Enclosure 3 to AEP-NRC-2016-81

Donald C. Cook Focused Scope Peer Review – Pre-Initiator Human Reliability Analysis

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D.C. COOK FOCUSED SCOPE PEER REVIEW – PRE-INITIATOR HRA

Prepared For

AEP INDIANA MICHIGAN POWER®
A unit of American Electric Power

Donald C. Cook Nuclear Plant
Indiana Michigan Power Company

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Approver: Brandon Irvin	[signature]	10/11/2016

REVISION RECORD SUMMARY

Revision	Revision Summary
0	Initial Issue

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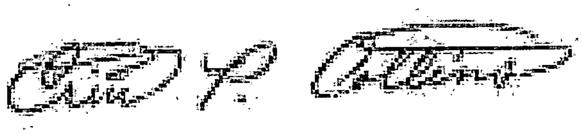
PEER REVIEWER SIGNATURE PAGE

I participated as a reviewer of the Focused Scope Peer Review of the D.C. Cook Pre-Initiator HRA completed in June 2016. I have not participated in the development or preparation of any portion of the D.C. Cook Level 1 PRA that I reviewed. I have verified that this report reflects the process used, and the element grading, facts, observations and conclusions resulting from the review.



Erin P. Collins
JENSEN HUGHES

EXECUTIVE SUMMARY

This report summarizes the results of a focused scope peer review to assess the compliance of the D.C. Cook pre-initiator Human Reliability Analysis (HRA) task for the internal events PRA. The review was performed against selected Supporting Requirements (SRs) related to pre-initiator HRA from the American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) PRA standard [Reference 1].

The scope of this review was confined to HRs-A1 through C3 on the process for identifying and screening pre-initiator HFEs. HR-D1 through D7 were not addressed because the pre-initiator quantification methodologies (THERP and ASEP) are unchanged from the previous analysis. It was concluded by D.C. Cook that the HEP development did not involve a new method and therefore was not part of the focused scope peer review.

This review was performed using the process defined in Nuclear Energy Institute (NEI) 05-04 [Reference 2] in accordance with the guidance in Appendix B of NRC Regulatory Guide RG 1.200, Rev. 2 [Reference 3], considering regulatory interpretations of the PRA Standard as published in Appendix A of RG 1.200.

As a result of this focused scope peer review, all SRs were found to be met. The D.C. Cook pre-initiator HRA update was considered to be of very good technical quality, addressed the high level and supporting standard requirements clearly and directly, and was for the most part well documented. Regarding Findings and Observations (F&Os), three (3) suggestions and one (1) finding were made, as summarized in Table ES-1 and described in detail in Appendix C.

Table ES-1 Pre-Initiator HRA Focused Scope Peer Review Results Summary

SR	Capability Category Compliance	F&Os
HR-A1	Meets All CCs	Suggestion
HR-A2	Meets All CCs	
HR-A3	Meets All CCs	Suggestion
HR-B1	Meets CCII/III	Suggestion
HR-B2	Meets All CCs	Finding
HR-C1	Meets All CCs	None
HR-C2	Meets CCII/III	None
HR-C3	Meets All CCs	None

1.0 INTRODUCTION

This report documents the focused scope peer review conducted by JENSEN HUGHES of the pre-initiator HRA task for the internal events PRA. This focused scope peer review is required to address a Request for Additional Information (RAI) by the U.S. NRC regarding use of a new method for the complete revision of the pre-initiator HRA completed in June 2016. The review was performed against selected Supporting Requirements (SRs) related to pre-initiator HRA from the American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) 2009 PRA standard [Reference 1].

This review was conducted by one individual, consistent with Section 1-6.2.4 of the PRA Standard, which states that "A single-person peer review shall only be justified when the review involves an upgrade of a single element and the reviewer has acceptable qualifications for the technologies involved in the upgrade." As stated in Nuclear Energy Institute (NEI) 05-04 [Reference 2], "It is assumed with regard to the independence requirement of [ASME/ANS PRA Standard] Section 1-6.2.1 (1.6.2.2) that reasonable and practicable interpretation will be made allowing, as needed, use of non-involved utility personnel from other sites for multi-site utilities, use of current contractors (on-site or otherwise) involved in other work, etc. A requirement of absolute independence coupled with the need for adequate technical expertise can be difficult to achieve in some situations."

Since the review was conducted by an individual with 30+ years of HRA experience working for a current contractor to AEP who did not perform the pre-initiator HRA, the requirements of independence and eligibility are considered to have been met.

2.0 PURPOSE AND SCOPE

2.1 Purpose

The purpose of the focused scope peer review was to evaluate the D.C. Cook internal events PRA pre-initiator HRA completed in June 2016 against the relevant requirements from the 2009 ASME/ANS PRA standard [Reference 1]. This assessment was performed using the process defined in Nuclear Energy Institute (NEI) 05-04 [Reference 2] in accordance with the guidance in Appendix B of NRC Regulatory Guide RG 1.200, Rev. 2 [Reference 3], considering regulatory interpretations of the PRA Standard as published in Appendix A of RG 1.200. Consistent with this process, findings and observations (F&Os) were issued where the analysis was found not to have met the Standard.

This review was performed against the approach and modeling revisions conducted for the pre-initiator HRA of the D.C. Cook internal events PRA as documented in PBA-NB-HRA-PRE, the Pre-Initiator HRA Notebook [Reference 4]. The pre-initiator HRA revisions were performed in response to F&Os obtained during a full scope peer review of the Internal Events PRA completed in 2015 [Reference 5]; these F&Os are listed in Appendix D of this report.

Following the update of the pre-initiator analysis, D.C. Cook submitted a Licensee Amendment Request (LAR) for adoption of Initiative 5b / TSTF-425 on Licensee control of surveillance frequencies [Reference 6]. The U.S. NRC review of the LAR resulted in the following Request for Additional Information (RAI):

RAI-PRA-1-01

In response to RAI-PRA-1, Indiana Michigan Power Company (I&M, the licensee) stated that the dispositions to the Facts and Observations (F&Os) on the pre-initiator Human Reliability Analysis (HRA) from the license amendment request (LAR) have been "replaced by a new analysis," similar to a methodology used by other licensees. Based on this response, it would seem that the methodology for pre-initiator HRA is a new methodology and constitutes a probabilistic risk assessment (PRA) upgrade as stated in the ASME/ANS PRA standard, in that "new should be interpreted as new to the subject PRA even though the methodology in question has been applied in other PRAs" (Section 1-A.1 of ASME/ANS RA-Sa-2009). Specifically cited as "Example 24" in Section 1-A.3.24 of ASME/ANS RA-Sa-2009 is that employing a different HRA approach to human error analysis constitutes a PRA upgrade.

a) If the "new analysis" fits the definition and criteria of ASME/ANS RA-Sa-2009 of a new methodology, and, therefore, a PRA upgrade, perform a focused scope peer review on the affected supporting requirements (i.e., at a minimum, those related to HRA in the applicable parts of ASME/ANS RA-Sa-2009), and provide the F&O's with a description of the impact to the TSTF-425 program.

b) If the "new analysis" does not fit the definition and criteria of a new methodology, explain why it does not fit the definition of a PRA upgrade as defined in the ASME/ANS Standard.

ASME/ANS PRA Standard Section 1-2 contains the following definition of a PRA upgrade:

PRA upgrade: the incorporation into a PRA model of a new methodology or significant changes in scope or capability that impact the significant accident sequences or the significant accident progression sequences. This could include items such as new human error analysis

methodology, new data update methods, new approaches to quantification or truncation, or new treatment of common cause failure.

Based on the RAI, the conclusion by D.C. Cook was to perform a focused scope peer review on the pre-initiator HRA to address the "New Analysis" concern.

2.2 Scope

For this focused scope peer review, only SRs for Internal Events related to the identification and screening of pre-initiator HFEs were reviewed and not those associated with pre-initiator HFE quantification. The reason for this scope is that the pre-initiator quantification methodologies (THERP and ASEP) for the 2016 analysis are unchanged from the previous analysis, so D.C. Cook concluded that the HEP development was not a new method and therefore would not be not part of the focused scope peer review.

