UNITED STATES
NUCLEAR REGULATORY COMMISSION
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SUBJECT: CLARIFICATION OF REGULATORY PATHS FOR LEAD TEST ASSEMBLIES

The purpose of this letter is to finalize the staff's views on the regulatory positions discussed in the U.S. Nuclear Regulatory Commission's (NRC's) letter from Dr. Mirela Gavrilas, "Response to Nuclear Energy Institute Letter Concerning the Regulatory Path for Lead Test Assemblies," to Mr. Andrew Mauer, dated June 29, 2017 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML17150A443). This letter supersedes the June 29, 2017, letter and is intended to clarify several issues in the June 29, 2017, letter, including those related to Section 4.2.1, "Fuel Assemblies," of the Standard Technical Specifications (STS), Volume 1[1]; the use of approved methods, Title 10 of the *Code of Federal Regulations* (10 CFR) 50.59, "Changes, tests, and experiments"; and 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors." As it gains more experience with these regulatory approaches, the NRC staff will continue to engage with stakeholders to determine whether further guidance is necessary.

Lead test assemblies (LTAs) are fuel assemblies that contain new design features or materials for which additional data may be needed to support batch loading. LTAs have been loaded in operating reactor cores safely over the past several decades. In the past, licensees have taken different approaches when conducting LTA campaigns. Some licensees obtained prior NRC approval via license amendments approving changes to Technical Specification (TS) 4.2.1 or exemptions from 10 CFR 50.46 for their LTA campaigns, or both. Other licensees conducted LTA campaigns under 10 CFR 50.59 without prior NRC approval. This letter is intended to clarify the NRC's current interpretation of when prior NRC approval is needed for LTA campaigns.

LTAs are a necessary and important step in the fuel development process and have led to safety improvements in the design of nuclear fuel, such as improved resistance to corrosion, improved thermal-hydraulic performance, increased heat transfer properties, and reductions in the number of leaking fuel pins. New features of LTAs can include design and/or material changes to the fuel, cladding, or other parts of the fuel assembly. For example, an LTA may be nearly identical to the co-resident fuel except for a new fuel filter design, or an LTA may be an assembly with a completely different design and materials.

[1] Revision 4 of NUREG-1430, "Standard Technical Specifications—Babcock and Wilcox Plants" (ADAMS Accession No. ML12100A177); NUREG-1431, "Standard Technical Specifications—Westinghouse Plants" (ADAMS Accession No. ML12100A222); NUREG-1432, "Standard Technical Specifications—Combustion Engineering Plants" (ADAMS Accession No. ML12102A165); NUREG-1433, "Standard Technical Specifications—General Electric Plants (BWR/4)" (ADAMS Accession No. ML12104A192); and NUREG-1434, "Standard Technical Specifications—General Electric Plants (BWR/6)" (ADAMS Accession No. ML12104A195), all issued April 2012.

LTA irradiation campaigns acquire the representative data needed to validate codes and methods by accomplishing the following tasks:

- Collection of data to characterize irradiated material properties and performance.
- Provision of irradiated material for subsequent hot-cell examination, characterization, and research.
- Demonstration of in-reactor performance.

Knowledge of, and experience with, irradiated material properties and performance is critical for qualifying analytical codes and methods and developing the design bases to license new fuel material or design features for batch loading. The staff's position on use of approved codes and methods for analysis of LTAs is described in detail in the "Use of Approved Methods" section below.

The NRC staff has identified two regulatory paths related to LTA campaigns. The first path applies to licensees that have the STS LTA provision described below or a substantively similar TS. The second path applies to licensees that do not have or do not meet the STS LTA provision or a substantively similar TS provision. Under either path, the licensee is responsible for assessing its ability to irradiate LTAs in accordance with its license and must comply with its license and the NRC's regulations. By doing so, the NRC expects that the loading of LTAs will be done safely. The remainder of this letter provides background on the STS LTA provision, the staff's view on the use of approved methods, a description of the regulatory paths related to LTA campaigns, LTA-specific guidance for 10 CFR 50.59, and the staff's assessment of exemptions from 10 CFR 50.46.

This letter does not address all regulatory requirements that should be considered when planning an LTA campaign, such as other TS, 10 CFR 50.68, "Criticality accident requirements," and transportation and storage requirements in 10 CFR Part 71, "Packaging and Transportation of Radioactive Material," and 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste." All applicable requirements should be considered by a licensee considering an LTA campaign. Additionally, a licensee may choose to request prior NRC approval under 10 CFR 50.90.

