VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

October 24, 1996

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 96-350
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Docket Nos. 50-280, 281
50-338, 339
License Nos. DPR-32, 37
NPF-4, 7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
NORTH ANNA POWER STATION UNITS 1 AND 2
RESPONSE TO NRC GENERIC LETTER 96-04

On June 26, 1996, the NRC issued Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks." The Generic Letter requested that licensees with spent fuel storage racks containing the neutron absorber Boraflex provide an assessment of the physical condition of the Boraflex and provide the results of that assessment and any actions to ensure compliance with GDC-62. Virginia Electric and Power Company's response to the requested actions is included in Attachment 1 for North Anna Power Station. Surry Power Station's spent fuel storage rack design does not include Boraflex as a neutron absorber.

The assessment of the physical condition of the Boraflex panels in the North Anna spent fuel storage racks is based, in part, on estimated gamma dose which bounds most of the utility data derived from Boraflex surveillance coupon programs. In situ testing of the Boraflex panels at North Anna has not been performed, and thus, the actual extent of the shrinkage and the axial distribution of any gaps are not known. The axial distribution of the gaps is fundamental in determining the effect shrinkage has on k_{eff} in the storage racks. Testing of a sample of storage cells in the North Anna racks will be performed to determine the extent of shrinkage and the resulting Boraflex gap distribution. The results of the testing will be evaluated to determine any impact on the current design and licensing bases of the North Anna spent fuel storage racks and what licensing actions, if any, are required.

Since the actual configuration of any gaps in the North Anna Boraflex panels is not currently known, criticality analyses were performed based on conservative assumptions with regard to gaps in the Boraflex. These analyses assumed that all Boraflex panels in the storage racks had shrunk by four percent in the most limiting configuration (i.e., all shrinkage occurred from the top down). Note that the Electric Power Research Institute has reported that gaps can occur in various axial locations within the Boraflex panel which would result in a very small penalty in k_{eff}. Therefore, it is expected that the actual condition of the Boraflex panels in the North Anna racks are less limiting than what was assumed in the criticality analyses. These analyses further took credit for the depletion of

A008 1/1

reactivity in irradiated fuel and identified interim compensatory actions which would ensure that five percent subcritical margin can be maintained even in the assumed worst case Boraflex configuration. Specifically, for the existing spent fuel inventory currently in the spent fuel pool at North Anna, the five percent subcritical margin is and would continue to be met based on the actual depletion of reactivity in the irradiated fuel. The compensatory measures for burnup credit are detailed in Section 5.0 of Attachment 1.

These compensatory measures will be implemented prior to loading any additional unirradiated or irradiated fuel to the spent fuel storage racks. The compensatory measures will remain in place until the issue of Boraflex degradation is resolved.

Testing and evaluation of the Boraflex panels will be completed as soon as reasonably practicable and is currently scheduled for completion by March 31, 1997.

The commitments made in response to this Generic Letter are delineated in Attachment 2. Should you have any questions regarding this response, please contact us.

Very truly yours,

James P. O'Hanlon

James P. O'Hanlon
Senior Vice President - Nuclear

Attachment

cc: U. S. Nuclear Regulatory Commission
Region II
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Mr. R. A. Musser
NRC Senior Resident Inspector
Surry Power Station

Mr. R. D. McWhorter
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North Anna Power Station

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by J. P. O'Hanlon, who is Senior Vice President - Nuclear, of Virginia Electric and Power Company. He is duly authorized to execute and file the foregoing document in behalf of that Company, and the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 24TH day of October, 1996.

My Commission Expires: May 31, 1998.

Vicki L. Hull
Notary Public

(SEAL)

Attachment 1

VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA UNITS 1 AND 2

RESPONSE TO NRC GENERIC LETTER 96-04

BORAFLEX DEGRADATION IN SPENT FUEL POOL STORAGE RACKS

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1.0 INTRODUCTION

North Anna Unit 1 and North Anna Unit 2 share a common spent fuel pool. In 1985 the North Anna spent fuel pool was re-racked with high storage density neutron absorber racks to increase the pool's storage capacity from 966 locations to 1737 storage locations. The neutron absorber racks were designed and manufactured by Nuclear Energy Services, Inc. (NES), of Danbury, Connecticut. Boraflex is the neutron absorber material used in these racks.

Recognizing the concerns regarding Boraflex degradation, Virginia Electric and Power Company developed a plan to perform an assessment of the physical condition of the Boraflex in the North Anna spent fuel storage racks. As a short term action, Virginia Electric and Power Company procedures were modified to administratively control the soluble boron concentration in the pool. The administrative minimum limit for the soluble boron concentration was established significantly higher than the minimum concentration required to maintain 5 percent subcritical margin, assuming no Boraflex existed in the storage racks. Credit for soluble boron is not assumed in the design basis of the storage racks, however, this administrative control was imposed as an interim defense-in-depth measure until the formal assessment of the physical condition of the Boraflex in the North Anna storage racks was completed and any compensatory actions taken.

Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Storage Racks," requests utilities using Boraflex as a neutron absorber in their spent fuel storage racks to submit the following information to the NRC:

- Provide an assessment of the physical condition of the Boraflex, including any deterioration, on the basis of current accumulated gamma exposure and possible water ingress to the Boraflex.

- Based on the physical condition of the Boraflex, state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water.

- Provide a description of any proposed actions to monitor or confirm that 5 percent subcriticality margin can be maintained for the lifetime of the storage racks and describe what corrective actions could be taken in the event it cannot be maintained.