Table 2-2 lists the specific supporting requirements of the ASME/ANS PRA Standard that formed the scope of this peer review. These SRs are a subset of those provided in Section 2-2 of the PRA Standard [Reference 1]. This scope definition is consistent with the Section 1-5.4 of the Standard, which states that "Changes to a PRA due to PRA maintenance and PRA upgrade shall meet the requirements of the Technical Requirements Section of each respective Part of this Standard. Upgrades of a PRA shall receive a peer review in accordance with the requirements specified in the Peer Review Section of each respective Part of this Standard, but limited to aspects of the PRA that have been upgraded."

In addition to a review of the applicable SRs, the adequacy of responses to F&Os generated in the 2015 peer review of the D.C. Cook pre-initiator HRA were also considered.

Table 2-2 Focused Scope Peer Review Relevant SR List

SR	Summary Description
HR-A1	Identification of activities that require realignment of equipment
HR-A2	Identification of activities that require recalibration of equipment
HR-A3	Identification of work practices that involve simultaneous impacts to either different trains of a redundant system or diverse systems of equipment
HR-B1	Establishment of rules for screening activities from further consideration
HR-B2	Not screening activities consistent with HR-A3
HR-C1	Define HFEs for further consideration
HR-C2	Include modes of unavailability that result from restoration errors and add failure modes identified through operating experience data collection
HR-C3	Include impact of miscalibration as a failure mode of standby system initiation

3.0 REFERENCES

The following references were used in the development of this report:

1. ASME/ANS RA-Sa-2009, Addenda to ASME/ANS RA-S-2008, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications, The American Society of Mechanical Engineers, New York, NY, February 2009.
2. NEI 05-04, Process for Performing Internal Events PRA Peer Reviews Using the ASME/ANS PRA Standard, Rev. 2, Nuclear Energy Institute, November 2008.
3. Regulatory Guide 1.200, Revision 2, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," U.S. Nuclear Regulatory Commission, Washington DC, March 2009.
4. D.C. Cook Calculation, Pre-Initiator Human Reliability Analysis Notebook, PRA-NB-HRA-PRE, Revision 7, 30 June 2016.
5. Pressurized Water Reactor (PWR) Owner's Group, "Peer Review of the D. C. Cook Nuclear Plant Internal Events Probabilistic Risk Assessment", PWROG-15076-P, Revision 0, Westinghouse Electric Company LLC, Cranberry Township, PA, September 2015.
6. Supplement to License Amendment Request to Adopt TSTF-425-A, Revision 3, "Relocate Surveillance Frequencies to Licensee Control – Risk Informed Technical Specification Task Force (RITSTF) Initiative 5B", AEP-NRC-2016-17, Donald C. Cook Nuclear Plant Units 1 and 2, 4 February 2016.

4.0 FOCUSED SCOPE PEER REVIEW

4.1 Overview of Review Process

The purpose of the PRA peer review process is to provide a method for establishing the technical capability and adequacy of a PRA relative to expectations of knowledgeable practitioners, using a set of guidance that establishes a set of minimum requirements. Full-scope and focused scope peer reviews that cover the scope of the ASME/ANS PRA Standard will use the supporting requirements (SRs) in Part 2 of the 2009 ASME/ANS PRA Standard [Reference 1].

The PRA peer review process is a tiered review process in which the reviewer begins with a relatively high level examination of the PRA technical element(s) against the requirements, and progresses successively to additional levels of detail as necessary to ensure the robustness of the model until all of the requirements are adequately reviewed.

Implementing the review involves a combination of a broad scope examination of the PRA element(s) within the scope of the review and a deeper examination of portions of the PRA element(s) based on what is found during the review. The SRs provide a structure which, in combination with the peer reviewers' PRA experience, provides the basis for examining the various PRA technical elements. The supporting requirements help to ensure completeness in the review. If a reviewer discovers a question or discrepancy, it is expected that a more thorough, detailed search will be conducted.

4.1.1 Capability Categories

For each SR, action statements define the minimum requirements necessary to meet a specific Capability Category. Some of the SR action statements apply to only one Capability Category, while others extend across two or three Capability Categories. When an action statement spans multiple categories, it applies equally to each Capability Category. When necessary, the differentiation between Capability Categories is made in other associated SRs. The interpretation of a SR whose action statement spans multiple categories is stated in Table 4-1. It is intended that, by meeting all the SRs under a given High Level Requirement (HLR), a PRA will satisfy the intent of that HLR.

Table 4-1 Interpretation of Supporting Requirements[1]

Action Statement Spans	Peer Review Finding	Interpretation of the Supporting Requirement
All Three Capability Categories (I/II/III)	Meets SR	Capable of supporting applications in all Capability Categories
	Does not meet SR	Does not meet minimum standard
Single Capability Category (I or II or III)	Meets individual SR	Capable of supporting applications requiring that Capability Category or lower
	Does not meet SR	Does not meet minimum standard
Lower Two Capability Categories (I/II)	Meets SR for CC I/II	Capable of supporting applications requiring Capability Category I or II

Table 4-1 Interpretation of Supporting Requirements[1]

Action Statement Spans	Peer Review Finding	Interpretation of the Supporting Requirement
	Meets SR for CC III	Capable of supporting applications in all Capability Categories
	Does not meet SR	Does not meet minimum standard
Upper Two Capability Categories (II/III)	Meets SR for CC II/II	Capable of supporting applications in all Capability Categories
	Meets SR for CC I	Capable of supporting applications requiring Capability Category I
	Does not meet SR	Does not meet minimum standard

Note 1: This is a reproduction of Table 1 from NEI 05-04 [Reference 2].

4.1.2 Peer Reviewer Assignment

This focused scope peer review of the D.C. Cook Internal Events PRA pre-initiator HRA identification and screening was conducted by Ms. Erin P. Collins of JENSEN HUGHES, whose full resume is included as Appendix F.

Ms. Collins is a Senior Consultant with 32 years of experience in safety, reliability, and risk assessment, specializing in data analysis and human reliability analysis for nuclear, chemical, and aerospace applications. She performed the Internal Events pre-initiator HRA update for Diablo Canyon, and assisted with the resolution of medium-priority F&Os for the Diablo Canyon Internal Events PRA peer review. Ms. Collins also participated in the Westinghouse PWR Owner's Group sponsored internal events PRA peer review teams for the H.B. Robinson and Indian Point 2 nuclear plants, serving as lead in the areas of Human Reliability Analysis, Accident Sequence Analysis, and Initiating Events. In addition, she participated in the Dominion sponsored limited scope internal events peer review of the Millstone 3 plant, leading the review of selected SRs under Data Analysis, Human Reliability Analysis, and Internal Flooding.

Ms. Collins is on the team developing EPRI-NRC RES Guidelines for Main Control Room Abandonment HRA and was the Principal Investigator for the EPRI Guidelines for PRA Data Analysis. She was an author of the NUREG-1921 Fire HRA Guidelines and was an instructor for the EPRI/NRC Fire PRA Training Course Fire HRA module. She was a key technical participant in the Fire HRA Task of the Fire PRAs for Prairie Island, Monticello, ANO-1, Nine Mile Point 1 and Kewaunee plants and provided review and input to the HRAs for the ANO-2, Browns Ferry, R.E. Ginna and Palo Verde Fire PRAs. She was also a primary analyst for the Main Control Room abandonment HRAs for the Diablo Canyon and V.C. Summer Fire PRAs. Ms. Collins was a reviewer of the EPRI Seismic HRA methodology and is a key participant on the JENSEN HUGHES Seismic HRA team for the Duke Energy fleet Seismic PRA projects.

4.1.3 Statement of Independence

Ms. Collins has had no previous involvement in the D.C. Cook Level 1 PRA. This is certified by the peer reviewer signature in the front matter of this report. This satisfies the independence requirements of Section 1-6.2.2(b) of the ASME/ANS PRA Standard [Reference 1].

