PRESSURIZED WATER REACTOR OWNERS GROUP

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PWR Owners Group

PWROG-20037-NP
Revision 0

WESTINGHOUSE NON-PROPRIETARY CLASS 3

PRA Upgrade/Maintenance and Newly Developed Methods Examples

Risk Management Committee

PA-RMSC-1647

May 2023

Westinghouse

PWROG-20037-NP
Revision 0

PRA Upgrade/Maintenance and Newly Developed Method Examples

PA-RMSC-1647

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Record of Revisions

Rev.	Date	Revision Description
0-A	09/29/2021	Original release for RMC and JCNRM review.
0-B	03/16/2022	Comments from RMC and JCNRM have been incorporated.
0	See PRIME	Comments from NRC have been addressed (electronically attached). Comments from PWROG on Section 3.2.8 have been addressed (electronically attached) Section 3.4.10 on HEAF modelling has been added. Section 4 has added discussion on the use of expert judgement in the context of NDM Section 4.2.3 has been added. Section 4.3.1 has been added for the reclassification of the Component Recovery Modeling method.

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Newly Developed Methods Requirements and Peer Review

Utility Member	Plant Site(s)	Participant	
		Yes	No
Asociación Nuclear Ascó-Vandellòs	Asco 1 & 2 (W)	X	
	Vandellos 2 (W)	X	
Centrales Nucleares Almaraz-Trillo	Almaraz 1 & 2 (W)	X	
CEZ**	Temelin		X
EDF Energy	Sizewell B (W)	X	
Electrabel	Doel 1, 2 & 4 (W)	X	
	Tihange 1 & 3 (W)	X	
Electricite de France	58 Units	X	
Elektriciteits Produktiemaatschappij Zuid-Nederland	Borssele 1 (Siemens)	X	
Eletronuclear-Eletrobras	Angra 1 (W)	X	
Emirates Nuclear Energy Corporation	Barakah 1 & 2	X	
Hokkaido	Tomari 1, 2 & 3 (MHI)	X	
Japan Atomic Power Company	Tsuruga 2 (MHI)	X	
Kansai Electric Co., LTD	Mihama 3 (W)	X	
	Ohi 1, 2, 3 & 4 (W & MHI)	X	
	Takahama 1, 2, 3 & 4 (W & MHI)	X	
Korea Hydro & Nuclear Power Corp.	Kori 1, 2, 3 & 4 (W)	X	
	Hanbit 1 & 2 (W)	X	
	Hanbit 3, 4, 5 & 6 (CE)	X	
	Hanul 3, 4, 5 & 6 (CE)	X	
Kyushu	Genkai 2, 3 & 4 (MHI)	X	
	Sendai 1 & 2 (MHI)	X	
Nuklearna Electrarna KRSKO	Krsko (W)	X	
Ringhals AB	Ringhals 2, 3 & 4 (W)	X	
Shikoku	Ikata 1, 2 & 3 (MHI)	X	
Taiwan Power Co.	Maanshan 1 & 2 (W)	X	

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ACRONYMS

Acronym	Definition
ANS	American Nuclear Society
AS	Accident Sequences Analysis (PRA Standard Technical Element)
ASME	American Society of Mechanical Engineers
BWROG	Boiling Water Reactor Owners Group
CCF	Common Cause Failure
CDFM	Conservative Deterministic Failure Mode
CFD	Computational Fluid Dynamics
CS	Cable Selection and Location (PRA Standard Technical Element)
DA	Data Analysis (PRA Standard Technical Element)
EDG	Emergency Diesel Generator
EPRI	Electric Power Research Institute
ET	Event Tree
FSS	Fire Scenario Selection and Analysis (PRA Standard Technical Element)
FT	Fault Tree
F&O	Facts and Observations
HDHC	High, Dry, High, Cleared
HDHI	High, Dry, High, Intact
HDLI	High, Dry, Low Intact
HEAF	High Energy Arching Fault
HEP	Human Error Probability
HFE	Human Failure Event
HLR	High Level Requirement
HR	Human Reliability analysis (PRA Standard Technical Element)
HRA	Human Reliability Assessment
HVAC	Heating, Ventilation and Air Conditioning
IE	Initiating Events Analysis (PRA Standard Technical Element)
IEF	Initiating Event Frequency
IFEV	Internal Flood-Induced Initiating Events Analysis (PRA Standard Technical Element)
IFSN	Internal Flood Scenario Development (PRA Standard Technical Element)
IFSO	Internal Flood Source Identification and Characterization (PRA Standard Technical Element)

Acronym	**Definition**
IGN	Ignition Frequency (PRA Standard Technical Element)
JCNRM	Joint Committee on Nuclear Risk Management
LERF	Large Early Release Frequency
LOC	Loss of Control
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
MCC	Motor Control Center
MCR	Main Control Room
MGL	Multiple Greek Letter
MTTR	Mean Time to Recovery
NEI	Nuclear Energy Institute
NDM	Newly Developed Method
NMA	Non-Mandatory Appendix
NRC	Nuclear Regulatory Commission
NRP	Non-Recovery Probability
NSBD	Non-Segregated Bus Duct
PA	Project Authorization
PI-SGTR	Pressure-Induced Steam Generator Tube Rupture
PRA	Probabilistic Risk Assessment
PRM	Fire PRA Plant Response Model (PRA Standard Technical Element)
PSA	Probabilistic Safety Analysis
PSF	Performance Shaping Factor
PWR	Pressurized Water Reactor
PWROG	PWR Owners Group
QA	Quality Assurance
QU	Quantification (PRA Standard Technical Element)
RCP	Reactor Coolant Pump
RG	Regulatory Guide
RICT	Risk-Informed Completion Time
RMC	Risk Management Committee
SC	Success Criteria (PRA Standard Technical Element)
SGTR	Steam Generator Tube Rupture

Acronym	**Definition**
SFR	Seismic Fragility Analysis (PRA Standard Technical Element)
SHA	Seismic Hazard Analysis (PRA Standard Technical Element)
SPR	Seismic Plant Response Analysis (PRA Standard Technical Element)
S-PRA	Seismic Probabilistic Risk Assessment
SSC	Structure, System and Component
SSHAC	Senior Seismic Hazard Advisory Committee
SSIE	Support System Initiating Event
SR	Supporting Requirement
SY	System Analysis (PRA Standard Technical Element)
TH	Thermal-Hydraulic
THIEF	Thermally Induced Electrical Failure
TI-SGTR	Thermally Induced Steam Generator Tube Rupture
TMSC	Tornado Missile Strike Calculator
U.S. NRC	United States Nuclear Regulatory Commission
WFR	Wind Fragility Analysis (PRA Standard Technical Element)
WHA	Wind Hazard Analysis (PRA Standard Technical Element)
XFHA	External Flooding Hazard Analysis (PRA Standard Technical Element)
XFPR	External Flooding Plant Response Model and Quantification (PRA Standard Technical Element)
ZOI	Zone of Influence

EXECUTIVE SUMMARY

The Pressurized Water Reactor Owners Group (PWROG) supported interaction between the PWROG Risk Management Committee (RMC), the United States Nuclear Regulatory Commission (USNRC), the Boiling Water Reactor Owners Group (BWROG) and the Joint Committee on Nuclear Risk Management (JCNRM) of the American Nuclear Society (ANS) and American Society of Mechanical Engineers (ASME) for the re-definition of critical terminology in the Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment (PRA) for Nuclear Power Plant Applications. One of the key objectives of this program is to provide unambiguous definitions of PRA upgrade and PRA maintenance to be used within utility PRA configuration control programs. The differentiation between PRA upgrade and PRA maintenance is critical in the decision of whether a focused scope peer review is needed following a change to the PRA. The new definitions for PRA upgrade and PRA maintenance are documented in PWROG-19027-NP Revision 2 (Reference 2) and are endorsed by the United States NRC in Revision 3 of Regulatory Guide (RG) 1.200 (Reference 3). As part of the evolution of the PRA Standard, the Non-Mandatory Appendix (NMA) 1-A of the current edition of the PRA Standard (i.e., Addendum B, Reference 4), is being removed from future editions of the Standard to allow for a more dynamic and dedicated set of examples, which will be managed by the PWROG using this report. In addition to examples of PRA upgrade and maintenance, Reference 2 introduces the definition of a Newly Developed Method (NDM). Additional peer review requirements are applicable when a PRA upgrade involves an NDM; these requirements are formalized in Reference 2 and in the new peer review guidance developed by the Nuclear Energy Institute (NEI) in NEI 17-07 (Reference 5). This report also discusses selected examples of NDMs.