This report provides the information requested in Generic Letter 96-04.

2.0 DESCRIPTION OF NORTH ANNA SPENT FUEL STORAGE CELLS

In 1985 the North Anna spent fuel pool was re-racked with sixteen rack arrays, increasing the storage capacity from 966 storage locations to 1737 storage locations. Reracking reduced the center-to-center spacing from 14 inches to 10-9/16 inches, and Boraflex was chosen as the fixed neutron absorber to maintain subcritical margin in the high density racks. The sixteen high density storage rack arrays in the North Anna spent fuel pool were designed and manufactured by Nuclear Energy Services, Inc. of Danbury, Connecticut.

Each rack array consists of a welded assembly of individual storage cells. The storage cells are comprised of Type 304 stainless steel boxes welded to each other with tie plates to maintain the center-to-center spacing. Each storage cell has an interior height of 168 inches and an interior square dimension of 8-7/8 inches.

A stainless steel wrapper is welded to each outside wall of every storage cell. The Boraflex sheets (panels) are 138 inches long by 7.5 inches wide by 0.085 inches thick and fit entirely within the wrapper. The wrapper nominally provides a 15 mil clearance for the 85 mil thick Boraflex panel and sufficient clearance on the sides of the panel so that the Boraflex is not press-fit into position by the wrapper. The Boraflex panel is axially fixed in position by a stainless steel poison stop welded at the bottom of the wrapper. Nominally, the Boraflex panel rests on the bottom poison stop with the center of the Boraflex panel at the approximate axial location of the center of the active fuel of a fuel assembly stored in the cell. A top poison stop is also welded at the top of the wrapper to close the top off. No adhesive was used to fix the Boraflex panel in place within the wrapper. A one-half inch diameter hole is located 4 inches below the top of the wrapper for venting.

Tie plates are axially welded to the corners of the storage cell boxes to form the rack array and maintain the center-to-center spacing of 10-9/16 inches. The bottoms of the storage cell boxes rest on and are welded to the bottom support plate. Each storage cell is located directly over a hole in the support plate to permit cooling water to flow within the cell. However, there are no flow paths through the bottom support plate located between the cells. Also, since the tie plates span the storage cell for nearly the full length, the space between the cells in a rack array is a stagnant pocket. That is, there is no forced flow of water between the storage cells. Therefore, the design of these storage racks is a mitigating factor in Boraflex degradation due to the restricted access to the flow of water. Boraflex degradation data suggest that free access to water flow tends to exacerbate the dissolution of the filler material (both silica and B_4C) from the polymer, thus reducing the effectiveness of the neutron absorber.

A limiting feature of the neutron absorbing storage rack design at North Anna is that the racks were specified and manufactured with Boraflex panels 138 inches in length. The active fuel length of the fuel assemblies used at North Anna is 144 inches. The Boraflex panels are axially positioned such that the center of the Boraflex panel is approximately at the same axial location as the axial center of the active fuel. Therefore, in a nominal, as-built storage cell, there is about a three inch region of active fuel at the top and the bottom of the fuel assembly that is not "poisoned" by Boraflex.

3.0 ASSESSMENT OF PHYSICAL CONDITION OF BORAFLEX

The North Anna neutron absorber spent fuel storage racks have been in service for over eleven years. Approximately 86% of the 1737 storage locations are currently occupied. The following assessment is based on an estimated integrated gamma exposure to the Boraflex panels, a correlation to determine Boraflex shrinkage as a function of integrated gamma exposure, measured spent fuel pool silica trends, and comparative data of silica concentration trends in other pools with racks of various manufacturers. To date, no in-situ measurements of the boron-10 areal density or Boraflex blackness testing of the storage cells has been conducted at North Anna to confirm the assessment of the physical condition of Boraflex.

3.1 Integrated Gamma Dose to Boraflex

Boraflex consists of a polymer matrix (polydimethyl siloxane or PDMS, a type of silicone rubber) which retains the boron carbide powder which serves as the neutron absorber. The as-fabricated composition of Boraflex is approximately 25 weight percent (w/o) PDMS, 50 w/o B_4C powder, and 25 w/o of silica, which is another filler material added to adjust material physical properties.

PDMS can be expected to exhibit significant changes of its physical properties in the spent fuel pool environment. One of the most significant of these changes is manifested by an increase in the material density, or shrinkage. Also, gamma radiation removes CH_3 and H radicals from the polymer which produces the release of gases such as H_2, CH_4, and C_2H_6. Bubbles of these gases can be seen at times rising from the spent fuel racks in the spent fuel pool, and are the direct result of gamma radiation induced changes in the Boraflex material. The Boraflex material becomes dose-saturated at integrated doses between $1x10^{10}$ rads and $2x10^{10}$ rads. When saturated, dimensional changes of the Boraflex tend to cease, and the maximum amount of length change that can be expected ranges between 3% and 4%.

An estimate of the integrated gamma exposure to the Boraflex panels in each cell in the North Anna storage racks was made based on a one-dimensional discrete ordinates model of a storage cell and its surrounding neighbor cells. The occupancy history of each cell was determined beginning with the time the Boraflex racks were first placed in service in 1985. There are 56 storage cells (about 3% of the total number of cells) that have a maximum estimated panel dose in the saturated dose region (integrated dose greater than $1.5x10^{10}$ rads). Over 70% of all the storage cells have an estimated integrated dose between $2x10^9$ rads and $1x10^{10}$ rads, and approximately 19% of the cells have an integrated dose at near saturation levels ($1x10^{10}$ rads to $1.5x10^{10}$ rads). The remaining cells have Boraflex panels that are estimated to have less than $2x10^9$ rads of absorbed dose.