4.2 Specific Review Information

A focused scope review of the D.C. Cook Level 1 pre-initiator HRA was performed as defined in Section 2 of this document. The review covered the applicable Supporting Requirements (SRs) from the ASME/ANS PRA Standard Part 2 as identified in Table 2-2.

A kick-off web conference was held on September 16, 2016 to provide the reviewer with an overview of the background, the scope and to introduce the review to the site and contractor contacts. A subsequent teleconference was held on September 22, 2016 to provide preliminary insights by the reviewer and to discuss initial questions.

Table 4-2 provides a list of the primary documents and databases that AEP supplied as documentation for those portions of the HRA within the scope of the peer review.

Table 4-2 Documentation List

Document Number	Title
PRA-NB-HRA-PRE	D.C. Cook Pre-Initiator Human Reliability Analysis Notebook, Rev. 0, June 2016
PRA-NB-HRA	D.C. Cook Human Reliability Analysis Notebook, Rev. 7, June 2016
DC Cook Pre-Initiators v51-041816.HRA	HRA Calculator file v. 5.1 of pre-initiator HFEs
DCC Pre Procedures	Folder of procedures relevant to calibration and post-maintenance testing, including shift rounds and day rounds
OP-1-5XXX Drawings	Unit 1 P&IDs
OP-2-5XXX Drawings	Unit 2 P&IDs
OP-1-98XXX and 99XXX drawings	ESFAS P&IDs
Solid state reactor protection and safeguards system drawings	Protection system P&IDs
PRA-NB-SY-XXXX	PRA System Notebooks

The focused scope peer review was performed using the process defined in Nuclear Energy Institute (NEI) 05-04 [Reference 2] in accordance with the guidance in Appendix B of NRC Regulatory Guide RG 1.200, Rev. 2 [Reference 3], considering regulatory interpretations of the PRA Standard as published in Appendix A of RG 1.200.

The entire text of sections 1.0 through 3.1.1 of the PRA-NB-HRA-PRE, as well as Appendices A, C and D, were reviewed. In addition, spot checks of procedures and P&IDs were conducted against the defined HFE descriptions in sections 3.1.2 through 3.1.21 as a review mechanism.

The quantification sections 4.0 and Appendix B were not within the scope of this review.

A preliminary assessment of compliance with the ANS/ASME PRA Standard SRs was performed by the reviewer prior to comparison with the Appendix C self-assessment. The comparison served as a confirmation of the reviewer's assessment for the most part, and in some cases, as an indication of information that should be re-considered in the review.

The identification of any issues/problems that were considered to impact the capability of the PRA was documented as an F&O. The importance of each such observation was classified consistent with the guidance in NEI 05-04 as either of the following categories:

Finding – an observation (an issue or discrepancy) that is necessary to address to ensure:

- the technical adequacy of the PRA (relative to a Capability Category),
- the capability/robustness of the PRA update process, or
- the process for evaluating the necessary capability of the PRA technical elements (to support applications)

Suggestion – an observation considered desirable to maintain maximum flexibility for PRA applications and consistency with industry practices. Failing to resolve a suggestion should have no significant impact on the PRA results or the integrity of the PRA. Some examples of a suggestion include:

- editorial and minor technical items
- recommendations for consistency with industry practices (e.g., replacing a given consensus model with a more widely used model)
- recommendations to enhance the PRA's technical capability as time and resource permit
- observations regarding PRA technical adequacy that may affect one or more risk-informed applications

This approach of classifying F&Os replaces the A/B/C/D significance level approach used in the original NEI 00-02 Peer Reviews, and the modification (with combined A/B) recommended in the original version of NEI 05-04 [Reference 2].

As a result of this focused scope peer review, one (1) finding and three (3) suggestions were made, as described in Appendix C.

4.3 Review of Previous Peer Review F&Os and Resolutions

Another part of the focused scope peer review was to examine the F&Os related to the pre-initiator HRA SRs within the scope of this review that were issued during the previous full scope peer review conducted in 2015.

Appendix D provides a table that lists the F&Os issued from this 1999 peer review, that were associated with common cause failure technical sub-elements. These sub elements were correlated to SRs from the PRA Standard based on the subject matter; this correlation is also shown in the table. The text of the F&O is given as is the D.C. Cook response and the focused scope peer review evaluation of the adequacy of the response.

As a result of this review, no F&Os from the 2015 peer review were considered to be still outstanding; they had all either been addressed or their omission was adequately justified by D.C. Cook.

4.4 Pre-Initiator HRA Assumptions and Sources of Uncertainty

The identification of assumptions and sources of uncertainty is listed in NEI 05-04, Section 4.7 as one of the recommended elements of a Peer Review Report. Table 4-3 summarizes the assumptions from Table 4.6 of PBA-NB-HRA-PRE that are relevant to the scope of this focused scope peer review. Notes are inserted in this table where F&Os have been issued by this review against the issues cited in the assumptions.

Table 4-3 D.C. Cook Pre-Initiator HRA Assumptions Relevant to Scope of Focused Scope Peer Review

Assumption	Basis
Maintenance acts that are performed incorrectly and result in component failure during a subsequent demand (e.g., misaligned motor bearing) are already included in failure data (including common cause data) for the component and are not considered for inclusion in the pre-initiator HRA.	Equipment failure data analysis is not performed at a high enough level of detail to consistently exclude failures that are caused by operator error. HRA methodologies are not advanced enough to identify or quantify errors at the level of detail that would include all of the failure modes associated with maintenance tasks. This assumption helps to ensure that the contributions to equipment failures are not double counted.
The HEP identification process can be limited to those systems and components modeled in the PRA.	Extensive effort has been expended as part of the accident sequence modeling tasks to capture the systems and components that can impact plant risk. This effort does not need to be duplicated for the HRA. The impact of excluding systems that do not impact plant risk from the HEP identification process is not expected to have any impact on the PRA results. The exception would be if items of potential importance had been overlooked; however, the intent of the HRA process is not to serve as a check of previous work.
Normally running systems can be screened in the HEP identification process provided that the running condition would identify any Type A failure.	Latent errors that would become immediately apparent when the system is returned to service would be addressed at the time of the return to service and the errors would not be contributors to a system's failure probability. The assumption reflects the operation of the plant and precludes the retention of Type A errors that would not realistically exist.
Single train HFEs may be screened from further review if: Equipment is automatically re-aligned on system demand, or Following test and maintenance activities, a post-maintenance functional test is performed that reveals misalignment, or Equipment position is indicated in the control room, status is routinely checked, and realignment can be affected from the control room, or Equipment status is required to be checked frequently (i.e., at least once a shift)	The basis is SR HR-B1 of the ANS/ASME PRA Standard. Slightly non-conservative in that there are potentially very low contributions from single train failures that would be excluded from the model.

Table 4-3 D.C. Cook Pre-Initiator HRA Assumptions Relevant to Scope of Focused Scope Peer Review

