North
Atlantic

North Atlantic Energy Service Corporation
P.O. Box 300
Seabrook, NH 03874
(603) 474-9521

The Northeast Utilities System

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

Seabrook Station
Response to NRC Generic Letter 96-04

North Atlantic Energy Service Corporation (North Atlantic) has enclosed the response to NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks[1]" for Seabrook Station. The enclosed response includes the information requested by Generic Letter 96-04 and demonstrates that the storage of spent fuel at Seabrook Station complies with 10CFR50 Appendix A, General Design Criterion 62 "Prevention of criticality in fuel storage and handling" and Seabrook Station Technical Specification 5.6 "Fuel Storage" which requires that the Spent Fuel Pool K_{eff} be maintained at less than or equal to .95.

Should you have any further questions regarding this letter, please contact Mr. Anthony Callendrello, Licensing Manager, at (603)474-9521 extension 2751.

Very truly yours,

NORTH ATLANTIC ENERGY SERVICE CORP.

Bruce L. Drawbridge
Executive Director - Services
and Senior Site Officer

290058

cc: H. J. Miller, Regional Administrator
A. W. De Agazio, NRC Project Manager, Seabrook Station
J. B. Macdonald, Senior Resident Inspector, Seabrook Station

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[1] NRC Generic Letter 96-04, dated June 26, 1996, "Boraflex Degradation in Spent Fuel Pool Storage Racks"

STATE OF NEW HAMPSHIRE

Rockingham, ss. October 23, 1996

Then personally appeared before me, the above-named Bruce L. Drawbridge, being duly sworn, did state that he is Executive Director - Services and Senior Site Officer of the North Atlantic Energy Service Corporation that he is duly authorized to execute and file the foregoing information in the name and on the behalf of North Atlantic Energy Service Corporation and that the statements therein are true to the best of his knowledge and belief.

Susan J. Messer, Notary Public
My Commission Expires: December 22, 1998

NORTH ATLANTIC ENE... Y SERVICE CORPORATION
RESPONSE TO NRC GENERIC LETTER 96-04
BORAFLEX DEGRADATION IN SFP STORAGE RACKS

SFP Rack Design

The Spent Fuel Pool (SFP) at Seabrook Station currently contains six Boraflex poisoned spent fuel rack modules supplied by Westinghouse. These modules accommodate 658 fuel assemblies or approximately 1/2 of the current licensed storage capacity of 1236 fuel assemblies. These spent fuel racks first received irradiated fuel in August of 1991. The decision to defer installation of the racks in the remainder of the SFP was based, in part, on the benefit to be gained from allowing for future enhancements in fuel storage technology.

The six existing spent fuel racks are free-standing self-supporting rack modules. Each rack module comprises an array of Boraflex poisoned, stainless steel cells with a center-to-center spacing of 10.35". Each storage cell is welded to a grid base and welded together at the top through an upper grid to form an integral structure 173.75" in height. A flux trap design is incorporated into the racks for reactivity control.

Boraflex sheets surround each non-peripheral cell. The Boraflex material is captured and positioned by a thin stainless steel wrapper. This stainless steel wrapper is attached to the ridged outside surface of each cell in a manner that allows the SFP water to contact the Boraflex material within. During the fabrication of the racks, no adhesive was used that might impede the motion of the Boraflex sheets and result in shrinkage induced stress tears or gaps.

Present plans for the SFP call for continued use of the 658 spent fuel cells with Boraflex poison material and the addition of 6 new rack modules scheduled to be installed in 1998. The 6 new racks to be installed into the east end of the SFP will incorporate Boral® poison material in lieu of Boraflex and maintain a center-to-center spacing equal to that of the exiting racks of 10.35".

The present refueling philosophy is to load the new fuel into the SFP prior to each refueling outage as permitted by the "checkerboard" requirements of the current Technical Specifications and criticality analysis.

Regulations and Design Basis

The applicable codes, standards and regulation of criticality safety for the SFP include the following:

- General Design Criterion 62 - Prevention of Criticality in Fuel Storage and Handling.
- NUREG-0800, USNRC Standard Review Plan, Section 9.1.2, Spent Fuel Storage.
- ANSI/ANS-57.2-1983, Design Requirements for Spent Fuel Storage Facilities At Nuclear Power Plants, Section 6.4.2.

These regulations and guides require that for spent fuel racks the maximum calculated K_{eff}, including margin for uncertainty in calculation methods and mechanical tolerances, be less than or equal 0.95 with a 95% probability at 95% confidence level. These requirements are imposed in Seabrook Station Technical Specification 5.6 Fuel Storage Criticality, section 5.6.1.1, Amendment No. 6.

