Commonwealth Edison Company
1400 Opus Place
Downers Grove, IL 60515-5701

November 6, 1996

ComEd

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

Subject: Braidwood Station Units 1 and 2
Byron Station Units 1 and 2
LaSalle Station Units 1 and 2
Quad Cities Units 1 and 2
Dresden Nuclear Power Station Units 2 and 3
Zion Nuclear Power Station Units 1 and 2

Commonwealth Edison Company (ComEd) Response to NRC Generic Letter 96-04, "BORAFLEX DEGRADATION IN SPENT FUEL POOL RACKS," dated June 26, 1996

NRC Dockets 50-456 and 50-457
NRC Dockets 50-454 and 50-455
NRC Dockets 50-373 and 50-374
NRC Dockets 50-254 and 50-265
NRC Dockets 50-237 and 50-249
NRC Dockets 50-295 and 50-304

Reference: 1. NRC Generic Letter 96-04, "BORAFLEX DEGRADATION IN SPENT FUEL POOL RACKS," dated June 26, 1996

2. J. Hosmer Letter to USNRC, Generic Letter 96-04, "BORAFLEX DEGRADATION IN SPENT FUEL POOL STORAGE RACKS," dated October 24, 1996

In the Reference 1 letter, the NRC staff informed all addressees of issues concerning the use of Boraflex in Spent Fuel Pool storage racks. In NRC Generic Letter 96-04, the NRC staff required all addressees that use Boraflex in their Spent Fuel Pool storage racks to submit a written response to the Generic Letter within 120 days of the date of the Generic Letter. The Reference 2 letter requested a 14 day extension (to November 7, 1996) to allow ComEd to submit a response to the Generic Letter. This letter is ComEd's response to Generic Letter 96-04.

All licensees of power reactors with installed Spent Fuel Pool storage racks containing the neutron absorber Boraflex are requested to respond as follows:

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"All licensees of power reactors with installed spent fuel pool storage racks containing the neutron absorber Boraflex are requested to 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 and state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water. Monitoring programs or calculational models in effect or being developed, or an estimation of anticipated concerns based on the specific rack design, are considered an appropriate basis for this response. All licensees are further requested to submit to the NRC a description of any proposed action to monitor or confirm that this 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. Licensees should describe the results from any previous post operational blackness tests and state whether blackness testing, or other in-situ tests or measurements, will be periodically performed. Chronological trends of pool reactive silica levels, along with the timing of significant events such as refuelings, pool silica cleanups, etc., should be provided. Implications of how these pool silica levels relate to Boraflex performance should be described."

ComEd Response to NRC Generic Letter 96-04

The Spent Fuel Pools at Braidwood, Byron, and LaSalle Unit 2, and Quad Cities have fuel racks installed that utilize sheets of Boraflex for reactivity suppression. Attachments 1 through 4 to this letter provide the detailed response for each affected station. The Spent Fuel Pool storage racks at Dresden, Zion, and LaSalle Unit 1 do not use Boraflex for reactivity suppression.

To the best of my knowledge and belief, the statements contained in this document are true and correct.

If you have any questions concerning this response, please direct them to Gary Benes, Licensing Administrator, at 630-663-7282.

Sincerely,

John B Hosmer

John B. Hosmer
Engineering Vice President

Signed before me on this 6th day,

of November 1996 Maryellen D Long 1996
Notary Public

OFFICIAL SEAL
MARYELLEN D LONG
NOTARY PUBLIC, STATE OF ILLINOIS
MY COMMISSION EXPIRES:04/16/98

Attachments

cc: A. Beach, Regional Administrator, RIII
R. Capra, Project Directorate, NRR
R. Assa, Braidwood Project Manager, NRR
G. Dick, Byron Project Manager, NRR
D. Skay, LaSalle Project Manager, NRR
R. Pulsifer, Quad Cities Project Manager, NRR
J. Stang, Dresden Project Manager, NRR
C. Shiraki, Zion Project Manager, NRR
C. Phillips, Senior Resident Inspector - Braidwood
S. Burgess, Senior Resident Inspector - Byron
M. Huber, Senior Resident Inspector - LaSalle
C. Miller, Senior Resident Inspector - Quad Cities
C. Vanderniet, Senior Resident Inspector - Dresden
R. Westberg, Acting Senior Resident Inspector - Zion
Office of Nuclear Safety - IDNS

ATTACHMENT 1

Braidwood Station
NRC Docket 50-456 and 50-457
Response to; NRC Generic Letter 96-04,
"BORAFLEX DEGRADATION IN SPENT FUEL POOL RACKS,"
dated June 26, 1996

NRC REQUEST:

"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 and state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water. Monitoring programs or calculational models in effect or being developed, or an estimation of anticipated concerns based on the specific rack design, are considered an appropriate basis for this response."

RESPONSE:

Spent Fuel Pool Design and Design Basis

Braidwood Station has a single spent fuel pool to support fuel storage for both units. The pool contains fuel racks for the storage of new and irradiated fuel assemblies in a two region design. The two regions are currently designed for a 95 percent probability at a 95 percent confidence level that the maximum Keff of ≤ 0.95 is met in unborated water. This design basis criticality analysis was performed accounting for Boraflex shrinkage and gapping, but not for a loss of boron from dissolution or other means.

The two regions of spent fuel racks are described as follows:

The Region 1 racks are constructed of corrosion resistant structural metals with Boraflex and Boral as the neutron poison material. Region 1 racks were designed with Boraflex panels covered with a stainless steel sheet and Boral panels in the flux trap between storage cells. The Boraflex panels, although covered with stainless steel, are not encapsulated. The Boral was added during the initial construction of the Region 1 racks to ensure that, for limited Boraflex degradation ,a Keff of ≤ 0.95 would still be met. Region 1 is designed to accommodate new and spent fuel. There are a total of 392 storage cells in four racks in Region 1.

The Region 2 racks are constructed of corrosion resistant structural metals with Boraflex as neutron poison materials. Region 2 racks were designed with Boraflex panels covered with a stainless steel sheet. The Boraflex panels, although covered with stainless steel, are not encapsulated. Region 2 is designed to accommodate spent fuel that satisfies an accumulated minimum burnup requirement. There are a total of 2472 storage cells and 6 failed fuel storage cells in 19 racks in Region 2.

Assessment

In 1987, ComEd first identified gamma radiation-induced damage of the Boraflex polymer. When Boraflex undergoes gamma irradiation in a spent fuel pool it progresses through two stages of radiation-induced damage. During the first stage the Boraflex cracks and shrinks, producing gaps. The second stage occurs after the polymer has sustained significant damage, and consists of the Boraflex becoming brittle and susceptible to dissolution in the Spent Fuel Pool cooling water.

There are three monitoring programs that can be used to assess the present physical condition of the Boraflex in the spent fuel pool: coupon testing, silica trending, and blackness testing.

Coupon Surveillance program

Coupon testing is performed per Braidwood procedures BwVS FH-1, High Density Fuel Rack Boraflex & Boral Specimen Surveillance and BwVP 500-86, In Service Surveillance Program for Boraflex & Boral Neutron Absorbing Materials. These procedures require that Boraflex coupons be removed from the pool every two years and sent off-site for analysis. To date, only expected shrinkage of coupons has been identified with all coupon test acceptance criteria met.

Silica Trending

Silica concentration in the spent fuel pool water is trended as an indicator of Boraflex degradation. The current concentration level of silica in the Spent Fuel Pool cooling water indicates that some storage locations have progressed into the second stage of damage. This data is provided later in this response.

Blackness Testing

Analysis results from the June 1996 fast scan blackness testing were received at Braidwood Station on 8/21/96, indicating shrinkage and gaps in the Boraflex panels in the Spent Fuel Racks. The largest gap identified had a width greater than four inches.

Blackness Testing (cont'd)

Results from this recent blackness testing campaign at Braidwood indicate progress into the second stage of damage has occurred, and that the maximum gap width allowed in the current criticality analysis has been exceeded in some spent fuel pool locations. Although blackness testing is useful for measuring cracks, gaps, and wastage, it does not measure the overall reduction in boron areal density. Therefore, blackness testing provides incomplete information regarding the current state of a given storage location. An approved methodology to measure boron areal density does not currently exist for PWRs.

Additional Evaluation

Braidwood Station has a Boraflex panel design that is particularly susceptible to water ingress and washout effects (per discussions with Northeast Technology Corporation, EPRI consultant). The design consists of Boraflex paneling approximately 144 inches in length, framed by a thin strip of stainless steel, with the stainless steel frame being tack welded to the storage location cell walls in at least 20 locations. This design exposes more Boraflex to water than other designs.