Assumption	Basis
The operating experience review may be limited to the last 10 years of data.	Given the changing regulatory requirements and plant practices related to plant maintenance and record keeping, the last 10 years of data may more accurately reflect the as-operated plant conditions. Potentially non-conservative. It is possible that events occurring more than 10 years in the past are still relevant to the plant. Limiting the scope of the data review could preclude the identification of failure modes that would not otherwise be identified. While this is true, the HEP identification process would generate a Type A event for the relevant train/function/channel (provided that it is susceptible to Type A failures) and there would be some representation of a Type A failure for the train/function/channel.
Non-risk significant HFEs may be assigned scoping values of: Independent event: 1.0E-02 Common mode failure events: 1.0E-03	NUREG-1792 indicates that screening values of not lower than 5.0E-03 should be used with the intent of making the quantification process more efficient; however, use of a 5.0E-03 failure for common mode failures of nearly any plant system would result in the need to perform a detailed HRA. Consequently, NUREG-1792 does not achieve its goal. Given that 1) industry plant data does not support common mode failure events in the range that would be implied by the NUREG-1792 screening values, 2) use of lower scoping values does not preclude the identification of important Type A contributors, and 3) current plant procedures and practices virtually ensure that at least one viable type of recovery is available for critical actions, the DC Cook pre-initiator HRA process reduces the NUREG-1792 conditional failure probability from 0.5 to 0.1. Non-conservative relative to NUREG-1792, but still conservative relative to the HEP resulting from a detailed HEP quantification. Pertains only to common cause failure HFEs using scoping HEPs. [Peer reviewer's note – F&O HR-B1-01 has been issued against this issue, recommending that the explanation from this assumption be added to Section 3.1 and Appendix A to provide greater clarity on the rationale.]
Because DC Cook implements a staggered testing/maintenance program, work would not be performed on similar equipment from separate redundant trains within the same shift by the same crew. This practice is considered to limit dependence factors related to misalignment events between trains and they are excluded from consideration except when common equipment can impact multiple trains. Additional review may be required for systems with separate equipment trains that are powered from the same AC/DC electrical division. In these cases, there may be circumstances in which the separate trains may be manipulated by the same crew on the same shift.	The extended period between potential misalignment actions forced by the staggered testing practice is a strong dependence breaking factor. Appendix C provides a more complete basis for this assumption. Potentially slightly non-conservative, but the potential contribution of such events is expected to be very low. This assumption precludes the inclusion of common human misalignment events for separate components in separate trains. [Peer reviewer's note – F&O HR-A3-01 has been issued against this assumption, suggesting that clarification be provided regarding any cases of hardware configurations and maintenance practices that were identified in the DC Cook analysis that simultaneously impact multiple trains/divisions or diverse systems.]

5.0 RESULTS AND RECOMMENDATIONS

5.1 Results

The ASME/ANS PRA standard (Reference 1) contains a total of 316 numbered supporting requirements for internal events and internal flooding in nine technical elements. The focused scope of this peer review covered a total of eight (8) supporting requirements.

All were rated as SR Met, Capability Category I/II/II or II/III.

The D.C. Cook pre-initiator HRA update was considered to be of very good technical quality, addressed the high level and supporting standard requirements clearly and directly, and was for the most part well documented.

While the pre-initiator HRA does meet the ASME/ANS PRA Standard, there are issues that have been documented in Appendices C and E that should be addressed to further improve the quality of the HRA and its documentation.

Appendix A presents the summary of the results of this peer review for each of the three (3) HLRs from the ASME/ANS PRA Standard included in the scope of this peer review.

Appendix B presents the summary of the results of this peer review for each of the eight (8) SRs from the ASME/ANS PRA Standard included in the scope of this peer review.

In the course of this review, one (1) Finding and three (3) Suggestions were identified, as shown in Appendix C, along with possible resolution strategies.

Appendix D summarizes the reviewer's assessment of D.C. Cook's disposition of F&Os from the 2015 Peer Review. All these F&Os were considered to have been addressed.

5.2 Recommendations

Appendix E provides reviewer editorial and minor technical comments on the D.C. Cook Pre-Initiator HRA Notebook, PBA-NB-HRA-PRE [Reference 4] that were identified during the focused scope peer review.

5.3 Identification of Assumptions and Sources of Uncertainty

The identification of assumptions and sources of uncertainty is cited in NEI 05-04, Section 4.7 as one of the elements of the Peer Review Report.

The assumptions from Table 4.6 of PBA-NB-HRA-PRE that are relevant to the scope of this peer review are identified in the previous section in Table 4-3 and are considered to be reasonable and appropriate.

The sources of uncertainty are related to:

1. The reduction of the screening HEP for subsequent dependent events from 0.5 to 0.1 and its potential impact on risk-relevance of pre-initiator HFEs, and
2. Analytical judgment in the identification and definition of pre-initiator HFEs.

The former is discussed for recommended clarification as Suggestion HR-B1-01 and the latter is reduced by virtue of the systematic process followed, the independent review performed by D.C. Cook and its contractor, the initial peer review, and this focused scope peer review.

APPENDICES
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A. APPENDIX A – HIGH LEVEL REQUIREMENT (HLR) REVIEW

Table A-1. High Level Requirement (HLR) Review

High Level Requirement	HLR Description	Summary of Assessed Capability
HLR-HR-A	A systematic process shall be used to identify those specific routine activities that, if not completed correctly, may impact the availability of equipment necessary to perform system function modeling in the PRA.	The D.C. Cook pre-initiator HRA implemented a systematic process for identifying activities that could result in restoration and calibration human errors. Suggestions have been made regarding improvements in documentation for this process.
HLR-HR-B	Screening of activities that need not be addressed explicitly in the model shall be based on an assessment of how plant-specific operational practices limit the likelihood of errors in such activities.	A plant-specific operational experience review was conducted by D.C. Cook in addition to a systems review to qualitatively screen pre-initiator HFEs. A finding was identified, however, related to procedure checks to ensure that the screening was properly performed for certain identified cases.
HLR-HR-C	For each activity that is not screened, an appropriate human failure event (HFE) shall be defined to characterize the impact of the failure as an unavailability of a component, system, or function modeled in the PRA.	Pre-initiator HFEs were defined by D.C. Cook prior to the screening process and were assessed for relevance at the component, train, system or functional level.

B. APPENDIX B - SUPPORTING REQUIREMENT (SR) REVIEW

Table B-1. Supporting Requirement (SR) Review

SR	Category I	Category II	Category III	Capability Assessment	Appli-cable F&O	Assessment Comments
HR-A1	For equipment modeled in the PRA, IDENTIFY, through a review of procedures and practices, those test, inspection, and maintenance activities that require realignment of equipment outside its normal operational or standby status.			SR MET	HR-A1-01	The review of systems and operating experience through the processes discussed in sections 2.1 Systems Review and 2.2 Operating Experience Review, respectively, have provided important input to the identification of relevant components and how they should be modeled (individual, train, system level) to best reflect the equipment impacts of any misalignments. This has been implemented through the <u>Identification Steps for Restoration Errors</u> listed on pgs. 13 – 14 and documented in Appendix A of Reference 4. This SR is considered to be MET with one applicable F&O (Suggestion).
HR-A2	IDENTIFY, through a review of procedures and practices, those calibration activities that if performed incorrectly can have an adverse impact on the automatic initiation of standby safety equipment.			SR MET	HR-A1-01	The review of systems and operating experience through the processes discussed in sections 2.1 Systems Review and 2.2 Operating Experience Review, respectively, have provided important input to the identification of relevant components and how they should be modeled (individual, train, system level) to best reflect the equipment impacts of any miscalibrations. This has been implemented through the <u>Identification Steps for Miscalibration Errors</u> listed on pgs. 15 – 16 and documented in Appendix A of Reference 4. This SR is considered to be MET with one F&O (Suggestion).