1 INTRODUCTION

The Pressurized Water Reactor (PWR) Owners Group (PWROG) Project Authorization (PA) RMSC-1647 (Reference 1) supported the interaction between the PWROG Risk Management Committee (RMC), the United States Nuclear Regulatory Commission (U.S. NRC), the Boiling Water Reactor Owners Group (BWROG) and the Joint Committee on Nuclear Risk Management (JCNRM) of the American Nuclear Society (ANS) and American Society of Mechanical Engineers (ASME) for the re-definition of critical terminology in the Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment (PRA) for Nuclear Power Plant Applications.

One of the objectives of this program is to provide unambiguous definitions of PRA upgrade and PRA maintenance, to be used within the plants PRA configuration control programs. The differentiation between PRA upgrade and PRA maintenance is critical in the decision of whether a focused scope peer review is needed following a change in the PRA.

The new definitions for PRA upgrade and PRA maintenance are documented in PWROG-19027-NP Revision 2 (Reference 2) and are endorsed by the U.S. NRC in Revision 3 of Regulatory Guide (RG) 1.200 (Reference 3).

As part of the evolution of the PRA Standard, the Non-Mandatory Appendix (NMA) 1-A of the current edition of the PRA Standard (i.e., Addendum B, Reference 4), is being removed from future editions of the Standard to allow for a more dynamic and dedicated set of examples, managed by the PWROG through the current report.

In addition to examples of PRA upgrade and maintenance, Reference 2 introduces the definition of Newly Developed Method (NDM). Additional peer review requirements are envisioned when a PRA upgrade involves an NDM, as formalized in Reference 2 and in the new peer review guidance developed by the Nuclear Energy Institute (NEI) NEI 17-07 (Reference 5). This report also discusses examples of NDMs.

The intent of this report is to provide clarifying examples to aid in interpreting the definitions. The report will be made publicly available and will be revised as deemed appropriate based on lessons learned from the industry.

Revision 0-B of this report was provided for information to the NRC (in ADAMS as ML22143A845) and comments received from the NRC have been addressed in Revision 0 of the report. Additional fire examples (see Section 3.4.10) were also added to the examples of upgrades and maintenance; an additional NDM example has been provided while the NDM characterization for the component recovery modelling has been modified based on the evolution of the method.

2 DEFINITIONS

The operating definitions that are discussed in this report are defined in Reference 2 and reported here for ease of consultation.

PRA Upgrade: A change in the PRA that results in the applicability of one or more Supporting Requirements (SRs) that were not previously included within the PRA (e.g., performing qualitative screening in Part 4 when this High Level Requirement, HLR, was previously not applicable or the addition of a new hazard model), an implementation of a PRA method in a different context, or the incorporation of a PRA method not previously used.

PRA Method: An analytical approach used to satisfy a SR or collection thereof in the PRA. An analytical approach is generally a compilation of the analyses, tools, assumptions, and data used to develop a model.

Model: A qualitative and/or quantitative representation that is constructed to portray the inherent characteristics and properties of what is being represented (e.g., a system, component or human performance, theory or phenomenon). A model may be in the form, for example, of a structure, schematic or equation. Method(s) are used to construct the model under consideration.

PRA: A quantitative assessment of the risk, including technical elements for modeled hazards, associated with plant operation and maintenance that is measured in terms of frequency of occurrence of risk metrics, such as core damage or a radioactive material release and its effects on the health of the public [also referred to as a probabilistic safety assessment (PSA)].

PRA Maintenance: A change in the PRA that does not meet the definition of PRA upgrade.

State-of–Practice: Those practices that are widely implemented throughout the commercial nuclear power industry, have been shown to be technically acceptable in documented analyses or engineering assessments, and have been shown to be acceptable in the context of the intended application.

Consensus Method/Model: A method/model that the U.S. NRC has used or accepted for the specific risk-informed application for which it is proposed.

Newly Developed Method: A PRA method that has either been developed separately from a state-of-practice method or is one that involves a fundamental change to a state-of-practice method. A newly developed method is not a state-of practice or a consensus method.

3 UPGRADE AND MAINTENANCE EXAMPLES

In the following section, examples of PRA changes are described with discussion on whether the changes would qualify as a PRA upgrade or maintenance activity. For a specific change, the analyst should step through the details of the change applying the criteria for the definition of an upgrade. The following table may be used to justify the classification of a change as upgrade or maintenance.

PRA Change description	☐Upgrade; ☐Maintenance
	Why upgrade (check all that apply): ☐ Applicability of one or more supporting requirements that were not previously included within the PRA ☐ An implementation of a PRA method in a different context ☐ Incorporation of a PRA method not previously used **Additional discussion of basis:** [discussion here]

The examples provided in the following sections are designed to provide guidance on how to judge plant-specific changes and classify them. Some examples are straightforward in the characterization, especially when method changes are involved. In other cases, examples of how a specific change can result in an upgrade or maintenance activity are provided.

Note that the discussion in this section is focused on, and limited to, only determination of a PRA upgrade or maintenance. The intent of this section is not to discuss whether methods used in the described changes are newly developed methods or not.

3.1 GENERIC CLARIFICATIONS

- Different hazards PRAs for the same plant are not to be considered independent/different PRAs

  In the definition of PRA Upgrade from Reference 2, a change in the PRA is characterized as an upgrade in case of “the incorporation of a PRA method not previously used.” This is intended to mean “not previously used in the plant PRA”. Note that in some peer reviews, some peer reviewers have made the differentiation between different hazards PRA for the same unit to be different PRAs. As a result, a Human Reliability Assessment (HRA) method used and peer reviewed in Internal Events, or Flood, or Seismic PRA, was considered a “new method” when applied to a change in the Fire PRA. This is not the generic intent of the definition. If the underlying HRA method is already used in the internal events model that is used as the foundation for the hazard model, then it can be said that the method is already used in the same context (i.e., development of the base Human Error Probability [HEP] that will later be modified by a hazard-specific method). Therefore, if the HRA method is extended from one hazard to another without any change and without changing applicability of any previously not applicable SRs, then such extension is to be considered a PRA maintenance activity.

- Use of different software

  Software is normally to be considered tools for implementation of a particular method (as opposed to a method per se) and as such, changing software or a software version is not per se a reason for classifying the associated PRA change as a PRA Upgrade. The technical adequacy of the software is normally addressed in the Quality Assurance (QA) program from the software developer (which is also addressed in the Configuration Control technical element of the PRA Standard) and does not need to be addressed in a PRA peer review (or an NDM peer review). While changing a software or a software version should be normally considered a maintenance activity, it is observed that changing a software (or a software version) can be an enabler for being able to use a new method. For example, the use of the Electric Power Research Institute (EPRI) HRA Calculator rather than other tools for HRA may allow the PRA analyst to use methods that are available in the HRA Calculator that were not available in the previous tools. This would be a PRA upgrade but it would be independent from the use of the tool. See examples 3.2.15 and 3.2.18 for specific scenarios.

- Data update

  Data update in a PRA should normally be considered a maintenance activity, under the assumption that all the methods used to assess data applicability to the plant remain the same. This is, in general, valid for all types of data (e.g., Initiating Event Frequencies (IEFs), component failure rates, pipe rupture data for internal flooding, fire ignition frequencies, external hazard data, etc.). This conclusion also includes plant-specific Bayesian update. If the use of new data is accompanied by different methods in processing the data that is used in the plant-specific PRA, or to assess the applicability of the data to the plant, then the change would be considered a PRA upgrade. This conclusion would be nevertheless independent from the actual data used (new or old), but on the processing methods. See examples in Sections 3.2.2 and 3.2.3 for specific scenarios.

3.2 INTERNAL EVENTS PRA EXAMPLES

3.2.1 Initiating Events

Change. A few initiating events are added to the model because of initial peer review comments.

Discussion: The inclusion in the model of a few additional initiating events should normally be considered a maintenance activity. This assumes that no new methodologies are used in such change, which implies that no new screening criteria are used in this theoretical change in the PRA, including screening criteria and grouping criteria or new approaches to evaluate initiating event frequencies or the assessment of related uncertainties. Note that if new screening or grouping criteria are used that were not previously peer reviewed for other initiating events, this should be considered an upgrade even if there are no practical changes in the initiating events that are added or excluded from the model.

Applicable Technical Element: Initiating Events Analysis (IE)

3.2.2 Initiating Events Frequency (Generic data update)

Change. A change of IEFs by using a more relevant or recent generic database.