Summary

In summary, Braidwood Station has determined that the Boraflex panels in some spent fuel pool locations have progressed into the second stage of degradation such that a subcritical margin of five percent in unborated water may not be maintained without compensatory actions.

NRC REQUEST:

"Submit to the NRC a description of any proposed action to monitor or confirm that this 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."

RESPONSE:

As discussed previously, gaps greater than four inches were found during recent blackness testing. A gap of greater than four inches in any Boraflex panel exceeds that assumed in the current criticality analysis. This placed the fuel racks outside the requirements of Technical Specification 5.6.1.1. An ENS phone call was made at 1349 on 8/22/96 and an LER submitted on 9/20/96 reporting this condition. Compensatory actions have been taken.

Short Term Actions

ComEd has performed calculations to demonstrate that 1000 ppm soluble boron in the spent fuel pool water will maintain a Keff $\leq$ 0.95 without any credit for Boraflex. Therefore, even if all Boraflex were to be removed from the Spent Fuel Racks, the 1000 ppm value is adequate to maintain the Spent Fuel Pool at $\leq$ 0.95 Keff. As a short term compensatory action, administrative procedures have been implemented to assure this boron concentration is maintained.

Intermediate Actions

As an intermediate corrective action, Braidwood will submit an interim Technical Specification change request in early November which will include some degree of Spent Fuel Pool checkerboarding based on burn-up and a requirement for a minimum soluble boron concentration. The combination of checkerboarding and boron credit will maintain a Keff $\leq$ 0.95. Without credit for soluble boron, this configuration will result in a Keff <1. The interim Technical Specification will require monitoring of the Spent Fuel Pool's boron concentration by sampling once every 24 hours as a minimum.

In applying the interim corrective action Technical Specification, Braidwood will move assemblies into a pattern dictated by a new criticality analysis, preferentially using the available Spent Fuel Pool storage cells that have seen lower service and, therefore, lower gamma exposure.

As an additional compensatory action to minimize potential Boraflex degradation, Spent Fuel Pool silica reduction using reverse osmosis is presently being restricted until a long term corrective action to the Boraflex degradation is in place.

Long Term Actions

The long term corrective actions being evaluated by ComEd are as follows:

- Submit a permanent license amendment request to allow soluble boron to be credited in maintaining the pool ≤ 0.95 Keff. The analysis for this amendment is in progress.
- Evaluate the feasibility of the insertion of Reactivity Suppression Devices into the fuel assemblies stored in the racks to compensate for the depletion of the Boraflex. This may include the rearrangement of and taking credit for approximately 100 Rod Cluster Control Assemblies currently in Braidwood's Spent Fuel Pool.
- Evaluate the feasibility of the replacement of current Spent Fuel Pool racks with racks which do not contain the Boraflex material.
- Evaluate the feasibility of dry cask storage on site at Braidwood.

These potential long term corrective actions will be evaluated and a course of action determined by 4/1/97.

NRC REQUEST:

"Describe the results from any previous post operational blackness tests and state whether blackness testing, or other in-situ tests or measurements, will be periodically performed."

RESPONSE:

Blackness Testing

Braidwood completed its first round of fast scan blackness testing on all cells in the Boraflex racks in August of 1989 and found no cracks or gaps.

Braidwood completed its second round of fast scan blackness testing on a representative 10% sample of the fuel rack locations in August of 1991. Test results indicated five gaps of varying size in five separate cells on five separate panels. The gap sizes were so small that they could not be readily quantified to any measurable extent with the fast scan testing technique. Therefore, the cells in question were administratively prohibited from use until slow scan testing could be completed to quantify the gaps.

After fabrication of a slow scan calibration cell, Braidwood completed the slow scan testing of the possible gaps in February of 1993. The calibration cell contained Boraflex with very specific gaps of known dimensions. This cell was used to compare to data obtained in slow scan blackness testing. The results of the slow scan blackness testing indicated that there were only two gaps that could be confirmed from the fast scan testing. These gaps were in cells L2B1 and L2C2. The largest of these gaps measured approximately 1.50 inches in width. Braidwood concluded that the observed abnormalities had no impact on the 5% subcriticality margin.

On 8/21/96, analysis results of the most recent Neutron Attenuation (blackness) test data (data collection occurred in June of 1996) were received at Braidwood Station, indicating shrinkage and gaps in the Boraflex in the Spent Fuel Racks. The largest gap identified had a width greater than four inches. These results indicate progress into the second stage of damage has occurred.

Blackness testing will continue to be conducted in accordance with Braidwood's present NRC commitment (Attachment 1, Reference 1). The commitment is to perform blackness testing within two years of placing the racks in service and every five years, thereafter.

Other In-Situ Tests or Measurements

Spent Fuel Pool coupon testing is done every two years per station procedures. To date, only expected shrinkage of coupons has been seen. No coupon testing acceptance criteria have been exceeded. A possible reason why the coupons may not have seen the same degradation as the blackness testing is that the coupons are more tightly encapsulated in stainless steel than the rack panels. Braidwood will continue to follow the surveillance schedule.

NRC REQUEST:

"Chronological trends of pool reactive silica levels, along with the timing of significant events such as refuelings, pool silica cleanups, etc., should be provided. Implications of how these pool silica levels relate to Boraflex performance should be described."

RESPONSE:

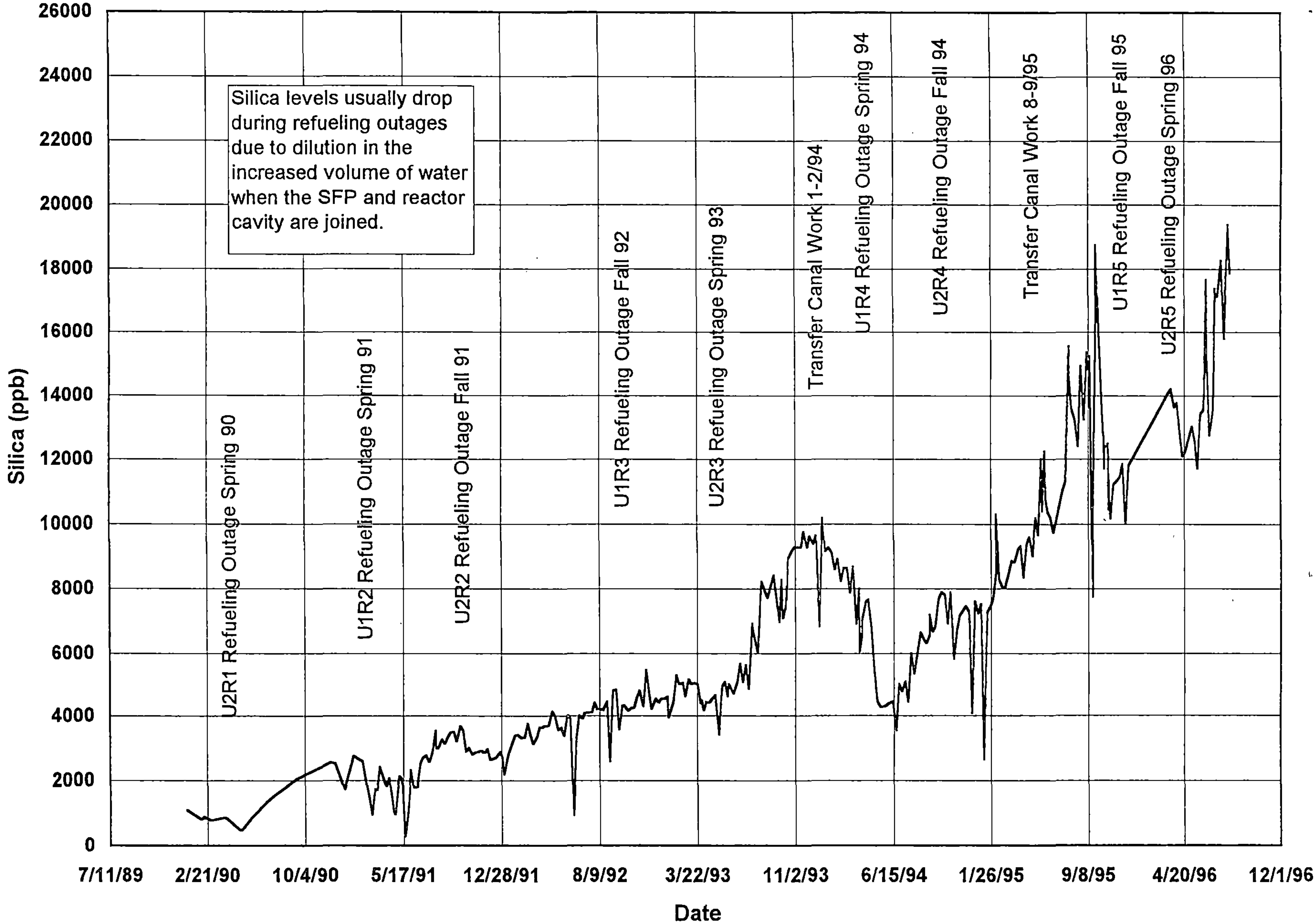
Chronological trends of the Spent Fuel Pool silica levels are shown in the following graph. Included in the data are silica levels, times of refueling, and replacements of Spent Fuel Pool Transfer Canal water inventory.