Table B-1. Supporting Requirement (SR) Review

SR	Category I	Category II	Category III	Capability Assessment	Applicable F&O	Assessment Comments
HR-A3	IDENTIFY the work practices identified above (HR-A1, HR-A2) that involve a mechanism that simultaneously affects equipment in either different trains of a redundant system or diverse systems [e.g., use of common calibration equipment by the same crew on the same shift, a maintenance or test activity that requires realignment of an entire system (e.g., SLCS)].			SR MET	HR-A3-01	Appendix C provides interpretation of SR HR-A3 intent and the rationale for the legitimacy of the analysis in meeting this SR. A suggestion is provided in F&O HR-A3-01 for how this argument could be further strengthened. The review of systems and operating experience through the processes discussed in sections 2.1 Systems Review and 2.2 Operating Experience Review, respectively, have provided important input to the identification of relevant components and how they should be modeled (individual, train, system level) to best reflect the equipment impacts of any misalignments or miscalibrations. This SR is considered to be MET with one applicable F&O (Suggestion).
HR-B1	If screening is performed, ESTABLISH rules for screening classes of activities from further consideration. Example: Screen maintenance and test activities if **the plant practices are generally structured to include independent checking of restoration of equipment to standby or operational status on completion of the activity.**	If screening is performed, ESTABLISH rules for screening classes of activities from further consideration. Example: Screen maintenance and test **activities** from further consideration only if: ***(a)* equipment is automatically re-aligned on system demand** ***(b)* following maintenance activities, a post-maintenance functional test is performed that reveals misalignment** ***(c)* equipment position is indicated in the control room, status is routinely checked, and realignment can be affected form the control room, or** ***(d)* equipment status is required to be checked frequently (i.e., at least once a shift)**		SR MET: (CC II/III)	HR-B1-01	Screening is performed along with the pre-initiator HFE identification process followed as discussed in sections 2.1 and 2.2 with the systems review and operating experience review, consistent with the examples provided in the PRA Standard Cat. II/III. Additional screening for detailed analysis is done on the basis of risk significance by assigning a screening value of 1E-02 for independent events, per NUREG-1792, and applying those values in the quantification to evaluate Risk Reduction Worth (RAW) and Risk Achievement Worth (RAW) values of the HFEs. For subsequent dependent events, however, the HEP recommended by the NUREG has been altered. Section 3.1 states that "...the conditional HEP value for the subsequent event is reduced from 5.0E-01 to 1.0E-01. This is still considered to be conservative, but more appropriate based on the results of the plant operating experience review documented in Appendix A.2."

Table B-1. Supporting Requirement (SR) Review						
SR	**Category I**	**Category II**	**Category III**	**Capability Assessment**	**Appli-cable F&O**	**Assessment Comments**
						However, the basis/rationale for the reduction of the conditional HEP value is not well explained in either Section 3.1 or Appendix A.2. A better rationale was found in Table 4-6 on Assumptions and states: "Given that 1) industry plant data does not support common mode failure events in the range that would be implied by the NUREG-1792 screening values, 2) use of lower scoping values does not preclude the identification of important Type A contributors, and 3) current plant procedures and practices virtually ensure that at least one viable type of recovery is available for critical actions, the DC Cook pre-initiator HRA process reduces the NUREG-1792 conditional failure probability from 0.5 to 0.1." It is recommended that this latter discussion be moved to either Section 3.1, Appendix A.2 or both to provide better clarification on the rationale for the conditional HEP value reduction from the level cited in NUREG-1792. This SR is considered to be MET with one applicable F&O (Suggestion).
HR-B2	DO NOT screen activities that could simultaneously have an impact on multiple trains of a redundant system or diverse systems (HR-A3).			SR MET	HR-B2-01	The processes for identifying HFEs in sections 2.1 and 2.2 state that systems and operating experience reviews were conducted and that "P&IDs, procedures, system descriptions and/or operating instructions [were used] to assist in the pre-initiator HEP identification process". The system analysis and operating experience reviews were very thorough and are documented in tables in Appendix A. They demonstrate that many pre-initiator HFEs were identified through system reviews alone. For example, Section 2.1 on Systems Review discusses Restoration Error identification steps. Step

Table B-1. Supporting Requirement (SR) Review

SR	Category I	Category II	Category III	Capability Assessment	Applicable F&O	Assessment Comments
						4.a. on Restoration Error Potential – No Auto-Realignment states that "Failures to restore auto-realignment capability to components should be considered as a failure mode when there is a definable common mode failure mechanism that could impact multiple trains of a redundant system or diverse systems." But there are instances in the Appendix A tables where it is not clear that procedures were also checked to ensure that the components cited should have been screened from inclusion in the pre-initiator HRA. This SR is considered to be MET with one (1) applicable F&O (Finding).
HR-C1	For each unscreened activity, DEFINE a human failure event (HFE) that represents the impact of the human failure at the appropriate level (i.e., function, system, train, or component affected).			SR MET	None	The identification process discussed in section 2.0 identifies candidate pre-initiator HFEs based on system and operating experience review and defines the level to which they apply, such as described in Cases A and B in section 2.1 for restoration errors. Table 2-1 provides a list of the Unit 1 and Unit 2 pre-initiator actions identified for DC Cook through these systems and operating experience reviews. This SR is considered to be MET and there are no applicable F&Os.

Table B-1. Supporting Requirement (SR) Review

SR	Category I	Category II	Category III	Capability Assessment	Applicable F&O	Assessment Comments
HR-C2	INCLUDE those modes of unavailability that, following completion of each unscreened activity, result from failure to restore (a) equipment to the desired standby or operational status (b) initiation signal or set point for equipment start-up or realignment (c) automatic realignment or power	INCLUDE those modes of unavailability that, following completion of each unscreened activity, result from failure to restore (a) equipment to the desired standby or operational status (b) initiation signal or set point for equipment start-up or realignment (c) automatic realignment or power **ADD failure modes identified during the collection of plant-specific or applicable generic operating experience that leave equipment unavailable for response in accident sequences.**		SR MET: (CC II/III)	None	The system review process outlined in section 2.1 as IDENTIFICATION STEPS FOR RESTORATION ERRORS and documented in Appendix A addressed the identification of the modes of unavailability from restoration errors cited in the standard SR. Appendix A.2 specifically documents the collection of plant-specific operating experience and the review for relevance to the pre-initiator HRA is documented in Table A-22: DC Cook Operating Experience Review. No ARs were found that resulted in any additions to the pre-initiator human failure events in the PRA, but in one case pre-initiator HFEs that had been defined by the systems review were confirmed. This SR is considered to be MET and there are no applicable F&Os.
HR-C3	INCLUDE the impact of miscalibration as a mode of failure of initiation of standby systems.			SR MET	None	Miscalibration as a mode of failure of initiation of standby systems is addressed by the HFE identification and definition process discussed in Section 2 and the further evaluation for inclusion in the PRA model is documented in Appendix A. Section 2.1 specifically discusses the review for Standby System Trains At-Power under the IDENTIFICATION STEPS FOR MISCALIBRATION ERRORS. Table A-19: Reactor Protection and Engineered Safeguards Actuation and Table A-21: Supplemental Diesel Generator provide examples of consideration of miscalibration as standby system initiators. This SR is considered to be MET and there are no applicable F&Os.

C. APPENDIX C – FOCUSED SCOPE PEER REVIEW FINDINGS AND OBSERVATIONS

Table C-1. Focused Scope Peer Review Findings and Observations

F&O No.	Supporting Require-ment	F&O Category	Discussion	Possible Resolution
HR-A1-01	HR-A1, HR-A2	Suggestion	2.3 SUMMARY OF PRE-INITIATOR ACTION IDENTIFICATION PROCESS states that "The Unit 2 events are the same as the Unit 1 events with the exception that the first character of the basic event ID (BEID), which is the unit designator, is a "2" instead of a "1". There are a small number of events that have unique Unit 2 BEIDs because the component numbers associated with the events are dissimilar to their Unit 1 counterparts." This seems to imply that the U1 and U2 systems are identical.	A conference call with D.C. Cook and contractor staff on September 22, 2016 clarified that the two units are very similar and any differences between them are identified in the System Notebooks. However, it is recommended to clarify in section 2.3 that the pre-initiator HRA focused on the HFEs that were identified for Unit 1 and that Unit 2 system notebooks were reviewed to ensure that these events were applicable to Unit 2. It should also be documented that the system notebook review did not identify other Unit 2 specific pre-initiator HFEs (except for those with unique Unit 2 BEIDs when their component IDs differed from those of Unit 1).

Table C-1. Focused Scope Peer Review Findings and Observations

F&O No.	Supporting Requirement	F&O Category	Discussion	Possible Resolution
HR-A3-01	HR-A3	Suggestion	Appendix C provides interpretation of SR HR-A3 intent and addresses most concerns well. However, it also states "For DC Cook, the use of a staggered testing/maintenance program eliminates the potential for maintenance events that could result in a misalignment of diverse trains/divisions of a system or diverse systems. There may be some cases in which there are hardware configurations that make it unavoidable, however. These cases, and any specific maintenance practices that simultaneously impact multiple trains/divisions or diverse systems should be the focus of the SR HR-A3 review." It is not clear whether the "SR HR-A3 review" means the review of systems and procedures undertaken as part of the pre-initiator HRA to meet the SR or the peer review to determine whether or not the SR has been met. In either instance, citing any particular cases of hardware configurations and maintenance practices that were identified in the D.C. Cook analysis would be helpful.	The argument for this latter statement would be strengthened if examples of any such cases in the D.C. Cook case could be cited.

