

UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
OFFICE OF NUCLEAR REACTOR REGULATION  
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS  
WASHINGTON, DC 20555-0001

Month XX, 20XX

NRC GENERIC LETTER 2016-XX: MONITORING OF NEUTRON-ABSORBING MATERIALS  
IN SPENT FUEL POOLS

**ADDRESSEES**

All nuclear power reactors with a license issued under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those that have permanently ceased operations with all reactor fuel removed from onsite spent fuel pool (SFP) storage.

AND

All holders of an operating license for a non-power reactor (research reactor, test reactor, or critical assembly) under 10 CFR Part 50 who have a reactor pool, fuel storage pool, or other wet locations designed for the purpose of fuel storage, except those who have permanently ceased operations with all reactor fuel removed from onsite wet storage.

**PURPOSE**

The U.S. Nuclear Regulatory Commission (NRC) is issuing this generic letter (GL) to address degradation of neutron-absorbing materials in wet storage systems for reactor fuel at power and non-power reactors. The primary focus of this GL is on the credited use of these materials at power reactors; however, the NRC staff is aware of the use of neutron-absorbing materials in similar applications at some non-power reactors for which the staff needs additional information. In the context of this GL, "credited" means that the neutron-absorbing material is necessary to limit the maximum effective multiplication factor ( $k_{\text{eff}}$ ), under optimum conditions of moderation and reflection, to less than that assumed in the licensing and design basis (e.g., criticality safety analysis, accident analysis, and technical specifications (TS) limit).

Specifically, the NRC is issuing this GL for two purposes:

- (1) To request that addressees submit information, or provide references to previously docketed information, which demonstrates that credited neutron-absorbing materials in the SFP of power reactors and the fuel storage pool, reactor pool, or other wet locations designed for the purpose of fuel storage, as applicable, for non-power reactors, are in compliance with the licensing and design basis, and with applicable regulatory requirements; and that there are measures in place to maintain this compliance.
- (2) To collect the requested information and determine if additional regulatory action is required.

Enclosure

Under 10 CFR 50.54(f), addressees are required to submit a written response to this GL.

## BACKGROUND

Maintaining subcriticality—i.e., conditions that do not allow self-sustaining fission reactions—is an important safety consideration for nuclear fuel storage. The NRC requires power reactor license holders to maintain SFP subcriticality in accordance with 10 CFR 50.68, “Criticality accident requirements,” General Design Criterion (GDC) 62, “Prevention of Criticality in Fuel Storage and Handling,” in Appendix A, “General Design Criteria for Nuclear Power Plants,” to 10 CFR Part 50, and other equivalent regulatory criteria. The NRC has a similar requirement included in the TS for non-power reactors.

The license holder usually documents the nuclear criticality safety (NCS) analyses in the updated final safety analysis report (UFSAR). The NCS analyses form the basis for demonstrating compliance with plant TS, compliance with NRC regulations, and adequate subcriticality for both normal operating conditions and design-basis events. In many SFP NCS analyses, neutron-absorbing materials are credited for maintaining subcriticality in the SFP, with assumptions on dimensions and boron-10 ( $^{10}\text{B}$ ) areal density. Hence, these materials must be able to perform their safety function during both normal operating conditions and design-basis events.

Unidentified, unmitigated, and unmonitored degradation or deformation of the credited neutron-absorbing materials may reduce the safety margin and potentially challenge the subcriticality requirement, especially when these materials are subjected to additional stressors during and following design-basis events. Many license holders use integrated defense-in-depth design features to account for the neutron-absorbing material’s degradation. For example, some pressurized-water reactors have been approved to take credit for the soluble boron in the SFP water.

Neutron-absorbing materials are composed of a neutron-absorbing component, generally  $^{10}\text{B}$  as boron carbide, in a matrix. Both metal matrix and nonmetal matrix materials have been used. Different neutron-absorbing materials used in U.S. nuclear power plants include:

- boron carbide in a silicone polymer (e.g., Boraflex)
- boron carbide in a phenol formaldehyde resin matrix (e.g., Carborundum, Tetrabor®)
- metal matrix composites, such as a cermet of boron carbide and aluminum (e.g., Boral®)
- a metal matrix of an aluminum and boron carbide (e.g., Metamic™)
- borated stainless steel

In the 1980s, Boraflex was the first neutron-absorbing material to exhibit significant degradation, as documented in Information Notice (IN) 1987-43 (Reference 1), IN 1993-70 (Reference 2), IN 1995-38 (Reference 3), and GL 1996-04 (Reference 4). The NRC staff documented additional concerns regarding monitoring and mitigating degradation of Boraflex in IN 2012-13 (Reference 5). Several license holders identified instances of degradation or deformation of Carborundum and Boral® neutron-absorbing materials in SFPs, such as that documented in IN 1983-29 (Reference 6) and IN 2009-26 (Reference 7).

Surveillance of neutron-absorbing material degradation can involve the use of monitoring methods to assess or measure degradation of the material and computer codes to model and

predict the condition of the materials used in the SFP. For Boraflex, a combination of the RACKLIFE computer code and the Boron Areal Density Gauge for Evaluating Racks (BADGER) in-situ measurement tool has been employed to manage degradation. The RACKLIFE computer code was developed in the mid-1990s to track and predict the loss of Boraflex and to manage the storage patterns of spent fuel in the SFP. The BADGER system was originally designed, assembled, and tested in the early to mid-1990s by Northeast Technologies Company (now a subsidiary of Curtiss–Wright) as a nondestructive scoping tool to evaluate neutron-absorbing materials placed in spent fuel racks. Although BADGER was designed and is employed primarily to measure the degradation of Boraflex, it is theoretically applicable to any neutron-absorbing material and has been used for Carborundum and Boral<sup>®</sup>. Other surveillance methods include testing of representative coupon samples. These tests may include dimensional, neutron attenuation, and weight tests.

