June 7, 1996

FOR: The Commissioners

FROM: James M. Taylor /s/
Executive Director for Operations

SUBJECT: PROPOSED NRC GENERIC LETTER TITLED "BORAFLEX DEGRADATION IN SPENT FUEL POOL STORAGE RACKS"

PURPOSE:

To inform the Commission, in accordance with the guidance in the memorandum dated December 20, 1991, from Samuel J. Chilk to James M. Taylor regarding SECY-91-172, "Regulatory Impact Survey Report - Final," of the staff's intent to issue the subject generic letter. The generic letter requests that each addressee that uses Boraflex as a neutron absorber in its spent fuel storage racks (1) assess the capability of the Boraflex to maintain a 5-percent subcriticality margin for the racks in unborated water, and (2) submit to the NRC a description of any proposed actions to confirm that this subcriticality margin can be maintained for the lifetime of the racks and a plan describing proposed actions if this subcriticality margin cannot be maintained by Boraflex material because of current or projected Boraflex degradation.

DISCUSSION:

Degradation of Boraflex has been previously addressed by the NRC in Information Notice (IN) 87-43, "Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks," September 8, 1987; IN 93-70, "Degradation of Boraflex Neutron Absorber Coupons," September 10, 1993; and IN 95-38, "Degradation of Boraflex Neutron Absorber in Spent Fuel Storage Racks," September 8, 1995. The Electric Power Research Institute (EPRI) has been studying the phenomenon of Boraflex degradation for several years and has identified two issues with respect to using Boraflex in spent fuel storage racks. The first issue relates to gamma-radiation-induced shrinkage of Boraflex and the potential of the material to develop tears or gaps. This phenomenon is typically accounted for in criticality analyses of spent fuel storage racks. The second issue concerns long-term Boraflex performance throughout the intended service life of the racks as affected by gamma irradiation and exposure to the wet pool environment.

Because Boraflex is used in spent fuel storage racks for nonproductive absorption of neutrons, a reduction in the amount of Boraflex could result in an increase in the reactivity of the spent fuel pool configuration, which may approach, or even exceed, the current NRC acceptance criterion of k_{eff} no greater than 0.95. The NRC has established this 5-percent subcriticality margin to comply with General Design Criterion (GDC) 62 of Appendix A to Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 50), which addresses the prevention of criticality in fuel storage and handling.

A notice of opportunity for public comment was published in the *Federal Register* (60 FR 56359) on November 8, 1995. Comments were received from 15 licensees and 1 industry organization. Copies of the staff evaluation of these comments have been made available in the public document room.

The generic letter was forwarded to the Committee to Review Generic Requirements (CRGR). The Committee determined that a formal review of the generic letter was not warranted.

The Office of the General Counsel reviewed this generic letter and has no legal objection to it.

The staff intends to issue this generic letter approximately 10 working days after the date of this information paper.

James M. Taylor
Executive Director for Operations

Contact: Laurence Kopp, SRXB/DSSA
301-415-2879

Attachment: Proposed Generic Letter 96-XX, "Boraflex Degradation in Spent Fuel Pool Storage Racks"

ATTACHMENT

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555-0001

NRC GENERIC LETTER 96-XX: BORAFLEX DEGRADATION IN SPENT FUEL POOL STORAGE RACKS

Addressees

All holders of operating licenses for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this generic letter to inform all addressees of issues concerning the use of Boraflex in spent fuel storage racks. Although this generic letter is being issued to all licensees of operating nuclear power reactors, only those licensees that use Boraflex are requested to respond. Each addressee that uses Boraflex as a neutron absorber in its spent fuel storage racks is requested to (1) assess the capability of the Boraflex to maintain a 5-percent subcriticality margin and (2) submit to the NRC a plan describing its proposed actions if this subcriticality margin cannot be maintained by Boraflex material because of current or projected future Boraflex degradation.

Background

Degradation of Boraflex has been previously addressed by the NRC in Information Notice (IN) 87-43, "Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks," September 8, 1987; IN 93-70, "Degradation of Boraflex Neutron Absorber Coupons," September 10, 1993; and IN 95-38, "Degradation of Boraflex Neutron Absorber in Spent Fuel Storage Racks," September 8, 1995. The Electric Power Research Institute (EPRI) has been studying the phenomenon of Boraflex degradation for several years and has identified two issues with respect to using Boraflex in spent fuel storage racks. The first issue related to gamma radiation-induced shrinkage of Boraflex and the potential to develop tears or gaps in the material. This phenomenon is typically accounted for in criticality analyses of spent fuel storage racks. The second issue concerned 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.