Table C-1. Focused Scope Peer Review Findings and Observations

F&O No.	Supporting Require-ment	F&O Category	Discussion	Possible Resolution
HR-B1-01	HR-B1	Suggestion	Screening is performed along with the identification process followed as discussed in sections 2.1 and 2.2 with the systems review and operating experience review. Additional screening for detailed analysis is done on the basis of risk significance. Risk significance of HFEs is identified by applying a screening value of 1E-02 for independent events, per NUREG-1792, and applying those values in the quantification to evaluate Risk Reduction Worth (RRW) and Risk Achievement Worth (RAW) values of the HFEs. For subsequent events, however, the HEP recommended by the NUREG has been altered. Section 3.1 states that "...the conditional HEP value for the subsequent event is reduced from 5.0E-01 to 1.0E-01. This is still considered to be conservative, but more appropriate based on the results of the plant operating experience review documented in Appendix A.2." However, the basis/rationale for the reduction of the conditional HEP value is not well explained in either Section 3.1 or Appendix A.2.	A conference call with D.C. Cook and contractor staff on September 22, 2016 identified that the risk significance of the conditional HEP was evaluated using Risk Reduction Worth (RRW). However, there is no clear connection between the operating experience review in Appendix A.2 and the reduction of the conditional HEP value. The only reference made is a parenthetical statement in section 3.1 that "This is still considered to be conservative, but more appropriate based on the results of the plant operating experience review documented in Appendix A.2 (i.e., it demonstrates that these types of events are rare)." A clearer conclusion could be made in Appendix A.2 through additional documentation such as: "Nineteen (19) events were initially identified as potentially relevant out of ten years of operational experience. Upon further review for relevance based on specific criteria, only one of these 19 events was found to be relevant, but was already addressed by existing HFEs. One event out of ten years for a human error is rather rare for a single event let alone an event that renders multiple equipment unavailable. This provides a basis for the reduction of the conditional HEP value stated in NUREG-1792, as discussed in section 3.1." In addition, the explanation from the assumption in Table 4-3 (taken from assumption #6 in Table 4-6 of the PRA-NB-HRA-PRE report [Reference 3]) could be added to Section 3.1 and Appendix A to provide greater clarity on the rationale for the conditional HEP reduction.

Table C-1. Focused Scope Peer Review Findings and Observations

F&O No.	Supporting Requirement	F&O Category	Discussion	Possible Resolution
HR-B2-01	HR-B2	Finding	The process for identifying HFEs in section 2.1 states that systems and operating experience reviews were conducted and that "P&IDs, procedures, system descriptions and/or operating instructions [were used] to assist in the pre-initiator HEP identification process". The system analysis and operating experience reviews were very thorough and are documented in tables in Appendix A. They demonstrate that many pre-initiator HFEs were identified through system reviews alone. However, there are instances in these tables where it is not clear that procedures were also checked to ensure that the components cited should have been screened from inclusion in the pre-initiator HRA. For example: Appendix A, Table A-8: Containment Spray, pg. 138, CTS-106, where the disposition in the Include in Pre-Initiator Listing? Column for this component says: "No, assuming no common mechanism or procedure that would include multiple manual valve manipulations (of CTS-106 AND CTS-105E or CTS105W)". But there is no documentation of a subsequent procedure check that was performed to ensure that this could legitimately be screened out.	Clarify the role of system reviews vs. procedure reviews when verifying screening decision-making, as well as the dispositioning of certain events in Appendix A.

D. APPENDIX D – PRIOR PEER REVIEW FINDINGS AND OBSERVATIONS

Table D-1. Assessment of Findings and Observations from 2015 Peer Review [Reference 5]

SR	PRA Assessed CC	Peer Review Assessment Basis	Applicable F&Os	Disposition	Focused Scope Peer Review Assessment
HR-A1	Not Met	D. C. Cook screened all component mispositioning. Some of these were screened using post-maintenance test, independent verification, or daily checks. Individual failure of these preinitiator recovery actions or even combinations of these recoveries results in higher probabilities than passive valve failures and should not be screened.	2-7	Pre-Initiator HFE screening re-evaluated to not pre-emptively screen mispositioning.	Equipment position was evaluated during HFE identification and again when representative procedures were selected based on, for example, whether it was checked as part of daily operator rounds. This F&O is considered to have been addressed.
HR-A2	Not Met	Miscalibrations of control instruments and/or miscalibration of instruments that are used to direct operator actions (e.g., RWT Level alarms) are needed to support mitigating system models and support applications like Fire PRA. There was no systematic review for identification of miscalibration events documented.	2-8	Pre-Initiator HFE screening re-evaluated to include miscalibrations.	The current analysis has employed a specific method for identifying miscalibration errors. This F&O is considered to have been addressed.
HR-A3	Not Met	Work practices that that involve a mechanism that simultaneously affects equipment in either different trains of a redundant system or diverse systems are not specifically addressed. Miscalibrations of pressurizer pressure and high containment pressure are included (although not directly linked to the ESFAS and containment isolation signals). However, other potentially important and common miscalibrations, such as miscalibration of RWT level transmitters preventing operators from diagnosing the need to swap ECCS suction to the sump, are not considered.	2-9	Pre-Initiator HFE screening re-evaluated to include cross-train and redundant equipment, and miscalibrations. Pressurizer pressure and containment pressure are now linked to ESFAS via the new ESFAS modeling.	The current analysis has employed a specific method for identifying miscalibration errors of Redundant System Trains or Redundant Components and has specifically identified HFEs for miscalibration of RWST level switches and channels. This F&O is considered to have been addressed.

Table D-1. Assessment of Findings and Observations from 2015 Peer Review [Reference 5]

SR	PRA Assessed CC	Peer Review Assessment Basis	Applicable F&Os	Disposition	Focused Scope Peer Review Assessment
HR-B2	Not Met	As noted in SR HR-B1, the screening of pre-initiator HRAs is aggressively beyond what is included in this standard. This includes miscalibrations and mispositioning that could impact support systems that impact multiple trains or systems.	2-7,2-8,2-9	Pre-Initiator HFE screening re-evaluated to include miscalibrations and mispositionings that could impact support systems.	The current analysis has employed a specific method for identifying miscalibration and restoration errors of Redundant System Trains or Redundant Components. This F&O is considered to have been addressed.

E. APPENDIX E – REVIEW COMMENTS ON PRE-INITIATOR HRA NOTEBOOK

Table E-1. Review Comments on Pre-Initiator HRA Notebook

Comment No.	Document Number Section / Paragraph	Review Comments/Basis for Comment
1	Section 1.1,top of pg. 13	Recommend adding the word "the" as shown in red in the following sentence: "These types of errors are not modeled using HRA; however, other events associated with component restoration that can be evaluated with HRA may be included in the model even if the hardware data already captures those contributions."
2	Section 2.1, first sentence, pg. 13	Recommend adding "a" as shown in red in the following sentence: "Pre-initiator HFEs are identified for inclusion in the PRA model using a systematic identification process based on systems analysis approaches."
3	Section 2.1, third paragraph, pg. 15	Correct spelling errors of "individual" and "desirable" shown in red in the following sentence: "If the recovery mechanisms for the header valve and the indivual load valves are the same, a single HFE quantified based on the recovery mechanisms for the header valve may be desireable because the impact envelopes all of the individual load isolation events."
4	Section 3.0	Replace "(RAW)" shown in red in the following sentence with "(RRW)": The delineation is made using the Risk Reduction Worth (RAW) and Risk Achievement Worth (RAW) values of the HFEs (which are based on screening values, as defined below).
5	Section 3.1	Section 3.1 discusses assigning "scoping" values to the HFEs. NUREG-1921 on fire HRA has a specific scoping method for quantification. Even though this report and analysis deals with pre-initiator internal events HRA, adding a footnote to clarify that the 1921 scoping method is not being used here is recommended.
6	Section 3.1.5	The Recovery Mechanism is identified as iv – shiftly status check, but the wording suggests it is Independent Verification, which would be ii, according to the classification scheme.
7	Section 3.1.8	The Recovery Mechanism is identified as iv – shiftly status check, but the wording suggests it is Independent Verification, which would be ii, according to the classification scheme.
8	Section 3.1.10	Remove the "'s" shown in red in the following sentence on pg. 36: "Other work that's may be performed on-line would include a work order process to return the RHR system to service using 1-OHP-4021-008-002, which includes an independent verification of the valve position."