3.2 Boraflex shrinkage

The type of polymer used in Boraflex can be expected to undergo significant changes in physical properties in the spent fuel pool environment. Such changes include a reduction in the dimensions of the material, increased density, and hardness. The material change of primary interest is the reduction of material dimensions, or shrinkage. The Boraflex panels used in the North Anna storage racks are 138 inches long, located such that the panel is approximately axially centered with the active fuel stored in the cell. Therefore, in a nominal, as-built storage cell, there is about a three inch region of active fuel at the top and the bottom of the fuel assembly that is not "poisoned" by Boraflex. There is a nominal space between the Boraflex material and the wrapper on all sides of the Boraflex panel. The wrapper does not pinch, or otherwise fix the axial position of the Boraflex, nor are the Boraflex panels adhered to any surface within the wrapper. Therefore, it is assumed that all axial shrinkage of Boraflex will result in an increase in the gap at the top. That is, the nominal three inch difference between the top of the Boraflex panel and the top of the active fuel will increase, inch for inch, with shrinkage. It should be noted that this assumption is conservative with respect to the rack criticality analysis as will be discussed in Section 4. No testing has been performed to determine the actual axial location of the gaps in the Boraflex panels or whether gaps exist randomly distributed over the axial length of the panels.

EPRI identified a correlation to determine the fractional change in length of a Boraflex panel as a function of integrated dose. Over 1150 storage cells have Boraflex panels that are conservatively estimated to have shrunk between 4.5 to 5.0 inches, and over 1660 storage cells (95.6% of the total storage cells in the pool) have Boraflex panels that are estimated to have shrunk more than 2.0 inches. No testing of the Boraflex panels has been performed, and it is not known what effect the shrinkage may have had on the gap distribution in the Boraflex panels. EPRI has reported that random axial gaps may form as a result of shrinkage.

3.3 Spent Fuel Pool Silica Evaluation

After long term exposure to gamma radiation and water, a chemical conversion of the polymer matrix occurs after which the polymer is likely to converted to a composition of silica or silica-like material. In this condition, the Boraflex material is likely to consist of B_4C in a matrix of primarily silica or silica-like material. Chemical analyses of irradiated Boraflex indicates a composition of 50 w/o B_4C, about 45 w/o silica, and about 5 w/o residual polymer.

Silica is somewhat soluble in warm water. With favorable conditions, the residual silica-based matrix of irradiated Boraflex can undergo dissolution leading to thinning of the Boraflex panels and a slow release of B_4C from the panels. The rate of dissolution has been found to primarily depend on the following factors:

- Concentration of reactive silica in the solute (the total silica is comprised of the reactive silica and the colloidal silica components)
- Integrated gamma dose
- Temperature
- Access of pool water to the surface of the irradiated Boraflex

The integrated gamma dose to the Boraflex panels in over 93% of the storage cells in the North Anna spent fuel pool is greater than $2x10^9$ rads. Under proper conditions, dissolution of Boraflex material with this amount of integrated dose can be expected. However, the conditions for rapid dissolution of Boraflex in the North Anna racks do not appear to be evident. The reasons for this are presented as follows.

Tests were performed under controlled laboratory conditions at 150°F to determine the relationship between reactive silica and colloidal silica. It was concluded from these tests that at relatively low levels of reactive silica (< 50 ppm), the reactive and total silica are essentially the same (i.e., the colloidal silica component is very small). However, in tests where the reactive silica approached an equilibrium concentration of 85 to 90 ppm, the colloidal silica component became significant. This suggests that significant polymerization of reactive silica to form colloidal silica does not occur until the reactive component is above 50 ppm for this temperature. The North Anna spent fuel pool is normally less than 100°F, but has approached 110°F during refuelings.

Figure 3.1 is the trend of reactive silica concentration in the North Anna spent fuel pool. The concentration has remained, on average, between 12 ppm and 16 ppm over the past 3 years. This concentration is consistent with levels considered to be intermediate for PWR pools (intermediate values defined as 35 ppm and < 20 ppm) and is consistent with concentrations for other pools with racks made by the same manufacturer. With pool temperatures lower than the test temperatures and silica concentrations that are not considered to be high, it is concluded that the colloidal silica component of the total silica concentration in the North Anna pool is small compared to the reactive silica concentration. That is, the concentration of reactive silica in the spent fuel pool is considered to be a representative indicator of the total silica in the pool.

The amount of "thinning" or reduction in the amount of B_4C in the Boraflex panels can be estimated given that the amount of colloidal silica in the pool is small compared to the amount of reactive silica in the pool and the amount of B_4C released from the Boraflex is equal in proportion to the amount of silica released. Based on the mass of the pool water, the total mass of the Boraflex in the racks, the silica concentration in the spent fuel pool, and the expected irradiated composition of Boraflex, the percentage of B_4C loss in the Boraflex panels with an integrated dose greater than $2x10^9$ rads is estimated to be approximately 0.3%.

The Boraflex panels in the North Anna racks are encapsulated in a stainless steel wrappers fixed to the outside four walls of each storage cell. There is no forced flow of cooling water between the storage cells where the Boraflex is located. With this type of design, access of pool water to the surface of the irradiated Boraflex is highly restricted. Test results indicate that the effect of encapsulation of Boraflex results in about a factor of ten decrease in the release rate of silica (and subsequently, B_4C material) to the pool environment compared to release rates from unencapsulated Boraflex. Therefore, the North Anna rack design is considered to be a mitigating factor for Boraflex degradation.