Criticality Analysis

The original criticality analysis, performed in support of the initial facility license, justified the placement of fuel with an enrichment of up to 3.5 w/o ^{235}U in the SFP racks. A second analysis, to support License Amendment 6, was performed by Yankee Atomic Electric Company to accommodate the placement of fuel with enrichment up to 5.0 w/o ^{235}U. In this analysis the fuel storage criticality design features, are satisfied through the institution of accrued fuel assembly burnup credit and administrative control on fuel assembly placement. This analysis assumed a 4% axial shrinkage in the installed Boraflex sheets due to gamma radiation exposure. At the time of this analysis an assumption of 4% shrinkage was believed to be conservative to accommodate the postulated mechanism for radiological damage in the Boraflex elastomer. This assumption of 4% shrinkage was incorporated into the criticality analysis supporting License Amendment 6 to establish the current Technical Specification 3/4.9.13, Spent Fuel Assembly Storage, and the associated Figure 3.9-1, Fuel Assembly Burnup vs. Initial Enrichment For Spent Fuel Assembly Placement. More extensive Boraflex damage scenarios including erosion and washout had not been recognized at the time.

In 1995, an evaluation was performed in response to questions involving the postulated extent in Boraflex degradation, including erosion and washout, on the validity of the criticality analysis. North Atlantic and Yankee Atomic Electric Company performed a sensitivity assessment of the SFP criticality analysis to ascertain the affects on the capability of spent fuel racks. This assessment, used conservative bounding assumptions of coplanar 4" gaps in every Boraflex panel at the midplane of the stored fuel, as indicated in EPRI TR-101986, "Boraflex Test Results and Evaluation", and uniform 10% Boraflex thinning. This effort produced conservative fuel placement criteria required to ensure that the K_{eff} specifications for the SFP are met. These more conservative fuel placement criteria were incorporated into administrative controls that are more restrictive than Technical Specification Figure 3.9-1, Fuel Assembly Burnup vs. Initial Enrichment For Spent Fuel Assembly Placement. These administrative controls were reviewed and approved within Technical Clarification TS-023 on November 8, 1995.

Boraflex Performance Monitoring

North Atlantic has maintained a Boraflex Monitoring Program throughout the entire period that the SFP has been in service. A station procedure defines the monitoring program used to assess the performance of the Boraflex in the SFP. This Boraflex Monitoring Program embodies the following activities:

- In Service Review and Summary: Each Boraflex Monitoring Report Package generated in the course of performing the Boraflex Monitoring procedure includes a brief description of events at Seabrook Station related to Boraflex and the SFP. The summary includes such information as; placement and removal of Spent Fuel in the SFP, changes to the SFP or the racks, industry experience, vendor recommendations and regulatory notice or requirements. These summaries have been updated once per fuel cycle.

- Coupon Monitoring: The coupon monitoring program at Seabrook Station was designed to conform to the recommendations of the Electric Power Research Institute (EPRI) and Yankee Atomic Electric Company. The coupon monitoring program provides an accurate depiction of the actual poison material within the spent fuel racks. The program employs three sets of 16 coupons exposed to three distinct environments. The nominal Boraflex coupon dimensions are listed in Table 1 below.

All 48 coupons were precharacterized to record their initial dimensions, hardness and weight in June 1991. The first 16 coupons represent the control group. They are maintained under normal warehouse conditions, free of radiation, excessive heat and moisture. The control coupons are not encapsulated in a coupon holder or "train" and selected control coupons are measured for base line data when exposed coupons are measured.

Thirty-two exposed coupons are contained in 2 stainless steel coupon trains. These trains each contain 16 coupons and were initially identical except for their identifying markings. Train #1 or the STANDARD TRAIN receives an accelerated radiation and thermal exposure. Train #2 or the SPECIAL TRAIN receives an average radiation and thermal exposure.

Each Boraflex coupon is contained in a stainless steel jacket designed to present the Boraflex material to the same radiological, chemical, thermal and mechanical conditions experienced by the Boraflex installed in the spent fuel racks. The coupon jacket has overall dimensions of 13.75" long, 7.25" wide by 0.17" thick. A 1/16 " stainless steel plate forms the back of each jacket and represents the ridged cell wall in the actual racks. This relatively thick backing plate prevents flexing of the Boraflex coupon during irradiation and handling. The mass of the backing plate also allows for any gamma heating that may directly heat the water space surrounding the Boraflex in both the coupon and the installed racks.