These pool silica trends and levels indicate that dissolution of the Boraflex is occurring. The rate of Boraflex dissolution is dependent, in part, on the concentration of reactive silica in the Spent Fuel Pool solution. It is believed that reduction of silica levels via processes such as reverse osmosis may contribute to increased dissolution of the Boraflex. Therefore, in order to minimize the Boraflex degradation, Spent Fuel Pool silica reduction using reverse osmosis will be restricted until a long term solution to the Boraflex degradation is in place.

BRAIDWOOD REFERENCE 1

"High Density Fuel Storage Racks Blackness Testing - Byron Station Unit Nos. 1 and 2; Braidwood Station Unit Nos. 1 and 2 (TAC Nos. 62112, 63266, 72234 and 72235)", 5/23/90, letter from Paul C. Shemanski, Project Manager, Project Directorate III-2, to Thomas J. Kovach, Nuclear Licensing Manager, Commonwealth Edison Company.

Braidwood Spent Fuel Pool Silica Data



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ATTACHMENT 2

Byron Station
<u>NRC Docket 50-454 and 50-455</u>
Response to; NRC Generic Letter 96-04,
"BORAFLEX DEGRADATION IN SPENT FUEL POOL RACKS,"
dated June 26, 1996

NRC REQUEST:

"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 and state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water. Monitoring programs or calculational models in effect or being developed, or an estimation of anticipated concerns based on the specific rack design, are considered an appropriate basis for this response."

RESPONSE:

<u>Spent Fuel Pool Design and Design Basis</u>

Byron Station has a single spent fuel pool to support fuel storage for both units. The pool contains fuel racks for the storage of new and irradiated fuel assemblies in a two region design. The two regions are currently designed for a 95 percent probability at a 95 percent confidence level that the maximum Keff of ≤ 0.95 is met in unborated water. This design basis criticality analysis was performed accounting for Boraflex shrinkage and gapping, but not for a loss of boron from dissolution or other means.

The two regions of spent fuel racks are described as follows:

The Region 1 racks are constructed of corrosion resistant metals for the structural requirements with Boraflex and Boral as the neutron poison material. Region 1 racks were designed with Boraflex panels covered with a stainless steel sheet and Boral panels in the flux trap between storage cells. The Boraflex panels, although covered with stainless steel, are not encapsulated. The Boral was added during the initial construction of the Region 1 racks to ensure that, for limited Boraflex degradation, a Keff of ≤ 0.95 would still be met. Region 1 is designed to accommodate new and spent fuel. There are a total of 392 storage cells in four racks in Region 1.

The Region 2 racks are constructed of corrosion resistant metals for the structural requirements with Boraflex as the neutron poison material. Region 2 racks were designed with Boraflex panels covered with a stainless steel sheet. The Boraflex panels, although covered with stainless steel, are not encapsulated. Region 2 is designed to accommodate spent fuel that satisfies an accumulated minimum burnup requirement. There are a total of 2472 storage cells and 6 failed fuel storage cells in 19 racks in Region 2.

Assessment

In 1987, ComEd first identified gamma radiation-induced damage of the Boraflex polymer. When Boraflex undergoes gamma irradiation in a spent fuel pool it progresses through two stages of radiation-induced damage. During the first stage, the Boraflex cracks and shrinks, producing gaps. The second stage occurs after the polymer has sustained significant damage, and consists of the Boraflex becoming brittle and susceptible to dissolution in the Spent Fuel Pool cooling water.

There are three monitoring programs that can be used to assess the present physical condition of the Boraflex in the spent fuel pool: coupon testing, silica trending, and blackness testing.

Coupon Surveillance program

Coupon testing is performed per Byron procedure 0BVS FH-1, High Density Fuel Rack Boraflex and Boral Specimen Surveillance. This procedure requires that Boraflex coupons be removed from the pool every two years and sent off-site for analysis. To date, only expected shrinkage of coupons has been identified with all coupon test acceptance criteria met.

Silica Trending

Silica concentration in the spent fuel pool water is trended as an indicator of Boraflex degradation. The current concentration level of silica in the Spent Fuel Pool cooling water indicates that some storage locations have progressed into the second stage of damage. This data is provided later in this response.

Blackness Testing

Analysis results from the June 1996 fast scan blackness testing were received at Byron Station on 9/03/96, indicating shrinkage and gaps in the Boraflex panels in the Spent Fuel Racks. The largest gap identified had a width greater than four inches.

Blackness Testing (Cont'd)

Results from this recent blackness testing campaign at Byron indicate progress into the second stage of damage has occurred, and that the maximum gap width allowed in the current criticality analysis has been exceeded in some spent fuel pool locations. Although blackness testing is useful for measuring cracks, gaps, and wastage, it does not measure the overall reduction in boron areal density. Therefore, blackness testing provides incomplete information regarding the current state of a given storage location. An approved methodology to measure boron areal density does not currently exist for PWRs.

Additional Evaluation

Byron Station has a Boraflex panel design that is particularly susceptible to water ingress and washout effects (per discussions with Northeast Technology Corporation, EPRI consultant). The design consists of Boraflex paneling approximately 144 inches in length, framed by a thin strip of stainless steel, with the stainless steel frame being tack welded to the storage location cell walls in at least 20 locations. This design exposes more Boraflex to water than other designs.

Summary

In summary, Byron Station has determined that the Boraflex panels in some spent fuel pool locations have progressed into the second stage of degradation such that a subcritical margin of five percent in unborated water may not be maintained without compensatory actions.

NRC REQUEST:

"Submit to the NRC a description of any proposed action to monitor or confirm that this 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."

RESPONSE:

As discussed previously, gaps of greater than four inches were found during recent blackness testing. A gap of greater than four inches in any Boraflex panel exceeds that assumed in the current criticality analysis. This placed the fuel racks outside the requirements of Technical Specification 5.6.1.1. An ENS phone call was made at 1140 on 9/3/96 and an LER submitted on 10/1/96 reporting this condition. Compensatory actions have been taken.

Short Term Actions

ComEd has performed calculations to demonstrate that 1000 ppm soluble boron in the spent fuel pool water will maintain a Keff $\leq$ 0.95 without any credit for Boraflex. Therefore, even if all Boraflex were to be removed from the Spent Fuel Racks, the 1000 ppm value is adequate to maintain the Spent Fuel Pool at $\leq$ 0.95 Keff. As a short term compensatory action, administrative procedures have been implemented to assure this boron concentration is maintained.

Intermediate Actions

As an intermediate corrective action, Byron will submit an interim Technical Specification change request in early November which will include some degree of Spent Fuel Pool checkerboarding based on burn-up and a requirement for a minimum soluble boron concentration. The combination of checkerboarding and boron credit will maintain a Keff $\leq$ 0.95. Without credit for soluble boron, this configuration will result in a Keff $<$1. The interim Technical Specification will require monitoring of the Spent Fuel Pool's boron concentration by sampling once every 24 hours as a minimum.

In applying the interim corrective action Technical Specification, Byron will move assemblies into a pattern dictated by a new criticality analysis, preferentially using the available Spent Fuel Pool storage cells that have seen lower service and, therefore, lower gamma exposure.

As an additional compensatory action to minimize potential Boraflex degradation, Spent Fuel Pool silica reduction using reverse osmosis is presently being restricted until a long term corrective action to the Boraflex degradation is in place.