### **Operating Experience**

In October 2003, the licensee for Seabrook, LLC, reported a condition involving Boral<sup>®</sup> SFP test coupons (Reference 8). The licensee reported that the inspection of test coupons revealed bulging or blistering of the aluminum cladding. Boral<sup>®</sup> test coupons had been placed in the SFP as monitoring specimens to assess the performance of similar Boral<sup>®</sup> neutron-absorbing material incorporated in the SFP racks. The licensee measured the <sup>10</sup>B areal density in the Boral<sup>®</sup> coupons by neutron-attenuation testing. The licensee reported that the areal density results were within specification and that there was no loss of <sup>10</sup>B material. Furthermore, the licensee stated that the impact of the Boral<sup>®</sup> blistering on the flux trap racks was determined to be small and within the bounds of the NCS analyses. Thus, the Boral<sup>®</sup> maintained its safety function. As a result of this event, the licensee developed a Boral<sup>®</sup> Monitoring Program and added a blistering allowance in the SFP criticality curves to account for the potential bulging or blistering of the material in the SFP racks.

In July 2008, the licensee for Palisades Nuclear Plant (Palisades) identified severe degradation of the SFP neutron-absorbing material Carborundum. Palisades performed blackness testing<sup>1</sup> to determine if the Carborundum neutron-absorbing material in the racks remained capable of performing its safety function. The testing revealed that several Carborundum panels were so severely degraded that only approximately one-third of its original <sup>10</sup>B remained. As a result, the licensee was unable to demonstrate that the SFP satisfied the subcriticality requirements in accordance with NRC regulations and plant TS (Reference 7). Because the licensee had not performed routine surveillance of the neutron-absorbing capacity of the material, the time of degradation onset and the degradation rate were unknown. The issue was resolved when the NRC approved a license amendment that removed credit for the Carborundum material as a neutron absorber in the SFP and restricted the pattern of the fuel assemblies in the pool.

In January 2009, the licensee for Beaver Valley Power Station, Units 1 and 2 submitted supplemental information identifying Boral<sup>®</sup> degradation in the SFP during review of its license renewal application (Reference 9). The licensee stated that inspections conducted in 2007 of the Boral<sup>®</sup> neutron-absorbing material coupons identified numerous blisters of the aluminum cladding, while only a few small blisters were identified in 2002. This degradation posed a potential safety concern because blisters may displace water from the flux trap between the deformed cladding and the boron-containing core in certain fuel storage racks that challenge the dimensional assumptions used in the NCS analyses. Based on these inspections, the licensee

---

<sup>1</sup> This is an in-situ testing technique with a neutron source and detector that measures the presence of neutron-absorbing material.

determined that the Boral® aluminum cladding blistering was an aging effect requiring management. The licensee proposed to credit the existing Boral® Surveillance Program for managing this aging effect in its license renewal application. As a result, the licensee has enhanced its monitoring programs to confirm that safety margins are maintained in the SFP.

In September 2009, the licensee for Turkey Point Nuclear Generating Station, Unit 3 informed the NRC that Unit 3 would be unable to fully implement license amendment No. 234 because of procurement challenges with Metamic™ neutron-absorbing material inserts. In this amendment, the NRC approved the replacement of Boraflex with a combination of rod cluster control assemblies, Metamic™ rack inserts, and administrative controls that required mixing storage of higher reactivity fuel with lower reactivity fuel. As a result of the procurement challenges with Metamic™ rack inserts and the continued Boraflex degradation, the NRC issued three violations, including a civil penalty (Reference 10). The licensee implemented compensatory measures, including increasing soluble boron concentration levels, to ensure that the SFP remained subcritical, as the NRC acknowledged in a confirmatory action letter (Reference 11). To provide a long-term solution for this issue, the licensee requested and the NRC approved a license amendment that included new spent fuel storage patterns and updated licensing-basis information demonstrating compliance with criticality requirements.

To address Boraflex degradation in 2010, the licensee for Peach Bottom Atomic Power Station, Units 2 and 3 performed an operability determination (OD) based on the RACKLIFE surveillance program that concluded it would maintain sufficient margin to criticality in its SFP until 2014. However, the NRC's review of the OD concluded that the licensee did not accurately project the rate of Boraflex degradation and used several nonconservative assumptions in the analysis. The licensee performed a re-analysis and determined that several Boraflex panels had degraded below TS requirements. As a result, the licensee declared multiple cells in the SFP inoperable, relocated spent fuel assemblies to maintain appropriate margin, and established additional administrative controls to govern use of affected cells. The NRC issued a violation associated with the licensee's failure to implement corrective actions to prevent the Boraflex panels from degrading below the TS requirements (Reference 12). To provide a long-term solution for this issue, the licensee requested and the NRC approved a license amendment that included installation of rack inserts and removal of credit for Boraflex as a neutron-absorbing material.

## **NRC Actions**

The operating experience coupled with regulatory actions (e.g., plant site inspections and reviews of license renewal applications and license amendments) indicated a gap in the NRC regulatory knowledge base of neutron-absorbing materials. In addition, the NRC determined that existing regulatory guidance did not adequately address the management of the effects of aging on the neutron-absorbing materials. Subsequently, the NRC developed license renewal interim staff guidance (Reference 13) for an aging management program for neutron-absorbing materials. This regulatory guidance on aging management of neutron-absorbing materials was incorporated into NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report," (Reference 14).

The NRC also prepared two technical letter reports (TLRs) (References 15 and 16) discussing some of the methods that license holders use to monitor the degradation of neutron-absorbing materials. The NRC commissioned these reports to gather more information on surveillance methodologies for neutron-absorbing materials employed in SFPs. These TLRs also identify uncertainties in the methodologies employed to monitor the performance of neutron-absorbing

materials. The reports provide a generic overview on the use of the RACKLIFE computational tool and the BADGER in-situ measurement technique. The reports discuss the reliability of these methodologies for certain applications. Some license holders use these surveillance tools to demonstrate compliance with their TS and NRC regulations.