Discussion: The use of a different database should normally be considered a maintenance activity. This assumes that no new methods are used to process the data before being entered in the PRA and that no new assumptions are needed to confirm the applicability of the alternative data to the plant. If, on the other hand, a different method is used to implement the generic data, then this change would be considered an upgrade. An example of this is the replacement of generic Loss of Coolant Accident (LOCA) initiating event frequencies with plant-specific LOCA frequencies assigned by using the generic EPRI pipe segment approach. This change should be considered an upgrade because the different approach used to evaluate the IEF for LOCAs likely requires the use of new assumptions about data availability. As such, the new calculation for the IEF would be considered a new method.

Applicable Technical Element: Initiating Events Analysis (IE)

3.2.3 Initiating Events Frequency (Bayesian update)

Change. A change of IEFs caused by incorporating plant data by using Bayesian update method.

Discussion: The inclusion of updated plant data through the Bayesian update process should normally be considered a maintenance activity. This assumes that plant-specific Bayesian update process is already used in the PRA model (even though not necessarily in the initiating events frequency but also in the component failure rates). If Bayesian update has not been used previously in the model, this change would represent an upgrade activity.

Applicable Technical Element: Initiating Events Analysis (IE)

3.2.4 Initiating Events Modeling

Change. Plant-specific fault trees are developed to model support system initiators and to quantify their frequency, replacing previous point estimate values.

Discussion: The development of plant (or design) specific fault tree modeling for support system initiators should be considered an upgrade activity when this approach is used instead of using individual point estimates values for initiating events. Even if the basic approach used in the fault tree system modeling between support systems modeled as initiators and any other system modeled for their mitigation function is the same, there are fundamental differences in the type of failure modes that needs to be modeled; the mission time that needs to be considered and the logical relations between the same components failing in the initiating events logic versus the mitigation logic also require different considerations. If system-specific fault trees are already used in the PRA for the modeling and quantification of initiating events frequency, the addition of a new initiator using this same approach should be considered a maintenance activity.

Applicable Technical Element: Initiating Events Analysis (IE)

3.2.5 Initiating Events Modeling - ISLOCA

Change. A model for loss of coolant outside of containment using a single initiating event to represent the sum of all contributors and assuming the most conservative consequences is replaced by several initiating events with individualized consequences (e.g., WCAP-17154-P, Reference 23).

Discussion: This change represents a model upgrade if no other initiating events are modeled with a fault tree approach, otherwise this change is simply adding additional initiators (and associated accident sequences) in the model using standard techniques that, if already used in other places in the model, should only be considered as a maintenance activity.

Applicable Technical Element: Initiating Events Analysis (IE)
Accident Sequences Analysis (AS)

3.2.6 Accident Sequences Modeling for Containment Sump Plugging

Change. The plant PRA model incorporates the containment sump plugging failures and failure probabilities for Large LOCA from WCAP-16882-NP (Reference 9).

Discussion: WCAP-16882-NP provides basic event data and provides analytical support for a more detailed modeling of the containment sump plugging. This matches the definition of PRA method and therefore the implementation of this method in the plant PRA should be considered an upgrade.

Applicable Technical Element: Accident Sequences Analysis (AS) – AS-B3[1]

System Analysis (SY) – SY-C2[1]

3.2.7 Success Criteria – Core Damage Definition

Change. Definition of core damage used to support success criteria is changed from one accepted definition to another accepted definition (e.g., use of 2,200°F instead of two-thirds of core height) without changing the thermal-hydraulic methodology.

Discussion: The definition of core damage is a critical assumption upon which other elements are based. This change in the PRA should be considered an upgrade.

Applicable Technical Element: Success Criteria (SC)

3.2.8 Success Criteria – Core Damage Timing

Change. MAAP5 is used as the basis to change PRA success criteria or timing previously based on MAAP4.

Discussion: This change would be considered a PRA maintenance activity given that MAAP4 was previously used to support Leven 1 PRA success criteria or timing. While use of MAAP5 represents a new version of a tool and requires updates to input and parameter files, the underlying methods are essentially the same and generally do not change insights relative to core damage timing or accident sequence / success criteria analysis.

Applicable Technical Element: Success Criteria (SC)

3.2.9 System Modeling

Change. System analysis modeling additions or changes, additional or missed dependencies and correction of logic errors in system analyses to reflect as-built/as-operated conditions.

Discussion: Additional system modeling performed to include additional systems in the PRA logic model, capture missed or modified dependencies (with support systems or initiating events) and/or correct logic errors should normally be considered a maintenance activity as long as the same methods are used for the modeling and supporting analysis (e.g., TH calculations). The addition of systems or components to a PRA implies that all the relevant supporting analyses also are performed using the same methods used in the original analysis (e.g., room heat-up calculations for internal events modeling, cable selection for Fire PRA modeling, flooding propagation paths for internal flooding, seismic fragility analysis, etc.). If additional system

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[1] Specific SRs are listed as examples only based on past focused scope peer review. They should not be considered to be exhaustive and the actual scope may change on a plant-specific basis.

modeling and/or the supporting analyses use different methods, the change would be classified as an upgrade.

Applicable Technical Element:	System Analysis (SY) Fire PRA Plant Response Model (PRM) Seismic Plant Response Analysis (SPR)

3.2.10 System Modeling for Reactor Coolant Pump (RCP) Seal

Change. The PRA is changed with the RCP seal failure model because of implementing low-leakage seals.

Discussion: Changing the PRA model to implement low-leakage seals is not necessarily an upgrade as it depends on the type of changes that are made to the model. If the change can be addressed with the same modelling methodology used before (e.g., if the same method is simply extended to an additional stage), then the change is only a maintenance activity; if a new method is implemented, or if the method requires more detailed analysis that makes some additional SR applicable, then this change would qualify as an upgrade. There are multiple possible permutations of changes associated with RCP Seal LOCA modeling, some of which imply significant changes while others are in essence only updating leakage rates and failure probabilities. The following changes are provided as a non-exhaustive list for consideration:

- Westinghouse seals ➔ N9000 seals
    - This change represents a PRA upgrade as this requires a change of the underlying method
- Westinghouse seals ➔ Addition of SHIELD
    - This change represents PRA maintenance as this only requires modeling an additional stage using the same underlying methodology
- N9000 seals ➔ Westinghouse seals
    - This change represents a PRA upgrade as this requires a change of the underlying method
- N9000 seals ➔ N900 seals with abeyance
    - This change represents PRA maintenance as this only requires modeling an additional stage using the same underlying methodology

It is noted that, if the change in RCP seal modeling requires new plant-specific TH analyses (e.g., using MAAP) to generate timing for HRA, this aspect is generally considered a maintenance activity assuming that the same TH analysis code/method is used elsewhere in the model and has previously been peer reviewed.

Applicable Technical Element:	System Analysis (SY) Success Criteria (SC) Accident Sequences Analysis (AS) Human Reliability analysis (HR)

3.2.11 System Modeling for Portable Equipment

Change. The plant PRA model is changed to reflect portable equipment and associated strategies (e.g., FLEX).

Discussion: The change of the model to reflect portable equipment and associated equipment involves numerous elements in the PRA, potentially spanning through the entire Standard. The characterization of this change update depends on how each of the elements is addressed. The system modeling (SY) element should be considered a maintenance activity under the assumption that the same standard system modeling techniques already used to model other systems are also adopted for the modeling of the FLEX components. Similarly, any accident sequence (AS) and success criteria (SC) elements associated with the modeling of FLEX strategies should be considered a maintenance activity under the expectation that the same TH codes and techniques are used to address the additional sequences being modeled, this also applies to component-specific mission time considerations.

The Data Analysis (DA) element could be considered a maintenance activity if the data used are directly applicable to the portable equipment being credited (e.g., by using the data provided in PWROG-18042-P (Reference 10)). In such case, no additional assumptions are needed to confirm applicability of the data to the FLEX equipment being modeled. On the other hand, if dedicated assumptions are made to address applicability of data that are otherwise not explicitly developed for portable equipment, then that part of the update should be considered an upgrade.

Similarly, for the HRA element, if the methods used for modeling actions related to portable equipment have not been previously used in the PRA or are used in a new context (e.g., debris removal), then the HRA activity related to portable equipment should be considered an upgrade. Here the new types of operator actions would generally use the same human error evaluation methods, but expand them to new situations (context) and likely include new SRs, some of which may have previously been not applicable.