STS LTA Provision

Many licensees have adopted the STS Section 4.2.1 language (e.g., NUREG-1431, Revision 4) or other substantively similar language into plant-specific TS, as follows:

> The reactor shall contain [###] fuel assemblies. Each assembly shall consist of a matrix of [Zircaloy or ZIRLO] fuel rods with an initial composition of natural or slightly enriched uranium dioxide (UO_2) as fuel material. Limited substitutions of zirconium alloy or stainless steel filler rods for fuel rods, in accordance with approved applications of fuel rod configurations, may be used. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

In the past, some licensees have interpreted this TS as requiring a TS amendment to load LTAs using different materials or fuel. The staff has approved such amendments. Other licensees have not submitted amendment requests for their LTA campaigns. This letter clarifies that the NRC staff interprets the TS as follows: the first two sentences provide a high-level description of the reactor core (i.e., many features of the reactor core and fuel assemblies important to safety are not described). The first sentence should be read to include LTAs (i.e., LTAs are fuel assemblies and count toward the specified [XXX] number of fuel assemblies). The third sentence includes a provision to allow loading of reconstituted fuel assemblies. The fourth sentence requires the use of "fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases." This requirement applies to the use of fuel assemblies for batch loading and reconstituted fuel. The final sentence includes a provision to allow loading of LTAs on a restricted basis, where "representative testing" means testing in the actual reactor conditions. Because LTAs may, by definition, incorporate new design features or materials, this sentence can be read as separate from the other limitations placed on fuel assemblies. As such, LTAs may comprise features with different mechanical or material design specifications than the approved co-resident fuel assemblies defined earlier in STS Section 4.2.1. For the remainder of this letter, the term "STS LTA provision" refers to this last sentence of STS Section 4.2.1 and similar plant-specific TS LTA sentences.

Because LTAs have not completed representative testing (i.e., collected sufficient data to support approval of codes and methods for batch loading), the STS LTA provision restricts LTAs to limited numbers in nonlimiting locations. Licensees can demonstrate compliance with the STS LTA provision that LTAs are of "limited number" and "in nonlimiting core regions" through an evaluation that finds that the quantity and placement of LTAs will not invalidate either the final safety analysis report (as updated) (UFSAR) Chapter 15 transient and accident analyses or the core operating limits report (COLR) limits. The NRC staff expects that licensees will use good engineering judgment and analytical codes and methods that reflect well-established engineering practices and consideration of risk to confirm that, with insertion of the LTAs, the COLR limits and UFSAR Chapter 15 transient and accident analyses remain applicable and bounding. "Applicable and bounding" means that the limits are still relevant to the LTAs, that the LTAs are not the most limiting assemblies, and that uncertainties in input parameters and models are conservatively addressed. To the extent practical, the licensee's evaluation of "limited number" and "nonlimiting core regions" should use the current state of knowledge, including all available data, to ensure the most complete evaluation. These evaluations are subject to verification through the Reactor Oversight Process (ROP).

To meet the TS provision of a "limited number" of LTAs, the evaluation should be informed by the degree of characterization of irradiated material properties and performance for a given material or design change. "Degree of characterization" refers to the amount and quality of the data that support the expected material or design performance. As irradiated material characterization matures, the quantity of "limited number" of LTAs may increase as further testing is performed. Historically, LTA campaigns have ranged from a few rods to 2 percent of the core, depending on the nature of the design and the degree of prior characterization of the LTAs' performance.

The TS provision of "nonlimiting core regions" is dependent upon plant operating parameters (e.g., COLR limits like power density), and the UFSAR Chapter 15 transient and accident analyses. A nonlimiting core region is a location where the LTA will not be the bounding assembly for any safety analyses (e.g., peak linear heat generation rate, peak clad temperature,

minimum departure from nucleate boiling). The licensee must select nonlimiting core regions such that the new design features of the LTA are conservative for the respective design, performance, and safety limits relative to the limiting fuel assemblies during normal operation, anticipated operational occurrences, and postulated accidents. As such, if the LTAs are more conservative with respect to the design, performance, and safety limits, then the performance of safety-related structures, systems, and components (SSCs) (i.e., their ability to perform intended safety functions) will not be dictated by the performance of the LTAs, and the LTAs may be safely loaded and irradiated under the STS LTA provision.

There may be instances where a licensee seeks to pursue an LTA campaign that does not meet the "limited number" and "nonlimiting core regions" provisions of the STS or substantively similar LTA TS provisions. Two LTA campaigns that did not meet the STS provisions were pursued at Catawba (ADAMS Accession No. ML042260223) and Millstone (ADAMS Accession No. ML053200224). These LTA campaigns impacted fundamental core dynamics and physics predictions, accident progression, and/or the radiological source term such that core operating limits, UFSAR Chapter 15 transient and accident analyses, or approved analytical methods were no longer applicable and/or bounding. In those instances, a license amendment was required.