Description of Circumstances

Palisades Nuclear Power Station

During the removal of several Boraflex surveillance coupons from the Palisades spent fuel pool in August 1993, a loss of as much as 90 percent of the Boraflex was observed and has been attributed to exposure to high-level gamma radiation in conjunction with interaction with the pool water. The Boraflex in these coupons was sandwiched and bolted between two stainless steel strips, allowing a relatively large area of Boraflex to be exposed to the pool water environment and flow. Neutron attenuation testing (blackness tests) of the actual Palisades storage racks indicated that because of the relatively watertight Boraflex panel enclosures, there was no similar degradation.

South Texas Project

The results of blackness tests performed in August 1994 at South Texas indicated that the Boraflex was degraded, as evidenced by gaps and/or localized washout of the boron content in 20 of the 37 storage cells tested. Of the eight cells that had been designated to receive an accelerated gamma dose, five cells exhibited substantial degradation (0.91 to 1.37 m [3 to 4.5 ft]). The licensee postulated that the degradation mechanism was washout-accelerated dissolution of the Boraflex caused by pool water flow through the panel enclosures. As a justification for continued operation, the licensee has placed restrictions on the use of the degraded storage cells to ensure compliance with the required subcriticality margin. In addition, a long-term neutron absorption panel management plan is being developed, as well as a dose-to-degradation correlation that will aid in establishing restrictions for the use of the spent fuel racks.

Fort Calhoun Station

As part of the Fort Calhoun Station rerack project, the old spent fuel storage racks containing Boraflex were removed and disassembled in December 1994 to determine the condition of the Boraflex. The new storage racks do not contain Boraflex. As part of the overall EPRI research program, the licensee inspected two cells from the removed Boraflex racks which had experienced the highest gamma flux since 1983. Only 40 percent of the Boraflex remained in one of the panels from these cells while another panel in the same cell exhibited no loss of Boraflex. An adjacent cell had a panel which had some Boraflex loss but subsequent attenuation and density tests confirmed that the average boron-10 areal density still exceeded the material minimum certifications. Visual observations made during the course of the rack disposal process indicated that the vast majority of cells had not undergone a significant loss of Boraflex. The licensee has determined that there was sufficient Boraflex in the walls of each cell to meet the minimum requirements in the design-basis criticality analysis.

Discussion

Experimental data from test programs, including blackness tests performed at various boiling-water reactor (BWR) and pressurized-water reactor (PWR) spent fuel storage pools, confirmed that when Boraflex is exposed to gamma radiation, the material may shrink by as much as 3 to 4 percent. Shrinkage saturates at an integrated gamma exposure of about 1 to 2×10^{10} cGy (1 to 2×10^{10} rad). The application of realistic assumptions based on these tests has demonstrated that the reactivity effects of Boraflex shrinkage and gaps are very small and can generally be accommodated within the existing design basis of most storage racks.

Data from laboratory tests and spent fuel pool silica measurements have identified a second factor that could affect storage rack service life, i.e., the potential gradual release of silica from Boraflex following gamma irradiation and long-term exposure to the wet pool environment. When Boraflex is subjected to gamma radiation in the pool's aqueous environment, the silicon polymer matrix becomes degraded and silica filler and boron carbide are released. Since irradiated Boraflex typically contains 46 percent of silica, 4 percent of polydimethyl siloxane polymer and 50 percent of boron carbide by weight, the presence of silica in the pool indicates the likely depletion of boron carbide from Boraflex. The loss of boron carbide from Boraflex is characterized by slow dissolution of the Boraflex matrix from the surface of the Boraflex and a gradual thinning of the material. In a typical spent fuel pool, the irradiated Boraflex represents a significant potential source of silica (several thousand kilograms) and is the most likely source of pool silica contamination. The boron carbide loss, of course, can result in a significant increase in the reactivity of the storage racks. An additional consideration is the potential for silica transfer through the fuel transfer canal into the reactor core during refueling operations and its effect on the fuel clad heat transfer capability.

EPRI has identified several factors that influence the rate of silica release from Boraflex. The access of water to and around the Boraflex panels is perhaps the most significant factor influencing the rate of silica dissolution from

Boraflex. Because of the different rack designs, this water access will vary from plant to plant. The rate of dissolution also increases with higher pool temperature and gamma exposure, suggesting that pool temperatures be maintained as low as practical and that freshly discharged fuel assemblies should not be placed in the same storage cells at each refueling outage. Experimental data indicates that once silica reaches an equilibrium value, the rate of dissolution is dramatically reduced. However, when water purification systems are used to remove silica from the pool water, the solubility equilibrium becomes unbalanced and panel dissolution resumes. Thus, although pool temperatures should be maintained as low as practical, additional cooling may require an increase in pool water flow and create the negative effect of forcing more water past the Boraflex panels thereby disturbing any localized silica equilibria.