Additionally, the NRC recently published a third TLR that summarizes the characteristics of the phenolic-resin-type neutron-absorbing materials, Carborundum and Tetrabor®, the qualification testing results, and the operating experience pertaining to degradation (Reference 17). The report also describes phenolic resin degradation mechanisms and analyzes current surveillance methods.

## **DISCUSSION**

Reactivity and, therefore, criticality is determined by local phenomena, including how far a neutron is expected to travel in the given environment. In the SFP environment, the minimum critical volume necessary to sustain a nuclear chain reaction may be as small as four fuel assemblies; certainly much smaller than the entire SFP. The conditions within the minimum critical volume will determine whether or not an inadvertent criticality event can occur and if the subcriticality requirements are met. The use of SFP-wide parameters, such as average neutron-absorbing material areal density or degradation, may not be appropriate to verify subcriticality requirements that are dependent on local properties.

To ensure that the requirements of 10 CFR 50.68 and GDC 62 (or equivalent) are met, the appropriate parameters on a local level must be known and appropriately considered. For license holders who credit neutron-absorbing material in their NCS analyses, this requires that the present condition of the neutron-absorbing material be known and that its future condition be managed. Two of the aforementioned TLRs issued by the NRC identify uncertainties with tools commonly used in the industry to monitor the condition of the neutron-absorbing materials used in SFPs. As described in the Operating Experience section, some license holders have had difficulty managing their neutron-absorbing materials' current condition, and in some cases, corrective action had to be taken to restore compliance with regulatory requirements.

SFP neutron-absorbing materials that are credited for maintaining subcriticality must be able to perform their safety function during both normal operating conditions and design-basis events. Monitoring neutron-absorbing materials is intended to identify when degradation may affect their ability to perform their safety function, so that appropriate corrective action can be taken. Therefore, the NRC is requesting information to confirm that addressees are in compliance with the regulations and to determine whether additional regulatory action is necessary.

For new reactors licensed under 10 CFR Part 52, the NRC was previously aware of the concerns discussed in this GL and considered them in the licensing review. The NRC obtained sufficient information to confirm regulatory compliance of the planned design, and imposed a license condition that requires 10 CFR Part 52 licensees to provide the necessary information on the surveillance or monitoring programs before operation. As for the additional information on the operation of the SFP being requested by this GL, this information would not apply to Part 52 licensees at this time because no 10 CFR Part 52 licensees currently have an SFP in operation and will not for several years. Consequently, 10 CFR Part 52 licensees are not being included among the addressees for this GL.

## APPLICABLE REGULATORY REQUIREMENTS

This section presents multiple regulatory requirements that relate to the subject of this GL and have been referenced in licensing and enforcement documents related to neutron-absorbing materials. While not all requirements might apply to a specific licensee, request, or condition, they are presented here for context.

The following regulatory requirements related to this GL are applicable to all reactor licensees:

- 10 CFR 70.24, “Criticality accident requirements,” which requires license holders who possess nuclear material to monitor the areas where the material is stored to detect accidental criticality.
- 10 CFR 50.36, “Technical specifications,” which requires licensees to develop administrative controls necessary to ensure safe operation.
- 10 CFR Part 50, Appendix B, “Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants,” Criterion XI, “Test Control,” and Criterion XII, “Control of Measuring and Test Equipment,” which establish requirements for planned and systematic actions necessary to provide adequate confidence that a structure, system, or component used to prevent or mitigate the consequences of postulated accidents will perform satisfactorily in service. In particular, Criteria XI and XII establish requirements for the testing and control of measuring or testing equipment to confirm that all structures, systems, or components will perform satisfactorily in service, including operational tests conducted during nuclear power plant operation.

The following additional regulatory requirements related to this GL are applicable to power reactor licensees:

- 10 CFR 50.68, which contains the regulations for maintaining SFP subcriticality. The NRC uses this regulation to develop acceptance criteria for monitoring programs for SFP neutron-absorbing materials.
- 10 CFR 50.65, “Requirements for monitoring the effectiveness of maintenance at nuclear power plants,” which requires licensees to monitor the performance or condition of structures, systems, and components against licensee-established goals, in a manner sufficient to provide reasonable assurance that these structures, systems, and components are capable of fulfilling their intended functions.
- Appendix A to 10 CFR Part 50 includes several requirements applicable to criticality control in fuel storage. Not all plants were licensed under the GDCs described in Appendix A, but they were generally licensed under similar site-specific principal design criteria.
  - GDC 2, “Design Bases for Protection Against Natural Phenomena,” which requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena.
  - GDC 61, “Fuel Storage and Handling and Radioactivity Control,” which requires that fuel storage and handling, radioactive waste, and other systems that may

contain radioactivity be designed to ensure adequate safety under normal and postulated accident conditions. These systems shall be designed with a capability to permit appropriate periodic inspection and testing of components important to safety.

- GDC 62, which requires that criticality in the fuel storage and handling system be prevented by physical systems or processes.

## **REQUESTED INFORMATION FROM POWER REACTOR ADDRESSEES**

The NRC requests information in the following five areas for use in verifying compliance:

- (1) a description of the neutron-absorbing material credited in the SFP NCS analysis of record (AOR) and its configuration in the SFP;
- (2) a description of the surveillance or monitoring program used to confirm that the credited neutron-absorbing material is performing its safety function, including the frequency, limitations, and accuracy of the methodologies used;
- (3) a description of the technical basis for determining the interval of surveillance or monitoring for the credited neutron-absorbing material;
- (4) a description of how the credited neutron-absorbing material is modeled in the SFP NCS AOR and how the monitoring or surveillance program ensures that the actual condition of the neutron-absorbing material is bounded by the NCS AOR; and
- (5) a description of the technical basis for concluding that the safety function for the credited neutron-absorbing material in the SFP will be maintained during design-basis events.

