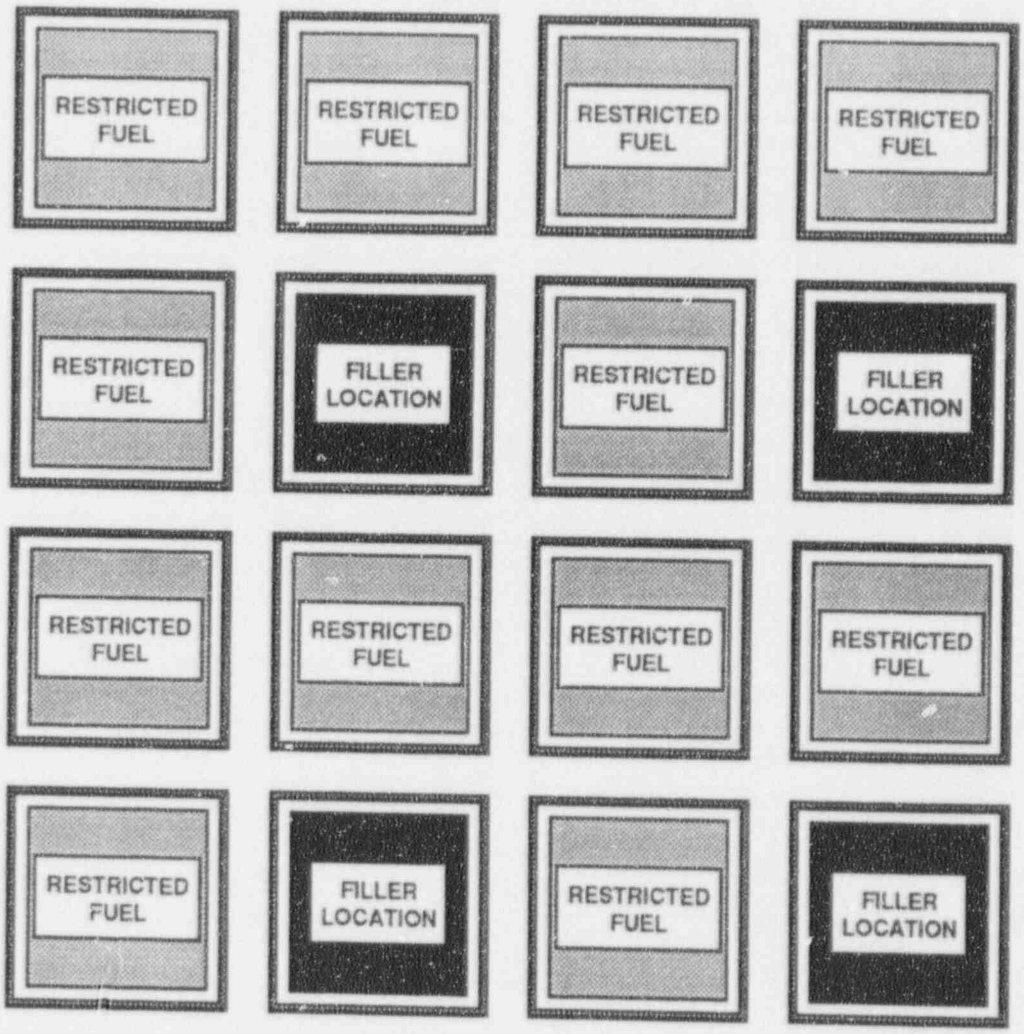
Initial Enrichment Weight% U-235	Assembly Burnup (GWD/MTU)
1.90 (or less)	0
2.00	16.83
2.50	26.05
3.00	35.11
3.50	43.48
4.00	51.99
4.50	60.36
5.00	67.28



Proposed Requirements: (Con't)

Figure 3.9-1

Required 3 out of 4 Loading Pattern
for Restricted Storage



Restricted Fuel: Fuel which does not meet the minimum burnup requirements of Table 3.9-1. (Fuel which does meet the requirements of Table 3.9-1 may be placed in restricted fuel locations as needed)

Filler Location: Either fuel which meets the minimum burnup requirements of Table 3.9-2, or an empty cell.