A 0.020" stainless steel jacket cover plate models the 0.020" wrapper used to contain the Boraflex installed in the racks. Spacing between the cover and backing plate is maintained by a 0.090 inch "window frame" which surrounds the coupon. The backing plate, "window frame" and cover are secured around the edge by eight removable rivets with the Boraflex coupon inside. Impingement of the Boraflex coupon is prevented by the 0.090" "window frame" to ensure accurate modeling of the Boraflex water-space in the coupon jacket as in the installed racks. Boraflex coupon impingement would present an exaggerated opportunity for stress induced crack formation and an artificially reduced rate of flow induced silica dissolution. Realistic similarity in water intrusion within the coupon jacket and the installed racks is carefully maintained by the loose fit of the coupon cover between rivets as compared to the wrapper between spot welds in the racks. The coupon cover is also provided with a 1/2 inch "verification hole" identical to that designed into the wrapper on the racks to further this similarity in water intrusion. Finally to ensure limiting water-space flow conditions within the coupon jacket as compared to the installed wrapper, a 1/8" flow hole is located in each corner of the coupon covers.

Each jacketed coupon is attached to one of the two train assemblies by four stainless steel machine screws for ease of removal and reattachment. Sixteen jacketed coupons are attached to each train, four per side, such that all 16 coupons are axially positioned adjacent to the uniform high burnup portion of the spent fuel in the spent fuel racks. The coupon trains are individually suspended within selected spent fuel rack cells during irradiation and removed with the aid of a special long handled tool for coupon examinations. A test cell, containing a coupon train, and the 24 adjacent cells, containing 24 selected spent fuel assemblies 2 deep around the train, constitute a Boraflex monitoring nest.

Train #1 or the STANDARD TRAIN, with its 16 dedicated coupons, receives an accelerated radiation and thermal exposure that is greater than the local exposure of any part of the installed racks. This accelerated radiation and thermal exposure is generated by loading the Train #1 nest with the 24 discharge assemblies of highest accrued burnup at each refueling. Train # 1 is resident in this accelerated exposure nest throughout the fuel cycle. Train # 1 is removed for coupon

examination and returned to a new nest location just prior to each refueling when the process of irradiation is started again. Care is used to select a new and distinct Train # 1 nest location at each refueling in order to ensure that only the coupons, and not the Boraflex installed in the actual racks, receive the accrued accelerated exposure.

Train #2 or the SPECIAL TRAIN receives an average radiation and thermal exposure indicative of the long term exposure expected for the majority of the installed spent fuel rack cells. Destructive testing of selected Train # 2 coupons is planned every five years following the initial discharge of spent fuel to the SFP. The first such examination of a SPECIAL TRAIN coupon should occur prior to the fifth refueling outage in 1997.

TABLE # 1
Nominal Boraflex Coupon Data

Length	13"
Width	6.5"
Thickness	0.071"
Mass	184 gm.
^{10}B Loading	0.020 gm/cm^2

- Accelerated Exposure Standard Coupon Monitoring Results: Three examinations of accelerated exposure coupons have been performed to date involving five different Train # 1 coupons. Two coupons were examined on September 2, 1992 prior to the second refueling, two on March 15, 1994 prior to the third refueling and a third pair on September 19, 1995 prior to the fourth refueling. Each visual examination revealed no gross cracks or splits in the Boraflex material and inconsequential material loss. The quantitative results of the three inspections are presented in Table #2 below.

Total average shrinkage, including erosion, in the length and width dimensions has progressed from -1.5% in 1992, -2.2% in 1994 and -2.5% 1995. The maximum shrinkage observed was -2.73%. All of these values are well within the 4% assumption used in the criticality analysis even without the allowance for erosion. The coupon thickness appears to swell in response to the initial radiation exposure. This swelling operates in competition with surface erosion which will overtake the swelling effect as the polymer disruption process runs to completion.

Total coupon mass loss is found to be within the measurement uncertainty of approximately 1%. This uncertainty is larger than might be expected due to water intrusion into the Boraflex coupons at varied degrees of degradation. This measurement uncertainty was reduced to approximately 0.1% after the first coupon inspection by the use of a specially designed desiccator. All indications of mass loss are well within the 2% loss implied by the 4" gap assumed in generating the present reactivity controls for the SFP.

Durometer hardness testing was discontinued after the second examination when the coupon hardness was found to exceed the Shore A hardness scale. Testing at greater hardness levels cracked one of the coupons without producing valid results. During the last examination both coupons were found to generate many small friable chips of degraded Boraflex material in handling during the inspection. The mass of these chips was found to be only a few milligrams hence their effect on the measurement results is minimal when appropriate care is used in coupon handling. The fragility of the Boraflex installed in the racks will only be of concern under conditions of significant mechanical excitation.