The NRC will accept responses based on a categorization, as follows:

- Category 1: Power reactor addressees that do not credit neutron-absorbing materials other than soluble boron in the AOR. In some cases, no neutron-absorbing material is present in the spent fuel storage racks, and in other cases, credit for the neutron-absorbing material has been removed through a regulatory action (e.g., approved license amendment). Those addressees may submit a response letter confirming that no neutron-absorbing materials are currently credited to meet NRC subcriticality requirements in the SFP.
- Category 2: Power reactor addressees that have an approved license amendment to remove credit for existing neutron-absorbing materials and that intend to complete full implementation no later than 24 months after the issuance of this GL. Licensees may request extensions to this implementation timeframe if there are extenuating circumstances. Those addressees may submit a response letter affirming that they will implement the approved license amendment request within the specified time. However, they must still provide information equivalent to Category 3 or Category 4 for any other neutron-absorbing material credited in the SFP criticality AOR after the license amendment has been fully implemented.

- Category 3: Power reactor addressees that have incorporated their neutron-absorbing material monitoring programs into their licensing basis through an NRC-approved TS change or license condition. Those addressees may submit a response letter referencing their approved TS change or license condition and affirming that no change has been made to their neutron-absorbing material monitoring program, as described in the referenced license amendment request. If a change has been made since NRC approval of the reference, the response letter should also describe any such changes. (Licensees with a monitoring program approved as part of a license amendment request or license renewal application that was not incorporated as a TS change or license condition are considered to belong in Category 4.)
- Category 4: All other power reactor addressees. The NRC seeks information in five areas depending upon the type of neutron absorber material used by the licensee in the SFP. A detailed discussion of the five areas of information can be found in Appendix A. Table 1, below, contains the areas of information to be provided by the licensee with respect to each type of neutron absorber material.

Table 1. Areas of Information by Neutron Absorber Material Types

Neutron-Absorbing Material Type	Areas of Requested Information (described in Appendix A of GL-2016-XX)				
	(1)	(2)	(3)	(4)	(5)
Boraflex Carborundum Tetrabor	x	x	x	x	x
Boral	x	x*		x	
Borated stainless steel Metamic Boralcan Other metallic matrix composites	x	x*			

\* Except for 2(b)(iii).

Previously-docketed information may be referenced (including license renewal applications and license amendment requests) if the addressee affirms that the information remains applicable and provides any updated or missing information. In all cases, the NRC is asking licensees to provide information available, based on a reasonable search of plant records, docketed information, and licensing basis.

The NRC is not requiring any new analyses, new programs, or new research to be developed or implemented in response to this GL. Licensees should maintain the information being requested in accordance with provisions found in Appendix B of 10 CFR Part 50 requiring the existence of a quality assurance program that appropriately characterizes each component (Criterion VII, "Control of Purchased Material, Equipment and Services," and Criterion VIII, "Identification and Control of Materials, Parts, and Components"), that provides for appropriate testing to demonstrate satisfactory inservice performance of components (Criterion XI), and that ensures that sufficient records will be maintained to furnish evidence of such activities in an identifiable and retrievable form (Criterion XVII, "Quality Assurance Records").



## **REQUESTED INFORMATION FROM NON-POWER REACTOR ADDRESSEES**

The NRC requests that each non-power reactor addressee provide the following information for use in determining the reliance on neutron-absorbing materials for NCS of reactor fuel or spent fuel in storage contained within reactor pools, fuel storage pools, or other wet locations designed for the purpose of fuel storage, as applicable:

- (1) Are neutron-absorbing materials used in a reactor pool, fuel storage pool, or other wet locations designed for the storage of reactor or spent fuel?
- (2) If neutron-absorbing materials are used, is their use credited in the licensing or design basis (i.e., criticality safety analysis) for the storage of reactor fuel or spent fuel in a reactor pool, fuel storage pool, or other wet locations, as applicable?
- (3) If neutron-absorbing materials are credited in the facility licensing or design basis for the storage of reactor or spent fuel in a reactor pool, fuel storage pool, or other wet locations, as applicable, then provide a description of, and technical basis for, any surveillance or monitoring programs used to confirm continued acceptable performance of the neutron-absorbing materials over time.

## **REQUIRED RESPONSE**

In accordance with 10 CFR 50.54(f), an addressee must respond as described below:

Within 210 days of the date of this GL, each addressee is requested to submit a written response consistent with the information requested above, and for power reactors, as described in Appendix A.

If an addressee cannot meet the requested response date, the addressee must provide a response within 30 days of the date of this GL and describe the alternative course of action that it proposes to take in place of providing this information, the basis for the acceptability of the proposed alternative course of action, and the estimated completion dates.

The required written response, signed under oath and affirmation, should be addressed "ATTN: Document Control Desk, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001," in accordance with 10 CFR 50.4, "Written communications." In addition, addressees should submit a copy of the response to the appropriate regional office and NRC resident inspector.

## **REASON FOR INFORMATION REQUEST**

The NRC is authorized under Section 182.a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f) to require the addressees of this GL to submit to the NRC the information described in "Requested Response." The NRC staff has determined that the information collection and reporting burden to be imposed on nuclear power plant and non-power reactor license holders by this GL is justified in view of the potential safety significance issue concerning degradation of neutron-absorbing materials in the SFP of nuclear power plants and the reactor pool, reactor tank, or fuel storage pool of non-power reactors. Unidentified and unmitigated degradation of these materials may challenge the subcriticality margin of the SFP for nuclear power plants and the reactor pool, reactor tank, or fuel storage pool for non-power reactors

required by the existing regulations. The existing regulatory criteria for subcriticality margin are designed to prevent an inadvertent criticality event. If local conditions in the SFP are such that criticality is achieved, the local heat generation is likely to increase from power generation through fission. Such an event could challenge the ability of the credited SFP structures, systems, and components to maintain adequate cooling of the fuel.

