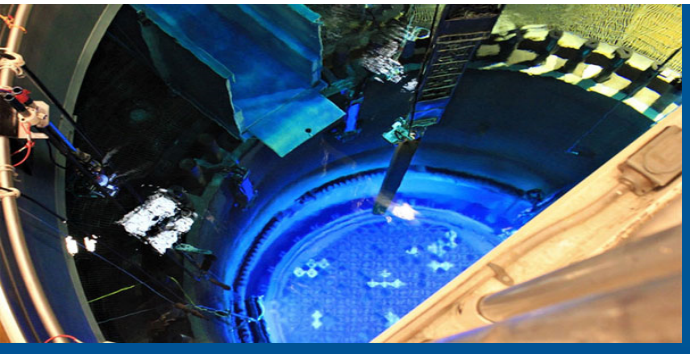
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Crediting FLEX in Probabilistic Risk Assessments Used To Support Risk-Informed Applications

June 21, 2022




Background

- In a memorandum dated May 30, 2017 (ADAMS Accession No. ML17031A269), NRC staff assessed the use of guidance in Nuclear Energy Institute (NEI) 16-06, "Crediting Mitigating Strategies in Risk-Informed Decision Making," for crediting mitigating strategies (FLEX) in probabilistic risk assessments (PRAs) used to support risk-informed (RI) applications.
- The NRC staff found that certain elements of NEI 16-06 lacked sufficient technical justification for crediting FLEX in PRAs used to support RI applications and identified areas where improved industry guidance was needed.

Background, Cont'd

- The 2017 memo identified 13 conclusions related to four areas in NEI 16-06 for which the NRC staff believed that additional technical justification would be needed. The four areas are:
  - Scope (Conclusion 1)
  - PRA Upgrade (Conclusions 2 and 3)
  - Data Analysis (Conclusions 4-10)
  - Human Reliability Analysis (HRA) (Conclusions 11-13)

- In a publicly available memo dated May 6, 2022 (ML22014A084), the NRC updated its assessment of each conclusion from the 2017 memo to reflect the impact of new information.

Scope

- Conclusion 1 – Claiming quantitative credit for the use of offsite portable equipment (equipment from SAFER centers) is inappropriate until additional guidance is provided, that meets the guidance in Regulatory Guide (RG) 1.200*
- Updated guidance was not provided.
- Conclusion 1 remains unchanged.
- Justification for quantitative credit for the use of offsite portable equipment in PRAs used for RI applications must be submitted to the NRC for review and approval.

* RG 1.200, Revision 2, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," or Revision 3, "Acceptability of Probabilistic Risk Assessment Results for Risk-Informed Activities"

PRA Upgrade

- Conclusion 2 remains unchanged - licensees who incorporate FLEX into PRAs used for RI applications should perform a focused scope peer review or demonstrate that the criteria for a PRA upgrade in RG 1.200 are not satisfied.
  - The criteria for a PRA upgrade changed in Revision 3 of RG 1.200.
- Conclusion 3 remains unchanged - licensees may incorporate FLEX into PRA models used to exercise self-approval for plant changes.

Data Analysis

- In August 2021, the PWROG issued Revision 1 of PWROG-18043, “FLEX Equipment Data Collection and Analysis,” which provides FLEX equipment reliability parameters for use in PRA and addressed the NRC’s observations associated with the draft report.
- The NRC reviewed PWROG-18043, which contained proprietary information.
- In February 2022, The PWROG issued a non-proprietary version of the report with the same equipment failure probabilities as PWROG-18042 (ML22123A259).
  - PWROG-18042 is expected to be updated periodically to incorporate new operating experience data; and will be publicly available.

Data Analysis Conclusions

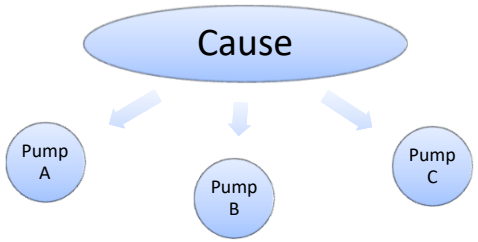
- PWROG-18042 provides generic failure probabilities for portable FLEX equipment that are acceptable to the NRC for use in PRAs used to support RI applications.
- Use of PWROG-18042/18043 eliminates the concerns in the following conclusions:
  - Conclusion 4 – Use of expert judgement
  - Conclusion 5 – Crediting spare equipment in lieu of equipment failure rates
  - Conclusion 6 – Use of permanently installed equipment failure rates
  - Conclusion 7 – Use of old data
  - Conclusion 9 – Use of PWROG-14003

FLEX Data Uncertainty

- Conclusion 8 - FLEX Data Uncertainty
  - PWROG-18042/18043 provide mean values and statistical uncertainty parameters that are acceptable to the NRC for use in PRAs used in RI applications.
  - It is unclear to the NRC staff if preventive maintenance or testing performed on FLEX equipment tests the components to perform their mission as defined in the PRA, as discussed in the ASME/ANS PRA Standard RA-Sa-2009, Supporting Requirement (SR) DA-C4.
  - Licensees should account for this uncertainty in the key assumptions and sources of uncertainty discussion as part of a RI application.