Long Term Actions

The long term corrective actions being evaluated by ComEd are as follows:

- Submit a permanent license amendment request to allow soluble boron to be credited in maintaining the pool ≤ 0.95 Keff. The analysis for this amendment is in progress.
- Evaluate the feasibility of the insertion of Reactivity Suppression Devices into the fuel assemblies stored in the racks to compensate for the depletion of the Boraflex. This may include the rearrangement of and taking credit for approximately 100 Rod Cluster Control Assemblies currently in Byron's Spent Fuel Pool.
- Evaluate the feasibility of the replacement of current Spent Fuel Pool racks with racks which do not contain the Boraflex material.
- Evaluate the feasibility of dry cask storage on site at Byron.

These potential long term corrective actions will be evaluated and a course of action determined by 4/1/97.

NRC REQUEST:

"Describe the results from any previous post operational blackness tests and state whether blackness testing, or other in-situ tests or measurements, will be periodically performed."

RESPONSE:

Blackness testing is conducted in accordance with Byron's present NRC commitment (Attachment 2, Reference 1). The commitment is to perform blackness testing within two years of placing the racks in service and every five years, thereafter. This was reviewed by the NRC staff and found acceptable.

Byron completed its first round of fast scan blackness testing on all cells in the Boraflex racks in June of 1989 and found no cracks or gaps.

Byron completed its second round of fast scan blackness testing on a representative 10% sample of the fuel rack locations in July of 1991. The results of this testing indicated 17 abnormalities in 16 panels. These abnormalities include apparent shortened sheets, gaps and indicated high count rates. The test results showed a lack of neutron attenuation material at the bottom of six panels in Region 1. The test revealed five gaps of varying size in four separate cells on four separate panels. Several of the panels in the Region 2 cells exhibited a higher count rate than should have been expected, however, when the testing was done on the same panel, but from a different cell, the count rate decreased to a rate lower than the other Region 2 panels. Based on a supplemental criticality analysis performed by Holtec International and research by EPRI and others, Byron Station concluded that the observed abnormalities had no impact upon the 5% subciticality margin. However, monitoring continued and a second campaign (slow scan) to characterize the configuration and to quantify the size of the abnormalities was conducted.

Byron completed the slow scan testing of the possible gaps in November 1992. The calibration cell contained Boraflex with very specific gaps of known dimensions. This cell was used to compare data obtained in slow scan blackness testing. The results of the slow scan blackness testing indicated that there were only five gaps that could be confirmed from the fast scan testing. The largest of these gaps measured approximately 2.97 inches in width. The test confirmed a Boraflex sheet had shortened approximately 5/8 inches (sheet starts at approximately 6.69 inches from bottom of cell).

On 9/3/96, analysis results of the most recent Neutron Attenuation (blackness) test data (data collection occurred in June of 1996) were received at Byron Station, indicating shrinkage and gaps in the Boraflex in the Spent Fuel Racks. The largest gap identified had a width greater than four inches. A gap of greater than four inches in any Boraflex panel exceeds that assumed in the current criticality analysis. These results indicate progress into the second stage of damage has occurred.

Blackness testing will continue to be conducted in accordance with Byron's present NRC commitment (Attachment 2, Reference 1). The commitment is to perform blackness testing within two years of placing the racks in service and every five years, thereafter.

Other In-Situ Tests or Measurements

Spent Fuel Pool coupon testing is done every two years per station procedures. To date, only expected shrinkage of coupons has been seen. No coupon testing acceptance criteria have been exceeded. A possible reason why the coupons may not have seen the same degradation as the blackness testing is that the coupons are more tightly encapsulated in stainless steel than the rack panels. Byron will continue to follow the surveillance schedule.

NRC REQUEST:

"Chronological trends of pool reactive silica levels, along with the timing of significant events such as refuelings, pool silica cleanups, etc., should be provided. Implications of how these pool silica levels relate to Boraflex performance should be described."

RESPONSE:

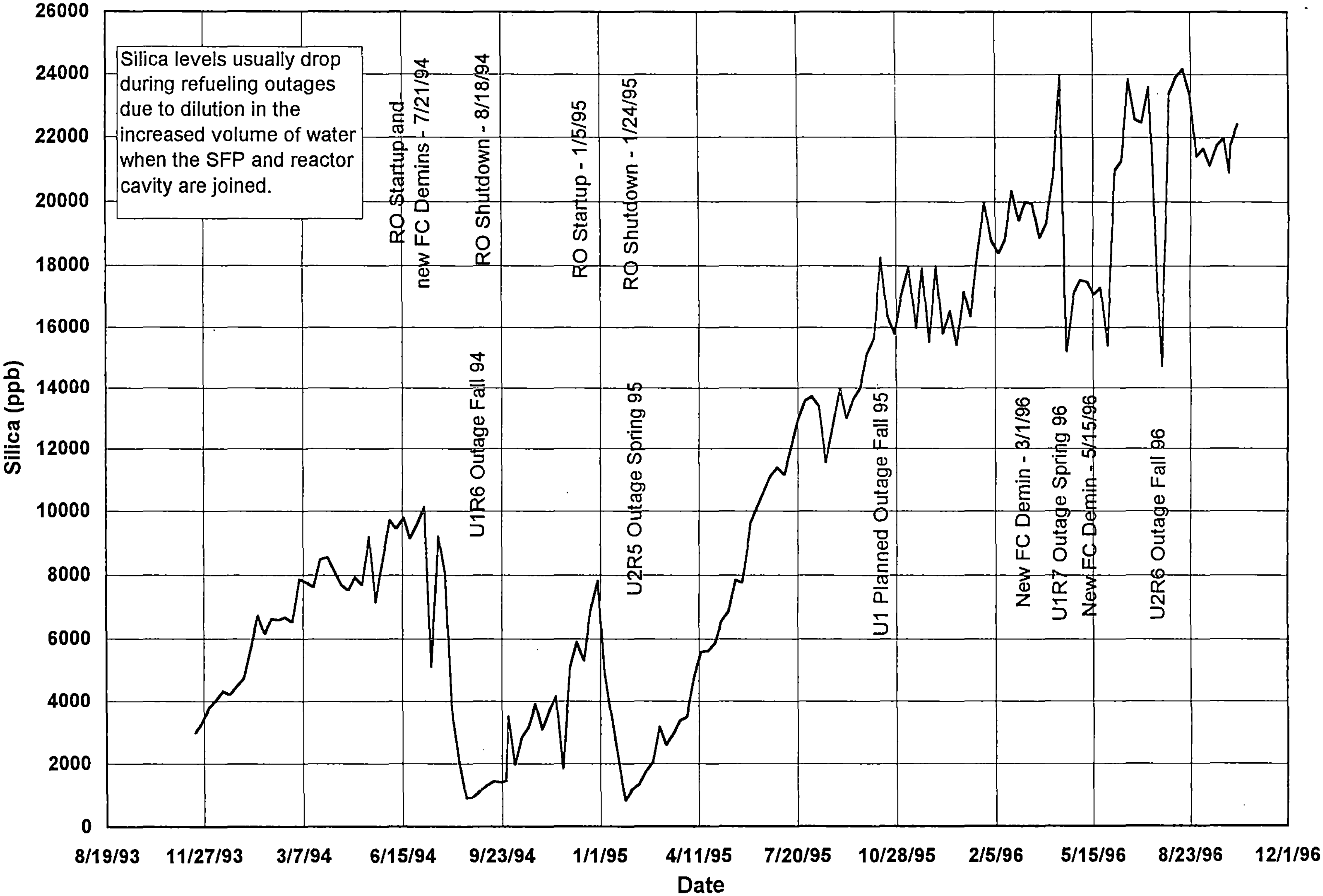
Chronological trends of the Spent Fuel Pool silica levels are shown in the following graph. Included in the data are silica levels, times of refueling, and replacements of Spent Fuel Pool Transfer Canal water inventory.

These pool silica trends and levels indicate that dissolution of the Boraflex is occurring. The rate of Boraflex dissolution is dependent, in part, on the concentration of reactive silica in the Spent Fuel Pool solution. It is believed that reduction of silica levels via processes such as reverse osmosis may contribute to increased dissolution of the Boraflex. Therefore, in order to minimize the Boraflex degradation, Spent Fuel Pool silica reduction using reverse osmosis will be restricted until a long term solution to the Boraflex degradation is in place.

BYRON REFERENCE 1

"High Density Fuel Storage Racks Blackness Testing - Byron Station Unit Nos. 1 and 2; Braidwood Station Unit Nos. 1 and 2 (TAC Nos. 62112, 63266, 72234 and 72235)", 5/23/90, letter from Paul C. Shemanski, Project Manager, Project Directorate III-2, to Thomas J. Kovach, Nuclear Licensing Manager, Commonwealth Edison Company.