Use of Approved Methods

The requirement for analysis of LTAs using approved methods is one that has been stated or implied in many of the documents reviewed by the NRC staff. The requirement was identified in GE's original LTA process as discussed in the letter from the NRC to Mr. Ron Engel, General Electric Company,[2] and it is still cited by licensees who use the GE methodology (NEDE-24011-P-A). This letter is intended to clarify the NRC's position regarding the use of approved methods for LTAs. As an initial matter, the licensee must perform reload analyses to establish core operating limits using NRC-approved analytical codes and methods listed in the licensee's TS (i.e., STS 5.6.3). If a new fuel material or design feature, including an LTA, necessitates a change to these approved analytical codes and methods to determine the COLR limits and UFSAR Chapter 15 analyses, then a license amendment would be required to use the new or changed analytical code or method. In some instances, an LTA campaign may be covered by an approved method. For example, some plants have methods included in STS 5.6.3 that specify conditions for LTA insertion (for example, NEDE-24011-P-A, also known as GESTAR). These methods have already been approved by the NRC through the topical report approval process and continue to be acceptable for use within the scope of their approval.

There have also been instances where the NRC staff approved use of previously unapproved methods for limited analysis of LTAs. For example, in 1981, the staff approved an amendment that allowed the use of LTAs at Peach Bottom Atomic Power Station, even though some of the analysis was outside the bounds of the approved method. In its letter dated May 20, 1981 (ADAMS Accession No. ML011300274), the staff stated, in part, that:

> We believe that the licensee's decision to use an uncorrected analysis for these four assemblies is acceptable because, (a) the allowable power rating of these assemblies at high exposures is significantly lower than the rest of the core, (b) only four lead test bundles are involved, and (c) the benefits to be derived

[2] Letter from Thomas A. Ippolito, NRC, dated September 23, 1981 (ADAMS Legacy Library Accession No. 8110090006)

> from this high-burnup lead test assembly program outweigh the small risk that will be taken by relying on an uncorrected analysis.

The NRC staff's position is that approved methods should be used wherever possible; however, approved methods for the LTA fuel (e.g., assembly-specific CHF correlations) may not exist. In those instances, the licensee should perform a conservative evaluation of the LTAs using the approved codes and methods for the core. For example, Tennessee Valley Authority inserted Atrium 11 LTAs at Browns Ferry and AREVA stated in the LTA Design and Licensing Report (ADAMS Accession No. ML15306A037):

> For the materials or features outside the current NRC approved codes and methods, the licensing analyses demonstrate that modeling of this small number of test fuel assemblies with NRC approved codes and methods produces either a conservative result or has a negligible impact with respect to cycle specific licensing analyses.

As described above, LTA campaigns help to collect the data necessary to approve the codes and methods used for generation of the core operating limits for batch loading. LTAs inserted in nonlimiting locations must, by definition, be within the bounds of the core operating limits. The evaluation of LTA campaigns necessarily requires some engineering judgment due to incomplete representative data availability prior to irradiation of the LTAs, and evaluation may necessitate modifications to approved codes and methods or the use of such codes and methods outside the bounds for which they were explicitly approved. These modifications, made solely for the evaluation of limited numbers of LTAs, may be acceptable for confirmation of the nonlimiting nature of the LTAs and the continued applicability of the core operating limits, which themselves are calculated using approved codes and methods.

With those clarifications on the NRC's interpretation of the STS and position on the use of approved methods, the NRC will now discuss two possible regulatory paths for LTA campaigns and then provide guidance on 10 CFR 50.59 related to LTA campaigns.

Regulatory Path 1

Regulatory Path 1 applies if the licensee's TS contain the STS LTA provision or substantively similar TS provision and there is no conflicting documentation elsewhere in the plant's licensing basis. In these circumstances, a licensee may be able to embark on an LTA campaign, which meets the STS LTA provision, under 10 CFR 50.59 without prior NRC approval.

As described above, licensees complete core reload analyses before refueling the reactor. The NRC staff notes that a licensee can consider an LTA campaign as part of the core reload and evaluate it using the 10 CFR 50.59 process that is done for the core reload. The paragraphs below provide LTA-specific guidance related to 10 CFR 50.59.

Regulatory Path 2

Regulatory Path 2 applies to licensees that do not have or do not meet the STS LTA provision or a substantively similar TS provision. A licensee must determine whether its LTA campaign requires prior NRC approval under 10 CFR 50.59. Because of the number of different combinations of licensing basis considerations, TS language, and LTA campaigns, the staff has not attempted to provide more specific guidance for this regulatory path.