Ancillary and supporting analysis to support the use of portable equipment (e.g., seismic fragility analysis for FLEX related equipment) should be considered for the full characterization of the change to see if different methods are applied to any of the additional components modeled. For example, if FLEX is added in a S-PRA and the fragility analysis for the added FLEX components uses Separation of Variable rather than Conservative Deterministic Failure Mode (CDFM) and all other fragilities in the S-PRA are managed with CDFM, this would be an upgrade.

Applicable Technical Element: System Analysis (SY)
Data Analysis (DA)
Success Criteria (SC)
Accident Sequences Analysis (AS)
Human Reliability analysis (HR)

3.2.12 Modeling of Loss of Offsite Power Recoveries

Change. Revised modeling of Station Blackout so that the Loss of Offsite Power (LOOP) event tree is incorporated into the Transient Event Tree, and recoveries are explicitly included in the model structure rather than by post quantification.

Discussion: The change discussed in this example is associated with how recoveries are handled (i.e., moving from a post-processing approach to embedding them in the fault tree logic), If recoveries are modeled via fault tree approach in other parts of the PRAs and are now also used for the LOOP scenarios, then this change should be considered a maintenance activity. If this approach to modeling recoveries has not been peer reviewed previously, then this would be considered an upgrade.

Applicable Technical Element: Accident Sequence Analysis (AS)
Quantification (QU)

3.2.13 Emergency Diesel Generator (EDG) Run Convolution

Change. The PRA is updated with EDG Run Time Convolution Factors

Discussion: A new method (i.e., a method not previously used in this PRA model) was applied to use convolution factors to account for the dependence between LOOP non-recovery events and time-dependent EDG failures for LOOP and Station Blackout sequences. Because a new method was used, this change should be considered an upgrade.

Applicable Technical Element: Accident Sequence Analysis (AS)
Quantification (QU)

3.2.14 Human Reliability Analysis

Change. Addition, combination or update of Human Failure Events (HFE)s.

Discussion: The characterization of this change depends on the methods used in the development of the HFEs. Adding new operator actions (e.g., in response to spurious operation) using the same methods already used in other HFEs in the PRA does not constitute an upgrade, even if the operator actions are added in a specific hazard PRA (e.g., adding isolation operator actions in flooding). If the same method is used for the development of the HFEs in previous revisions of the PRA, then this should be considered a maintenance activity. Any change in HFE that is the result of a change/update of the underlining procedure or sequence timing due to plant modifications but is still obtained with the same HRA method should be considered a maintenance activity. Similarly, a scenario where an HEP is changed from one method to another (e.g., from screening value to ASEP) should be considered a PRA maintenance if the method is already used in other HFEs in the PRA. If a new HFE is evaluated with a method not previously adopted (e.g., from SHARP to ASEP) or an existing HFE is recalculated with a method not previously adopted, then the change is to be considered an upgrade.

Applicable Technical Element: Human Reliability analysis (HR)

3.2.15 Human Reliability Analysis – Use of HRA Calculator

Change. Transition to the EPRI HRA Calculator

Discussion: The adoption of the EPRI HRA Calculator per se does not represent a change in method, as the HRA Calculator is a tool, which can be used for applying different methods (see generic clarifications in Section 3.1). Use of EPRI HRA Calculator for calculating HEPs should be considered a maintenance activity if the methods implemented using the EPRI HRA Calculator are the same as the alternate tool previously used. Therefore, the same approaches are being used in the PRA and the change does not meet any of the criteria for consideration as an upgrade. If new underlying methods are used through the EPRI HRA Calculator that were not used in the alternate tool, then this change should be considered an upgrade.

Applicable Technical Element: Human Reliability analysis (HR)

3.2.16 Data - Unavailability

Change. Unavailability values for a number of mitigation systems are significantly increased due to the introduction of an aggressive on-line preventative maintenance program.

Discussion: This change is due to a plant change and under the assumption that no new methodologies are involved, should be considered a maintenance activity.

Applicable Technical Element: Data Analysis (DA)

3.2.17 Data - Common Cause Failure

Change. Update of CCF modeling.

Discussion: The characterization of this change depends on the method used in the update. The addition of new common cause failure groups in the model, with the same method used for existing groups, should be considered a maintenance activity, as well as an update of the CCF values due to the adoption of an updated data source. A change in CCF methodology (e.g., beta factor to alpha factor, alpha to Multiple Greek Letter [MGL] method) should be considered an upgrade.

Applicable Technical Element: Data Analysis (DA)

3.2.18 Quantification Approach

Change. Use of an alternate PRA modeling approach through software implementation.

Discussion: The quantification and modeling approaches used in a PRA is correlated with the choice of the software used for the PRA; a transition from one PRA software to a different one may result in a change in the method used for the quantification (e.g., linked Event Tree [ET] to linked Fault Tree [FT] method). While the change in software per se should not be considered an upgrade (see Section 3.1), the changes in method that may be implemented along with the change in the code used for the modeling and quantification of the PRA would be considered an upgrade. Such changes normally involve a significant effort to transfer data and models between the two computer codes; this includes not only the event tree and fault tree structure and data, but also quantification and dependency rules, with a high potential for introducing errors. Under the assumption that the change is between codes that are both well documented and generally accepted by the PRA community, this change could be considered a maintenance activity if both old and new codes use same underlying modeling and quantification philosophy (e.g., linked fault tree or event tree based approaches). A change from an event tree linking to a fault tree linking code should be considered an upgrade because of the expected significant change in the modeled event tree and fault tree dependencies. The change should be supported by documentation of meaningful result comparisons and disposition of differences between the old and new codes.

Applicable Technical Element: Quantification (QU)

3.2.19 Quantification Routine

Change. Update to PRA quantification routine.

Discussion: Changes in the quantification routine should be considered a maintenance activity. This includes, for example, the change in the base truncation to reflect enhanced PRA results or a change in the criteria used in a truncation study. Another example is the quantification of an external hazard (e.g., S-PRA, Fire PRA) using the FRANX interface of CAFTA rather than physically injecting the additional logic in the PRA backbone logic; although minor modifications in the quantification settings are needed for the two approaches, the change can be considered a maintenance activity because it uses recognized alternatives of a well-established dedicated code and still relies on the same underlying quantification methodology.

Applicable Technical Element: Quantification (QU)

3.2.20 Recovery of Offsite Power

Change. The LOOP analysis used plant-specific-data for the IEF, but a generic recovery curve. The recovery curve is updated for long-duration outages by incorporating plant-specific data for hurricane-induced LOOP.

Discussion: The update of generic data with plant-specific information should be considered an upgrade when performed for the first time. Any subsequent update that uses the same update approach but is new data should be considered maintenance. In this example, the update of the recovery curve to include long-duration outages due to hurricanes should be considered a maintenance activity. On the other hand, splitting hurricane related LOOP recovery data in the context of performing a high wind PRA should be considered part of the high winds PRA activities and should be peer reviewed as part of the high winds PRA. Adding the high wind hazard to the plant PRA qualifies as a PRA upgrade.

Applicable Technical Element: Quantification (QU)

3.2.21 Large Early Release Frequency (LERF) Modeling

Change. The PRA model incorporates the PI-SGTR and thermal induced (TI) SGTR probabilities developed via the event tree quantification approach documented in Appendix E of WCAP-16341-P (Reference 11) on a plant-specific basis.

Discussion: The change from generic probabilities to detailed, plant-specific conditional probabilities of PI-SGTR and TI-SGTR in the LERF analysis should be considered an upgrade. Note that WCAP-16341-P may already be used but the approach documented in Appendix E, if applied to the PRA, represents the detailed, plant-specific approach that is new.

Applicable Technical Element: LERF Analysis (LE) – LE-D6[2]

3.3 INTERNAL FLOODING PRA EXAMPLES

3.3.1 Internal Flooding Initiating Events Frequency (Generic data update)

Change. Updating internal flooding IEFs using a more relevant or recent generic supporting database.

Discussion: The use of a different (i.e., more updated) database should normally be considered a maintenance activity. This assumes that no new methods are used to process the data before being entered in the PRA and that no different assumptions are needed to confirm the applicability of the alternative database to the plant. A practical example is a change from Revision 2 to Revision 3 of the EPRI Pipe Rupture frequencies for Internal Flooding PRA (References 12 and 13) or incorporating the EPRI data for Service Water pipe rupture frequency (Reference 14).

Applicable Technical Element: Internal Flood-Induced Initiating Events Analysis (IFEV)

3.3.2 Maintenance Related Floods

Change. The Internal Flooding PRA is updated to include the EPRI methodology for the identification and frequency calculation associated with maintenance-induced events documented in EPRI 3002000079 (Reference 13).