Byron Spent Fuel Pool Silica Data



ATTACHMENT 3

LaSalle Station Unit 2
NRC Docket 50-374
Response to; NRC Generic Letter 96-04,
"BORAFLEX DEGRADATION IN SPENT FUEL POOL RACKS,"
dated June 26, 1996

NRC REQUEST:

"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 and state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water. Monitoring programs or calculational models in effect or being developed, or an estimation of anticipated concerns based on the specific rack design are considered an appropriate basis for this response."

RESPONSE:

Spent Fuel Pool Design and Design Basis

LaSalle Station has two Spent Fuel Storage Pools, one for each unit, connected by a double-gated transfer canal.

The Unit 1 storage racks contain a poison wall rack design based on a Boral neutron poison material.

The Unit 2 storage racks contain a poison wall rack design based on a Boraflex neutron poison material. The cells are constructed of a series of stainless steel boxes. The sheets of Boraflex are physically captured between the side walls of the adjacent storage cells. The side walls of each cell are pressed together to form individual arrays of racks. Rack construction is such that the Boraflex is exposed to flow. However, manufacturing the racks by pressing the walls together creates a tight fit that limits the amount of water that can contact the Boraflex material. Reducing the amount of water which contacts the Boraflex material reduces the potential for silica dissolution. The Unit 2 Spent Fuel Pool has 4073 storage cells.

The storage racks are designed for a 95 percent probability at a 95 percent confidence level that the maximum Keff of ≤ 0.95 is met in unborated water at maximum fuel assembly reactivity. Because BWRs have a relatively small fuel assembly pitch, and use burnable poison to control the reactivity of fresh fuel, there are wide margins to the 5 percent subcriticality criterion. The LaSalle design basis criticality analysis for currently loaded fuel designs typically shows an in-rack Keff of .84 to .86 (at fuel peak reactivity), which demonstrates a wide margin to the required

.95 criterion. This margin can accommodate substantial amounts of Boraflex shrinkage, gapping, loss of areal density and reduction in width.

Assessment

The physical condition of the Boraflex was assessed based on the station's rack exposure management, coupon surveillance program, and the wide margin to the 5 percent subcriticality requirement. A calculational model using the EPRI-sponsored RACKLIFE computer code is also under development. The assessment indicates that a 5% subcriticality margin is being maintained. The results of this assessment are discussed in the following sections.

Rack Exposure Management

Because Boraflex degradation is strongly influenced by accumulated gamma exposure, LaSalle Station has taken actions to minimize individual cell exposure by rotating core offload locations each refueling outage. As a result, the maximum exposure to the racks is less than that for which significant degradation has been predicted to occur.

Coupon Surveillance Program

In order to assess the integrity of the Boraflex, an inservice Boraflex surveillance program controlled by procedure LTS-1200-07 was established. This program includes the use of two full length coupons (BA2 and BA3) and two assemblies (1A and 1B). Each assembly contains 13 short length coupons. The Boraflex in the surveillance coupons are made with the same Boraflex material used in the manufacturing of the Spent Fuel Pool racks. The coupons are sandwiched between stainless steel plates similar to the actual Boraflex in the racks.

Coupon BA2 and assembly 1A are rotated to the fuel discharge areas each refueling outage so as to irradiate these surveillance coupons to an exposure higher than any cell location in the fuel pool. Coupon BA3 and assembly 1B are not always rotated to the discharge area each refuel outage and thus are irradiated to an exposure which is representative of an average cell location.

In July 1992, all the test coupons (full length and individual coupons) were sent to Northeast Technology Corporation for testing. Coupon BA2 and Assembly 1A had been exposed to an integrated gamma exposure of approximately 1E9 rads. Coupon BA3 and Assembly 1B had been exposed to an integrated gamma exposure of approximately 1E8 rads. The thickness, length, weight, and areal density were evaluated and the results were that no significant degradation had occurred.

In August 1996, two short length coupons were sent to Northeast Technology Corporation for testing. Coupon 1A7, which was representative of the highest exposure to the Spent Fuel cells as described above, received an integrated gamma exposure of 5.2E9 rads. This coupon did not indicate any significant thinning, significant B-10 reduction or loss of integrity of the polymer matrix. Coupon 1B3, which was representative of the average exposure to the spent fuel cells as described above, received an integrated gamma exposure of approximately 2.1E8 rads. The thickness, width, length and areal density of this coupon were evaluated with the conclusion that no significant degradation had occurred.

Silica Trending

The silica concentration level in the Spent Fuel Pool is being monitored and trended (see attached graph). The present data shows fairly low levels of silica, and is consistent with data observed at other BWRs. This information will be used as input for the RACKLIFE model.

RACKLIFE Calculational Model

In order to further minimize the potential degradation of Boraflex, LaSalle Station is presently in the process of modeling the spent fuel pools using the EPRI-sponsored RACKLIFE computer code. The RACKLIFE code has been developed to predict the long-term degradation of Boraflex as a result of gamma irradiation and exposure to fuel pool water. The RACKLIFE predictions will then be used to support the rack management strategy, and to identify the need for additional activities to offset any degradation.

Additional Evaluation

LaSalle 2 Spent Fuel Pool has a substantial margin to the 5% subcriticality requirement. As an indication of this margin, an evaluation has been performed that show that the spent fuel stored in the Boraflex racks meet the 5% subcriticality margin even under the assumption of a 40% loss in Boron-10 areal density, gap formation ranging from 1.3 to 3.25 inches and erosion of the edges up to 30% in width. The change in dimensions and areal density from the most recent coupon surveillance campaign are not approaching the values used for the criticality analysis.

Summary

In summary, LaSalle Station has determined that a subcritical margin of 5% can be maintained for the racks in unborated water. This is based on determining that no significant degradation of its Boraflex racks has been identified, exposure to the racks is managed and monitored, and a calculational model is under development to further manage rack exposure.

NRC REQUEST:

"Submit to the NRC a description of any proposed action to monitor or confirm that this 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"

RESPONSE:

The response to the previous question described monitoring programs and a calculational model to assure that a 5% subcriticality margin can be maintained.

Possible Corrective Actions

In the event a 5% subcritical margin cannot be maintained, the following corrective actions could also be taken if necessary:

- measurement of the rack B10 areal density
- checkerboarding the fuel with empty spaces
- installing neutron absorbing inserts
- limiting the allowable fuel reactivity in some racks
- replacement of the current Spent Fuel Pool racks with racks that do not contain the Boraflex material
- use of dry cask storage

In July of 1995, LaSalle successfully demonstrated the feasibility of installing borated inserts between the fuel assemblies and the rack walls.

NRC REQUEST:

"Describe the results from any previous post operational blackness tests and state whether blackness testing, or other in-situ tests or measurements, will be periodically performed."

RESPONSE:

LaSalle Station has not performed any blackness testing and such testing is not being planned at this time. The coupon surveillance program has not indicated unacceptable results, and there are no localized areas that have excessive exposure. The coupon surveillance program, as described in the above sections, will continue. If the coupon surveillance program shows unacceptable results or the RACKLIFE computer code predicts degradation, LaSalle Station will evaluate what actions are prudent, including the possibility of blackness testing.

