Using Integrated Risk-Informed Decisionmaking Process to Address HEAF Events at U.S. Nuclear Power Plants

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Refresher - Integrated Decision-Making Process for Emergent Issues (LIC-504)

• Developed as a lessons learned from a 2001 Davis Besse reactor vessel head degradation Event
• Provides a structured process and expectations to document decisions for issues that may warrant safety orders
• Provides guidance to apply integrated decisionmaking including risk, defense-in-depth, and safety margins considerations
• Has been used frequently for a range of emergent plant-specific and generic issues
• Most recent update (Revision 5, NRC ADAMS Accession No. ML19253D401) has incorporated significant changes (e.g., consideration of Enterprise Risk) based on lessons learned from the use of previous versions.
• Recent LIC-504 assessments have incorporated some elements of NRC’s Be RiskSMART framework (NUREG/KM-0016) to develop recommendations.
Factors Considered in LIC-504 Implementation – Refresher on LIC-504 Process

1. Change meets current regulations unless it is explicitly related to a requested exemption or rule change
2. Change is consistent with defense-in-depth (DiD) philosophy
3. Maintain sufficient safety margins
4. Proposed increases in risk are small and are consistent with the Commission’s Safety Goal Policy Statement
5. Use performance measurement strategies to monitor the change

Linked to:
- Radiation exposure to plant workers
- Enterprise Risk
- Be RiskSMART framework
LIC-504 Risk-Informed Regulatory Actions (examples)

Weigh a Spectrum of Regulatory Options

- Immediate regulatory action - compensatory measures
- Formal backfit analysis ($\geq 10^{-4}$)
- 50.54(f) letters
- Bulletin
- Information Notice/Outreach
- Smart inspection samples - within baseline program
- No Actions

Use RIDM – not numbers alone; Facility DID and SM are also considered.
Two coordinated tracks

• **NRR LIC-504 Assessment**
  • Developed and documented risk-informed options to disposition HEAF issues for management consideration.
  • Updated HEAF PRA Methodology, which was the primary input to examine the change in estimated risk significance.

• **Research Activities**
  • In coordination with EPRI, developed and validated a HEAF PRA methodology that characterizes the thermal heat transfer from an arc.
Some Features of the Updated HEAF PRA Method (Enhanced realism)

- Credits the ability of electric raceway fire barriers to prevent potential damages to cables;
- Substantial changes to zones of influence of HEAFs for non-isophase bus ducts and for low and medium voltage switchgears;
- Uses updated HEAF frequencies; and
- Enables modelling of more realistic HEAF damage potential that considers factors such as arc duration.
Copper and aluminum HEAF zones of influence should be treated the same based on the current state of knowledge.

The LIC-504 assessment was then focused on examining the change in estimated HEAF risks associated with the use of the new HEAF PRA methodology.
STEP 1 – NO IMMEDIATE SAFETY CONCERN (NRC ADAMS ACCESSION NO. ML21272A262).

STEP 2 – DETAILED EVALUATION USING DRAFT OF UPDATED HEAF PRA METHODOLOGY (NRC ADAMS ACCESSION NO. ML22158A071)
Visited one BWR and one PWR; Use of best available information provided by each reference plant was instrumental in staff’s ability to enhance realism of results.


The team issued Publicly available memo on July 22, 2022 (NRC ADAMS Accession Nos. ML22201A000-A0003) documenting teams’ analyses and recommendations.
The risk of HEAF could be higher or lower than calculated under the previous methodology.

Risk varies significantly based on plant configuration.

For certain configurations, the estimated risk from bus ducts can be notably higher than previously modeled.

Concluded there is no significant increase in total HEAF risk, not warranting the need for any additional regulatory requirements.
HEAF LIC-504 – Some risk-informed Insights (Based on review of ASP events, Maanshan HEAF event and EPRI report 3002015459).

HEAFS LEADING TO STATION BLACKOUT SCENARIOS CONSTITUTE THE HIGHEST HEAF RELATED RISKS. THEREFORE, PLANT DESIGN AND OPERATIONAL CHANGES THAT HAVE BEEN ADOPTED TO ENHANCE THE MITIGATION OF BEYOND DESIGN BASIS ACCIDENTS NRC ORDER [EA-12-049] ARE LIKELY TO REDUCE HEAF RELATED RISKS.

HEAFS THAT CAN LEAD TO SBOS ARE LIKELY TO INITIATE AT BUSES OR SWITCHGEAR THAT ARE ESSENTIAL TO SUPPLY AC POWER FROM BOTH OFFSITE POWER AND EMERGENCY DIESELS (OR ANOTHER EMERGENCY SUPPLY). RESOURCES FOCUSED TO MINIMIZE THE LIKELIHOOD OF HEAF OCCURRENCE AT THOSE SWITCHGEAR AND BUSES (E.G., IMPROVED PREVENTIVE AND PREDICTIVE ELECTRICAL MAINTENANCE) CAN REDUCE HEAF RELATED RISKS. MEASURES TAKEN TO MINIMIZE THE POSSIBILITY OF A HEAF AT ONE EMERGENCY BUS, CAUSING FAILURE OF THE REDUNDANT ELECTRICAL TRAIN DUE TO CONSEQUENTIAL FAILURES (E.G., DUE TO SMOKE, OR DESIGN DEFICIENCIES), WILL ALSO MINIMIZE THE SBO RELATED HEAF RISKS.TION

WITH RESPECT TO CIRCUIT BREAKERS, MAINTENANCE OF THE UNIT AUXILIARY TRANSFORMER (UAT) BREAKER IS PARTICULARLY IMPORTANT BECAUSE ITS FAILURE CAN LEAD TO AN EXTENDED DURATION GENERATOR-FED FAULT AT THE FIRST SWITCHGEAR BUS. OPERATING EXPERIENCE HAS SHOWN THIS BREAKER TO FAIL DURING AUTOMATIC BUS TRANSFERS.

WITH RESPECT TO SWITCHGEAR, CRITICAL SWITCHGEAR, SUCH AS FEEDER CIRCUIT BREAKERS THAT CARRY HIGHER CURRENTS AND SWITCHGEAR THAT IS PART OF A BUS TRANSFER SCHEME, PROPER MAINTENANCE OF CONNECTIONS ON BOTH THE BUS DUCT SIDE AND THE CIRCUIT BREAKER SIDE IS ESPECIALLY IMPORTANT.
HEAF LIC-504 - Recommendations

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<tr>
<th>Issue</th>
<th>Information Notice</th>
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<tr>
<td>Incorporate</td>
<td>Risk insights into NRR’s ongoing PRA configuration control initiative.</td>
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<tr>
<td>Consider</td>
<td>Integrating risk insights into NRR’s inspection program in accordance with ROP’s change control processes.</td>
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<tr>
<td>Communicate</td>
<td>Risk insights with internal and external stakeholders.</td>
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HEAF LIC-504 - Next Steps

- **Webinar**: Insights with internal and external stakeholders. (Fall 2022)
- **Info Notice**: Information Notice. (Winter 2022)
- **Complete**: Supporting technical documents (RES). (December 2022)
CONCLUDING REMARKS

The NRC has successfully developed a process to address safety issues that emerge as a result of world-wide nuclear power plant operating experiences in an efficient and effective manner. NRR developed an Office Instruction entitled, “LIC-504, Integrated Risk-Informed Decisionmaking for Emergent Issues” that describes this process, which enables NRC staff to use best available information to assess risk (quantitative or qualitative), defense-in-depth, and safety margins. This process allows for the NRC to disposition issues in a timely manner, consistent with risk-informed decision-making principles.