3.4 Boraflex Physical Assessment Conclusions

The assessment of the physical condition of the Boraflex material in the North Anna spent fuel storage racks is summarized in the following conclusions:

(1) The integrated dose to the Boraflex panels in the North Anna storage racks indicates that 56 storage cells have an estimated integrated dose in the saturated dose range (integrated dose exceeding $1.5x10^{10}$ rads)

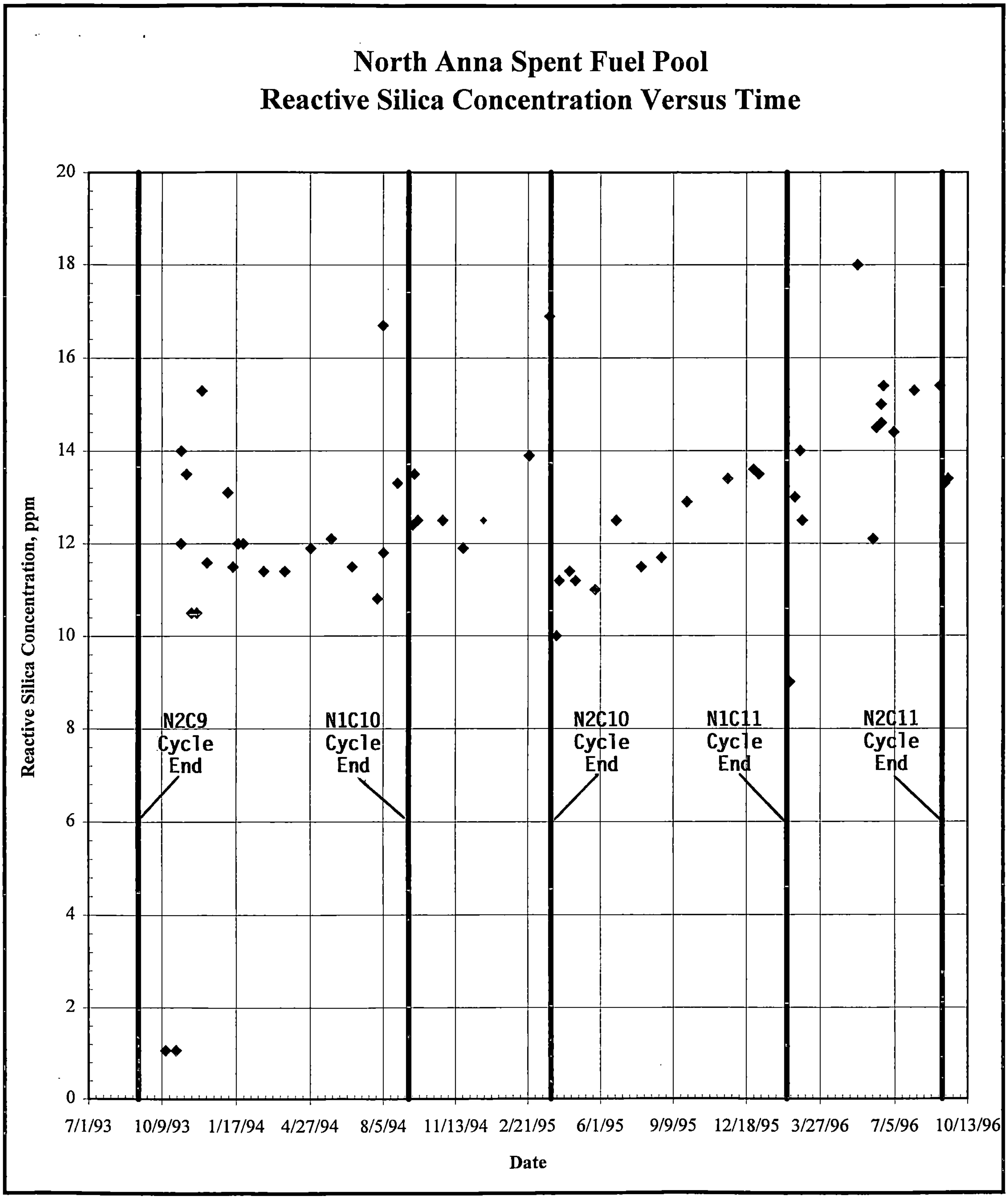
(2) Greater than 93% of the 1737 storage cells in the spent fuel storage racks are estimated to have greater than $2x10^{9}$ rads. Dissolution of Boraflex material can become significant with dose greater than $2x10^{9}$ rads if the proper conditions exist.

(3) Based on conservative analysis, over 1150 storage cells may have boraflex panels that potentially have shrunk between 4.5 to 5.0 inches, and over 1660 storage cells (95.6% of the total storage cells in the pool) may have Boraflex panels that potentially have shrunk more than 2.0 inches. No testing has been performed to determine the gap distribution in the panels.

(4) Conditions do not appear to be favorable for the rapid dissolution of Boraflex for the following reasons:

- (a) The reactive silica concentration in the spent fuel pool has been stable over the past 3 years, averaging between 12 ppm and 16 ppm.
- (b) The Boraflex panels in the North Anna racks are encapsulated in stainless steel wrappers fixed to the outside four walls of each storage cell. With this type of design, access of pool water to the surface of the irradiated Boraflex is highly restricted.
- (c) It is estimated that approximately 0.3% of the B_4C in the Boraflex has been "washed out" of the racks. This will be shown in Section 4 to be negligible.