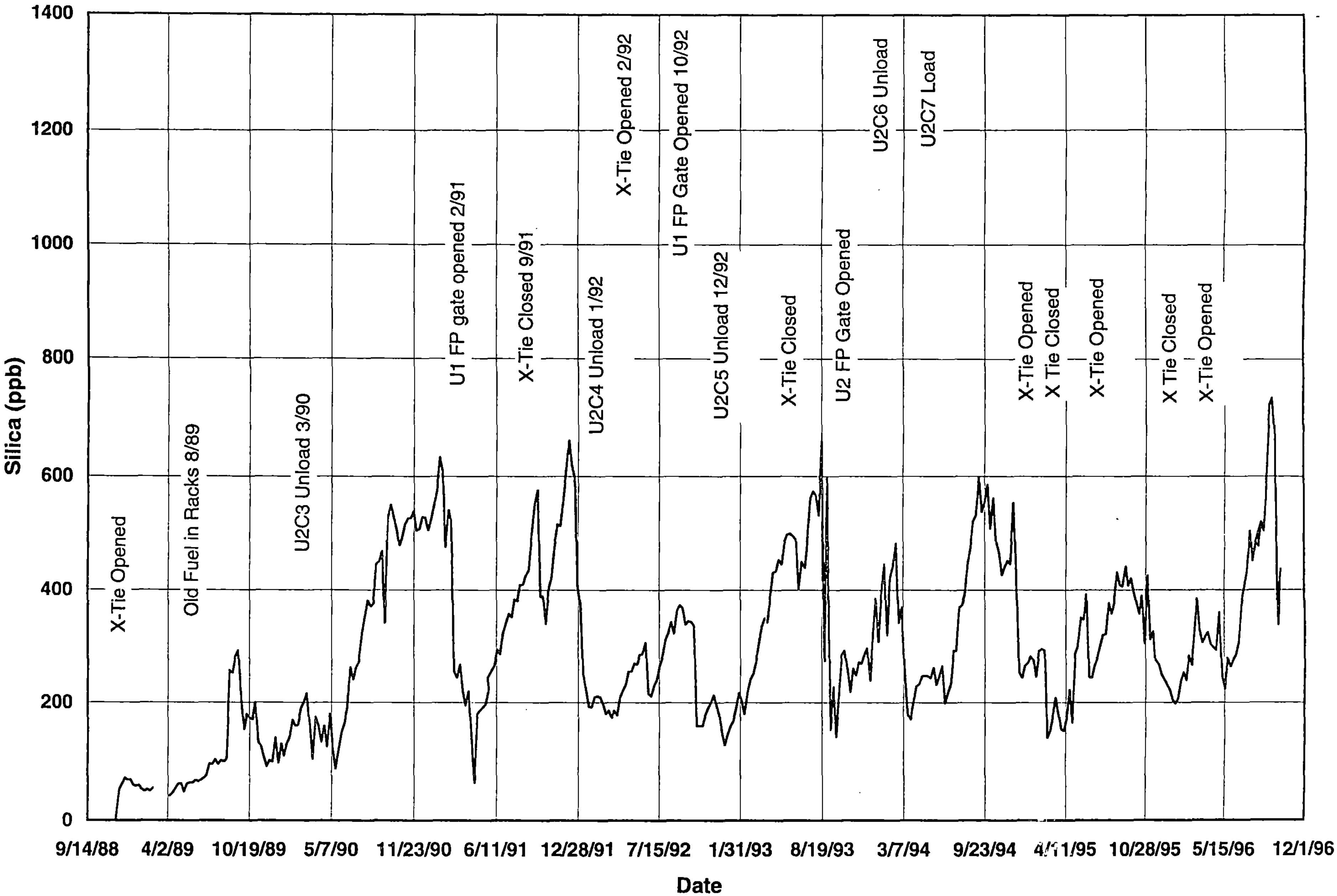
NRC REQUEST:

"Chronological trends of pool reactive silica levels, along with the timing of significant events such as refuelings, pool silica cleanups, etc., should be provided. Implications of how these pool silica levels relate to Boraflex performance should be described."

RESPONSE:

The chronological trend of Spent Fuel Pool silica levels, along with the timing of significant events are provided in the following graphs. The present data shows fairly low levels of silica and is consistent with data observed at other BWRs. However, the silica data alone may not provide a direct indication of the Boraflex performance

LaSalle Unit 2 Silica Data



ATTACHMENT 4

Quad Cities Station Units 1 and 2
NRC Dockets 50-254 and 50-265
Response to; NRC Generic Letter 96-04,
"BORAFLEX DEGRADATION IN SPENT FUEL POOL RACKS,"
dated June 26, 1996

NRC REQUEST:

"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 and state whether a subcritical margin of 5 percent can be maintained for the racks in unborated water. Monitoring programs or calculational models in effect or being developed, or an estimation of anticipated concerns based on the specific rack design, are considered an appropriate basis for this response."

RESPONSE:

Spent Fuel Pool Design and Design Basis

Quad Cities Station has two Spent Fuel Storage Pools, one for each unit, connected by a double-gated transfer canal. Both Units 1 and 2 storage racks contain a poison wall rack design based on a Boraflex neutron poison material. The racks are made from angular and straight stainless steel elements formed into cruciform shapes which create modular cells. A cavity for the Boraflex is created using end strips of stainless steel to form a "picture frame" between adjacent cells. This construction allows the pool water to be in contact with the Boraflex, but the flow exchange rate is low. The Unit 1 Spent Fuel Pool has 3657 storage cells, and the Unit 2 Spent Fuel Pool has 3897 storage cells.

The storage racks are designed for a 95 percent probability at a 95 percent confidence level that the maximum Keff of ≤ 0.95 is met in unborated water at maximum fuel assembly reactivity. Because BWRs have a relatively small fuel assembly pitch, and use burnable poison to control the reactivity of fresh fuel, there are wide margins to the 5 percent subcriticality criterion. The Quad Cities design basis criticality analysis for currently loaded fuel designs typically shows an in-rack Keff of .84 to .86 (at fuel peak reactivity), which demonstrates a wide margin to the required .95 criterion. This margin can accommodate substantial amounts of Boraflex shrinkage, gapping, loss of areal density and reduction in width.

Assessment

The physical condition of the Boraflex was assessed based on the station's current rack management approach, the wide margins to criticality, the low flow exchange rate, and the surveillance and trending results described below. The assessment indicates that a 5% subcriticality margin is currently being maintained for all stored fuel.

Based on the service that the Quad Cities racks have seen, some specific storage locations may have reached a gamma exposure level at which Boraflex dissolution can be expected to occur. As a conservative measure, Quad Cities Station began administratively preventing use of these specific locations prior to the start of the most recent refueling outage (Q1R14). These restrictions will remain in effect until the Boraflex integrity is verified by testing and the Spent Fuel Pool racks are modeled using the RACKLIFE computer model as described below.

Rack Exposure Management and RACKLIFE Calculational Model

Boraflex degradation is strongly influenced by accumulated gamma exposure. Because of their proximity to the reactor cavity, a block of approximately 750 cells in each pool have been used to receive fuel unloaded from the core during each of the previous refueling outages subsequent to the High Density Fuel Racks installation in December 1981. These cells are referred to as the "offload block" of cells. These cells have accumulated significantly more gamma radiation exposure than the remainder of the cells in the pools, which have generally received single, permanently discharged bundles. The "offload block" cells are currently administratively prevented from being used.

Quad Cities Station is now modeling the Unit 1 and 2 Spent Fuel Pools with the EPRI-sponsored RACKLIFE computer program. The RACKLIFE code has been developed to predict the long-term degradation of Boraflex as a result of gamma irradiation and exposure to fuel pool water. The RACKLIFE predictions (in conjunction with the pool cell BADGER testing described below) will then be used to develop a general rack management strategy, and to identify the need for additional activities to offset any degradation. The predictions will also be used to determine if the administratively restricted locations in the "offload block" can be used.

BADGER Testing

ComEd has contracted for testing services to obtain measurements of Boraflex areal density in the existing fuel storage racks in both Quad Cities fuel pools. This testing is scheduled for completion in late 1996, using the EPRI-developed BADGER test equipment and methodologies. This testing will sample fuel pool storage locations from each of several populations based on accumulated gamma exposure. The test population is biased towards the higher exposure locations to enhance the effectiveness of the test data as benchmarking input to the RACKLIFE model.

Coupon Surveillance Program

A Boraflex coupon surveillance program, controlled by procedure QCTS 941-4, was established following the installation of the Boraflex fuel racks. The coupons are sandwiched between stainless steel plates so as to provide stagnant water conditions very similar to that seen by the installed racks' Boraflex. A total of 18 coupons, representative of the various as-fabricated Boraflex batches, were installed in the two Spent Fuel Pools.

Between 1983 and 1995 ten coupons were removed from the fuel pools and sent out for laboratory examination. Although these coupons have not been exposed to the same gamma exposure as the highest use racks in the "offload area", their performance does reflect the racks which have been used primarily for permanently discharged fuel. The thickness, length, weight, and areal density were evaluated and the results were that no significant degradation had occurred.

Blackness Testing

Quad Cities Station has performed four blackness testing campaigns on irradiated spent fuel racks to identify the presence of any unexpectedly high Boraflex degradation. The tests were performed in 1986 (twice), 1989 and 1992. These tests, as expected, showed the presence of gaps caused by irradiation induced cracking and shrinkage. The largest gaps found were between 3 and 4 inches, which corresponds to a reactivity loss that is accommodated by the margins available in the design basis criticality analysis. Additional information concerning blackness testing is provided later in this response.

