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

October 28, 2009

NRC INFORMATION NOTICE 2009-26: DEGRADATION OF NEUTRON-ABSORBING MATERIALS IN THE SPENT FUEL POOL

ADDRESSEES

All holders of operating licenses or construction permits for nuclear power reactors under the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities."

PURPOSE

The U.S. Nuclear Regulatory Commission (NRC) is issuing this information notice (IN) to inform addressees on the issue of degradation of the Carborundum neutron-absorbing materials in the spent fuel pools (SFP) and the deformation of Boral® panels in SFPs. The NRC expects that recipients will review the information for applicability to their facilities and consider actions, as appropriate, to avoid similar problems. Suggestions contained in this IN are not NRC requirements; therefore, no specific action or written response is required.

DESCRIPTION OF CIRCUMSTANCES

Carborundum

In July 2008, the licensee at the Palisades Nuclear Plant discovered that the region 1 SFP storage racks contained less neutron-absorbing material than assumed in the SFP criticality analysis of record and that the licensee was in noncompliance with the SFP criticality requirements in Technical Specification (TS) 4.3.1.1.b.

In 1988, the licensee encountered difficulty inserting a fuel assembly into one of the region 1 SFP storage rack cells because the north wall of the cell had experienced swelling. Since 1988, several other locations have been determined to be swollen. Most of these locations were identified because their fuel assemblies could not be removed. To date, 14 cells have experienced swelling, 11 with fuel stored in them and 3 empty. When a stuck fuel assembly was identified in 2007, the licensee performed an apparent cause evaluation that determined that the swelling of the region 1 rack may be due to degradation of the Carborundum B_4C neutron absorber plates. In response to this concern, on July 15, 2008, the licensee performed "blackness testing" of the region 1 SFP racks to validate that the racks continue to perform neutron attenuation as credited in the licensee's criticality analysis of record and to satisfy regulatory requirements and renewed license commitments.

ML092440545

The licensee performed in situ Boron-10 Areal Density Gauge for Evaluating Racks (BADGER) testing of approximately 2 percent of the storage locations, which revealed that the Boron-10 areal density of the SFP racks was, at a minimum, approximately one-third of its original design value. The neutron-absorbing material, Carborundum, which is relied on to maintain subcriticality in the SFP, was much less effective than assumed in the criticality analysis. Therefore, region 1 of the SFP no longer met 10 CFR 50.68, "Criticality Accident Requirements," or TS 4.3.1.1.b, which require that K-effective (K_{eff}) for region 1 fuel racks be less than or equal to 0.95 if fully flooded with unborated water.

The licensee determined that the apparent cause of the degradation of the Carborundum B_4C plates was the environment of the SFP. The exact degradation mechanism or mechanisms are not clearly understood but likely involve changes in the physical properties of the Carborundum B_4C plates that occur during prolonged exposure to the SFP environment. The swelling of the racks, which prevents fuel assemblies from being inserted or removed, indicates a potential problem with neutron-absorbing capacity. The swelling in the racks could result from dimensional changes of the Carborundum, which may be replaced by a gas-filled space, and could challenge the assumptions of the criticality analysis. This unknown impact on the criticality analysis led the licensee to perform BADGER testing of the racks and discover the Carborundum degradation. This degradation may have been occurring as early as 1988 when the first impedance to inserting a fuel assembly was documented at Palisades. Since there was no surveillance of the neutron-absorbing capacity of the material, the start of the degradation and the degradation rate are unknown.

The noncompliant criticality analysis was resolved when the licensee submitted and the NRC approved a license amendment to change the criticality analysis to remove any credit for the Carborundum material as a neutron absorber in the SFP. The amendment also restricted the pattern of the fuel assemblies in the pool.