Figure 3.1


North Anna Spent Fuel Pool
Reactive Silica Concentration Versus Time
Reactive Silica Concentration, ppm
20
18
16
14
12
10
8
6
4
2
0
N2C9
Cycle
End
N1C10
Cycle
End
N2C10
Cycle
End
N1C11
Cycle
End
N2C11
Cycle
End
7/1/93
10/9/93
1/17/94
4/27/94
8/5/94
11/13/94
2/21/95
6/1/95
9/9/95
12/18/95
3/27/96
7/5/96
10/13/96
Date

4.0 CRITICALITY ANALYSIS RESULTS

The North Anna spent fuel racks are currently licensed to store up to 1737 fuel assemblies with a maximum initial U-235 enrichment of 4.3 weight percent. A margin of 5 percent subcriticality in the spent fuel storage racks when flooded with unborated water is required by NUREG-0800 and Technical Specifications for North Anna Unit 1 and Unit 2. The as-built configuration of the North Anna storage racks included Boraflex panels initially six inches shorter than the active fuel height in a North Anna fuel assembly. Shrinkage of the Boraflex material will affect the subcritical margin in the spent fuel pool. Section 4.1 summarizes the results of a criticality analysis performed to evaluate the effects of Boraflex shrinkage on the k_{eff} of the storage racks. Section 4.2 summarizes the results of analyses which would ensure that 5 percent subcritical margin is maintained in the spent fuel pool.

4.1 Criticality Analysis with Irradiated Boraflex

A criticality analysis was performed of the North Anna spent fuel storage racks using the KENO-V.a Monte Carlo code from Version 4.3 of the SCALE code system. A full pool 3-dimensional KENO-V.a model of the storage racks was developed which includes the concrete walls, stainless steel liner, and concrete floor. A pin by pin geometric representation of the fuel assemblies was used for all calculations. Rack or fuel structural materials, with the exception of the stainless steel storage cells and Boraflex wrappers, were not included in the model. The following assumptions were used in the development of the North Anna KENO-V.a model:

- No credit for soluble boron in the pool water is taken.

- Fuel assemblies have no discrete burnable absorbers.

  All fuel assemblies are fresh and have the maximum allowable initial U-235 enrichment of 4.3 weight percent. Separate analyses with depleted fuel with initial enrichment of 4.3 w/o were also performed.

- Boraflex is assumed to have shrunk 4% in both height and width (5.5 inches and 0.3 inches, respectively). Four percent shrinkage is expected to bound all reported shrinkage data. The 3.5 percent shrinkage assumed in Section 3 bounded most of the utility data.

- Shrinkage is assumed to create a gap at the top, in addition to the as-built 3 inch gap. For the North Anna storage rack design, assuming a gap at the top is more conservative than assuming a gap forms elsewhere in the Boraflex panel. If the as-built Boraflex panels were at least as long as the active fuel, it would be more conservative to assume a gap forms in the middle of the Boraflex panel because axial leakage would nearly compensate for effects of end-shrinkage. However, since the as-built Boraflex panels were initially shorter than the active fuel stored in the racks, axial leakage does not compensate for the amount of estimated shrinkage. KENO-V.a cases were run to confirm this effect.

- All calculations assumed a 17X17 fuel design.

An uncertainty in the prediction of k_{eff} was applied to the best estimate prediction of k_{eff} obtained with the above model. The uncertainty analysis included uncertainties related to the bias in the KENO-V.a code in addition to uncertainties related to the code modeling, experimental uncertainty, uncertainty from Monte Carlo analysis, structural tolerances, and fuel placement eccentricity within the storage cell. The total combined uncertainty was determined to be 2.3% Δk. The uncertainty in the prediction of k_{eff} of 3.4% Δk identified in Section 5.6.1.1 of the North Anna Unit 1 and North Anna Unit 2 Technical Specifications is not applicable to the current licensing basis storage rack analysis. The current amendment was approved using a different value for the total uncertainty as stated in the NRC's Safety Evaluation Report. This represents no safety concern and will be corrected via a future Technical Specifications amendment.

The results of this criticality analysis indicate that Boraflex panel shrinkage of up to 2 inches is acceptable and sufficient to maintain 5 percent subcritical margin. Figure 4.1 shows the results of the k_{eff} of the storage racks versus Boraflex panel shrinkage. Note that this curve does not include the 2.3% Δk uncertainty and was evaluated based on a fixed Boraflex panel width. However, this curve demonstrates the change in the rate of increase of k_{eff} with panel shrinkage greater than 2 inches. When uncertainties are added, the value for k_{eff} at 2 inches of shrinkage is slightly less than 0.95. As previously indicated, the reactivity effects of shrinkage reported here are based on the conservative assumption that all shrinkage occurs at one end. EPRI has reported that if the total shrinkage occurs in randomly distributed gaps along axial length of the Boraflex panels, the penalty in k_{eff} is very small. The actual shrinkage of the North Anna Boraflex panels and resultant gaps, if any, are not known.