Discussion: The change in method used for the systematic identification of the maintenance-induced flood and the associated calculation of IEF classifies this as an upgrade. Note that this should be considered an upgrade even if the final conclusion does not change the events included in the model (e.g., concludes that no maintenance events need to be included in the model). In

[2] Specific SRs are listed as examples only based on past focused scope peer review. They should not be considered to be exhaustive and the actual scope may change on a plant-specific basis.

this case, the change in methodology for screening and identification may be different from how maintenance-induced flood scenarios were addressed in the PRA before the change (e.g., through a review of the plant operating history).

Applicable Technical Element: Internal Flood Source Identification and Characterization (IFSO) – IFSO-A4[3]
Internal Flood-Induced Initiating Events Analysis (IFEV) – IFEV-A7[3]

3.3.3 Door Failures

Change. Change from simplified failure criteria for door failure during flood (i.e., 1 foot or 3 feet based on opening direction) to a more refined door-specific analysis.

Discussion: In this change, a simplified approach for the assessment of the critical water elevation used as criteria for failure criteria for door failure is replaced by a more refined method (e.g., one that assesses the load of the accumulated water more specifically) and allows for a more detailed assessment of flooding propagation paths. Because a different method is used, this change would be characterized as a PRA upgrade if it was not used in the PRA before. If the method was already used for some flood scenarios (and was part of the peer review) extending use of this method for other scenarios should be characterized as a PRA maintenance activity.

Applicable Technical Element: Internal Flood Scenario Development (IFSN)

3.3.4 Use of Gothic code for Propagation Path Development

Change. Simplified analysis of flood propagation paths is replaced by a method that uses the Gothic code for assessing propagation paths.

Discussion: In this change, a more simplified approach for developing propagation path is replaced by the usage of the Gothic code. Note that the selection of a specific code/software is not per se a PRA upgrade, but in this example, the change to the Gothic code represents a method that more realistically simulates the flood propagation path. In other words, the Gothic code is an enabler for a more refined method for the evaluation of propagation paths; the change is therefore classified as a PRA upgrade. Note that even if the Gothic code is used in other parts of the PRA (i.e., in a different context, for example addressing room heat-up calculations in support to heating, ventilation and Air Conditioning [HVAC] modeling), its use in a different context (i.e., to support flood propagation paths) should classify this change as a PRA upgrade.

Applicable Technical Element: Internal Flood Scenario Development (IFSN)

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[3] Specific SRs are listed as examples only based on past focused scope peer review. They should not be considered to be exhaustive and the actual scope may change on a plant-specific basis.

3.3.5 Spray Events

Change. Add consideration of spray effects for select systems in the internal flooding PRA.

Discussion: Assuming spray events are added using the same methodology as existing spray scenarios, this change would be considered PRA maintenance. Including spray events in the flooding PRA should only be considered an upgrade if the previous analysis was intended only for a different set of failure modes (e.g., flood/major flood) and did not model any spray events. In that case, the analyst needs to apply screening criteria and assumptions that were not made or exercised before. If the intent of the previous analysis included spray events, but some spray events were missed, then the change should be considered a maintenance activity.

Applicable Technical Element: Internal Flood-Induced Initiating Events Analysis (IFEV)

3.3.6 Plant-Specific Experience Review

Change. Different screening criteria are used to support the review of plant-specific flooding information

Discussion: Review of plant-specific experience is used to support numerous assessments in the PRA. The process is normally associated with a review of condition reports. Appropriate review criteria should be selected in support of the issue that needs to be addressed. Different review criteria can result in significantly different conclusions. Some amount of judgment should be applied in the assessment of the new set of review criteria. The definition of a new or substantially different set of review criteria may be categorized as an upgrade, while variations or extension of existing review criteria might be considered maintenance activities.

This discussion is applicable to any SR that requires review of plant-specific operating experience. This change was specifically identified as an upgrade in a Facts and Observations (F&O) closure for a flooding assessment where a new set of review criteria were defined and there was no documentation associated with the original review criteria used years before.

Applicable Technical Element: Internal Flood-Induced Initiating Events Analysis (IFEV) – IFEV-A6[4]

3.4 FIRE PRA EXAMPLES

3.4.1 Ignition Frequencies Update (Generic data update)

Change. Updating internal fire IEFs using a more relevant or recent generic supporting database.

[4] Specific SRs are listed as examples only based on past focused scope peer review. They should not be considered to be exhaustive and the actual scope may change on a plant-specific basis.

Discussion: The use of a different (i.e., more updated) database should normally be considered a maintenance activity. This assumes that no new methods are used to process the data before being entered in the PRA and that no different assumptions are needed to confirm the applicability of the alternative database to the plant.

Applicable Technical Element: Ignition Frequency (IGN)

3.4.2 Cable Routing Refinement

Change. The Fire PRA incorporates detailed cable routing information for cables that were previously treated using an exclusionary routing approach.

Discussion: The "exclusionary routing approach" establishes locations where a cable is not present and, hence, may be credited as operational for fire scenarios impacting those locations. The exclusionary approach is in contrast to detailed cable-routing information that would establish locations where a cable is present and, hence, must be considered a potential fire-damage target for fire scenarios impacting those locations. This change should be considered a maintenance activity under the assumption that the detailed cable routing approach was previously used for other cables and is now extend to additional cables in the analysis with the intent of increasing the level of details of the analysis.

Applicable Technical Element: (CS) Cable Selection and Location

3.4.3 Incipient Fire Detection

Change. An incipient fire-detection system is installed in a physical analysis unit that was previously found to be a significant fire-risk contributor, and the new detection system is incorporated into the Fire PRA; this is the first such system installed at the plant.

Discussion: Incipient fire-detection systems are designed to detect fire precursors during the earliest, or incipient, stage. This detection affords the opportunity for preignition intervention to disrupt or prevent fire development. Incipient fire-detection systems are analyzed using methods that are entirely unique from those applied to other types of detection systems. For this reason, if the plant PRA has not modeled incipient fire detection, this would be considered an upgrade. If incipient fire detection is already modeled and is now expanded to more scenarios, then this should be considered a maintenance activity.

Applicable Technical Element: Fire Scenario Selection and Analysis (FSS)

3.4.4 Refined Fire Modeling

Change. The method for fire scenario analyses for significant physical analysis units is refined.

Discussion: Per the upgrade definition, the key deciding factor is whether any method that was not previously used is applied during the change. If previous methods are used and expanded to new areas, then the change is a maintenance activity. If, for example, there is a change of method from a simple zone-type compartment fire model calculation to a computational fluid dynamics (CFD) fire model, and CFD methods were not applied in the previous revision of the PRA, this change should be considered an upgrade. If CFD was used in some scenarios and is now extended to other scenarios, using the same approach, then this should be considered a maintenance activity.

Applicable Technical Element: Fire Scenario Selection and Analysis (FSS)

3.4.5 Fire Spreading in Cabinet

Change. The Fire PRA is updated to include modeling of a fire scenario spreading from one cabinet to another using the method discussed in Appendix L of NUREG/CR-6850 (Reference 15).

Discussion: The usage of Appendix L of NUREG/CR-6850 should be considered a new method if not previously used; this change should be characterized as an upgrade.

Applicable Technical Element: Fire Scenario Selection and Analysis (FSS) – FSS-A6[5]

3.4.6 Secondary Combustible

Change. The Fire PRA was updated to include treatment of secondary combustibles and new secondary ignition scenarios.

Discussion: Lack of treatment of secondary combustibles would result in not meeting the PRA Standard. Assuming therefore that treatment of secondary combustible was already included in the PRA model at the time of the original peer review, revisions to the amount of secondary combustibles or extension to additional fire scenarios should be considered maintenance.

Applicable Technical Element: Fire Scenario Selection and Analysis (FSS)

3.4.7 Thermally Induced Electrical Failure

Change. Implementation of THIEF fire modeling tool.

Discussion: Assuming this treatment was not included in the PRA model at the time of the original peer review, this change would represent a change in method and should be considered an upgrade.

Applicable Technical Element: Fire Scenario Selection and Analysis (FSS)

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[5] Specific SRs are listed as examples only based on past focused scope peer review. They should not be considered to be exhaustive and the actual scope may change on a plant-specific basis.

3.4.8 Main Control Room Abandonment

Change. The Fire PRA is updated using quantitative guidance for analyzing main control room (MCR) abandonment upon loss of control (LOC) provided in NUREG-1921 Supplement 2 (Reference 24).

