UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

September 8, 1995

NRC INFORMATION NOTICE 95-38: DEGRADATION OF BORAFLEX NEUTRON ABSORBER IN SPENT FUEL STORAGE RACKS

Addressees

All holders of operating licenses or construction permits for nuclear power reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice to alert addressees to a potentially significant problem pertaining to degradation of the Boraflex neutron absorber material in spent fuel storage racks. It is expected that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. However, suggestions contained in this information notice are not NRC requirements; therefore, no specific action or written response is required.

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, and IN 93-70, "Degradation of Boraflex Neutron Absorber Coupons," September 10, 1993. The Electric Power Research Institute (EPRI) has been studying the phenomenon of Boraflex degradation for several years and recently issued EPRI report TR-103300, "Guidelines for Boraflex Use in Spent-Fuel Storage Racks," December 1993, identifying two issues with respect to using Boraflex in spent fuel storage racks. The first related to gamma radiation-induced shrinkage of Boraflex and the potential to develop tears or gaps in the material. The second concerned gradual long-term Boraflex degradation over the intended service life of the racks as a result of gamma irradiation and exposure to the spent fuel pool environment. This second issue has previously been observed in degradation of Boraflex surveillance coupons at the Palisades plant (IN 93-70), but further testing of the actual Palisades storage racks indicated no similar degradation. Because of the relatively watertight Boraflex panel enclosures in most spent fuel storage rack designs, this type of degradation was typically not previously considered.

The potential exists for a gradual release of silica and boron carbide from Boraflex following gamma irradiation and long-term exposure to the spent fuel pool environment. When Boraflex is subjected to gamma radiation in the aqueous environment of the pool, the silicon polymer matrix becomes degraded and silica filler and boron carbide are released. Because Boraflex is composed of approximately 25 percent silica, 25 percent polydimethyl siloxane polymer, and 50 percent boron carbide, the presence of silica in the pool provides an indication of depletion of boron carbide from Boraflex. The loss of boron carbide (washout) from Boraflex is characterized by slow dissolution of the silica 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 source of silica (several thousand kilograms) and is the most likely source of pool silica contamination. The boron carbide loss will result in an increase in the reactivity of the matrix of fuel and Boraflex in the spent fuel pool.

EPRI report TR-103300 has identified several factors that influence the rate of silica release from Boraflex. The presence of water 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 rate will vary from plant to plant. The rate of dissolution also increases with higher pool temperature and gamma exposure, suggesting that Boraflex degradation can be reduced by keeping pool temperatures low and by not placing freshly discharged fuel assemblies in the same storage cells at each refueling outage.

Description of Circumstances

The South Texas Project, Unit 1, has fuel storage racks installed in the spent fuel pool that use Boraflex as a neutron absorber. The pool contains two rack types. The Region 1 racks are designed to receive high reactivity fuel assemblies, including fresh fuel, and use Boraflex panels in a removable stainless steel box. The Region 2 racks are designed for low reactivity spent fuel assembly storage and contain fixed Boraflex panels between the cell walls. The Boraflex panels were designed to ensure that adequate negative reactivity would be maintained if the pool were accidentally flooded with unborated water.

Blackness (neutron absorption) testing was performed during August 1994 on selected South Texas Project Unit 1 spent fuel pool storage racks to determine the condition of the Boraflex and to determine the size and location of any gaps that may have developed. However, in addition to gap development, which is a known phenomenon, the results also indicated that the Boraflex had significantly degraded due to a decrease of the boron content in several of the storage cells tested. Of the eight cells that had been designated to receive an accelerated gamma dose in Region 1, five cells exhibited large areas of degradation (0.9 to 1.4 meters [3 to 4.5 feet] in length) postulated to result from accelerated dissolution of the Boraflex caused by pool water flow through the panel enclosures as well as the high accumulated gamma dose.

Similar Boraflex degradation was discovered at the Fort Calhoun Station. As part of their rerack project, the old spent fuel storage racks containing Boraflex were removed and disassembled in December 1994 to determine the condition of the Boraflex. Two cells from the removed Boraflex racks which had experienced the highest gamma flux since 1983 were inspected. 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. The new Fort Calhoun Station storage racks do not contain Boraflex.

Discussion

Because Boraflex is used in the South Texas Project spent fuel storage racks for 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.

In response to the identified Boraflex problem, Houston Lighting & Power Company, the licensee for the South Texas Project, developed restrictions to not use the substantially degraded storage cells in Region 1 for discharged spent fuel. In addition, the licensee is developing a long-term neutron absorption panel management plan, as well as a dose-to-degradation correlation, which will aid in establishing restrictions for use of the spent fuel racks in both Units 1 and 2. The licensee also cited criticality analyses that showed that the fuel will remain subcritical by at least 5 percent, even with no Boraflex, as long as the soluble boron concentration is at least 2,500 ppm.

Although pressurized-water reactor spent fuel pool water is normally borated to approximately 2,000 ppm of boron, current regulatory requirements do not allow credit for the soluble boron except under accident conditions. Many boiling-water reactor (BWR) storage racks also contain Boraflex. Because BWR spent fuel pool water does not contain boron, any significant Boraflex degradation in a BWR pool may challenge the 5 percent subcritical margin.

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Dennis M. Crutchfield

Dennis M. Crutchfield, Director
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95-32	Thermo-Lag 330-1 Flame Spread Test Results	08/10/95	All holders of OLs or CPs for nuclear power reactors.
95-31	Motor-Operated Valve Failure Caused by Stem Protector Pipe Interference	08/09/95	All holders of OLs or CPs for nuclear power reactors.

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Discussion

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the material minimum certifications. No other storage cells exhibited as significant a loss of Boraflex. The new Fort Calhoun Station storage racks do not contain Boraflex.

Discussion

Because Boraflex is used in the South Texas Project 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 62, "Prevention of Criticality in Fuel Storage and Handling."

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