LTA-Specific Guidance on 10 CFR 50.59

LTA campaigns that are not described in the UFSAR meet the definition of a change, test, or experiment under 10 CFR 50.59(a), and the licensee must perform a 10 CFR 50.59 evaluation to determine if it may proceed with its campaign without prior NRC approval. Several of the 10 CFR 50.59 criteria most applicable to LTAs are discussed below.

The regulation under 10 CFR 50.59(c)(1) states the following:

> A licensee may make changes in the facility as described in the final safety analysis report (as updated), make changes in the procedures as described in the final safety analysis report (as updated), and conduct tests or experiments not described in the final safety analysis report (as updated) without obtaining a license amendment pursuant to § 50.90 only if:
>
> (i) A change to the technical specifications incorporated in the license is not required, and
> (ii) The change, test, or experiment does not meet any of the criteria in paragraph (c)(2) of this section.

If a licensee's TS contains a provision allowing for use of LTAs, and if the LTA irradiation campaign satisfies the TS, then a change to that TS is not required (item (i) above).

With respect to item (ii), it may be possible to evaluate all the criteria in 10 CFR 50.59(c)(2) and not trigger the need for a license amendment. Although all criteria must be addressed, 10 CFR 50.59(c)(2)(ii), (vii), and (viii) are of particular interest to LTA campaigns.

For 10 CFR 50.59(c)(2)(ii), "Result in more than a minimal increase in the likelihood of occurrence of a malfunction of an SSC important to safety," the NRC-endorsed guidance[3] in Section 4.3.2 of the Nuclear Energy Institute (NEI) report NEI 96-07, Revision 1, "Guidelines for 10 CFR 50.59 Implementation," November 2000 (ADAMS Accession No. ML003771157) states, in part, that after identifying the affected SSCs and the direct and indirect effects of the proposed activity, "[q]ualitative engineering judgment and/or an industry precedent is typically used to determine if there is more than a minimal increase in the likelihood of occurrence of a malfunction." Section 4.3.2 of NEI 96-07, Revision 1, also states, in part, the following:

> Although this criterion allows minimal increases, licensees must still meet applicable regulatory requirements and other acceptance criteria to which they are committed (such as contained in regulatory guides and nationally recognized industry consensus standards, e.g., the [American Society of Mechanical Engineers Boiler and Pressure Vessel Code] and [Institute for Electrical and Electronics Engineers] standards). Further, departures from the design, fabrication, construction, testing and performance standards as outlined in the General Design Criteria (Appendix A to Part 50) are not compatible with a 'no more than minimal increase' standard

[3] Regulatory Guide 1.187, "Guidance for Implementation of 10 CFR 50.59, Changes, Tests, and Experiments," dated November 2000 (ADAMS Accession No. ML003759710), states that NEI 96-07, Revision 1, provides methods that are acceptable to the NRC staff for complying with the provisions of 10 CFR 50.59.

The NRC staff expects licensees to evaluate LTAs against applicable design and functional requirements, and to ensure that any new failure modes introduced by LTAs are analyzed against the existing analyses. For LTA campaigns where the design and functional requirements and new failure modes are bounded, the licensee may not meet this criterion (and thereby would not need to request a license amendment due to this criterion). Absent an evaluation showing that the LTAs satisfy the bounding analysis, the licensee would meet this criterion, and thus require a license amendment.

For 10 CFR 50.59(c)(2)(vii), "Result in a design basis limit for a fission product barrier as described in the FSAR (as updated) being exceeded or altered," NEI 96-07, Revision 1, Section 4.3.7 states, in part, that "[i]f an engineering evaluation demonstrates that the analysis presented in the UFSAR remains bounding, then no further 10 CFR 50.59(c)(2)(vii) evaluation is required." If the LTA campaign demonstrates, via the selection of a "limited number" of LTAs placed in "nonlimiting core regions," that the COLR limits and UFSAR Chapter 15 transient and accident analyses continue to be applicable and remain bounding, then the licensee may not meet this criterion (and thereby would not need to request a license amendment due to this criterion). For example, if an LTA campaign impacts a design basis parameter (such as linear heat generation rate) but does not challenge the existing design basis limit associated with that parameter, then the limit remains bounding. If, however, the LTA is inserted such that the design basis parameter exceeds the design basis limit associated with that parameter, then the criterion would be met and prior NRC approval would be required to change the limit.