Discussion: The use of the MCR abandonment method in NUREG-1921 (Reference 24) represent a new method that was not previously applied and should be considered an upgrade when first implemented in an existing Fire PRA as some elements are not part of the base HRA methods.

Applicable Technical Element: Fire Scenario Selection and Analysis (FSS) – FSS-B1

3.4.9 Obstructed Plume Modeling

Change. The Fire PRA is updated using the guidance for obstructed plume modeling in joint NUREG-2178 Vol 1 (Reference 17).

Discussion: The approach for the obstructed plume model relies upon evaluation of a set of “data” generated by FDS, a fire model. This fire model, although used in some Fire PRAs, had not been used to credit shielding of cables in the top of the electrical cabinet; therefore, this is considered applications of a method in a different context and should be considered an upgrade. Alternatively, if this model was not used in the PRA previously, it would also be a considered an upgrade.

Applicable Technical Element: Fire Scenario Selection and Analysis (FSS)

3.4.10 HEAF Modeling

Change. The Fire PRA is updated using the guidance for HEAF (High Energy Arching Fault) Frequency and Consequence Modeling in NUREG-2262 (Reference 25).

Discussion: The methodology described in NUREG-2262 (Reference 25) addresses the following elements:

- A generic nuclear power plant electrical distribution system fault zone map
- The technical basis for expected fault durations given a fault in a particular zone
- New ignition source counting methodology for Bin 16.a (low voltage switchgears) and Bin 16.b (medium-voltage switchgears)
- Updated HEAF ignition frequencies using operating experience data through 2021
- Updated HEAF manual non-suppression probabilities using operating experience data through 2021
- Zone of Influence (ZOIs) for low voltage switchgears (load centers), medium voltage switchgear, and non-segregated bus ducts (ZOI for the iso-phase bus duct remains unchanged from NUREG/CR-6850, Supplement 1). The equipment-specific ZOIs account for the enclosure material (for bus ducts only), fault duration, and fault location:

  - Load centers: 12 energetic ZOIs based on bus supply circuit breaker location (end or interior), height (top, middle, bottom), bus supply circuit breaker elevation (lower or upper), and fragility threshold (15 MJ/m2 or 30 MJ/m2).
  - Medium-voltage (MV) switchgear: energetic screening ZOIs and configuration/design specific ZOIs are developed. Screening ZOIs are intended to be applied around the entire switchgear bank. When more detail is necessary, configuration specific ZOIs with split fractions are provided separately for Zone 1 and Zone 2 switchgear. These configuration specific ZOIs consider power source, fault clearing time, fault location, and fragility threshold.
  - Non-segregated bus duct (NSBD): 44 energetic ZOIs are provided considering the power source, fault clearing time, enclosure material, and fragility threshold.
  - The characteristics of the post-HEAF thermal fire for low voltage switchgears and medium voltage switchgears

Among those listed above, the following are considered as upgrades as they imply a different method (i.e., assumptions and implementation from the PRA team is different from what may be done before this change):

- New HEAF ignition source counting methods for low voltage switchgears (Bin 16.a) and for medium voltage switchgears (Bin 16.b)
- New Post-HEAF thermal fire modeling guidance for low voltage switchgears and for medium voltage switchgears
- Applying new ZOIs for low voltage switchgears, medium voltage switchgears, and NSBD (Note that iso phase bus duct ZOI remained unchanged from NUREG/CR-6850, Supplement 1 (Reference 15).)

Note that none of these are considered NDMs since they are neither developed separately from a state-of-practice method, nor involve a fundamental change to a state-of-practice method.

Applicable Technical Element:

- Fire Ignition Frequency (IGN): new HEAF ignition source counting methods for load centers (Bin 16.a) and for Medium Voltage Switchgear (Bin 16.b),
- Fire Scenario Selection and Analysis (FSS):
  - Applying new HEA F ZOIs for low voltage switch gears, medium voltage switchgears, and non-segregated bus ducts
  - Applying new post-HEAF thermal fire modeling for low voltage switchgears and for medium voltage switchgears

3.5 SEISMIC PRA EXAMPLES

3.5.1 Seismic Hazard Update

Change. An update of the seismic source characterization catalogue is used to support a revision to the seismic hazard at the plant site.

Discussion: The compilation of a seismic source characterization catalogue is often a regional effort beyond the individual plant expertise and activity. The compilation and update of the catalogue requires a structured program (e.g., Senior Seismic Hazard Advisory Committee – SSHAC – program as discussed in NUREG/CR-6372) that includes a participatory peer review program. Once the catalogue is updated, the regeneration of the seismic hazard at the site should be considered a maintenance activity if the same process used in previous seismic hazard estimates is maintained. If the overall process used to generate the hazard is changed (e.g., from a SSHAC Level 2 to a SSHAC Level 3 approach) then the change is to be considered an upgrade.

Applicable Technical Element: Seismic Hazard Analysis (SHA)

3.5.2 Fragility Analysis Scope

Change. Additional components or failure modes are included within the scope of the seismic fragility analysis.

Discussion: The inclusion of additional components in the seismic fragility analysis should be considered a maintenance activity if the methodology used for the analysis remains the same (e.g., CDFM, or Separation of Variables) as that used in the peer-reviewed S-PRA. This includes the extension of existing fragility analysis to additional failure modes that may have been previously missed or otherwise screened.

Applicable Technical Element: Seismic Fragility Analysis (SFR)
Seismic Plant Response Analysis (SPR)

3.5.3 Fragility Analysis Method

Change. Change in the method used for the determination of seismic fragilities.

Discussion: Deviating from an existing fragility methodology with respect of its usage in the peer-reviewed S-PRA is to be considered an upgrade because the change in method makes this example an upgrade. Change in methods includes performing separation of variables for new or updated fragilities when the previous S-PRA used only CDFM. Scaling of fragilities should also be considered a change in method if scaling criteria were not previously defined.

Applicable Technical Element: Seismic Fragility Analysis (SFR)

3.5.4 Updated or New Fragility due to New Walkdowns

Change. Seismic fragility updates due to follow-up walkdowns.

Discussion: Fragility updates performed as a result of follow-up walkdowns should be considered maintenance activities under the assumption that the process for the walkdowns is maintained consistent with previous walkdowns and the fragilities are calculated following the same methodology. Note that if the screening criteria from the walkdowns are changed (e.g., earthquake level is increased), the conclusions related to seismic interaction may be significantly different; in this case fragility updates due to the new walkdown may be considered an upgrade.

Applicable Technical Element: Seismic Fragility Analysis (SFR)

3.5.5 Partial Correlation of Fragilities

Change. The fragility analysis is updated to support partial correlation of seismic fragilities.

Discussion: The transition from full correlation to partial correlation is a change in method and qualifies as an upgrade.

Applicable Technical Element: Seismic Fragility Analysis (SFR)
Seismic Plant Response Analysis (SPR)

3.5.6 Seismic PRA Model Development

Change. S-PRA event trees are changed to move building failures from the individual system fault trees to be their own top events at the beginning of each event tree.

Discussion: Re-arrangement of the S-PRA model logic should be considered a maintenance activity if it does not change the critical assumptions associated with seismic dependencies.

Applicable Technical Element: Seismic Plant Response Analysis (SPR)

3.5.7 Seismic Human Reliability Analysis

Change. Change in the method used for the evaluation of the impact of seismic-induced performance shaping factors on the Human Reliability Analysis.

Discussion: The change in method makes this update example an upgrade. Change in methods include the transition from a single multiplier per bin approach (e.g., screening approach in the EPRI external hazard HRA guidance, Reference 6) to a more detailed evaluation where seismic-specific performance shaping factors are applied in the different elements of the HRA calculation (i.e., detailed HEP calculation approach). Changing the rationale for the definition of the multipliers, or the number of multipliers, should also be considered a change in method and therefore an upgrade. Changing the intervals (i.e., breaking points) at which the different multipliers are applied should be considered a maintenance activity. If an updated quantification slightly changes the overall plant fragility curve and the criteria for the selection of the breaking points are changed, this would be considered an upgrade.

Applicable Technical Element: Seismic Plant Response Analysis (SPR)

3.5.8 Seismic Human Reliability Analysis – Detailed HEP Refinement

Change. The seismic HRA is updated to include new seismic-specific HFEs; the original analysis only included modification (either simplified or detailed) of applicable internal events operator actions to reflect seismic-specific performance shaping factors.