This GL requests information from the addressees so that the NRC can determine if the degradation of the neutron-absorbing materials in the SFP for nuclear power plants and the reactor pool, reactor tank, or fuel storage pool for non-power reactors is being managed to maintain reasonable assurance that the materials are capable of performing their safety function, and to verify that the addressees are in compliance with the regulations. The level of detail required to perform this determination is not found in documents readily available to the NRC, such as the final safety analysis reports. The NRC is not requiring any new analyses or new programs to be developed and implemented. Accordingly, the burden on licensees is estimated to be no more than 170 hours per unit for all but two power reactors, and no more than 20 hours per site for non-power reactors to collect the information from documents available to the licensees and submit a final response to the NRC. Two power reactor licensees credit more than two neutron-absorbing materials to meet regulatory requirements, so they may take up to 250 hours.

#### RELATED GENERIC COMMUNICATIONS

Document Number	Document Name	Agencywide Documents Access and Management System (ADAMS) Accession No.
IN 2012-13	Boraflex Degradation Surveillance Programs and Corrective Actions in the Spent Fuel Pool	ML121660156
IN 2009-26	Degradation of Neutron-Absorbing Materials in the Spent Fuel Pool	ML092440545
GL 1996-04	Boraflex Degradation in Spent Fuel Pool Storage Racks	ML031110008
IN 1995-38	Degradation of Boraflex Neutron Absorber in Spent Fuel Storage Racks	ML031060277
IN 1993-70	Degradation of Boraflex Neutron Absorber Coupons	ML031070107
IN 1987-43	Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks	ML031130349
IN 1983-29	Fuel Binding Caused by Fuel Rack Deformation	ML14043A291
GL 1978-11	Review and Acceptance of Spent Fuel Storage and Handling Application	ML031280383

#### BACKFITTING AND ISSUE FINALITY DISCUSSION

This GL requests information from holders of 10 CFR Part 50 operating licenses, including licensees who have submitted the certification under 10 CFR 50.82(a)(1) that they have permanently ceased reactor operations, unless they have removed all fuel from the SFP. This

GL is also applicable to non-power reactors, if they have fuel on site in wet storage in a fuel storage pool, reactor pool, or reactor tank. The NRC is requesting information to determine if neutron-absorbing materials in the SFP of power reactors and the fuel storage pool, reactor pool, or reactor tank, as applicable, for non-power reactors are in compliance with the licensing and design bases, as well as with applicable regulatory requirements, and if there are measures in place to maintain this compliance.

Based upon this information, the NRC will determine if additional regulatory action is required. If the NRC imposes regulatory action on holders of 10 CFR Part 50 operating licenses for nuclear power plants with respect to neutron absorbers in SFPs as a result of the NRC's evaluation of the information submitted in response to this GL, then the NRC will address the requirements of the Backfit Rule, 10 CFR 50.109, "Backfitting," no later than the time it imposes the regulatory action.

In addition, the information requested by the NRC in this GL is not required, solely as a result of the NRC's request, to be included or reflected in the UFSAR under 10 CFR 50.71(e). If the NRC takes regulatory action to require that the information submitted in response to this GL be treated by the licensee as a legally binding requirement for that licensee's facility, then the NRC will address the requirements of the Backfit Rule, no later than the time it requires the licensee to treat the submitted information as a legally binding requirement.

For these reasons, the NRC concludes that the GL does not effectively constitute backfitting for holders of 10 CFR Part 50 operating licenses. Therefore, the NRC staff has not performed a backfit analysis.

This GL is not addressed to holders of combined licenses under 10 CFR Part 52, for the reasons set forth in the **Discussion Section**. Therefore, the issuance of this GL is not inconsistent with the issue finality provisions applicable to those combined license holders in 10 CFR 52.98, "Finality of combined licenses; information requests." Holders of licenses for non-power reactors are not subject to the Backfit Rule and are not licensed under 10 CFR Part 52. Therefore, this GL may be issued to non-power reactor licensees without consideration of backfitting or issue finality under 10 CFR Part 52.

#### **FEDERAL REGISTER NOTIFICATION**

A notice of opportunity for public comment on this GL was published in the *Federal Register* (79 FR 13685) for a 60-day posting period on March 11, 2014. The NRC received 11 sets of comments, all from the nuclear industry or vendors associated with the nuclear industry. The NRC staff's evaluation of the comments is publicly available in ADAMS under Accession No. ML14181B130.

A notice of opportunity for public comment regarding the burden on respondents was published in the *Federal Register* (80 FR 31930) on June 4, 2015, as part of the process for obtaining clearance from the Office of Management and Budget to issue this GL. The NRC staff's evaluation of the comments related to burden is publicly available in ADAMS under Accession No. ML15222A005.

#### **CONGRESSIONAL REVIEW ACT**

This GL is not a rule as defined in the Congressional Review Act (5 U.S.C. 801–808).

## PAPERWORK REDUCTION ACT STATEMENT

This GL contains information collection requirements that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.). This information collection was approved by the Office of Management and Budget, approval number 3150-0231, with an expiration date of March 31, 2019. This collection of information is authorized under the provisions of Section 182a of the Atomic Energy Act of 1954, as amended, and issued pursuant to 10 CFR 50.54(f).

The burden on the public for this information collection is estimated to be no more than 170 hours per unit for all but two power reactor units licensed under 10 CFR Part 50 and no more than 20 hours per response for non-power reactors, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the information collection. Two power reactor licensees credit more than two neutron-absorbing materials to meet regulatory requirements, so they are expected to take up to 250 hours per unit.

