



UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

U.S. NUCLEAR REGULATORY COMMISSION STAFF FEEDBACK REGARDING GENERAL ATOMICS ELECTROMAGNETIC SYSTEMS WHITE PAPER: “FAST MODULAR REACTOR SELECTION OF LICENSING BASIS EVENTS” (EPID L-2024-LRO-0007)

SPONSOR INFORMATION

Sponsor: General Atomics Electromagnetic Systems
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DOCUMENT INFORMATION

Submittal Date: January 11, 2024

Submittal Agencywide Documents Access and Management System (ADAMS) Accession No.: ML24011A221

Purpose the White Paper: The purpose of this white paper (WP), “Fast Modular Reactor Licensing Basis Event Selection,” is to describe and develop, the process of Licensing Basis Events (LBE) selection applicable to the General Atomics Electromagnetic Systems (GA–EMS) Fast Modular Reactor (FMR) design. The WP (1) identifies, and provides an overview of, the regulatory guidance to be considered in LBE selection; (2) describes the technology-inclusive, risk-informed, and performance-based LBE selection process; (3) describes how probabilistic risk assessment (PRA) will be used; and (4) provides a historically guided example of potential LBE sequences to be considered during design.

Action Requested: GA–EMS requested that the U.S. Nuclear Regulatory Commission (NRC) staff review and provide feedback on the acceptance of the proposed selection of LBEs. Specific feedback was requested on the LBE selection process and on whether there are any LBEs missing from the initial list of selected LBEs.

Enclosure

FEEDBACK

The feedback on this white paper is preliminary and subject to change. The feedback provided by the NRC staff on this WP are not regulatory findings on any specific licensing matter and are not official agency positions. Lack of feedback regarding a certain aspect of the white paper should not be interpreted as NRC agreement with GA-EMS's position.

Given the preliminary nature of the GA-EMS FMR design and WP information, the NRC staff feedback is focused on the approach used to determine LBEs versus the acceptability of specific LBEs and the completeness of cited LBEs. General feedback, including comments on LBEs and the LBE selection process is provided below.

- 1. Regulatory Compliance and Approach:** The NRC staff found the cited regulatory requirements and guidance in the WP appropriate for LBE identification. Specifically, the WP's recounting and proposed implementation of guidance (e.g., Nuclear Energy Institute (NEI) 18-04, Revision 1, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development" (ML19241A472) as endorsed in Regulatory Guide (RG) 1.233, Revision 0, "Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors," Revision 0 (ML20091L698)) was found to be a practical and methodical approach to selecting preliminary LBEs.

While the WP accurately identified that LBEs can, and are encouraged to, be selected near the beginning of the Licensing Modernization Process (LMP) framework, LBEs should be continuously developed and described, as appropriate, to the context of potential planned licensing submittals (e.g., construction permit, design certification, operating license, topical report). Specifically, as noted in NEI 18-04, LBEs should evolve iteratively with the design as other key aspects associated with LMP implementation are further developed, such as the PRA, safety analysis, safety classification of structures, systems, and components (SSCs), determination of initiating event frequencies, and completion of a defense-in-depth (DID) evaluation. Some regulations and guidance regarding the level of detail required to adequately support NRC approval include: 10 CFR 50.34, "Contents of applications; technical information" and 10 CFR 50.35, "Issuance of construction permits" (for construction permits); NEI 21-07, Revision 0, "Technology Inclusive Guidance for Non-Light Water Reactor Safety Analysis Report: For Applicants Utilizing NEI 18-04 Methodology" (ML21250A378); and RG 1.253, Revision 0, "Guidance for a Technology-Inclusive Content of Application Methodology to Inform the Licensing Basis and Content of Applications for Licenses, Certifications, and Approvals for Non-Light-Water Reactors" (ML23269A222). Additionally, a number of the NRC interim staff guidance documents were recently issued as part of the Advanced Reactor Content of Application Project, which is further detailed on the NRC public website at <https://www.nrc.gov/reactors/new-reactors/advanced/modernizing/rulemaking-and-guidance/advanced-reactor-content-of-application-project.html>.

- 2. Methodology:** The proposed methodology aligns with NEI 18-04 and RG 1.233, which emphasizes (with respect to initial LBE selection): "These events are to be selected deterministically and may be supported by qualitative risk insights based on all relevant and available experience, including prior experience from the design and licensing of reactors." While preliminary identification of LBEs can be used to gain risk insights, the process is iterative and the LBEs should be subject to potential change as the design and analysis

mature. Identification of safety-related SSCs may result in identification of additional initiating events, LBEs, or event tree branches in the PRA process.

3. **Initial LBEs:** Based upon the limited preliminary design information available and the knowledge that additional LBEs will be identified during later stages in the LMP process, the NRC staff can not verify a comprehensive list of initiating events, LBEs, and event trees at this time. For example, depending on the final design, potential additional initiating events may include local faults and stochastic SSC failures across the plant (currently limited to turbine-compressor-generator shutdown, leaks in the reactor coolant system (RCS) pressure boundary, and turbine). In addition, given final design and full scope PRA insights (e.g., seismic, fire), initiating events may change and could diverge from those identified based on historical precedent reactors and their associated safety cases on which the preliminary list is based.

Though based on preliminary information, initial feedback on LBEs is provided below:

- a. An additional LMP report that may be of interest for LBE examples is: "Moe, W. L., & Afzali, A. (2020). Modernization of Technical Requirements for Licensing of Advanced Non-Light Water Reactors: Selection and Evaluation of Licensing Basis Events (No. INL/EXT-20-60394; SC-29980-100-Rev. 01). Idaho National Lab." The NRC staff notes that in a future licensing submittal, terms like "transient initiating event" would be expanded to the actual event causing the transient, much like how "capability lost" (found in this WP) should also be expanded upon, when possible, to better inform the event tree and frequencies.
- b. With respect to initiating events, consider whether events other than those listed can result in loss of "main loop" cooling. This consideration may evolve or expand as the design matures.
- c. As only RCS pressure boundary leaks are included in the list of LBEs as an initiating event, in a future licensing submittal the NRC staff would likely seek additional information to confirm that GA-EMS also considered other areas of the system with respect to safety-significant leaks or other faults. Specifically:
 - I. The reactor vessel, reactor vessel cooling panel, power conversion unit, and recirculatory do not appear to be in the preliminary list.
 - II. The helium in the generator is stated to be isolated from the primary coolant. As such, there is at least one other source of leaking in the system.
- d. While the list of LBEs includes turbine shutdown due to control rod withdrawal, consider whether there may be additional event trees or operational consequences that could arise from rod withdrawal, insertion, or cycling.
- e. With respect to helium pressure boundary leaks, these can be seen as loss of helium, but also as ingress of contamination or moisture. Such potential leaks or ingresses should be considered.
- f. The WP described the importance of evaluating LBEs against integrated risk measures, such as the Commission's quantitative health objectives. In support of this, the NRC staff would also expect that the list of LBEs include those initiated from

low power and shutdown conditions, particularly for events that would involve an increased risk of radionuclide release to the public because they bypass the reactor coolant pressure boundary or containment (e.g., fuel handling accidents).

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