Silica Trending

The silica concentration level in the Spent Fuel Pool is being monitored and trended (see attached graphs). The present data shows fairly low levels of silica, and is consistent with data observed at other BWRs. This information will be used as input for the RACKLIFE model.

Additional Evaluation

As described above, the The Quad Cities Units 1 and 2 Spent Fuel Pools have substantial margin to the 5% subcriticality requirement. To demonstrate this margin, an evaluation has been performed that shows that the spent fuel permanently discharged in the Boraflex racks meet the 5% subcriticality requirement, even under the assumption of a 50% loss in Boron-10 worth, or a loss of approximately .20 delta Keff. This large margin could accomodate a 50% loss in boron areal density as well as gaps substantially in excess of those observed during blackness testing.

Summary

In summary, Quad Cities Station has determined that a subcriticality margin of 5% can be maintained in unborated water for all racks currently in use. This is based on determining that no significant degradation of these Boraflex racks has been identified, the rack design has a low water exchange rate, substantial criticality margin exists for discharged fuel, and a calculational model is under development to further manage rack exposure.

The planned BADGER testing and RACKLIFE predictions will provide Quad Cities Station with the information necessary to develop a strategy to return some or all of the administratively restricted rack locations to service. This strategy, in conjunction with the substantial criticality margin inherent in the rack design, will ensure that the 5% criterion can be maintained for these racks.

NRC REQUEST:

"Submit to the NRC a description of any proposed action to monitor or confirm that this 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"

RESPONSE:

The response to the previous question described the Quad Cities monitoring and testing programs and a calculational model to assure that a 5% subcriticality margin can be maintained.

Possible Corrective Actions

In the event a 5% subcritical margin cannot be maintained, the following corrective actions could also be taken if necessary:

- measurement of the rack B10 areal density
- checkerboarding the fuel with empty spaces
- installing neutron absorbing inserts
- limiting the allowable fuel reactivity in some racks
- replacement of the current Spent Fuel Pool racks with racks that do not contain the Boraflex material
- use of dry cask storage

In July of 1995, LaSalle successfully demonstrated the feasibility of installing borated inserts between the fuel assemblies and the rack walls. This provides confidence that inserts are likely feasible in the Quad Cities fuel pools as well.

NRC REQUEST:

"Describe the results from any previous post operational blackness tests and state whether blackness testing, or other in-situ tests or measurements, will be periodically performed."

RESPONSE:

In July of 1986 Quad Cities became aware that Point Beach Nuclear Power Station was observing degradation of their Boraflex test coupons. In August of 1986 the planned blackness testing for the Quad Cities High Density Fuel Racks (Boraflex) was expanded to include 14 cells (56 walls). The test locations had been used as offload racks and thus were expected to have the highest integrated gamma exposure. This test indicated 7 cells (11 walls) had demonstrated anomalies (gaps). The test method in use was not well suited to accurately characterize the gaps.

In October and November of 1986 a new test method (special test) had been developed that was better suited to characterizing the size of the suspected gaps. First, 118 cells were tested using the old test method (standard test) which would indicate potential gaps. The 30 worst anomalies were then examined using the special test method. The test data indicated the largest gap to be 3-4 inches. Various studies were initiated to determine the damage mechanism and the impact of gaps on the criticality analysis, and the results were used to develop a preliminary gap growth model.

In 1987 it was identified that the Boraflex polymer sustains gamma radiation-induced damage. The damage progresses through two stages. First, the Boraflex cracks and shrinks, producing cracks and gaps. The second phase occurs after the polymer has sustained significant damage, and consists of the Boraflex becoming brittle and susceptible to dissolution in the Spent Fuel Pool cooling water.

In July and August of 1989 additional testing was performed to better define both the location and size of the gaps. During this testing 286 cells were examined with the standard test method and 50 defects were analyzed with the special test method. The largest gaps were determined to be 3-4 inches in size.

In July of 1992 the final post operational testing was performed. This testing examined 300 cells using the standard test method and 50 cells with defects using the special test method. The results were similar to what was seen in 1989 and the results are accommodated by the margins available in the design basis criticality analysis.

The coupon surveillance program as described in the above sections, will continue. If the coupon surveillance program or BADGER testing shows unacceptable results or the RACKLIFE computer code predicts degradation, Quad Cities Station will evaluate what actions are prudent.

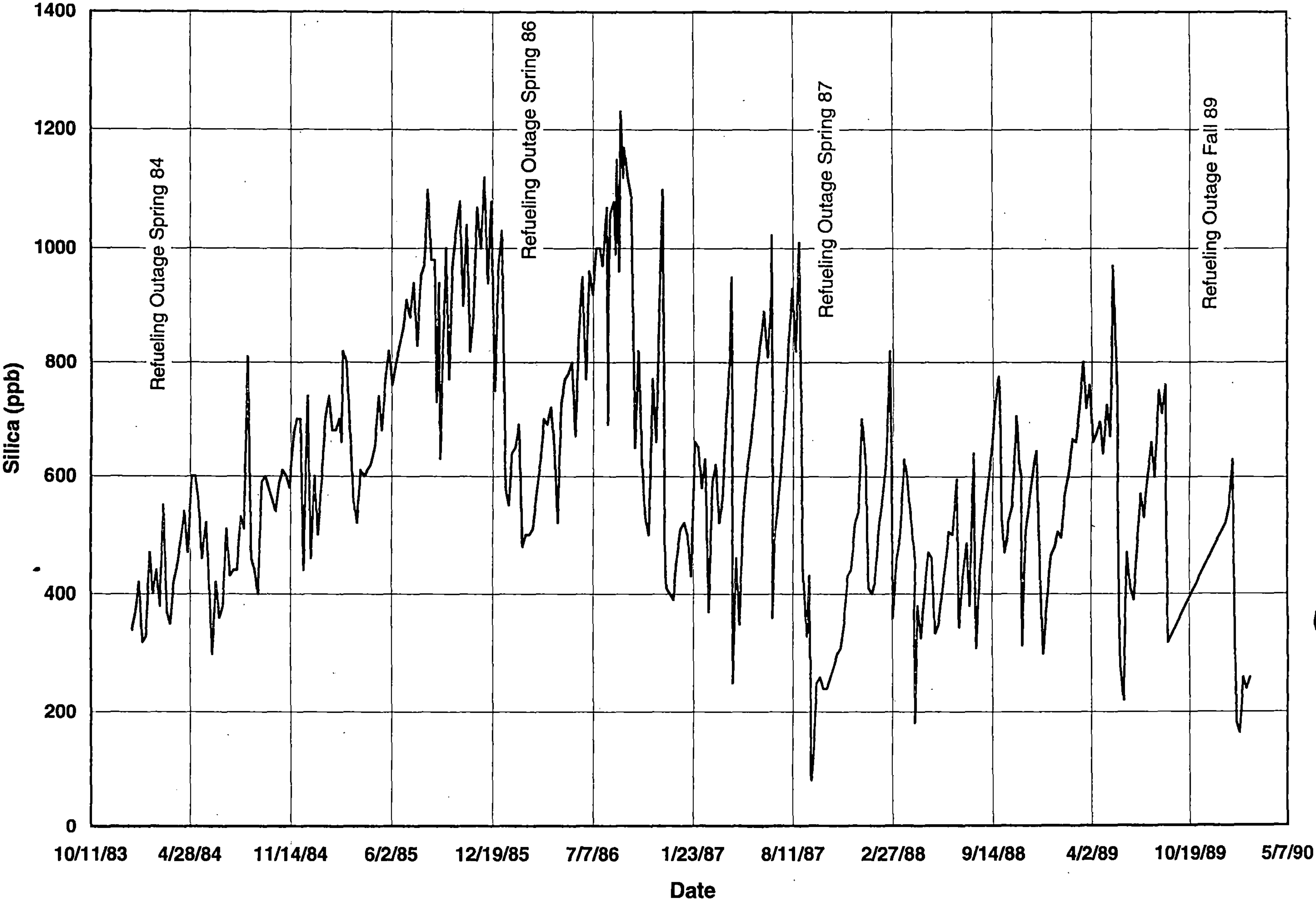
NRC REQUEST:

"Chronological trends of pool reactive silica levels, along with the timing of significant events such as refuelings, pool silica cleanups, etc., should be provided. Implications of how these pool silica levels relate to Boraflex performance should be described."