Send comments on this burden estimate or any other aspect of these information collections, including suggestions for reducing the burden, to the Freedom of Information Act, Privacy, and Information Collection Branch (T5-F53), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or to [Infocollects.Resource@nrc.gov](mailto:Infocollects.Resource@nrc.gov), and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202 (3150-0231), Office of Management and Budget, Washington, DC 20503.

## PUBLIC PROTECTION NOTIFICATION

The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid Office of Management and Budget control number.

## REFERENCES

1. Information Notice 1987-43, "Gaps in Neutron-Absorbing Material in High-Density Spent Fuel Storage Racks," September 8, 1987, ADAMS Accession No. ML031130349.
2. Information Notice 1993-70, "Degradation of Boraflex Neutron Absorber Coupons," September 10, 1993, ADAMS Accession No. ML031070107.
3. Information Notice 1995-38, "Degradation of Boraflex Neutron Absorber in Spent Fuel Storage Racks," September 8, 1995, ADAMS Accession No. ML031060277.
4. Generic Letter 1996-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks," June 26, 1996, ADAMS Accession No. ML031110008.
5. Information Notice 2012-13, "Boraflex Degradation Surveillance Programs and Corrective Actions in the Spent Fuel Pool," August 10, 2012, ADAMS Accession No. ML121660156.

6. Information Notice 1983-29, "Fuel Binding Caused by Fuel Rack Deformation," May 6, 1983, ADAMS Accession No. ML14043A291.
7. Information Notice 2009-26, "Degradation of Neutron-Absorbing Materials in the Spent Fuel Pool," October 28, 2009, ADAMS Accession No. ML092440545.
8. Letter from Florida Power & Light Energy Seabrook, LLC, to NRC, "Boral Spent Fuel Pool Test Coupons Report Pursuant to 10 CFR Part 21.21," October 6, 2003, ADAMS Accession No. ML032880525.
9. Letter from FirstEnergy Nuclear Operating Co, "Supplemental Information for the Review of Beaver Valley Power Station, Units 1 and 2, License Renewal Application and License Renewal Application Amendment No. 34," January 19, 2009, ADAMS Accession No. ML090220216.
10. Notice of Violation from NRC to Florida Power & Light Co, "Final Significance Determination of White Finding and Notice of Violation; Notice of Violation and Proposed Imposition of Civil Penalty – \$70,000 (NRC Inspection Report 2010009–Turkey Point)," June 21, 2010, ADAMS Accession No. ML101730313.
11. Confirmatory Action Letter [CAL-2-2010-002], "Turkey Point Unit 3 Commitments to Address Degraded Spent Fuel Pool Storage Rack Neutron Absorber," February 19, 2010, ADAMS Accession No. ML100539266.
12. NRC Integrated Inspection Report from NRC to Pacilio, M J, "Peach Bottom Atomic Power Station – NRC Integrated Inspection Report 05000277/2012002 and 05000278/2012002," May 7, 2012, ADAMS Accession No. ML12129A016.
13. LR-ISG-2009-01, Final License Renewal Interim Staff Guidance, "Aging Management of Spent Fuel Pool Neutron-Absorbing Materials Other than Boraflex," April 27, 2010, ADAMS Accession No. ML100621321.
14. NUREG-1801, Revision 2, "Generic Aging Lessons Learned (GALL) Report," December 2010, ADAMS Accession No. ML103490041.
15. Technical Letter Report, "Boraflex, RACKLIFE and BADGER: Description and Uncertainties," September 30, 2012, ADAMS Accession No. ML12216A307.
16. Technical Letter Report, "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012, ADAMS Accession No. ML12254A064.
17. Technical Letter Report, "Monitoring Degradation of Phenolic Resin-Based Neutron Absorbers in Spent Nuclear Fuel Pools," June 5, 2013, ADAMS Accession No. ML13141A182.

## CONTACT

Please direct any questions about this matter to the technical contact or the lead project manager listed below or to the appropriate Office of Nuclear Reactor Regulation project manager.

John Tappert, Director  
Division of Decommissioning, Uranium Recovery,  
and Waste Programs  
Office of Nuclear Material Safety and Safeguards

Lawrence E. Kokajko, Director  
Division of Policy and Rulemaking  
Office of Nuclear Reactor Regulation

Technical Contact: Scott Krepel, NRR/DSS  
301-302-0399  
E-mail: [Scott.Krepel@nrc.gov](mailto:Scott.Krepel@nrc.gov)

Lead Project Manager: Serita Sanders, NRR/DPR  
301-415-2956  
E-mail: [Serita.Sanders@nrc.gov](mailto:Serita.Sanders@nrc.gov)

Note: NRC generic communications may be found on the NRC public website, <http://www.nrc.gov>, under NRC Library/Document Collections.

Enclosure:  
Appendix A

**CONTACT**

Please direct any questions about this matter to the technical contact or the lead project manager listed below or to the appropriate Office of Nuclear Reactor Regulation project manager.

John Tappert, Director  
Division of Decommissioning, Uranium Recovery,  
and Waste Programs  
Office of Nuclear Material Safety and Safeguards

Lawrence E. Kokajko, Director  
Division of Policy and Rulemaking  
Office of Nuclear Reactor Regulation

Technical Contact: Scott Krepel, NRR/DSS  
301-302-0399  
E-mail: [Scott.Krepel@nrc.gov](mailto:Scott.Krepel@nrc.gov)

Lead Project Manager: Serita Sanders, NRR/DPR  
301-415-2956  
E-mail: [Serita.Sanders@nrc.gov](mailto:Serita.Sanders@nrc.gov)

Note: NRC generic communications may be found on the NRC public website, <http://www.nrc.gov>, under NRC Library/Document Collections.