Discussion: Because seismic-specific operator actions (e.g., relay re-set) are added to the model, supporting requirement SPR-D2 (code case, Reference 16) was previously considered not applicable. As such, even though the same approach used for the generation of basic HFE and detailed HEP quantification, this change qualifies as an upgrade because of the applicability of a new SR. The change in methodology has to do with the seismic-specific elements and PSFs that are built into the new seismic-specific HFEs, as opposed to modified internal events operator actions where the seismic considerations are applied at the end as a multiplier to the total HEP.

Applicable Technical Element: Seismic Plant Response Analysis (SPR) – SPR-D2[6] (code case, Reference16)

3.6 HIGH WINDS PRA EXAMPLES

3.6.1 Tornado Missile Hit Probabilities

Change. The Tornado Missile Strike Calculator (TMSC) is used to determine the wind-generated missile “hit” probability for a high-winds PRA; this method replaces the original methodology, which was implemented via TORMIS.

Discussion: Use of TMSC to replace TORMIS represents a change in the wind-generated missile ‘hit’ probability calculation methodology and should be considered an upgrade. Note that while TORMIS and TMSC are tools, this example represents an upgrade as the methods inherently included within the two codes determine the System, Structure and Components (SSC) failure probabilities from wind-generated missiles differently. Although TORMIS also calculates the hit probability, a conditional failure probability of 1.0 given missile hit is assumed.

Applicable Technical Element: Wind Hazard Analysis (WHA)
Wind Fragility Analysis (WFR)

3.7 EXTERNAL FLOODING PRA EXAMPLES

The examples provided for the external flooding are more conceptual because of the limited experience in External Flooding PRA development compared to other hazard PRAs.

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[6] Specific SRs are listed as examples only based on past focused scope peer review. They should not be considered to be exhaustive and the actual scope may change on a plant-specific basis.

3.7.1 Use of Mechanistic Model for Flood Hazard Evaluation

Change. An external flooding hazards assessment based on the extreme value estimates method is changed to use a mechanistic model for the hazard assessment.

Discussion: This change is a fundamental change in the way the hazard is calculated and is therefore an upgrade. If a mechanistic model is already used in a previous version of the external flooding PRA and only the underlying data are updated, (e.g., to reflect the availability of more recent or updated data) then the change would be considered a maintenance activity.

Applicable Technical Element: External Flooding Hazard Analysis (XFHA)

3.7.2 External Flooding Procedures

Change. The external flooding PRA is changed to reflect external flooding procedures modified at the plant.

Discussion: Similar to other hazards, updating a PRA to reflect a procedure change that uses HRA methods already applied should be considered a maintenance activity. In the case of external flooding, a nuance exists because external flooding procedures may involve considerations of organizational factors that would likely need to be addressed with a different HRA method. In this case, the change would represent an upgrade because of the use of a different method, not necessarily related to the update in the procedures.

Applicable Technical Element: External Flooding Plant Response Model and Quantification (XFPR)

4 EXAMPLES OF PRA METHODS AND NDMS

The purpose of this section is to provide a listing of examples of PRA methods and their characterization as NDMs. The listing of methods presented herein is not intended to be a comprehensive list of historical methods that are to be considered state of practice methods.

As discussed in Reference 2 and Reference 3, an NDM peer review is only one possible avenue for the technical adequacy assessment of a PRA method. A direct review by the USRNC is always an acceptable path.

Note that some methods developed in collaboration with or by the U.S. NRC may be considered NDM per the definition. This is due to the fact that a new U.S. NRC developed method (e.g., a method documented in a NUREG) that is not yet state of practice and has not yet been used in a risk-informed application accepted by the U.S. NRC may technically meet the definition of NDM.

A NDM technical acceptability peer review is not expected to add value to NDMs documented in NUREGs. Submission of such methods to the NRC as part of a risk-informed application is expected to be more efficient if the methods are used without deviations. NRC reviewers would then review those NDMs as a part of the licensing actions. However, the level of effort for such reviews can vary based on several factors such as the context of the method documented in the NUREG compared to its use in the PRA (i.e., was the method intended for use in a PRA), extent of familiarity of the reviewers with the NDM, level of specificity for the NDM (e.g., framework or implementation details), or any deviations from the method documented in the NUREG. If NDMs documented in NUREGs are used without submission to the NRC staff as part of licensing actions, review of the methods can occur under the oversight process subject to the above caveats about the level of effort.

If a specific submittal requires a utility to indicate if any NDM methods were used, a U.S. NRC method that is judged to meet the definition of NDM would need to be listed; however, an NDM peer review need not be performed.

If modifications to the method are proposed, then the technical adequacy of the modified method should be assessed following the appropriate process.

PRA methods may apply different degrees of expert elicitation applied to different contexts. The NRC white paper Practical Insights and Lessons Learned on Implementing Expert Elicitation (Reference 34) identifies a number of applications of expert elicitation in support of PRA models, including estimation of loss-of-coolant-accident frequencies (NUREG-1829, Reference 35); estimation of human error probabilities for methods of human reliability analysis (e.g., NUREG-2199, Reference 36); and estimations of probabilistic seismic hazards (NUREG/CR-6372, Reference 37). Thus, expert elicitation is clearly a consensus method that has been utilized extensively in PRAs. Expert elicitation per se is not to be considered a NDM even if applied to different context, under the assumption that a recognized and structured approach is applied.

Sections 4.1 and 4.2 list examples of methods that can be defined as NDMs; based on the definitions provided in Section 2, these methods are defined as either being developed separately from the state of practice or involving a fundamental change to a state of practice method. Section 4.3 discusses a method that was concluded not to be an NDM. The list of methods presented herein is provided as an exemplification of what constitutes an NDM, and the inclusion of these NDMs as examples does not make any statements regarding their acceptability by the NRC.

4.1 METHODS DEVELOPED SEPARATELY FROM STATE OF PRACTICE

4.1.1 Room Cooling PRA Screening and Modeling

PWROG-18027-NP, Revision 0 (Reference 7) discusses a method for addressing loss of room cooling. The method includes a screening approach and criteria to decide whether loss of room cooling needs to be modeled in the PRA. The method also addresses the conditional failure probability of equipment based on the increased room temperature due to the loss of room cooling; this replaces the assumption of guaranteed equipment failure if the HVAC system fails.

One of the drivers for this method was that there was not a state-of-practice methodology for screening failure of HVAC. It is therefore judged to have been developed “separately from a state-of-practice method” which would constitute it as an NDM per the definitions provided in Section 2.

An NDM peer review and a subsequent F&O closure was performed for this method, as documented in PWROG-19020-NP, Revision 1 (Reference 8). The conclusion of the peer review and F&O closure is that the method meets the requirements documented in Reference 2 with no open F&Os. As such, the implementation of this method in a PRA does represents an upgrade but only a plant-specific implementation peer review is needed.

4.1.2 Fraction of Complete Fire Damage to a NUREG-2187 Volume 1 Group 4 Electrical Cabinet

This method addresses the development of scenarios for in-cabinet fire damage of a multi-function control cabinet defined as a NUREG-2178 (Reference 17) Vol. 1 Group 4 Electrical Cabinet. This method is not applicable to switchgear, load centers, Motor Control Center (MCCs), inverters or battery chargers. This method is only applicable to cabinets with diverse power supplies functions. This would include power being maintained for spurious actuation. This method is used to sub-divide fire scenarios that, per NUREG/CR-6850 (Reference 15) Section 8.5.1.2 (pg. 8-10), would only damage a single cabinet and is considered a method developed separately from state of practice. This improves on the existing practice of assuming full damage of the ignition source at the time of ignition. This method establishes a frequency modifier to predict the likelihood that a fire will result in a partial loss of cabinet functions as well as the likelihood all functions will be lost. Consequently, this approach reduces the overall frequency for the loss of all functions associated with an electrical cabinet meeting the criteria for the application of the method.

4.1.3 Main Control Room Abandonment on Loss of Control

NUREG-1921 (Reference 21), Supplement 2 provide quantitative guidance for analyzing MCR abandonment upon LOC. Prior to this document, no quantitative guidance has been issued by

NRC or industry on the decision to abandon the MCR upon LOC and it is therefore judged to have been developed “separately from a state-of-practice method” which would constitute it as an NDM per the definition.

It is recognized that this method was developed jointly by EPRI and NRC and therefore a technical adequacy evaluation (i.e., an NDM peer review) is not needed for this method (see the discussion at the beginning of Section 4).