Boundary Condition: Any row bounded by an Unrestricted Storage Area shall contain a combination of restricted fuel assemblies and filler locations arranged such that no 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.

BASES

3/4.9.12 and 3/4.9.13 SPENT FUEL POOL BORON CONCENTRATION and SPENT FUEL ASSEMBLY STORAGE

The requirements for spent fuel pool boron concentration specified in Specification 3.9.12 ensure that a minimum boron concentration is maintained in the pool. The requirements for spent fuel assembly storage specified in Specification 3.9.13 ensure that the pool remains subcritical. The water in the spent fuel storage 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 with the pool fully loaded. The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 4) 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 increase the reactivity of the spent fuel pool. To mitigate this postulated criticality related accident, boron is dissolved in the pool water.

Specification 3.9.13.c allows for specific criticality analysis for configurations other than those explicitly defined in Specifications 3.9.13. These analyses would require using NRC approved methodology to ensure that $k_{eff} \leq 0.95$ with a 95 percent probability at a 95 percent confidence level as described in Section 9.1 of the FSAR.

In verifying the design criteria of $k_{eff} \leq 0.95$, the criticality analysis assumed the most conservative conditions, i.e. fuel of the maximum permissible reactivity for a given configuration. Since the data presented in Specification 3.9.13.a and 3.9.13.b represents the maximum reactivity requirements for acceptable storage, substitutions of less reactive components would also meet the $k_{eff} \leq 0.95$ criteria. Hence an empty cell, or a non-fuel component may be substituted for any designated fuel assembly location. These, or other substitutions which will decrease the reactivity of a particular storage cell will only decrease the overall reactivity of the spent fuel storage pool.

If both restricted and unrestricted storage is used, an additional criteria has been imposed to ensure that the boundary row between these two configurations would not locally increase the reactivity above the required limit.

The action statement applicable to fuel storage in the spent fuel pool requires that 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

Proposed Requirements:

Technical Specification Reference: 3/4.9 Refueling Operations

immediately suspending the movement of fuel assemblies. Prior to the resumption of fuel movement, the requirements of the LCOs must be met. This requires restoring the soluble boron concentration and the correct fuel storage configuration to within the corresponding limits. This does not preclude movement of a fuel assembly to a safe position.

The surveillance requirements ensure that the requirements of the two LCOs are satisfied, namely boron concentration and fuel placement. The boron concentration in the spent fuel pool is verified to be greater than or equal to the minimum limit. The fuel assemblies are verified to meet the subcriticality requirement by meeting either the initial enrichment and burnup requirements of Table 3.9-1 and 3.9-2, or by using NRC approved methodology to ensure that $k_{eff} \leq 0.95$. By meeting either of these requirements, the analyzed accidents are fully addressed.

The fuel storage requirements and restrictions discussed here and applied in specification 3.9.13 are based on a maximum allowable fuel enrichment of 5.0 weight% U-235. The enrichments listed in Tables 3.9-1 and 3.9-2 are nominal enrichments and include uncertainties to account for the tolerance on the as built enrichment. Hence the as built enrichments may exceed the enrichments listed in the tables by up to 0.05 weight% U-235. Qualifying burnups for enrichments not listed in the tables may be linearly interpolated between the enrichments provided. This is because the reactivity of an assembly varies linearly for small ranges of enrichment.

REFERENCES

1. "Regulatory Guide 1.13: Spent Fuel Storage Facility Design Basis", U.S. Nuclear Regulatory Commission, Office of Standards Development, Revision 1, December 1976.

2 "Design Objectives for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations", American Nuclear Society, ANSI N210-1976/ANS-57.2, April 1976.

3. FSAR, Section 9.1.

4. 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).

Current Requirements:

Technical Specification Reference: 5.6 Fuel Storage

Section 5.0 DESIGN FEATURES

5.6 Fuel Storage

CRITICALITY

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

a. A k_{eff} equivalent to less than or equal to 0.95 when flooded with unborated water, which includes a conservative allowance for uncertainties as described in Section 9.1.2.3.1 of the FSAR, and

b. A nominal 21-inch for new fuel and a nominal 13.5-inch for spent fuel center-to-center distance between fuel assemblies placed in the storage racks.