Common Cause Failure Data

- Conclusion 10 - Common Cause Failure (CCF) Parameters
  - PWROG-18042/18043 did not calculate CCF parameters for portable FLEX equipment.
  - Conclusion 10 remains unchanged in that currently available CCF values should continue to be used for portable FLEX equipment until additional data becomes available.
  - Updates to NUREG/CR-5497, “Common Cause Failure Parameter Estimations,” include generic CCF terms for equipment with no prior CCF data.



EPRI HRA for FLEX Guidance

- In November 2018, EPRI issued Technical Update 3002013018, “Human Reliability Analysis (HRA) for Diverse and Flexible Mitigation Strategies (FLEX) and Use of Portable Equipment.”
- EPRI 3002013018 includes examples and guidance for how to perform HRA for the use of onsite portable equipment in a variety of contexts using existing HRA methods.
  - Where gaps existed between the technical basis of existing HRA methods and modeling of human actions using portable equipment, the report provides guidance for supplementing existing HRA methods.
  - Additional guidance was provided for declaring ELAP, transporting equipment, and refueling.

Additional EPRI HRA for FLEX Guidance

- In 2021, EPRI issued two knowledge-based articles (KBAs) clarifying their guidance in EPRI 3002013018 to:
  - supplement the guidance for modeling refueling of portable equipment (KBA 2021-007) and
  - supplement the information addressing pre-initiating event HRA for portable equipment (KBA 2021-001).
- EPRI also modified their HRA calculator to facilitate modeling HRA for FLEX actions.

Use of Surrogates

Conclusion 11 – Use of Surrogates

- EPRI 3002013018 does not provide quantitative guidance for performing HRA for actions impacted by extreme external events.
  - Until acceptable guidance is provided, justification for quantitative credit for the use of portable equipment in an extreme external event should be submitted to the NRC for review and approval.
- EPRI 3002013018 developed surrogates for transporting portable equipment, connecting temporary hoses, and validation of portable pump operability.
  - These three surrogates have been adequately documented and are acceptable for use in a licensee's PRA used for risk-informed applications, if applicable, without additional NRC review. Any other proposed surrogates should be submitted to the NRC for review and approval.

Connecting/Disconnecting Trailers

- EPRI 3002013018 does not include guidance for calculating the HEPs for actions such as connecting/disconnecting trailers or loading/unloading equipment.
  - EPRI 3002013018 states that the feasibility study or task analysis decided these items would not drive the HRA results because there were no credible failure mechanisms, or the impact of the failure mechanisms were negligible.
- EPRI's conclusion is specific to the plant used in the examples and may not be applicable to all plants.
- Each licensee should confirm that there have not been any changes to their mitigating strategies since the feasibility study was completed that may impact the ability to complete these tasks and, if applicable, licensees are to document the basis for excluding such tasks from HRA.

Refueling

- EPRI 3002013018 does not include detailed guidance for modeling refueling actions where no personnel are available to monitor the fuel level or there are no clear pre-defined procedures or plans directing refueling.
  - In this situation, the licensee should submit a justification for the modeling approach used to the NRC for review and approval.
- EPRI 3002013018 includes screening criteria that may be used to determine whether refueling can be excluded from the PRA model.
  - EPRI KBA 2021-007 provides additional guidance for modeling refueling of portable equipment, including clarification of when use of the refueling screening criteria is appropriate.