Erosion and washout of the boron carbide particulate from the degraded Boraflex coupons is clearly demonstrated by the Seabrook Station coupon monitoring program. Inspections to date have shown the expected progression of glossy black Boraflex becoming frosty gray. Later the sharp definition of the coupon edges became rounded and eroded. Presently erosion is indicated extending from sites where the Boraflex is directly exposed to the SFP water such as verification and flow holes in the coupon jacket. The coupon, as described above, is designed to ensure a level of degradation in advance of that existing in the installed racks. This advanced level of degradation in the coupons is still well within the assumptions used in the criticality analysis. Therefore the coupon monitoring program provides strong indication that the Boraflex in the installed racks is in conformance with the assumptions of the SFP criticality analysis.

- SFP Silica Trending: Silica analysis and trending of the SFP was instituted on May 29,1991, prior to the initial introduction of irradiated fuel into the spent fuel racks. The plot of "Spent Fuel Pool Silica" herein is consistent with the early stages of Boraflex degradation. This trend is presently approaching 3 ppm which is far short of the industry experience indicating 30 to 90 ppm silica concentrations encountered for more advanced Boraflex degradation. This low silica concentration is indicative of minimal degradation in the installed racks.

  This correlation is supported by the fact that the Seabrook Station SFP silica concentration is low, 3 ppm, and essentially monotonically increasing except for the incidental dilutions associated with water exchange with the Refueling Water Storage Tank during refueling. No silica reduction effort has been undertaken for the Seabrook Station SFP. Therefore, the silica concentration is indicative of the total silica generated from the Boraflex, without any effort to reduce the SFP silica concentration.

  A specific example of the silica-to-degradation correlation may be drawn from the Millstone 3 experience where the SFP reactive silica concentration (6 to 7 ppm) is reported to be more than twice that at Seabrook Station (3 ppm). However, the results of two blackness testing campaigns on the Millstone 3 spent fuel racks, which are similar to the Seabrook Station racks, indicate only small randomly distributed gaps, all of which are within the Seabrook Station analysis assumptions.

TABLE # 2
Standard Coupon Monitoring Results

September 2, 1992 (Prior to 2nd Refueling)

Coupon	#114	#121
Length	-1.34%	-1.36%
Width	-1.75%	-1.63%
Thickness	+4.4%	+4.7%
Mass	+0.63%	+0.10%

March 15, 1994 (Prior to 3rd Refueling)

Coupon	#112	#123
Length	-2.07%	-2.25%
Width	-2.22%	-1.63%
Thickness	+8.32%	+7.64%
Mass	+0.094%	+0.031%

September 19, 1995 (Prior to 4th Refueling)

Coupon	#114	#141
Length	-2.42%	-2.73%
Width	-2.38%	-2.27%
Thickness	+5.76%	+5.77%
Mass	+0.095%	+0.041%