DRAINAGE

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

CAPACITY

5.6.3 The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1418 fuel assemblies.

5.7 COMPONENT CYCLIC OR TRANSIENT LIMIT

5.7.1 The components identified in Table 5.7-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.7-1.

Proposed Requirements:

Technical Specification Reference: 5.6 Fuel Storage

Section 5.0 DESIGN FEATURES

5.6 Fuel Storage

CRITICALITY

5.6.1 a. The spent fuel storage racks are designed and shall be maintained with:

1) $k_{eff} \leq 0.95$ if fully flooded with unborated water as described in Section 9.1 of the FSAR; and

2) A nominal 13.5" center to center distance between fuel assemblies placed in the spent fuel storage racks.

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

1) $k_{eff} \leq 0.95$ if fully flooded with unborated water as described in Section 9.1 of the FSAR; and

2) $k_{eff} \leq 0.98$ if moderated by aqueous foam as described in Section 9.1 of the FSAR; and

3) A nominal 21" center to center distance between fuel assemblies placed in the new fuel storage racks.

DRAINAGE

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

CAPACITY

5.6.3 The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1418 fuel assemblies.

5.7 COMPONENT CYCLIC OR TRANSIENT LIMIT

5.7.1 The components identified in Table 5.7-1 are designed and shall be maintained within the cyclic or transient limits of Table 5.7-1.

VIII.2 Proposed FSAR Modifications

Sections 4.3, Nuclear Design, and 9.1, Fuel Storage and Handling, are the only sections of the Catawba FSAR which will require modification as a result of the proposed technical specification changes detailed in this license amendment submittal. Specific language will be developed upon approval of this amendment request. In general however, changes will focus on the following sections:

4.3.2.6 Criticality of the Reactor During Refueling and Criticality of Fuel Assemblies

The description of the codes and methodology used in the criticality analysis would be updated to reflect the use of both the CASMO-3/TABLES-3/SIMULATE-3 and SCALE/KENO Va methodologies. The use of burnup credit will also be discussed.

9.1.1.3 Safety Evaluation

The descriptions of the assemblies pertaining to the enrichment will be changed to reflect the increase in the upper enrichment limit to 5.00weight%.

9.1.2.3.1 Criticality Analysis

Assumption number 5 in the listing of those made in evaluating criticality safety will be changed to reflect both the increase in the upper enrichment limit to 5.00weight%, and the use of burnup credit for assemblies greater than 4.05weight% U-235.

The calculated worst case k_{eff} values will be updated to reflect the increase in enrichment. The discussion of postulated accidents will be revised to include accidents which could increase reactivity.

9.1.3.1.1 Spent Fuel Pool Cooling

While the spent fuel cooling system will not be modified as a result of this submittal, the normal and abnormal heat load assumptions will change as a result of the higher anticipated discharge burnups. The results of an analysis based on these higher heat loads will be reflected in this section.

IX ADMINISTRATIVE CONTROLS

Although there are no storage restrictions currently in place at Catawba, there are administrative controls concerning the placement of new and irradiated assemblies in the spent fuel pool. These controls include individual assembly record keeping and review to accurately track and verify various fuel characteristics, as well as specific fuel handling procedures. For the most part, the current controls will be retained under the proposed technical specification revision. Additional administrative controls will be added to include the necessary restrictions required to accommodate the higher fuel enrichments and the new fuel loading pattern.

IX.1 Current Loading Restrictions

Currently there are no loading restrictions in the spent fuel storage pools at Catawba. All fuel is qualified for 100% storage.

IX.2 Proposed Loading Restrictions

The proposed technical specification revision will add 2 fuel categories which are listed below with their respective loading restrictions:

Fuel Category	Loading Pattern Restriction
Unrestricted	None
Restricted	75% Restricted Fuel w/ 25% Fillers

The unrestricted fuel will have a corresponding burnup curve as discussed in section VII.2 which represents the maximum reactivity level allowed by that category. The restricted fuel is simply limited to new or irradiated fuel with initial enrichments at or below $5.00_{weight\%}$.