4.2 METHODS INVOLVING A FUNDAMENTAL CHANGE TO A STATE OF PRACTICE METHOD

4.2.1 Tornado Missile Strike Calculator (TMSC)

The TMSC is a software tool that implements a different method for the calculation of wind-borne missile strike probabilities during a tornado or straight-line wind event (i.e., thunderstorm or extratropical storm) and should be considered an NDM. The method implemented by TMSC is fundamentally different from the method applied by TORMIS, which is considered state of practice. TORMIS performs explicit calculations of aerodynamic forces at each location relative to the wind field at a small time step and then calculates the resulting trajectories of missiles for a small subset of the missile population. It then uses statistical techniques to estimate missile hit probabilities for the entire missile population. The TORMIS basis is well documented and is associated with an NRC safety evaluation concluding that “the methodology can be utilized when assessing the need for positive tornado missile protection for specific safety-related plant features in accordance with the criteria of SRP Section 3.5.1.4” (Reference 20). TORMIS has been used in support of several risk-informed application submittals that were approved by the NRC.

TMSC Version 1.0 Beta 1 (Reference 22) performs a similar calculation of aerodynamic forces and resulting missile trajectories in an external process, then creates probability distributions that missiles will achieve a certain distance or height in a given wind event, and samples those probability distributions using a Monte Carlo process to estimate the hit probabilities (i.e., does not explicitly use a time step). TMSC Version 1.0 Beta 2 (not yet released at the time this report is written) is more similar to TORMIS in that it performs explicit calculations of aerodynamic forces and resulting missile trajectories at a small time step but differs from TORMIS in that it performs these calculations for the entire missile population (i.e., does not use the statistical techniques TORMIS does to apply results from a sample to the entire missile population). Another key difference between TMSC and TORMIS is that neither of the existing beta versions of TMSC calculate the conditional failure probability of an SSC given a missile hit. Both versions of TMSC represent a fundamental change to a state-of-practice method (i.e., TORMIS).

4.2.2 Partial Correlation of Seismic Fragilities

The assumption of full correlation of SSCs for seismic failures is the current state of practice for S-PRAs. This translates into assuming that similar components modeled in a single fragility group based on the same expected seismic demand and the same expected seismic capacity, thus it is assumed that they will fail together (i.e., if one fails the other fails). In the current state of practice, components are either completely correlated (i.e., a correlation factor of 1.0) or completely uncorrelated (i.e., a correlation factor of 0.0). A method to assess partial correlation of seismic failure for SSCs (i.e., a correlation factor between 1.0 and 0.0) is developed in Reference 19 and is considered a fundamental change from the state of practice.

It is recognized that this method is an NDM per the definition, although it was developed by the NRC and therefore a technical adequacy evaluation (i.e., an NDM peer review) is not needed for this method under the assumption that the method is implemented as described (see the discussion at the beginning of Section 4).

4.2.3 Updated Thermally-Induced Steam Generator Tube Rupture (TI-SGTR) Methodology

Appendix C or PWROG-21024-P (Reference 26) developed an updated and more detailed TI-SGTR methodology that incorporates features of two separate state-of-practice methods. The TI-SGTR methodology in Appendix C of PWROG-21024 (Reference 26) was developed separately from the prior state-of-practice methodology offered in WCAP-16341-P (Reference 27) and also includes several modifications to the TI-SGTR methodology presented in NUREG-2195 (Reference 28) that represent a fundamental change to that methodology. Specifically, this analysis extends the applicability of the High, Dry, Low Intact (HDLI) condition analyzed in NUREG-2195 (Reference 28) to the High, Dry, High, Intact (HDHI) and High, Dry, High, Cleared (HDHC) conditions by applying scaling factors or other assumptions from WCAP-16341-P (Reference 27) and NUREG-1570 (Reference 29).

4.3 METHODS NOT CONSIDERED NDMS

4.3.1 Component Recovery Modeling

PWROG-16029-P, Revision 0 (Reference 18) provides recovery data for a subset of pumps based on expert elicitation and recommends specific methods for implementing recovery parameters into PRA models. The method provided in Revision 0 of PWROG-16029-P (Reference 18) was considered to be an NDM and had an NDM peer review performed. One of the drivers for determining that the method in Revision 0 of PWROG-16029-P was an NDM is that there is not a state-of-practice methodology for the modeling of component recovery and it was therefore judged to have been developed “separately from a state-of-practice method” per the definition of an NDM. However, following the NDM peer review of Revision 0, significant modifications were made such that the updated method (documented in PWROG-16029-P, Revision 1, Reference 30) has been judged to no longer be an NDM. This is based on the following considerations:

> The method for generating recovery-time estimates uses expert elicitation applied to pump recovery data. Expert elicitation is a consensus method since it has been used in a number of applications, principally by the U.S. NRC. Recovery-time estimates have been developed for offsite power (Reference 31) and for diesel generators (Reference 32), but without explicit application of expert elicitation. The application of expert elicitation to generate recovery-time estimates, as done in this project, could be considered an

enhancement over the methods used for recovery-time estimates for offsite power and diesel generators.

The method for adjusting recovery times with the adjusted recovery times combined into non-recovery curves involves modifying the experts' recovery-time estimates to account for the additional complications of recovery in an accident sequence context, using the structure of existing HRA methodology.

The method for adjusting recovery times uses the structure for human reliability analysis as implemented in the EPRI HRA Calculator (Reference 33), with distinct contributions from cognitive-type actions and execution-type actions and accounting for times associated with delay, cognition, and execution. Thus, this method is clearly a consensus method that has been utilized extensively in PRAs.

The recovery time is used in two separate PRA applications. The first is the process of generating Non-Recovery Probability (NRP) curves from adjusted recovery times, which involves standard data analysis techniques. These NRP curves could be used as part of routine PRA maintenance and are not NDMs. The use of NRP Curves is similar to the application of offsite power recovery that is often used in plant PRAs; however, because of the differences in accident sequences that need to be considered for pump recovery, this method could be considered in a "different context". In addition, it is likely that such changes in a PRA would result in the applicability of supporting requirements (such as SY-A24 and DA-C15 related to modeling the repair of hardware faults) that are typically not included in PRAs. Thus, it is expected that application of NRP curves would constitute a PRA upgrade. However, this is not a newly developed method.

A second application utilizes component recovery data in the estimation of the Mean Time to Recovery (MTTR) for a Support System Initiating Event (SSIE) model. The MTTR represents the mission time of the standby component during the repair of the failed normally-running component, consistent with requirement IE-C10. This is the same as the method used for SSIEs in utility PRAs and is in the same context. This would not make any SRs newly applicable. Thus, it is expected that application of this NRP method would constitute PRA maintenance and this is not a newly developed method.

In summary, the updated method discussed in PWROG-16029-P, Revision 1 (Reference 30) includes multiple PRA upgrades, but none are classified as NDMs.

5 CONCLUSIONS

The current report is designed as a compilation of examples of PRA changes and their catheterization as PRA upgrade or PRA maintenance. This is provided as a guidance document to support the characterization of plant-specific PRA changes to be performed as part of the PRA Configuration Control process at each site.

The report also provides a compilation of examples of PRA methods along with their characterization as whether they are NDMs. Usage of a new method will require a plant-specific implementation peer review after being used at a site PRA. An NDM not yet peer reviewed will also require an NDM peer review or other equivalent assessment of the technical adequacy of the method (e.g., direct review by the NRC).

This compilation is intended to be updated periodically when new examples of PRA upgrade and maintenance are encountered in the industry or when new PRA methods are available.

Note that there is an expectation that a notification is provided to the U.S. NRC of the fact that an NDM peer review has been conducted. This is a step discussed in PWROG-19027-NP (Reference 2) to ensure that a referenceable document is made available of the peer review for plants that want to use the method in the future. There is no formal submittal process for this and a simple letter for information may be generated. For the room cooling PRA screening and modeling method discussed in Section 4.1.1, PWROG letter OG-20-203 was used to communicate the completion of the NDM peer review and F&O closure (see Reference 8).

For the majority of the risk-informed applications and for the day-to-day usage of the PRA for risk-formed decision making, there are no requirements for a submittal or any notification to the U.S. NRC that the plant-specific PRA has been updated. Similarly, there are no requirements for a submittal or any notification to the U.S. NRC that an NDM was part of the change in the PRA. It remains an expectation of the PRA configuration control program at the site that all changes in the PRA are assessed for upgrade and maintenance and that any focused scope peer review of any upgrade is maintained available for audit.

An exception to the above for plants who submit License Amendment Requests to adopt TSTF-505-A, Rev. 2 for the Technical Specification Risk Informed Completion Time Program is that a *report shall be submitted in accordance with Specification [5.6.8] following each PRA upgrade and associated peer review involving a newly developed PRA method that has not been previously reported to the NRC for a RICT program.*

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