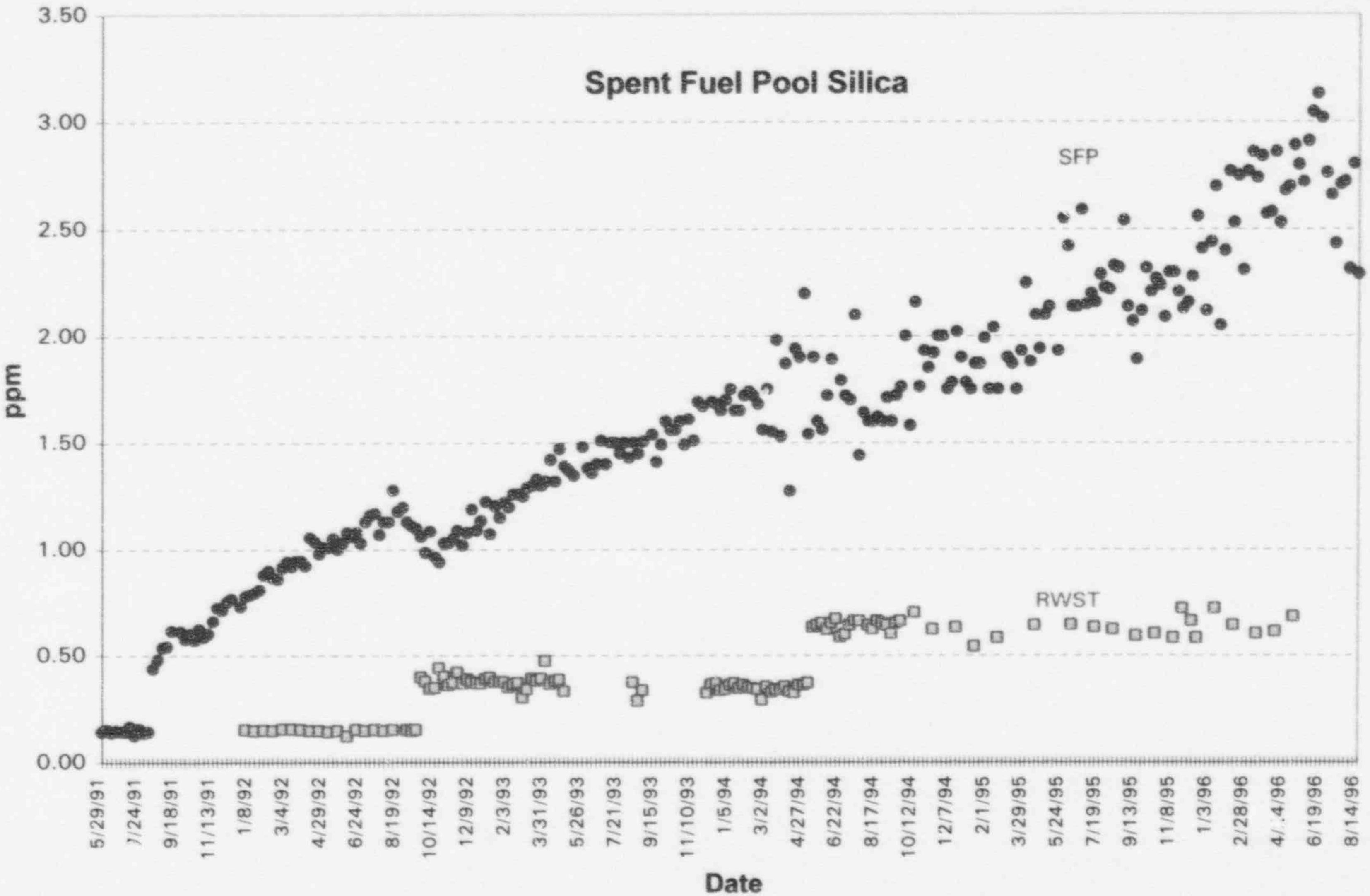
Short Term Plans

The spent fuel racks installed at Seabrook Station have been in service only since 1991. The level of Boraflex degradation has been demonstrated to be in the early stages and well within acceptable parameters. The Boraflex coupon monitoring program has been demonstrated as an early indicator of the condition of the Boraflex in the installed spent fuel racks. The acceptable indications of the coupon results are supported by the SFP silica concentration trending and industry experience. Technical Specifications and associated administrative controls for the SFP conservatively account for Boraflex shrinkage, gaps and erosion. Given the foregoing considerations, as developed above, it is safe and prudent to pursue continued operation of the SFP in its present configuration through the completion of Cycle 6 under the close scrutiny of the Boraflex Monitoring Program.

Blackness testing has not been performed at Seabrook Station due to the acceptable results generated by the Boraflex Monitoring Program. Future blackness testing is not planned in light of North Atlantic's long-term plans as discussed below. Furthermore, blackness testing at Millstone 3, on similar spent fuel racks, has shown gap formation that is within the Seabrook Station analysis assumptions.

Long Term Plans

New spent fuel racks, containing Boral® in lieu of Boraflex, are scheduled for installation in the remainder of the SFP during 1998. These new racks shall be immune to the problems presented by the Boraflex poison material. Once installed, the new Boral® racks will be available to receive all highly reactive and freshly irradiated fuel thereby reducing the future Boraflex exposure rate. The existing Boraflex racks will then be used to hold low reactivity fuel,(low residual fissile content) without the need to derive any credit from Boraflex in satisfying the restrictions on SFP K_{eff}. Preliminary calculations indicate the feasibility for a revised criticality analysis of the SFP that would take no credit for the installed Boraflex poison material or soluble boron concentration. Under the provisions of such an analysis, administrative controls would be instituted, pursuant to a Technical Specification change to require the placement of low reactivity fuel in the existing Boraflex racks. Once the required change to Technical Specifications has been approved, to require these administrative controls, reliance on Boraflex as a SFP poison material is eliminated and concerns for Boraflex are reduced to that of silica concentration only.


Spent Fuel Pool Silica
ppm
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
SFP
RWST
5/29/91
7/24/91
9/18/91
11/13/91
1/8/92
3/4/92
4/29/92
6/24/92
8/19/92
10/14/92
12/9/92
2/3/93
3/31/93
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Date