The restricted fuel, which will require the most restrictive loading pattern, is intended to accommodate any new or discharged assemblies which do not qualify for unrestricted storage. The primary use for this category will be temporary storage of new (fresh) fuel assemblies above the $4.05_{weight\%}$ initial enrichment. It is anticipated that all irradiated fuel will qualify for unrestricted storage as defined in proposed TS. 3.9.13.a.

IX.3 Filler Assembly Requirements

As noted above, the designated loading patterns for restricted fuel will require the placement of filler assemblies into appropriate locations of the loading pattern.

Consequently, an additional fuel subcategory is identified for the purpose of defining qualification requirements for these fillers. The filler category is summarized as follows:

Fuel Category	Application
Filler	Filler Fuel for Restricted Region

As is the case for the unrestricted fuel, qualification of fuel for placement into the filler fuel category is governed by a separate burnup curve which is detailed in section VII.2.

IX.4 Pre-Staging of Restricted Storage Areas

The added flexibility provided by this proposed license amendment, while allowing for increased storage efficiency, does add some degree of complexity through the allowance of 2 loading configurations. It should be noted, however that all irradiated fuel from the Catawba reactors is expected to qualify for unrestricted storage, thus keeping the quantity of fuel subject to a misplacement accident to a minimum.

Procedural controls to ensure correct placement of new and irradiated fuel will be carefully developed and implemented through ongoing interactions between the general office, who performed the criticality analyses, and the station, who must adhere to the new requirements. Additionally, specific pre-staging of the filler assemblies required for the restricted storage configuration will occur as needed to further protect against fuel misplacement. Specific pre-staging plans for the restricted configuration are as follows:

> Restricted fuel assemblies which are required to be placed into a 75% (3 of 4) loading pattern will only be moved into the spent fuel pools after the appropriate number of filler assemblies needed for this pattern have been qualified and put in place. This clearly identifies the rack locations that can safely be used for storing these assemblies, thus precluding fuel assembly misloading.

Additional misloading protection is provided by the fact that the restricted storage region will generally be assembled in a somewhat isolated area of the pool such as corners, along walls, or at one end of the pool. Consequently, the ongoing need for fuel movement into, out of, or within these areas is also minimized.

When fuel movement in or out of the restricted region does occur, or if the entire region must be relocated to another area of the pool, quality verified procedures will be used to direct the actual fuel movements. Such QA-1 procedures, combined with operator awareness and careful visual verification, eliminates the need for interlocking devices or special fuel labeling that would prevent inadvertent movement of a filler assembly.

IX.5 Pre-Staging of Interface Restrictions

As summarized in section VII.3 and discussed in detail in Appendix A of the June 13, 1994 McGuire License Amendment Request, the fuel loading pattern required for restricted fuel has specific restrictions related to the interface that can exist with unrestricted fuel. This interface restriction will be accommodated through appropriate orientation of the pre-placed filler assemblies required for that pattern.

Proper identification and placement of fuel assemblies with respect to these categories will occur through administrative review of SNM accountability records, qualification against applicable burnup vs. enrichment curves, and finally through administratively controlled procedures which will govern actual fuel placement. The accountability system to be used for fuel characterization and the existing procedural controls for movement of fuel in and out of the core, and for moving fuel between spent fuel pools will all be retained. The procedural controls for movement of fuel in the spent fuel pool will be updated to reflect the new storage requirements regarding restricted and unrestricted fuel. Burnup versus initial enrichment curves which determine fuel category are detailed in the proposed technical specifications found in section VIII.

Appendix A

Methodology for Development of Region Interface Restrictions

APPENDIX A REGION INTERFACE RESTRICTIONS METHODOLOGY

This appendix provides supplemental information on the methodology used to establish the necessary interface restrictions between fuel storage regions as discussed in sections VII and IX of this submittal. This methodology is described in detail, as it applies to the McGuire spent fuel pools, in Appendix A of the request for License Amendment for the McGuire Nuclear Station dated June 13, 1994. Although this description is specific to the interfaces in the McGuire spent fuel pool, the methodology is equally applicable to the interfaces of any spent fuel storage region.

The following sections discuss the region interface evaluation for the Catawba spent fuel pools.