Because Boraflex is used in spent fuel storage racks for nonproductive absorption of neutrons, a reduction in the amount of Boraflex could result in an increase in the reactivity of the spent fuel pool configuration, which may approach, or even exceed, the current NRC acceptance criterion of k_{eff} no greater than 0.95. The NRC has established this 5-percent subcriticality margin to comply with General Design Criterion (GDC) 62 of Appendix A to Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR Part 50), which addresses the prevention of criticality in fuel storage and handling. Those plants that have installed storage racks containing Boraflex have the 5-percent subcriticality margin included in the plant technical specifications and/or a written commitment to meet this subcriticality margin, as reflected in the plant updated final safety analysis report (FSAR). The technical specifications for most other operating power reactors also include this 5-percent subcriticality requirement.

Several corrective actions have been used to account for any reactivity increase due to Boraflex loss. Many licensees have taken credit for the reactivity decrease associated with fuel depletion or have restricted storage patterns to a checkerboard-type configuration. Others have inserted neutron absorber rods into stored assemblies with protective features to prevent inadvertent removal. The NRC is also presently evaluating a proposed methodology by which credit could be taken for the soluble boron in PWR pool water. Although some of these schemes cannot be used for BWR fuel storage facilities, there have been discussions and demonstrations of specially designed neutron absorbing inserts as a replacement for deteriorating Boraflex which would be applicable to both PWR and BWR storage racks.

Safety Assessment

On the basis of test and surveillance information from plants that have detected areas of Boraflex degradation, no safety concern exists that warrants immediate action. Boraflex dissolution appears to be a gradual and localized effect forewarned by relatively high silica levels in the pool water. This occurrence of increased pool silica is more pronounced in PWRs than BWRs because of the greater effectiveness of silica removal by the BWR demineralizers in the non-borated pool water environment. Because of the safety margin present in spent fuel storage pools, compliance with the required subcriticality margin (or conformance with the same margin to which licensees have committed in their updated FSARs) can be expected to be maintained during the initial stage of Boraflex degradation. This safety margin is due to the conservatism in treating the reactivity effects of possible variations in material characteristics and mechanical tolerances and the generally lower reactivity of stored fuel than that assumed in the safety analysis. However, to verify compliance with both the regulatory requirements of GDC 62 and the 5-percent subcriticality margins, either contained in the technical specifications or committed to in the updated FSARs, and to maintain an appropriate degree of defense-in-depth measures, the NRC staff has concluded that it is appropriate for licensees to submit the following information.

Requested Information

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 actions 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. All licensees are requested to submit the information to the NRC to ensure that the onsite storage of spent fuel is in compliance with GDC 62 for the prevention of criticality in fuel storage and handling and with the 5-percent subcriticality margin position of the NRC staff to assure compliance with GDC 62.

Required Response

All addressees that use Boraflex in their spent fuel storage racks are required to submit a written response to the information requested above within 120 days of the date of this generic letter. If an addressee chooses not to respond to specific questions, an explanation of the reason and a description of any proposed alternative course of action should be provided, as well as the schedule for completing the alternative course of action (if applicable), and the safety basis for determining the acceptability of the planned alternative course of action.

Address the required written reports to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555, under oath or affirmation under the provisions of Section 182a, Atomic Energy Act of 1954, as amended, and 10 CFR Part 50.54(f). In addition, submit a copy to the appropriate regional administrator.

Backfit Discussion

This generic letter only requires information from the addressees under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR Part 50.54(f). Therefore, the staff has not performed a backfit analysis. The information requested will enable the NRC staff to determine whether licensees are complying with the current licensing basis for the facility with respect to GDC 62 for the prevention of criticality in fuel storage and handling and 5-percent subcriticality margins either contained in the technical specifications, or committed to in the updated FSARs, of plants containing Boraflex in the spent fuel storage racks. The staff is not establishing a new position for such compliance in this generic letter. Therefore, this generic letter does not constitute a backfit and no documented evaluation or backfit analysis need be prepared.

Federal Register Notification

A notice of opportunity for public comment was published in the *Federal Register* (60 FR 56359) on November 8, 1995. Comments were received from 15 licensees and 1 industry organization. Copies of the staff evaluation of these comments have been made available in the public document room.

Paperwork Reduction Act Statement

This generic letter contains information collections that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.). These information collections were approved by the Office of Management and Budget, approval number 3150-0011, which expires July 31, 1997.

The public reporting burden for this collection of information is estimated to average 150 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. The U.S. Nuclear Regulatory Commission is seeking public comment on the potential impact of the collection of information contained in the generic letter and on the following issues:

1. Is the proposed collection of information necessary for the proper performance of the functions of the NRC, including whether the information will have practical utility?
2. Is the estimate of burden accurate?
3. Is there a way to enhance the quality, utility, and clarity of the information to be collected?
4. How can the burden of the collection of information be minimized, including the use of automated collection techniques?

Send comments on any aspect of this collection of information, including suggestions for reducing this burden, to the Information and Records Management Branch, T-6 F33, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202 (3150-0011), Office of Management and Budget, Washington, DC 20503.

The NRC may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

If you have any questions about this matter, please contact one of the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

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Attachment: List of Recently Issued NRC Generic Letters