Boston Edison

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December 18, 1996
BECo Ltr. #96-107

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

Docket No. 50-293
License No. DPR-35

Generic Letter (GL96-04): Boraflex Degradation in Spent Fuel Pool Storage Racks

By letter dated June 26,1996, the Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 96-04 to inform licensees of issues concerning the use of Boraflex in spent fuel storage racks.

Two issues are identified concerning the use of Boraflex in spent fuel storage racks. The first issue relates to gamma radiation-induced shrinkage of Boraflex and the potential to develop tears or gaps in the material. This phenomenon is normally accounted for in more recent criticality analyses of spent fuel storage racks. The second issue concerns long-term Boraflex performance throughout the intended service life of the racks as a result of gamma irradiation and exposure to the wet pool environment.

As a result, GL96-04 requires licensees using Boraflex as a neutron absorber in spent fuel storage racks to provide a response within 120 days that: (1) assesses the capability of the Boraflex to maintain a 5-percent subcriticality margin and (2) submits to the NRC a plan describing its proposed actions to provide assurance that the 5% subcriticality margin continues to be maintained in the future.

By letter of September 23, 1996, Pilgrim requested an extension to December 18,1996, to allow blackness testing to be conducted and an assessment of the test results. The following provides the information requested in GL 96-04.

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PILGRIM BACKGROUND

The PNPS spent fuel pool is licensed to store 3859 fuel assemblies, but there are currently 2891 installed fuel storage cells. Pilgrim has nine nuclear fuel storage racks aggregating 2333 fuel storage cells that employ Boraflex for reactivity control (2333 Boraflex; 558 Boral)

The Boraflex-protected high density spent fuel pool racks were installed in 1986. Five of the nine Boraflex-protected racks were loaded with 1322 spent fuel assemblies within approximately the first year after their installation at Pilgrim. Most of these fuel assemblies' (discharges from cycles 1-5) fission product inventories no longer included the active short and intermediate half-life species, having already decayed to insignificance before they were relocated into the high-density racks. The fuel discharges from cycles 6 and 7 would have had a significant portion of their intermediate half-life fission products remaining to contribute a modest gamma radiation exposure to the storage racks. None of these earlier fuel assemblies contributed to a significant rate of accumulation of gamma exposure to the Boraflex material. The aggregate inventory did not generate significant heat such as to result in a large flow potential across the racks. This potential would cause flow through potential ingress and egress points to/from the interstitial spaces in the rack structure. Only three fuel discharges from 1991-1995 have generated the more intense gamma exposure history and higher thermal energy output characterized by a relatively short cooling period between critical operation and placement in the storage racks. These conditions were aggregated in the equivalent space of less than two standard racks of the nine using Boraflex.

The nine Boraflex-protected spent fuel storage racks are generally of a rectangular, "egg crate" design, the standard rack consisting of a 19 x 14 array of 6.050 (nominal) inch square cells on a (nominal) pitch of 6.243 inches. The nominal 193 mil cell wall consists of two stainless steel panels with a 68 mil thick sheet of Boraflex sandwiched between. Each sheet of Boraflex was originally installed as a 5.56 inch wide by 136.25 inch long "window pane" facing and parallel to each side of the fuel assembly. The neutron poison material was initially centered axially over the standard 145.24 inches of active fuel length expected. The rack assembly's top edge stands 14.5 feet above the floor of the pool's steel liner.

All nine Boraflex-protected racks are based upon the same Joseph Oat design, using cruciform, ell, and tee shaped sub-elements to assemble each fuel storage array. Each sub-element is composed of stainless steel panel walls, Boraflex sheets, and stainless steel edge strips. The Boraflex is enclosed between the stainless steel panel walls, and the edge strips surrounding the Boraflex sheet are welded in place to frame the Boraflex sheet. Vent holes were provided at the top of the racks to allow air to escape when the racks were submerged in the spent fuel pool. However, design and tolerances dictate that the panel walls are very restrictive to the internal flow of coolant because the joint construction is labyrinthine with geometry that resists water entry.

FUEL POOL SUBCRITICALITY MARGIN

A subcriticality margin greater than 5% is currently available in Pilgrim's fuel pool.

Reanalysis of the Pilgrim's spent fuel pool subcriticality was performed using a comparable methodology to that previously used in Pilgrim's rerack submittal which was approved by the NRC. The reanalysis confirms that the margin to criticality is greater than the minimum required 5%. Boraflex degradation conditions exceeding those indicated by the most recent tests were assumed in the analysis.

1996 SPENT FUEL POOL TEST

Blackness testing in 56 Boraflex-protected storage cells was conducted in 1996.

The expected shrinkage and gapping of Boraflex material exposed to intense and prolonged gamma radiation fields were found; however, the patterns and extent of material gapping indicate that material degradation beyond shrinkage is not significant.