A.1 Boundary Evaluation

The above referenced methodology was applied to the single storage region interface in the Catawba spent fuel pools, namely the boundary between the Restricted and Unrestricted storage areas. This interface is very similar to the Region 1A and Region 1B interface from the referenced methodology description. The Restricted storage area allows for storage of fresh fuel with enrichments in excess of 4.05weight% arranged in a 75/25 checkerboard configuration as shown in figure A-1. All fuel was assumed to be of the Westinghouse Optimized Fuel Assembly (OFA) design, since this was the most reactive fuel for the conditions analyzed. For this analysis, the restricted fuel was conservatively modeled as 5.00weight% fresh fuel, and the filler fuel was modeled as 2.0weight% fresh fuel as discussed below. If this group of four is repeated periodically the pattern forms alternating rows of 100% 5.00weight% fuel and mixed rows of 5.00/2.00weight% fuel in both X and Y directions. This pattern is illustrated in figure A-1 below.

Filler fuel is defined as fuel that meet the acceptance curve shown in Figure 7-1. While the maximum fresh fuel enrichment for filler fuel from Figure 7-1 is 1.90weight%, the filler fuel is modeled as 2.00weight%. This modeling assumption did not change the results of the calculation since the results focused on the change in reactivity of the system as opposed to an absolute reactivity.

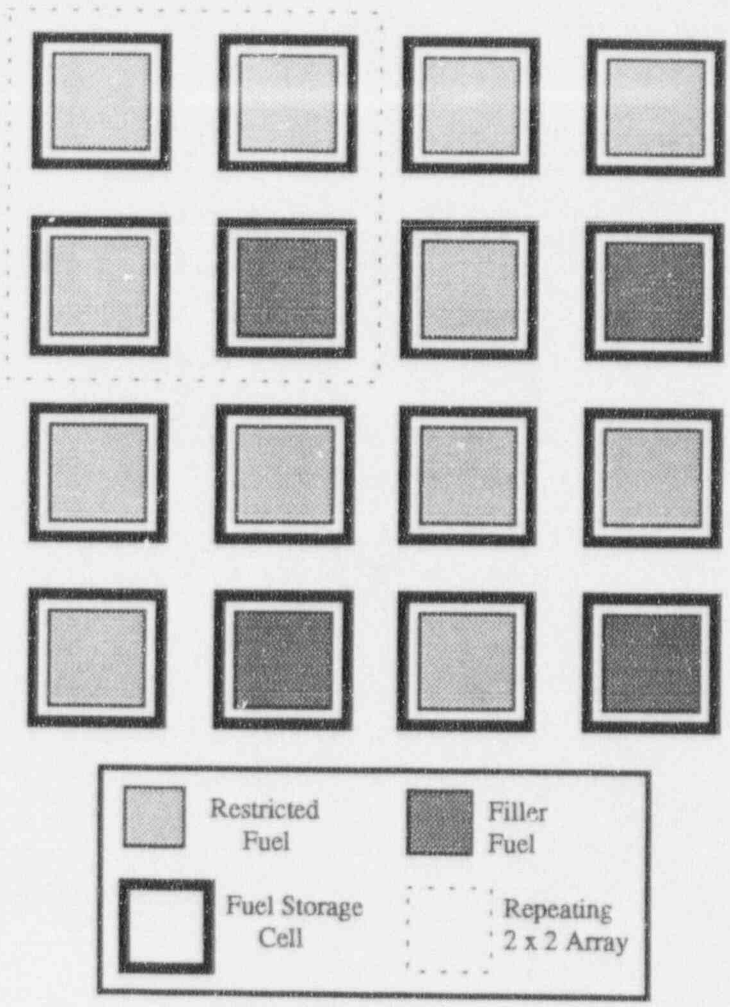


Figure A-1
Restricted Storage Loading Pattern

The Restricted storage configuration was modeled directly adjacent to the Unrestricted storage configuration using both Restricted row "types" shown above as the interface between the regions. Criticality analysis using these two models indicated a need to administratively require a row of alternating Restricted/Filler fuel assemblies to be maintained as the boundary. Based on this requirement, an Unrestricted storage area could be adjacent to either the right hand side or the bottom of Figure A-4, but an Unrestricted storage area could not be located adjacent to either the left hand side or the top of Figure A-1.