Additional information is available in (1) Palisades Licensee Event Report 05000255/2008-004, "Noncompliance with Technical Specification 4.3.1.1.b," dated September 15, 2008, and viewable on the NRC's public Web site in the Agencywide Documents Access and Management System (ADAMS) under Accession No. ML082660584, and (2) a letter from Entergy Nuclear Operations, Inc. (Palisades), to the NRC, "Commitments to Address Degraded Spent Fuel Pool Storage Rack Neutron Absorber," dated August 27, 2008, which can be found in ADAMS under Accession No. ML082410132.

Boral

Beaver Valley Power Station. In a license renewal application supplement dated January 19, 2009 (ADAMS Accession No. ML090220216), the licensee at Beaver Valley stated that licensee inspections in 2007 of the Boral neutron absorber material coupons identified numerous blisters of the aluminum cladding, while only a few small blisters were identified in 2002. In region 1 fuel storage racks, blisters can displace water from the flux traps between storage cells and challenge dimensional assumptions used in the criticality analysis. Based on these inspections, the licensee determined that the Boral aluminum cladding blistering was an aging effect and that it would credit the existing Boral Surveillance Program with management of this aging.

Susquehanna Steam Electric Station. In a license renewal application letter dated May 13, 2009 (ADAMS Accession No. ML091520031), the licensee at Susquehanna stated that it had identified a significant bulge in a poison can wall. Although the licensee has not definitively determined the cause of the bulge, the licensee's letter states that it may be the result of hydrogen gas generation from either moisture contained in the Boral at the time of manufacture or a leaking seal weld in the poison can. This bulge prevented the placement of a blade guide into the deformed cell.

BACKGROUND

NRC Generic Letter 78-11, "Guidance for Spent Fuel Pool Modifications," and enclosure, "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications," dated April 14, 1978 (ADAMS Accession No. ML031280383), provide NRC guidance on testing of the SFP neutron-absorbing materials to ensure the long-term safety and integrity of the pool and fuel rack system. Generic Letter 78-11 states, "Methods for verification of long-term material stability and mechanical integrity of special poison material utilized for neutron absorption should include actual tests…to assure long-term safety and integrity of the pool and fuel rack system."

Electric Power Research Institute Report TR1013721, "Handbook of Neutron Absorber Materials for Spent Fuel Transportation and Storage Applications," issued 2006, states the following concerning Boral:

> Similarly, in-pool blistering of Boral has, to date, proved to be primarily an esthetic effect; however, the potential effects on fuel assembly clearance and the reactivity state of region 1 racks have been noted. In addition, it has been noted that, in a few instances, rack cell wall deformation has occurred making it difficult to remove fuel. With plant life extension now the norm at most [light water reactors] LWRs in the US, some Boral, which originally had a design service life of 40 years, will be in service more than 60 years. This suggests a prudent course is continued vigilance and surveillance so that onset of any degradation can be detected early and appropriate mitigation measures applied.

DISCUSSION

The regulations in 10 CFR 50.68(b)(4) state that if no credit for soluble boron is taken, the K_{eff} of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, if flooded with unborated water. If credit is taken for soluble boron, the K_{eff} of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, if flooded with borated water, and the K_{eff} must remain below 1.0 (subcritical), if flooded with unborated water. In addition, standard TS 4.3.1.1.b requires that the spent fuel storage racks be designed and maintained with K_{eff} less than or equal to 0.95 if fully flooded with unborated water. This IN provides examples of degradation of neutron-absorbing materials that resulted in, or had the potential to result in, noncompliance with 10 CFR 50.68(b)(4) and standard TS 4.3.1.1.b.

At Palisades, degradation of the neutron-absorbing material Carborundum, which is relied on to maintain subcriticality in the SFP, was much less effective than assumed in the criticality analysis. This degradation also may have resulted in the physical deformation (swelling) of the Carborundum plates.