ASSESSMENT OF BORAFLEX'S PHYSICAL CONDITION

Decreasing periods required to exhaust fuel pool cleanup system resin beds and increasing rates of fuel pool water silica concentration buildup were noted at PNPS after 1991. These trends tend to be irregular but may be associated with those storage racks that have accumulated more gamma exposure and provided more pool heat loading for periods after 1991 than before. As no other source or explanation for the changes in pool silica concentration has been confirmed, degradation of the Boraflex via material dissolution into pool water migrating through the interstitial spaces within the wall is suspected. Results from direct, in-situ measurements of Boron-10 have not eliminated the possibility of incipient material loss but suggests damage has not progressed significantly.

The Boraflex sheets in the nine fuel storage racks installed in 1986 have been exposed to various levels of accumulated gamma radiation and water ingress/egress. These factors cause the material changes reported by EPRI under Project 2813-04. Shrinkage and consequential gapping of the material is expected and was confirmed by in-situ measurements to have progressed at Pilgrim to the point of near maximum possible shrinkage (approximately 4%) of the materials' installed dimensions. The relatively weak or short-lived hydraulic forces available and the highly restricted flow paths expected suggest that the potential for pool water flow through the interstitial spaces in the cell walls would be very limited. In-situ measurements have not indicated that Boraflex erosion caused by water flow past exposed surfaces has caused significant degradation of material continuity. However, spent fuel pool fluctuations in silica levels after 1991 suggest that incipient material degradation cannot be ruled out.

The accumulated Boraflex exposure in the highest gamma exposure storage cell population segment is expected to approach the 1×10^{10} RADS critical level for which material shrinkage is believed to saturate. While other cells' accumulated gamma exposures are believed to be significantly less, the persistent accumulation of gamma exposure from the balance of the expected operating life of the fuel storage racks precludes any assumption other than that virtually all Boraflex material's accumulated gamma exposure in the 2333 storage cells will eventually rise above the critical level.

MAINTENANCE OF A 5% SUBCRITICALITY MARGIN

The PNPS spent fuel pool maintains a 5% margin of subcriticality based upon a substantial margin of Boron-10 areal density in the nine Boraflex-protected fuel storage racks. When originally designed, the margin of subcriticality was specified as ≥10% for these racks. These racks were installed with 37% more Boron-10 inventory than the more recently installed Boral-protected racks upon which the 5% subcriticality margin and fuel reactivity design limits of the PNPS spent fuel pool are based. The estimated degradation in reactivity control capability of the PNPS Boraflex material in its present condition is very small compared to the margin of safety above the 5% minimum required. This is true for even the most reactive fuel allowed to be stored; i.e., K_{∞} = 1.32. BECo has no fuel design currently stored, available in the reactor core, or ordered whose maximum reactivity is not significantly less than this limit.

Analysis indicates a > 5% subcriticality margin using an analytical methodology comparable to the methodology used in our last submittal to the NRC for expanding Pilgrim's spent fuel pool to its present capacity. This analysis assumed Boraflex conditions more degraded than those described above. ***This analysis will be incorporated into the PNPS design basis in the UFSAR.***

CURRENT PLANNED CORRECTIVE ACTIONS

No corrective actions are required at this time.

PROPOSED ACTIONS TO ENSURE SUBCRITICALITY MARGIN

Pilgrim plans another blackness test of Boraflex in 1998.

The expected physical condition of the Boraflex material through 2012 is an extrapolation of the most recent *in-situ* examination of highly exposed storage cells. All material is expected to shrink and develop additional gaps until saturation is reached. In three racks, saturation is nearly realized. Other cells first occupied by long cooled fuel or never occupied by any irradiated fuel will eventually experience material shrinkage of similar extent.

Pilgrim does not plan to use analytical models to augment surveillance or testing programs for Boraflex material management. The available models depend on estimating integral gamma dosage to storage cells and using pool silica data to predict the most likely location of Boraflex degradation. Uncertainties in the variability of available flow paths through the interstitial spaces of the different panels cannot be accounted for with these models. Estimating the pool silica source term due only to Boraflex is also expected to be difficult for a pool environment that undergoes nearly continuous filtering and demineralizing processes and whose chemistry sample stream does not consistently represent a true pool volume average. Confronted with these analytical barriers, Pilgrim does not believe calculations are an acceptable substitute for direct material measurements at Pilgrim.

Pilgrim's spent fuel operational history and the understanding of the fission product decay process provide a means to identify the best candidate cells for examination. ***Theref re, BECo plans to conduct another blackness test of selected Boraflex cell panels in 1998 with higher integrated gamma exposure than cells tested in 1996. Further testing intervals thereafter will be based upon the comparison of results and the availability of empty cells necessary to create an adequate testing region. Spent fuel pool silica data trending will be continued over cycle 12 as a continuation of normal practices. These trending results will be considered as an additional factor for determining the post-1998 schedule of direct material surveillance.***

SPENT FUEL POOL REACTIVE SILICA LEVELS

A chart titled "Fuel Pool Demineralizer Inlet Silica" is attached and provides a chronological trending of silica in Pilgrim's spent fuel pool from January 2, 1991, to October 2, 1996.