Enclosure:  
Appendix A

**DISTRIBUTION:**

RidsNrrDss Resource	RidsNrrDpr Resource	RidsNrrDe Resource
RidsOeMailCenter Resource	SKrepel, NRR/DSS/SRXB	SSanders, NRR/DPR/PGCB
SStuchell, NRR/DPR/PGCB	RidsOIS Resource	NrrDlr Resource
RidsNmssDuwp Resource	RidsNrrDorl Resource	RidsOGCMailCenter Resource

**ADAMS Accession No.: ML16049A374**      \*via e-mail      **TAC MF0581**

OFFICE	NRR/DSS/SRXB	NRR/DE/ESGB	NRR/DSS/SRXB	Tech Editor	NRR/DPR/LA	NRR/DLR
NAME	SKrepel	MYoder*	KWood*	JDougherty*	ABaxter* w/comments	AHiser*
DATE	08/25/15	08/27/15	08/27/15	08/28/15	08/25/15	08/28/15
OFFICE	NMSS/DUWP/RDB/BC	NRR/DPR/PRLB/BC	NRR/DSS/SRXB/BC	NRR/DE/ESGB/BC	NRR/DSS/D	NRR/DE/D
NAME	BWatson*	AAdams*	KWood for CJackson*	GKulesa*	TMcGinty*	MRossLee for JLubinski*
DATE	8/31/15	8/31/15	8/31/15	9/1/15	9/1/15	9/2/15
OFFICE	NRR/DORL/D	NMSS/DUWP/D	NRR/PMDA	OIS	OE	OGC
NAME	ABoland*	LCamper*	LHill*	TDonnell	TMarenchin*	GMizuno
DATE	9/2/15	9/1/15	9/8/15	9/14/15	9/8/15	12/14/15
OFFICE	NRR/DPR/PGCB:LA	NRR/DPR/PGCB:PM	NRR/DPR/PGCB:BC	NRR/DPR/DD	NRR/DPR:D	
NAME	ELee	SSanders	SStuchell	AMoheni	LKokajko	
DATE	09/15/15	09/17/15	09/21/15	12/15/15	12/18/15	

**OFFICIAL RECORD COPY**

## Appendix A

### Guidance for Category 4 Responders to Generic Letter 2016-XX

This appendix describes the level of detail for the information requested in Generic Letter (GL) 2016-XX from Category 4 responders. The list of information herein is provided as guidance on responding to this GL. The U.S. Nuclear Regulatory Commission (NRC) recognizes that addressees may find that site-specific considerations make it necessary to deviate from this guidance, but any such deviations should be justified. Licensees are encouraged to discuss any potential deviations with the NRC before making their formal responses. If a specific section or item of this appendix is neither applicable nor part of the licensee's licensing basis, a response to that effect is sufficient. If an addressee has additional information relevant to the question of regulatory compliance, such items should be included in the GL response letter.

The information that each power reactor addressee should provide varies, depending on the neutron-absorbing materials credited by each licensee and known susceptibility to degradation. The table below summarizes the type of information that should be provided for each type of neutron-absorbing material.

Neutron-Absorbing Material Type	Areas of Requested Information				
	(1)	(2)	(3)	(4)	(5)
Boraflex Carborundum Tetrabor	x	x	x	x	X
Boral	x	x*		x	
Borated stainless steel Metamic Boralcan Other metallic matrix composites	x	x*			

\* Except for 2(b)(iii).

#### Areas of Requested Information

- 1) Describe the neutron-absorbing material credited in the spent fuel pool (SFP) nuclear criticality safety (NCS) analysis of record (AOR) and its configuration in the SFP, including the following:
  - a) manufacturers, dates of manufacture, and dates of material installation in the SFP;
  - b) neutron-absorbing material specifications, such as:
    - i) materials of construction, including the certified content of the neutron-absorbing component expressed as weight percent;
    - ii) minimum certified, minimum as-built, maximum as-built, and nominal as-built areal density of the neutron-absorbing component; and

Enclosure



- iii) material characteristics, including porosity, density, and dimensions;
  - c) qualification testing approach for compatibility with the SFP environment and results from the testing;
  - d) configuration in the SFP, such as:
    - i) method of integrating neutron-absorbing material into racks (e.g., inserts, welded in place, spot welded in place, rodlets); and
    - ii) sheathing and degree of physical exposure of neutron-absorbing materials to the SFP environment;
  - e) current condition of the credited neutron-absorbing material in the SFP, such as:
    - i) estimated current minimum areal density;
    - ii) current credited areal density of the neutron-absorbing material in the NCS AOR; and
    - iii) recorded degradation and deformations of the neutron-absorbing material in the SFP (e.g., blisters, swelling, gaps, cracks, loss of material, loss of neutron-attenuation capability).
- 2) Describe the surveillance or monitoring program used to confirm that the credited neutron-absorbing material is performing its safety function, including the frequency, limitations, and accuracy of the methodologies used.
- a) Provide the technical basis for the surveillance or monitoring method, including a description of how the method can detect degradation mechanisms that affect the material's ability to perform its safety function. Also, include a description and technical basis for the technique(s) and method(s) used in the surveillance or monitoring program, including:
    - i) approach used to determine frequency, calculations, and sample size;
    - ii) parameters to be inspected and data collected;
    - iii) acceptance criteria of the program and how they ensure that the material's structure and safety function are maintained within the assumptions of the NCS AOR;
    - iv) monitoring and trending of the surveillance or monitoring program data; and
    - v) industry standards used.
  - b) For the following monitoring methods, include these additional discussion items.
    - i) If there is visual inspection of inservice material:
      - (1) describe the visual inspection performed on each sample; and