The effect on Boraflex "thinning" (washout of the B_4C material from the Boraflex as discussed in Section 3.3) on pool k_{eff} was also evaluated in the criticality analysis. It was estimated in Sections 3.3 and 3.4 that approximately 0.3% of the B_4C material could be removed from the Boraflex panels. According to the criticality analysis, the net effect of this amount of "thinning" increases the k_{eff} in the storage racks by less than 0.02% Δk. Therefore, the effect of Boraflex "thinning" in the North Anna storage racks is considered to be negligible.

4.2 Burnup Credit Analysis Results

Criticality calculations were performed taking some credit for fuel assembly burnup. The same assumptions that were used in the criticality analysis for fresh fuel were also applied in the burnup credit analysis, except that credit for depletion of fissionable isotopes and concentrations of some stable fission product isotopes were added to the fuel composition. As in the analysis for fresh fuel, the burnup credit analysis also assumed that Boraflex was fully shrunk by the maximum of 4%.

The results of the burnup credit analysis indicate that fuel assemblies can be stored in the spent fuel storage racks without configuration limitations if the following conditions are met:

- Fuel assemblies with an initial enrichment of 3.3 w/o or less, or
- Fuel assemblies whose average burnup fall above the straight line defined by the points (3.3 w/o initial enrichment, 0 MWD/MTU Burnup) and (4.3 w/o initial enrichment, 19,000 MWD/MTU burnup) on a fuel assembly burnup versus initial enrichment plot.

Figure 4.2 shows the history of every irradiated fuel assembly that has been stored in the North Anna spent fuel pool on a burnup versus enrichment plot. This is historical in the sense that a fuel assembly may be represented more than once on the plot as it is offloaded to the spent fuel pool during refueling outages through the course of its cycle life. The burnup credit line for fuel storage with shrunken Boraflex is also displayed. As can be seen on Figure 4.2, there has never been an occurrence where irradiated fuel has been stored in the storage racks that did not meet the criteria listed above.

New fuel assemblies or irradiated fuel assemblies which do not meet the minimum burnup requirement for their initial enrichment would have to be patterned with particular face-neighbor fuel assemblies in order to maintain 5 percent subcritical margin. Acceptable face-neighbor fuel assemblies must meet the following face-neighbor criterion:

> A face-neighbor fuel assembly must have an average burnup of 35,000 MWD/MTU or greater **AND** having an initial enrichment of 3.65 w/o or less.

A review of the fuel assemblies currently stored in the spent fuel pool indicates there are several hundred fuel assemblies meeting this criterion. An open cell may be substituted in lieu of a fuel assembly meeting the above criterion.