The other examples in this IN involve degradation of aluminum cladding of the neutron-absorbing material Boral. Blisters and bulges of Boral cladding are material deformations that change the dimensions of the material. These blisters and bulges can be either water filled or gas filled (from the reaction of the SFP water and aluminum from the Boral), which may not be accounted for in the criticality analysis. In the case of Beaver Valley, the blisters could grow to a point where the water from the flux trap of the region 1 rack could be displaced with gas. This deformation has the potential to challenge dimensional assumptions made in the fuel pool criticality analysis. In the case of Susquehanna, the SFP racks do not have flux traps; however, if the bulges in the rack are filled with gas, the dimensional assumptions of the combined moderation and neutron attenuating geometry assumed in the SFP criticality analysis could be challenged. Susquehanna currently stores only non-fuel bearing components in the vicinity of the identified bulged cell.

The degradation mechanisms and deformation rates of any of the neutron-absorbing materials in the SFP are not well understood. Therefore, for licensees that credit the use of a neutron-absorbing material to maintain subcriticality in their SFP, knowing the condition of the neutron-absorbing material in the SFP and monitoring the SFP for any indications that degradation of the material may be occurring can prevent noncompliance with SFP criticality requirements.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

/RA by TQuay for/

Timothy J. McGinty, Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contacts: Emma L. Wong, NRR
301-415-1217
E-mail: emma.wong@nrc.gov

Matthew G. Yoder, NRR
301-415-4017
E-mail: matthew.yoder@nrc.gov

Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.

At Palisades, degradation of the neutron-absorbing material Carborundum, which is relied on to maintain subcriticality in the SFP, was much less effective than assumed in the criticality analysis. This degradation also may have resulted in the physical deformation (swelling) of the Carborundum plates.

The other examples in this IN involve degradation of aluminum cladding of the neutron-absorbing material Boral. Blisters and bulges of Boral cladding are material deformations that change the dimensions of the material. These blisters and bulges can be either water filled or gas filled (from the reaction of the SFP water and aluminum from the Boral), which may not be accounted for in the criticality analysis. In the case of Beaver Valley, the blisters could grow to a point where the water from the flux trap of the region 1 rack could be displaced with gas. This deformation has the potential to challenge dimensional assumptions made in the fuel pool criticality analysis. In the case of Susquehanna, the SFP racks do not have flux traps; however, if the bulges in the rack are filled with gas, the dimensional assumptions of the combined moderation and neutron attenuating geometry assumed in the SFP criticality analysis could be challenged. Susquehanna currently stores only non-fuel bearing components in the vicinity of the identified bulged cell.

The degradation mechanisms and deformation rates of any of the neutron-absorbing materials in the SFP are not well understood. Therefore, for licensees that credit the use of a neutron-absorbing material to maintain subcriticality in their SFP, knowing the condition of the neutron-absorbing material in the SFP and monitoring the SFP for any indications that degradation of the material may be occurring can prevent noncompliance with SFP criticality requirements.

CONTACT

This IN requires no specific action or written response. Please direct any questions about this matter to the technical contacts listed below or the appropriate Office of Nuclear Reactor Regulation (NRR) project manager.

/RA by TQuay for/

Timothy J. McGinty, Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Technical Contacts: Emma L. Wong, NRR
301-415-1217
E-mail: emma.wong@nrc.gov

Matthew G. Yoder, NRR
301-415-4017
E-mail: matthew.yoder@nrc.gov

Note: NRC generic communications may be found on the NRC public Web site, http://www.nrc.gov, under Electronic Reading Room/Document Collections.

ADAMS Accession Number: ML092440545 ME1659

OFFICE	DCI:CSGB	TECH EDITOR	BC:DCI:CSGB	D:DCI	BC:DSS:SRXB
NAME	EWong	KA-Kribbs	MGavrilas	MEvans	GCranston
DATE	9/30/2009	9/11/2009 email	10/1/2009	10/5/2009	10/7/2009

OFFICE	PGCB:DPR	PGCB:DPR	BC:PGCB:DPR	D:DPR
NAME	DBeaulieu	CHawes	MMurphy	TQuay for TMcGinty
DATE	10/7/2009	10/8/2009	10/28/09	10/28/09

OFFICIAL RECORD COPY