- (2) describe the scope of the inspection (i.e., number of panels or inspection points per inspection period).
- ii) If there is a coupon-monitoring program:
    - (1) provide a description and technical basis for how the coupons are representative of the material in the racks. Include in the discussion the material radiation exposure levels, SFP environment conditions, exposure to the SFP water, location of the coupons, configuration of the coupons (e.g., jacketing or sheathing, venting bolted on, glued on, or free in the jacket, water flow past the material, bends, shapes, galvanic considerations, and stress-relaxation considerations), and dimensions of the coupons;
    - (2) provide the dates of coupon installation for each set of coupons;
    - (3) if the coupons are returned to the SFP for further evaluation, provide the technical justification for why the reinserted coupons would remain representative of the materials in the rack; and
    - (4) provide the number of coupons remaining to be tested and whether there are enough coupons for testing for the life of the SFP. Also provide the schedule for coupon removal and testing.
  - iii) If RACKLIFE is used:
    - (1) note the version of RACKLIFE being used (e.g., 1.10, 2.1);
    - (2) note the frequency at which the RACKLIFE code is run;
    - (3) describe the confirmatory testing (e.g., in-situ testing) being performed and how the results confirm that RACKLIFE is conservative or representative with respect to neutron attenuation; and
    - (4) provide the current minimum RACKLIFE predicted areal density of the neutron-absorbing material in the SFP. Discuss how this areal density is calculated in RACKLIFE. Include in the discussion whether the areal densities calculated in RACKLIFE are based on the actual as-manufactured areal density of each panel, the nominal areal density of all of the panels, the minimum certified areal density, the minimum as-manufactured areal density, or the areal density credited by the NCS AOR. Also discuss the use of the escape coefficient and the total silica rate of Boraflex degradation in the SFP.
  - iv) If in-situ testing with a neutron source and detector is used (e.g., BADGER testing, blackness testing):
    - (1) describe the method and criteria for choosing panels to be tested and include whether the most susceptible panels are chosen to be tested. Provide the statistical sampling plan that accounts for both sampling and measurement error and consideration of potential correlation in sample results. State whether it is

statistically significant enough that the result can be extrapolated to the state of the entire pool;

- (2) state if the results of the in-situ testing are trended and whether there is repeat panel testing from campaign to campaign;
  - (3) describe the sources of uncertainties when using the in-situ testing device and how they are incorporated in the testing results. Include the uncertainties outlined in the technical letter report titled "Initial Assessment of Uncertainties Associated with BADGER Methodology," September 30, 2012 (Agencywide Document Access and Management System Accession No. ML12254A064). Discuss the effect of rack cell deformation and detector or head misalignment, such as tilt, twist, offset, or other misalignments of the heads and how they are managed and accounted for in the analysis; and
  - (4) describe the calibration of the in-situ testing device, including the following:
    - (a) describe how the materials used in the calibration standard compare to the SFP rack materials and how any differences are accounted for in the calibration and results;
    - (b) describe how potential material changes in the SFP rack materials caused by degradation or aging are accounted for in the calibration and results; and
    - (c) if the calibration includes the in-situ measurement of an SFP rack "reference panel," explain the following:
      - (i) the methodology for selecting the reference panel(s) and how the reference panels are verified to meet the requirements;
      - (ii) whether all surveillance campaigns use the same reference panel(s); and
      - (iii) if the same reference panels are not used for each measurement surveillance, describe how the use of different reference panels affects the ability to make comparisons from one campaign to the next.
- 3) For any Boraflex, Carborundum, or Tetrabor being credited, describe the technical basis for determining the interval of surveillance or monitoring for the credited neutron-absorbing material. Include a justification of why the material properties of the neutron-absorbing material will continue to be consistent with the assumptions in the SFP NCS AOR between surveillances or monitoring intervals.
  - 4) For any Boraflex, Carborundum, Tetrabor, or Boral being credited, describe how the credited neutron-absorbing material is modeled in the SFP NCS AOR and how the monitoring or surveillance program ensures that the actual condition of the neutron-absorbing material is bounded by the NCS AOR.
    - a) Describe the technical basis for the method of modeling the neutron-absorbing material in the NCS AOR. Discuss whether the modeling addresses degraded neutron-absorbing

material, including loss of material, deformation of material (such as blisters, gaps, cracks, and shrinkage), and localized effects, such as non-uniform degradation.

- b) Describe how the results of the monitoring or surveillance program are used to ensure that the actual condition of the neutron-absorbing material is bounded by the SFP NCS AOR. If a coupon monitoring program is used, provide a description and technical basis for the coupon tests and acceptance criteria used to ensure the material properties of the neutron-absorbing material are maintained within the assumptions of the NCS AOR. Include a discussion on the measured dimensional changes, visual inspection, observed surface corrosion, observed degradation or deformation of the material (e.g., blistering, bulging, pitting, or warping), and neutron-attenuation measurements of the coupons.
  - c) Describe how the bias and uncertainty of the monitoring or surveillance program are used in the SFP NCS AOR.
  - d) Describe how the degradation in adjacent panels is correlated and accounted for in the NCS AOR.
- 5) For any Boraflex, Carborundum, or Tetrabor being credited, describe the technical basis for concluding that the safety function for the credited neutron-absorbing material in the SFP will be maintained during design-basis events (e.g., seismic events, loss of SFP cooling, fuel assembly drop accidents, and any other plant-specific design-basis events that may affect the neutron-absorbing material).
- a) For each design-basis event that would have an effect on the neutron-absorbing material, describe the technical basis for determining the effects of the design-basis event on the material condition of the neutron-absorbing material during the design-basis event, including:
    - i) shifting or settling relative to the active fuel;
    - ii) increased dissolution or corrosion; and
    - iii) changes of state or loss of material properties that hinder the neutron-absorbing material's ability to perform its safety function.
  - b) Describe how the monitoring program ensures that the current material condition of the neutron-absorbing material will accommodate the stressors during a design-basis event and remain within the assumptions of the NCS AOR, including:
    - i) monitoring methodology;
    - ii) parameters monitored;
    - iii) acceptance criteria; and
    - iv) intervals of monitoring.