Figure 4.1

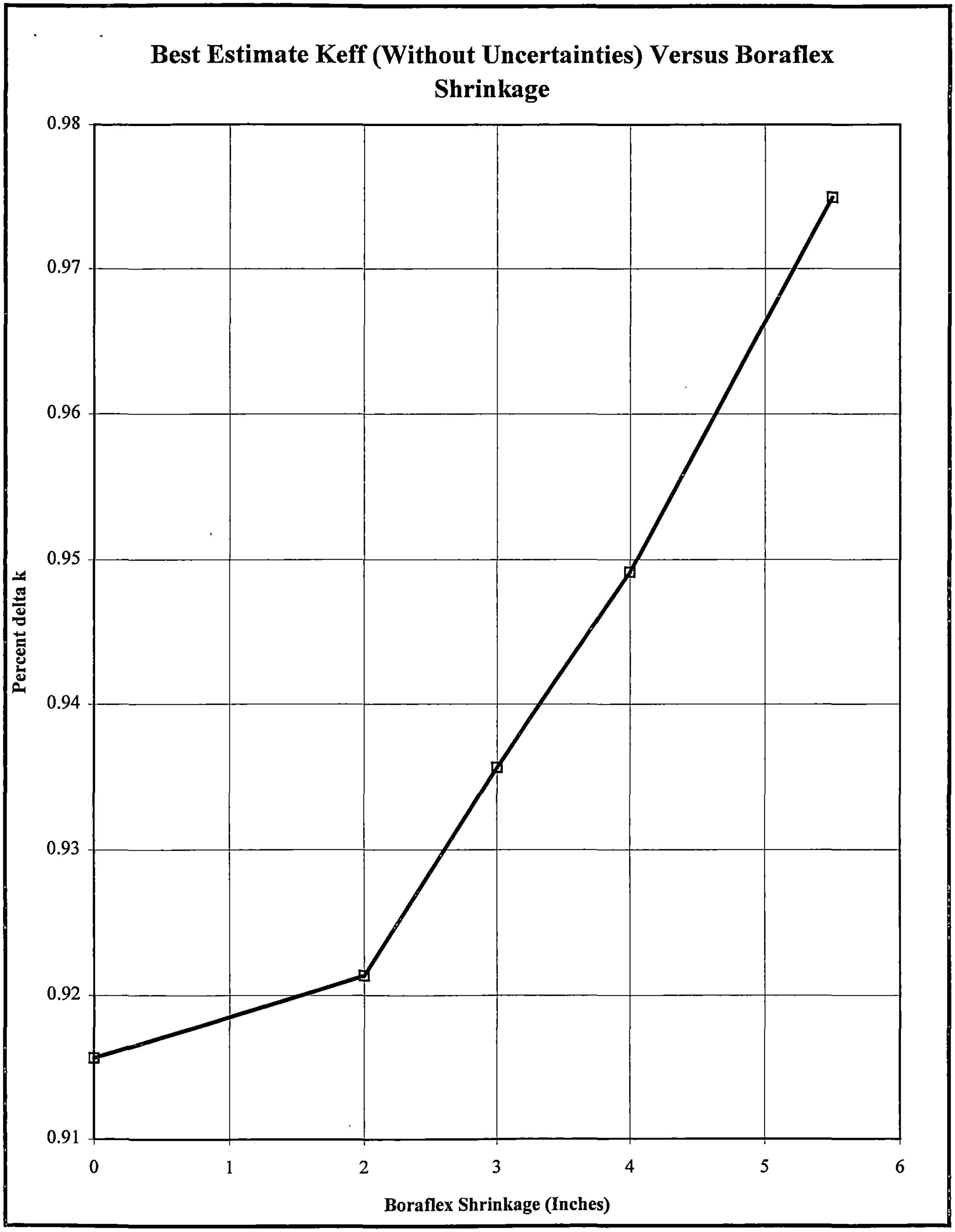
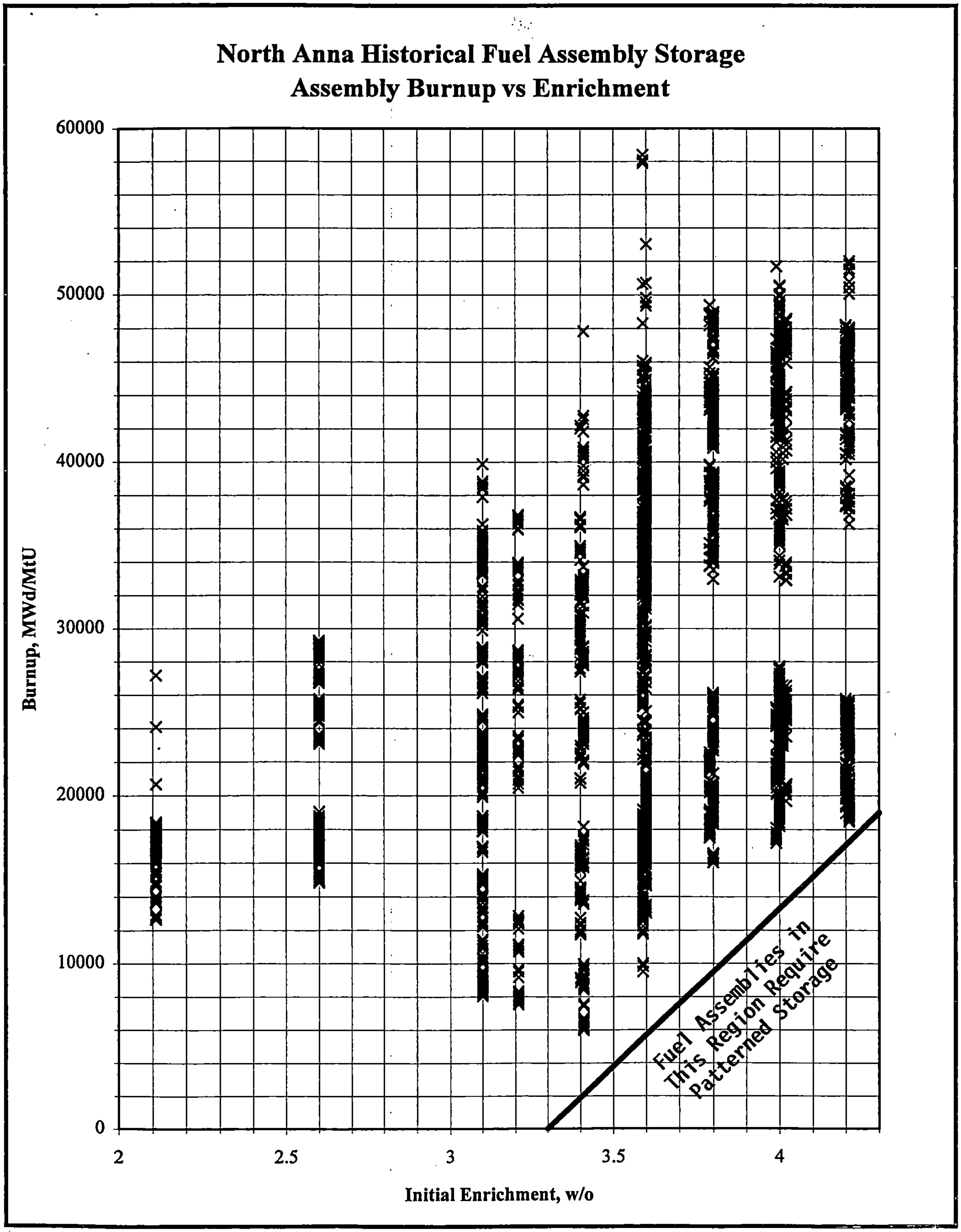

Best Estimate Keff (Without Uncertainties) Versus Boraflex Shrinkage
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
Percent delta k
0
1
2
3
4
5
6
Boraflex Shrinkage (Inches)

Figure 4.2


North Anna Historical Fuel Assembly Storage
Assembly Burnup vs Enrichment
Burnup, MWd/MtU
60000
50000
40000
30000
20000
10000
0
2
2.5
3
3.5
4
Initial Enrichment, w/o
Fuel Assemblies in
This Region Require
Patterned Storage