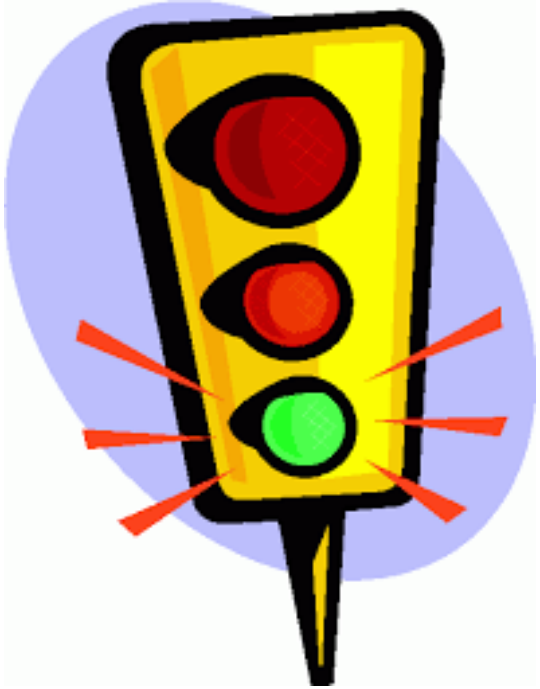
Load Shedding

- EPRI 3002013018 uses Technique for Human Error Rate Prediction (THERP)* to calculate the HEPs associated with DC load shedding.
  - The EPRI report states that a self-check value of 0.5 is applied as a recovery factor for failure to open a breaker and is appropriate because of general improvements in operator training since THERP was published in 1983.
- The NRC does not agree with this statement because the execution values in THERP already account for self-checking.
  - If this approach is taken, it should be submitted to the NRC for review and approval.

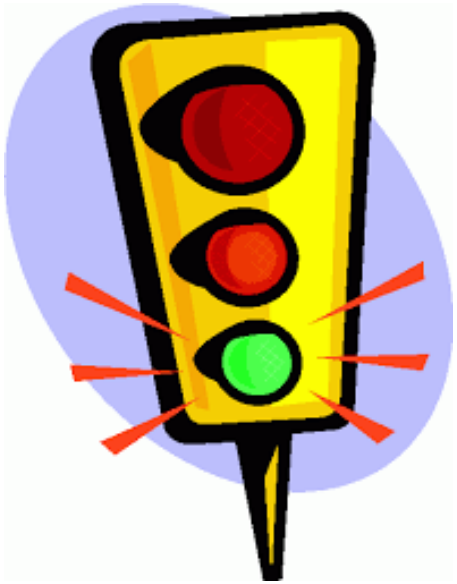
* NUREG/CR1278, “Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications - Final Report," ML071210299).

Initiating FLEX

- Conclusion 12 – Procedures for Initiating FLEX
  - If procedures for initiating FLEX are not explicit and if failure probabilities are not analyzed using accepted approaches, technical bases for failure to initiate FLEX should be submitted to the NRC for review.
- EPRI 3002013018 provides updated detailed guidance for modeling the decision to declare an extended loss of AC power (ELAP), including variations where various amounts of judgement are required to make the decision.

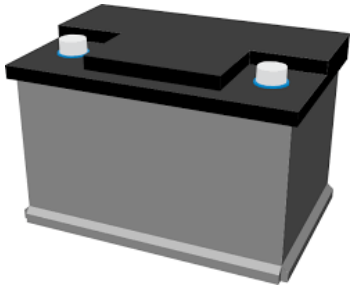


Initiating FLEX, Cont'd



- If the decision to initiate FLEX (declare ELAP) is not modeled in the PRA, the technical basis for the rationale used to exclude the decision should be submitted to the NRC for review and approval.
- If FLEX is credited in the PRA for events other than ELAP (such as for maintenance or other equipment failures), procedures must explicitly indicate when and how to implement FLEX for the additional events.

Pre-Initiators



Conclusion 13 – Pre-Initiator Analysis

- The licensee should ensure that any changes made to the FLEX implementation plans, since original implementation, are thoroughly reviewed for their impacts on HRA, including pre-initiators.
- The assessment of pre-initiator human failure events (HFEs) is intended to capture the contribution of latent failures that are not captured in equipment failure rates.
  - Battery failures may not always be included in equipment failure rates, depending on the nature of the battery failure. The licensee should ensure battery failures are appropriately considered in the pre-initiator assessment if not included in equipment failure rates.
- EPRI KBA 2021-001 provides additional guidance for identifying and assessing pre-initiating events for mitigating strategies.

Expected Outcome

- Perfect World
  - Licensees will model FLEX using the HRA guidance in EPRI 3002013018 and the associated KBAs, and the equipment failure probabilities from PWROG-18042/18043.
  - Licensees will address the NRC's concerns outlined in the NRC's updated assessment for modeling FLEX in PRAs and state this in their application.
  - Licensees describe how FLEX was credited in the PRA as part of their RI application.
  - The NRC does not need to ask RAIs about how FLEX was modeled in the PRA for the RI application.
- Alternative
  - If licensees choose not to use the updated guidance or fail to mention how FLEX was modeled in the RI application, the NRC will continue to ask RAIs related to how FLEX was modeled in the PRA.

Questions?