Table E-1. Review Comments on Pre-Initiator HRA Notebook

Comment No.	Document Number Section / Paragraph	Review Comments/Basis for Comment
9	Section 3.1.10	States that "In addition, 1-OHL-4030-SOM-031 (Unit 1 Tours - U1 CR M1&2 Shift Checks) provides a check of the 1(2)-IMP-390 valve position every shift, which is credited in the evaluation." RWST level is checked each shift but a search of IMP-390 does not show up in this procedure; please define which page this check is listed on.
10	Section 3.1.13	The Recovery Mechanism is identified as iv – shiftly status check, but the wording suggests it is Independent Verification, which would be ii, according to the classification scheme.
11	Sections 3.1.16, 17 and 18	The Recovery Mechanism is identified as iv – shiftly status check, but the wording suggests it is Independent Verification, which would be ii, according to the classification scheme.
12	Section 7.0	NUREG-1792 is cited in Section 3.1 as reference [4] but is not listed here.
13	Appendix A, Table A-4, pg. 98, entry for FW-137-1 FW-137-1 FW-137-3 FW-137-4	1) Is there a reason FW-137-1 is repeated in the Train/Function/Component column? 2) Delete "on" as shown in red in the following sentence: "Misalignment of one (or two) SG manual isolation valves on in the PP-4 train would not fail the PP-4 function without other failures and pre-initiator events are not required."
14	Appendix A, Section A.2, second paragraph, pg. 198	Correct spelling errors for "pre-initiator" and "trains" shown in red in the following sentence: "In order to collect the ARs that were potentially relevant to the pre-initaitor analysis, a search for keywords such as "miscalibration," "misposition," "wrong position," and so forth was performed. Twenty three ARs were identified in the D.C. Cook record search process, which were then further screened using the following criteria to eliminate all but those records related to Type A events that could fail the trans/functions/components that are modeled in the PRA:"
15	Appendix A, Table A-22: DC Cook Operating Experience Review, pg. 203, AR 00824819.	States that "Additionally, in order for this miscalibration to impact the function of the system, multiple miscalibrations would be required." Implies that multiple miscalibrations were involved in this AR; recommend removing this text.
16	Appendix B, B.11 1D-CPP3EWFS--HE, PRE-INIT - CC MISCAL: FLW SNSRS FFS-244, FFS-245, FFS-254, and FFS-255	In Identification and Definition section, replace ")" shown in red with "O" in the following sentence: "Common cause miscalibration of FFS-244, FFS-245, FFS-254 and FFS 255 such that flow is measured higher than actual flow will result in closure of FM)-212, FMO-242, FMO-222 and FMO232 (no flow from either the PP-3E or PP-3W pump train paths)."

F. APPENDIX F – PEER REVIEWER RESUME

ERIN P. COLLINS

SUMMARY

Erin Collins is a Senior Consultant with 32 years of experience in safety, reliability, and risk assessment, specializing in data analysis and human reliability analysis for nuclear, chemical, and aerospace applications. Ms. Collins is an author of the NUREG-1921 Fire HRA Guidelines and was an instructor for the EPRI/NRC Fire PRA Training Course Fire HRA module. She was a key technical participant in the Fire HRA Task of the Fire PRAs for Prairie Island, Monticello, ANO-1, Nine Mile Point 1 and Kewaunee plants and provided review and input to the HRAs for the ANO-2, Browns Ferry, R.E. Ginna and Palo Verde Fire PRAs. She was also a primary analyst for the Main Control Room abandonment HRAs for the Diablo Canyon and V.C. Summer Fire PRAs. Ms. Collins was a reviewer of the EPRI Seismic HRA methodology and is a key participant on the JENSEN HUGHES Seismic HRA team for the Duke Energy fleet Seismic PRA projects. Ms. Collins is on the team developing EPRI-NRC RES Guidelines for Main Control Room Abandonment HRA and was the Principal Investigator for the EPRI Guidelines for PRA Data Analysis. She performed PRA equipment reliability database updates for ANO-1, Hatch and Palisades and was the Data Analysis Task Leader for the Dodewaard Nuclear Power plant and the US DOE Hanford N-Reactor PRAs.

EDUCATION/TRAINING

BS, Environmental Science, Elmira College, 1979

EXPERIENCE

Senior Consultant September 2012-Present
JENSEN HUGHES

Ms. Collins has been a technical lead for the Fire HRA Task of the Fire PRAs for Prairie Island and Monticello and provided technical review and input to the Fire HRAs for the ANO-2, Browns Ferry and Palo Verde Fire PRAs. She has also been a primary analyst for the Main Control Room abandonment HRAs for the Diablo Canyon and V.C. Summer Fire PRAs. Using this expertise, Ms. Collins is participating with an industry team on the development of Guidelines for MCR Abandonment HRA as part of a joint EPRI and U.S. NRC-RES effort.

Ms. Collins is currently on the HRA team for the Robinson and Oconee Seismic PRAs. She provided technical review for the Catawba and McGuire High Wind HRAs and conducted detailed HRA for specific recovery actions for the Monticello external flooding SDP response to NRC for Xcel Energy.

Regarding internal events PRA, Ms. Collins served as technical lead for the data analysis and HRA updates for ANO-1. She also performed the Internal Events pre-initiator HRA update for Diablo Canyon, and assisted with the resolution of medium-priority F&Os for the Diablo Canyon Internal Events PRA peer review.

In the research area, Ms. Collins provided input to the IDHEAS HRA methodology joint research project between the Electric Power Research Institute (EPRI) and the US NRC in response to

an ACRS SRM. For this effort, she assisted in the development of the quantification module by participating in workshops for HEP value estimation and trial application to actual PRA events involving operator recovery actions.

PREVIOUS EXPERIENCE

Senior Risk Analyst 1984-August 2012
SAIC

<u>Nuclear Plant PRA Experience</u>

Ms. Collins led SAIC's support of the Fire HRA Task of the Fire PRAs/NFPA 805 transition efforts for the Dominion Energy Kewaunee plant and for the Constellation Energy Nine Mile Point 1 and R.E. Ginna plants. This involved the review of internal events PRA human failure events (HFEs) for relevance and modification for fire effects, the identification of new fire-specific HFEs, the coordination with the PRA model, the quantification of HFEs using HRA methods, and documentation of the entire process to facilitate peer review and ASME/ANS PRA standard requirement adherence. As part of this responsibility, she attended the peer review meetings for these fire PRAs and responded to peer review questions, amending the fire HRA and documentation as necessary to address F&Os. NMP1 and Ginna were awarded Best Practices in the area of Fire HRA. In addition, she provided documentation development support, internal review, fire procedure review, and conducted operator interviews for the San Onofre Nuclear Generating Station (SONGS) Fire HRA. She also compiled the LAR Attachment G table of recovery actions to resolve VFDRs for Kewaunee and SONGS.

Ms. Collins participated in the development of the joint EPRI/NRC-RES Fire HRA Guidelines, published in July 2012 as NUREG-1921. The guidelines document provides a methodology for Fire PRA-related human reliability analysis, extending the methods outlined in NUREG/CR-6850, *Fire PRA Methodology for Nuclear Power Facilities.* Consistent with this effort, she was part of the team presenting the Fire HRA module of the joint EPRI/NRC Fire PRA Training Courses.