5.0 COMPENSATORY ACTIONS

The assessment of the physical condition of the Boraflex is based, in part, on estimated gamma dose to Boraflex panels and a conservative shrinkage correlation as a function of gamma dose reported by EPRI which bounds most of the utility data derived from Boraflex surveillance coupon programs. The actual extent of the shrinkage of the North Anna Boraflex panels and resultant gaps are not known. EPRI has reported that it is possible for gaps to form at various axial locations along the panels. EPRI has further reported that if random axial gaps have formed along the Boraflex panel, the resultant penalty in k_{eff} is very small. It is therefore expected that the actual condition of the Boraflex panels in the North Anna racks is less limiting than what was assumed in this analysis. However, testing of a sample of the Boraflex panels is required in order to determine the actual extent of the shrinkage and the resultant gap distribution. The following actions will be taken to determine the extent of the Boraflex shrinkage in the North Anna racks and ensure that sufficient subcritical margin can be maintained until it is determined by testing what licensing actions, if any, are required:

(1) Test of a sample of storage cells in the North Anna storage racks to determine the extent of shrinkage and the resulting Boraflex gap distribution. The results of the testing will be evaluated to determine any impact on the current design and licensing bases of the North Anna spent fuel storage racks and what licensing actions, if any, are required.

(2) As a defense-in-depth measure, procedures will be modified to incorporate the burnup credit configuration requirements presented in Section 4.2 to ensure that 5 percent subcriticality is maintained until any further licensing actions, if any, are required to be taken as a result of the Boraflex test results. Specifically:

(a) No storage configuration limitation is required for any fuel assembly having an initial enrichment of 3.3 w/o or less.

(b) No storage configuration limitation is required for any fuel assembly whose average burnup falls above the straight line defined by the points (3.3 w/o initial enrichment, 0 MWD/MTU Burnup) and (4.3 w/o initial enrichment, 19,000 MWD/MTU burnup) on a fuel assembly burnup versus initial enrichment plot.

(c) New fuel assemblies or any irradiated fuel assemblies which do not meet the minimum burnup requirement for their initial enrichment in Item (b) above will have to be patterned with certain spent fuel assemblies that meet a face-neighbor requirement.

(d) Acceptable face-neighbors for a fresh fuel assembly or an irradiated fuel assembly which does not meet the minimum burnup requirement for its initial enrichment in Item (b) above are assemblies which have an average burnup greater than 35,000 MWD/MTU **and** have an initial enrichment less than 3.65 weight percent. An open cell location may be substituted for a face-neighbor fuel assembly.

(3) The reactive silica concentration in the spent fuel pool will continue to be monitored. A strong increasing trend may be an indication of further degradation of Boraflex. Should this occur, additional testing or stricter requirements will be evaluated.

(4) The administrative limit for the minimum soluble boron concentration of 2300 ppm in the spent fuel pool will continue in effect. While it is recognized that credit for soluble boron is not part of the design basis for the spent fuel storage racks, maintaining administrative control for the minimum boron concentration provides an additional degree of defense in depth.

(5) A program will be developed and implemented via procedures to limit the amount of increased gamma exposure to the cells that currently have Boraflex panels with saturated dose. Examples of factors that could be considered in this program are to limit the fuel assemblies stored in these cells to fuel assemblies that have been cooling for 2 years or more and maintain fuel pool temperature as low as practical.

In addition to these actions, Virginia Power currently plans to further evaluate options to eliminate Boraflex from the North Anna spent fuel storage rack design basis. Such options include a combination of burnup and boron credit, burnup credit in combination with poison inserts, or inserting poison inserts within the rack storage cells.

6.0 CONCLUSIONS

The assessment of the physical condition of the Boraflex provided in this report is based, in part, on estimated gamma dose to the Boraflex panels and an empirical shrinkage correlation as a function of gamma dose which bounds most of the utility data derived from Boraflex surveillance coupon programs. Further testing is planned at North Anna to determine the actual configuration of the Boraflex panels as a result of the potential shrinkage. The results of the testing will determine whether the current licensing basis for the North Anna rack design must be modified. However, interim compensatory actions have been identified and will be implemented to ensure that 5 percent subcritical margin can be maintained for the North Anna storage racks in unborated water even under the worst case configuration assumed in this evaluation. Also, based on the design of the North Anna racks, this report concludes that conditions do not appear to be favorable for the rapid dissolution of Boraflex.

It should be noted that Virginia Power plans to further evaluate options to eliminate Boraflex from the North Anna spent fuel storage rack design basis as discussed above. Any required licensing actions from this potential change in design basis will be identified at that time.

ATTACHMENT 2

Commitments made in Response to NRC GL 96-04
"Boraflex Degradation in Spent Fuel Pool Storage Racks"

1. The compensatory measures will be implemented prior to loading any additional unirradiated or irradiated fuel to the spent fuel storage racks. The compensatory measures will remain in place until the issue of Boraflex degradation is resolved. (Attachment 1, Section 5.0)

2. Testing and evaluation of the Boraflex panels will be completed as soon as reasonably practicable and is currently scheduled for completion by March 31, 1997. (Cover Letter)

3. Virginia Electric and Power Company plans to further evaluate options to eliminate Boraflex from the North Anna spent fuel storage rack design basis. (Attachment 1, Section 5.0)

4. The uncertainty in the prediction of k_{eff} of 3.4% Δk identified in Section 5.6.1.1 of the North Anna Unit 1 and North Anna Unit 2 Technical Specifications is not applicable to the current licensing basis storage rack analysis. The current amendment was approved using a different value for the total uncertainity as stated in the NRC's Safety Evaluation Report. This represents no safety concern and will be corrected via a future Technical Specifications amendment. (Attachment 1, Section 4.1)