With respect to 10 CFR 50.59(c)(2)(viii), "Result in a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design bases or in the safety analyses," NEI 96-07, Revision 1, Section 4.3.8.1 states, in part, the following:

> The definition of "departure..." provides licensees with the flexibility to make changes under 10 CFR 50.59 to methods of evaluation whose results are "conservative" or that are not important with respect to the demonstrations of performance that the analyses provide. Changes to elements of analysis methods that yield conservative results, or results that are essentially the same, would not be departures from approved methods.

Section 4.3.8.2 of NEI 96-07, Revision 1, provides guidance for changing from one method of evaluation to another. LTA campaigns that meet the STS LTA provision (i.e., the COLR limits and Chapter 15 UFSAR analyses remain applicable and bounding) will not affect the performance of safety-related SSCs and, therefore, the method of evaluation used in establishing the design bases will remain the same, and the licensee may not meet this criterion (and thereby would not need to request a license amendment due to this criterion).

Exemptions from Applicability Statement in 10 CFR 50.46(a)(1)(i) for LTA Campaigns

The regulation under 10 CFR 50.46 provides a means (via analytical requirements and prescriptive analytical limits) to satisfy General Design Criterion (GDC) 35, "Emergency core cooling," in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50. Section 50.46 does not prohibit the use of fuel systems that do not use uranium oxide fuel within cylindrical zircaloy or ZIRLO cladding. In the past, some licensees have requested exemptions to expand the applicability of 50.46 to other zirconium alloys. The NRC staff has granted these exemptions. However, because the acceptance criteria of 10 CFR 50.46 still apply while LTAs are utilized, preparation and approval of an exemption request is not necessary for an LTA campaign. Moreover, the staff does not see a substantial

safety benefit associated with processing exemptions expanding the applicability of 10 CFR 50.46 to other zirconium-based claddings.

Additionally, the NRC based the prescriptive fuel performance analytical limits in 10 CFR 50.46 on testing conducted for uranium oxide fuel within cylindrical zirconium alloy cladding. For non-zirconium cladding material and fuel other than uranium oxide, there is no expectation that the prescriptive fuel performance analytical limits apply, nor would they ensure acceptable performance under loss-of-coolant accident conditions. For example, for non-zirconium-based cladding, the 2,200-degree-Fahrenheit peak clad temperature and the maximum local oxidation limit may not be applicable, as the reaction rate that drives these limits is material-specific. For cladding materials outside the scope of 10 CFR 50.46, the acceptance criteria would be evaluated as part of a license amendment request for batch loading of fuel.

In sum, it is the staff's position that an exemption from the applicability statement in 10 CFR 50.46(a)(1)(i) is not required for LTAs. However, while power reactors utilize fuel with uranium oxide pellets within cylindrical zircaloy or ZIRLO cladding,[4] compliance with 10 CFR 50.46 must be maintained, even while utilizing LTAs with different fuel and/or cladding materials.

Conclusions

LTAs are a necessary and important step in the fuel-development process and have led to safety improvements in the design of nuclear fuel. LTAs provide the material and data necessary to license new design features and provide in-reactor performance demonstration before broader commercial implementation. Throughout LTA campaigns, safety remains the primary focus of the NRC.

This letter supersedes the June 29, 2017, letter. This letter clarifies the NRC staff's interpretation of the STS 4.21, provides the NRC's position on the use of approved methods for LTA campaigns, and identifies two regulatory paths for the use of LTA campaigns. It is important to note that regardless of the path, NRC oversight is maintained (e.g., ROP inspection sampling includes review of licensees' 10 CFR 50.59 evaluations). This letter also provides 10 CFR 50.59 guidance related to LTA campaigns and finalizes the NRC staff's preliminary view that LTA campaigns do not require exemptions from 10 CFR 50.46. This letter does not address all regulatory requirements that should be considered when planning an LTA campaign, such as other TS, 10 CFR 50.68 requirements, and transportation and storage requirements in 10 CFR Part 71 and 10 CFR Part 72. Such issues are should be considered by licensees considering an LTA campaign.

As next steps, the NRC staff will continue to engage with licensees that are planning to embark on LTA campaigns, as well as external stakeholders, to collect lessons learned and feedback on the approaches described in this letter. As part of this outreach, the staff will determine whether additional formal guidance is necessary.

[4] Depending on the facility, this material list may be expanded based on previously issued exemptions.

Questions on this letter can be directed to Mirela Gavrilas at 301-415-3283 or Mirela.Gavrilas@nrc.gov, Kathryn Brock at 301-415-1453 or Kathryn.Brock@nrc.gov, or Michael King at 301-415-1004 or Michael.King2@nrc.gov.

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