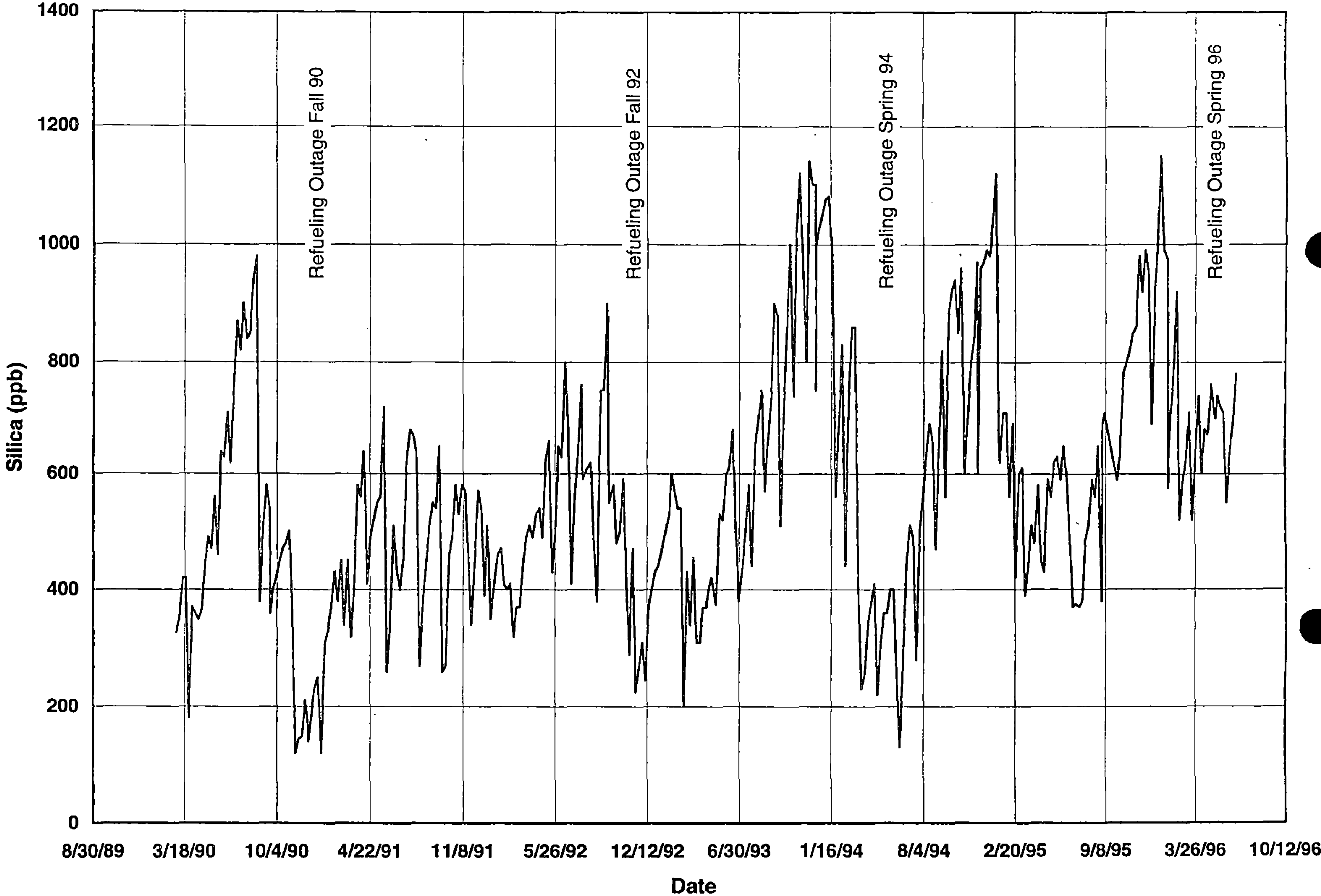
RESPONSE:

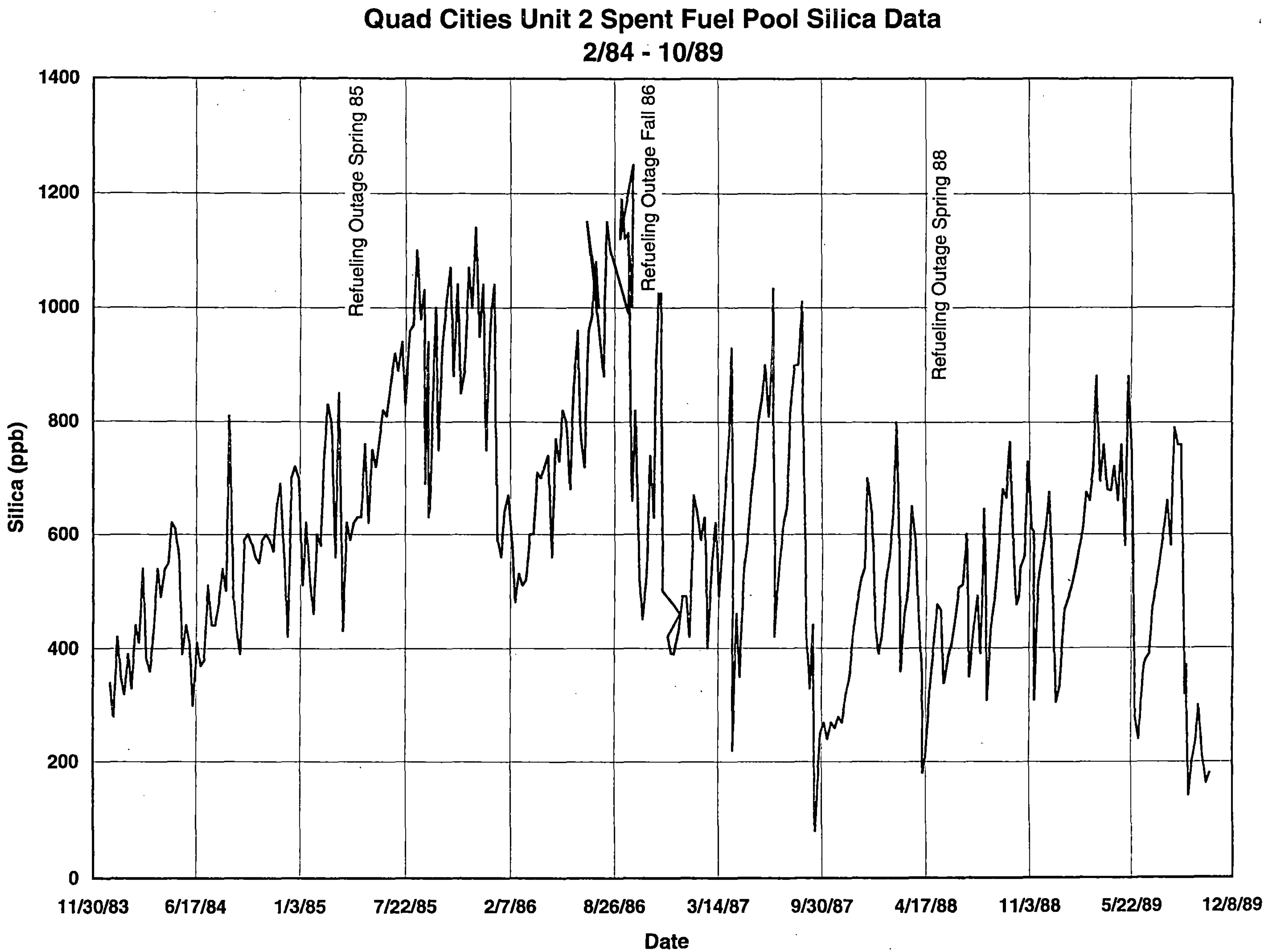
The chronological trend of Spent Fuel Pool silica levels, along with the timing of significant events are provided in the following graphs. The present data shows fairly low levels of silica and is consistent with data observed at other BWRs. However, the silica data alone may not provide a direct indication of the Boraflex performance.

Quad Cities Unit 1 Spent Fuel Pool Silica Data
1/84 - 2/90



Quad Cities Unit 1 Spent Fuel Pool Silica Data
2/90 - 6/96





Quad Cities Unit 2 Spent Fuel Pool Silica Data
2/84 - 10/89
Silica (ppb)
1400
1200
1000
800
600
400
200
0
Refueling Outage Spring 85
Refueling Outage Fall 86
Refueling Outage Spring 88
11/30/83
6/17/84
1/3/85
7/22/85
2/7/86
8/26/86
3/14/87
9/30/87
4/17/88
11/3/88
5/22/89
12/8/89
Date

Quad Cities Unit 2 Spent Fuel Pool Silica Data
10/89 - 6/96