Commitments

- Pertinent Boraflex analysis information concerning the >5% subcriticality margin will be incorporated into the FSAR.
- Another blackness test of selected Boraflex cell panels will be conducted in 1998.
- The post-1998 schedule for direct material surveillance will be determined using the 1996 and 1998 blackness testing data and will consider spent fuel pool silica data.

Should you require further information on this issue, please contact P.M. Kahler at (508) 301-7939.

H. V. Oheim

Commonwealth of Massachusetts)
County of Plymouth)

Then personally appeared before me, H. V. Oheim, who being duly sworn, did state that he is General Manager - Technical of Boston Edison Company and that he is duly authorized to execute and file the submittal contained herein in the name and on behalf of Boston Edison Company and that the statements in said submittal are true to the best of his knowledge and belief.

My commission expires: September 20, 2002 DATE Peter M Kahler NOTARY PUBLIC

PMK/dmc/boropm

Attachment: Fuel Pool Demineralizer Inlet Silica Chart for January 2, 1991 to October 2, 1996

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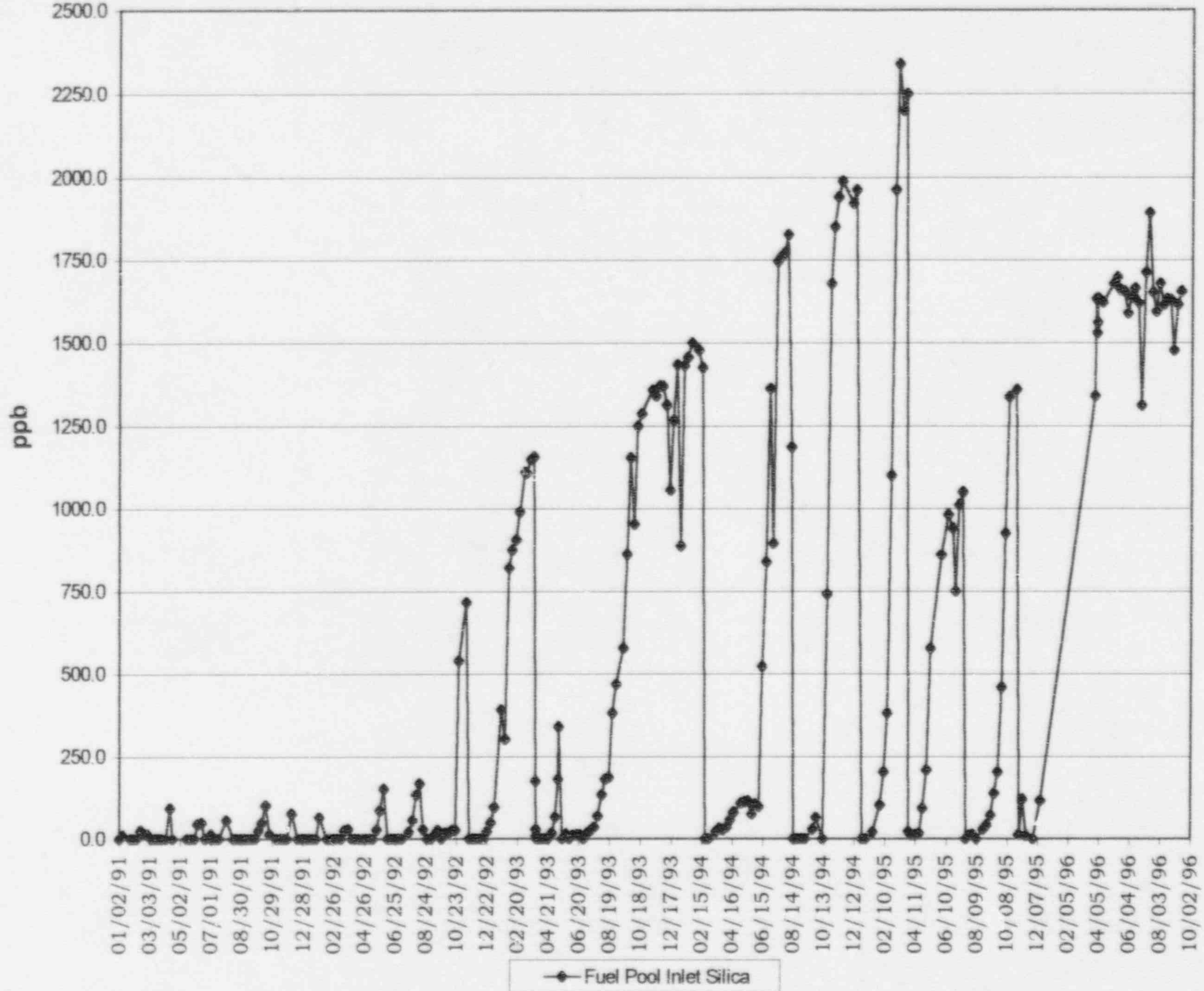
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