A.2 Conclusions

A summary of the resulting interface restriction for the Catawba spent fuel storage pools is provided in Table A-1 below.

Table A-1

Summary of
Region Interface Loading Restrictions

Interface	Restrictions
Restricted and Unrestricted	Row of Restricted fuel bounding the Unrestricted fuel must be a row of alternating Restricted and Filler fuel.

Appendix B

Methodology
for
Burnup Credit Analysis

APPENDIX B METHODOLOGY FOR BURNUP CREDIT ANALYSIS

B.1 Background

The burnup credit analysis methodology employed for this submittal is generic and applicable to all three Duke Power nuclear facilities. This methodology is described in detail in Appendix B of the request for License Amendment for the McGuire Nuclear Station dated June 13, 1994.

Although the above referenced methodology is generic, the biases and uncertainties dependent on the specific storage rack characteristics must be determined for each rack. Therefore, the biases and uncertainties developed specifically for the Catawba storage racks are presented in the following sections.

B.2 Biases And Uncertainties

Listed below is a summary of the biases and uncertainties developed for the McGuire spent fuel storage racks.

Methodology Bias
Boraflex Width Shrinkage Bias
Boraflex Self-Shielding Bias
Boraflex Axial Shrinkage Uncertainty
95/95 Methodology Uncertainty
Mechanical Uncertainty
Exposure Reactivity Uncertainty
Burnable Poison Reactivity Uncertainty

The methodology bias and uncertainty were developed for the methodology and are independent of the storage rack. The three biases and uncertainties related to boraflex are dependent on the use of boraflex in the rack. Since the Catawba storage racks do not use any explicit poison material, the boraflex related uncertainties are not applicable. The exposure reactivity uncertainty was developed using data from all three nuclear stations, and thus is applicable to Catawba. The burnable poison reactivity uncertainty is dependent on the fuel design and was determined for McGuire as the most conservative value from all the McGuire and Catawba fuel types. Thus, of the above 8 biases and uncertainties, only one, the mechanical uncertainty, needs to be calculated for the Catawba storage racks.

The biases and uncertainties applicable to the Catawba spent fuel storage racks are summarized in the table below.

Table B-1

Biases and Uncertainties for the Catawba Spent Fuel Storage Rack

	Bias or Uncertainty	K
Δk_{cb}	Methodology Bias	-0.00189
Δk_{cu}	95/95 Methodology Uncertainty	0.01080
Δk_{me}	Mechanical Uncertainty	0.008873
Δk_{exp}	Exposure Reactivity Uncertainty	0.00448
Δk_{BP}	Burnable Absorber Reactivity Uncertainty	0.01

The first three values above are combined to yield a total new fuel bias/uncertainty as follows.

$$\Delta k_{eff} = \Delta k_{cb} + \sqrt{\Delta k_{cu}^2 + \Delta k_{me}^2}$$

$$\Delta k_{eff} = -0.00189 + \sqrt{0.01080^2 + 0.008873^2}$$

$$\Delta k_{eff} = 0.01209$$

As detailed in the McGuire submittal, the last two uncertainties in Table B-1 are related to burned fuel. These uncertainties are applied as a function of burnup. Since the burnable absorber reactivity uncertainty is applied as a function of burnup until reaches a maximum value, two equations are needed to define the reactivity uncertainty versus burnup. These two equations are included in the maximum reactivity curves in the following section.

B.3 Maximum Reactivity Curve

The final equations for the maximum reactivity curve for the Catawba spent fuel storage racks are summarized below.

$$k_{max} = 0.95 - \Delta k_{cb} - \sqrt{\Delta k_{cu}^2 + \Delta k_{me}^2} - \Delta k_{exp} - \Delta k_{BP}$$

[For Burnup ≤ 14]

$$k_{max} = 0.95 - 0.01209 - \frac{0.00448 \times \text{Burnup}}{50} - \frac{0.01 \times \text{Burnup}}{14}$$

[For Burnup > 14]

$$k_{max} = 0.95 - 0.01209 - \frac{0.00448 \times \text{Burnup}}{50} - 0.01$$