She worked with EPRI on the development of Guidelines for PRA Data Analysis, utilizing her own experience and that of utilities who have updated their PRA databases. She also assisted with the development of presentation materials for the EPRI Education of Risk Professionals Course modules on Data Analysis and HRA.

Ms. Collins conducted a gap assessment as part of an SAIC team to recommend ways for Constellation Energy to address Peer Review comments on the gap between ANS/ASME PRA Standard requirements and their internal events PRA documentation in the areas of data analysis and HRA.

She participated in the Westinghouse PWR Owner's Group sponsored internal events PRA peer review teams for the H.B. Robinson and Indian Point 2 nuclear plants, serving as lead in the areas of Human Reliability Analysis, Accident Sequence Analysis, and Initiating Events. In this capacity, she coordinated the evaluation of the PRA against the ASME/ANS PRA Standard in these areas, documenting and presenting comments and findings to the utility management. She was also a supporting reviewer in the areas of Data Analysis, Systems Analysis and Quantification and responded to utility comments to finalize the peer review report. In addition, she participated in the Dominion sponsored limited scope internal events peer review of the Millstone 3 plant, leading the review of selected SRs under Data Analysis, Human Reliability Analysis, and Internal Flooding.

Ms. Collins was project manager for the SAIC ATHEANA HRA team for the Sandia Empirical Study effort to assess HRA methods against a specific set of empirical data collected from simulator exercises. Another major objective of the study is to test the consistency of HRA predictions among analyst teams using the same methods and across different methods. The SAIC team utilized the ATHEANA method to evaluate Human Error Probabilities (HEPs) for a specified set of nuclear plant PRA scenarios and Human Failure Events (HFEs).

For the Calvert Cliffs nuclear plant flooding analysis update that SAIC performed for Constellation Energy, Ms. Collins assisted in conducting operator interviews to identify timing, accessibility and procedure information for key flooding scenarios. She developed a set of recovery screening values for the initial human error probability estimates and refined the recovery analysis through detailed analysis of the risk-significant flooding scenarios.

Ms. Collins worked on the Pre-Closure Safety Assessment (PCSA) performed by Bechtel SAIC Corporation (BSC) in support of the U.S. Department of Energy's (DOE) License Application to the U.S. Nuclear Regulatory Commission (NRC) for the YMP. Her primary tasks on the PCSA were to develop the active component reliability database for use in quantifying the risk models and to support the qualitative and quantitative analyses for the Human Reliability Analysis (HRA). She also responded to NRC's requests for additional information (RAI) on the HRA.

On past nuclear plant HRAs, Ms. Collins provided technical review and support of the HRAs for the Ascó and the Santa Maria de Garoña nuclear plant PRAs, and for the Kola and Novovoronesh Russian nuclear reactor PRAs for the DOE. In the United States, Ms. Collins participated in HRAs for the Hanford N-Reactor, Crystal River 3 and Catawba PRAs.

Ms. Collins' recent nuclear plant component failure data analysis experience includes failure records review and categorization for the Hatch plant and maintenance schedule review and summary for the Palisades plant. She also provided generic data for the PRA components for these efforts.

On previous PRAs and analyses, Ms. Collins served as Task Leader for the Component Reliability Data Analysis task of the PRAs for the Dodewaard Nuclear Power plant and the US DOE Hanford N-Reactor PRA, as well as the Portland General Electric Trojan Nuclear Plant Service Water System Reliability Study. These projects required the collection of plant-specific information to calculate component level failure rates and probabilities for the fault tree models of the systems. The N-Reactor project in particular required Ms. Collins' supervision of the sorting of 60,000 maintenance records and the encoding and compilation of 30,000 of these records. Ms. Collins also compiled a data set for the Initiating Event level of data for N-Reactor using their 20 years of Outage Reports, and sorting them by the affected system and function.

She participated for several years in the In-Plant Reliability Data System (IPRDS) project for Oak Ridge National Laboratory (ORNL), which included on-site nuclear plant reliability data collection, post-visit data inventory and analysis, correlation of records with drawings and plant identifiers, and integration of analysis products into functional results. She participated directly in three plant site data collection visits during this project.

Other International Projects

Ms. Collins was selected for the 1985 Nuclear Reactor Safety Delegation to the People's Republic of China under the auspices of People to People International. During this trip, she presented papers on data analysis and HRA to engineering university staff in Beijing and Chengdu.

Ms. Collins was a prime participant in a Safety Hazard Analysis of an acrylic fiber spinning facility in northeastern Italy. This analysis evaluated worker risk in various areas of the facility

through the use of hazard analysis techniques, including HAZOP, and resulted in the recommendation of economical risk reduction measures. On a separate project, she assisted in the development of site environmental audit protocols for this same location, which housed numerous chemical processing activities. Also in northern Italy, Ms. Collins participated in an availability study of a proposed offshore fossil power station, including event tree analysis to rank the major initiating events (including external events, such as earthquake) which could compromise power production capability. Ms. Collins was one of three instructors for a course entitled "Process Reliability and Risk Analysis", a four-day intensive course for engineers held in Amsterdam, for which she taught the Data Analysis and Human Reliability Analysis modules.

She served as Task Leader for the Data Analysis portion of a Power Station Availability Scoping Study for the ISMES S.p.A. structural engineering laboratories in Bergamo and Sondrio, Italy. For this effort, she worked on-site and conducted field surveys, data collection, and construction of a reliability database for landslide area monitoring equipment. She provided training to ISMES personnel on the data aggregation code and communicated the data categorization concepts (in Italian) to ISMES data collection team members. For Alenia Spazio in Turin Italy, she supported SAIC's development of Human Error Avoidance Guidelines for the European Space Agency Human Dependability Tools, Techniques and Guidelines effort. These guidelines were developed from a basis of understanding of aerospace design phases and human error mechanisms.

Other Industry Risk and Reliability Projects

She participated in the Screening Quantitative Risk Assessment (QRA) as well as document reviews, from the safety perspective, of the design documentation for the Army's ACWA facilities for destruction of the chemical weapons stockpiles at the Blue Grass and Pueblo Army Depots. For this effort, she has also provided data administration on the number of design documents that have been reviewed on a monthly basis and the disposition of comments.

Ms. Collins performed transportation analyses in support of the county permit requirements for the Chemical Agent Munitions Disposal System (CAMDS) closure waste disposal and for the waste associated with the proposed Pueblo, Colorado facility. For the latter analysis, she conducted extensive internet searches for newspaper articles, databases, technical papers, reports and journals to evaluate historical and estimated future truck accident risk in the Pueblo area. She also participated in a public consequence risk/hazard analysis of a proposed Russian chemical weapons destruction facility by evaluating reactor overpressurization and BLEVE events, supplying data and documenting this work for the formal report.

Ms. Collins was responsible for the development and administration of the equipment failure database used to quantify the US Chemical agent Disposal Facility (CDF) QRA risk models using operational experience from the Tooele, Utah and Johnston Island CDFs. She developed the initial component reliability failure database of failure rates and associated uncertainty bounds for the Tooele, Anniston, Umatilla and Pine Bluff CDFs, using generic equipment performance data as well as prototype facility operating experience.

In response to an inquiry by the CMA Program Manager for Elimination of Chemical Weapons, Ms. Collins has researched and reviewed government and industry standards for categorizing and labeling hazardous materials to evaluate their applicability to the Army's labeling needs. This effort included familiarization with Army requirements for system safety, such as would be done for a hazard analysis. She has developed guidance for a Safety Performance Indicator program to allow management to monitor safety issues at the CDFs.

For the FAA, Ms. Collins participated in SAIC's risk assessment projects since 1997 to evaluate the likelihood of loss of function of the regional air route traffic control centers (ARTCCs). As

part of the risk ranking of ARTCC electric power system issues, she developed and quantified fault tree models to evaluate the risk and availability impact of proposed design changes to the ARTCC emergency diesel generator fuel oil system. In addition, she provided equipment and human failure data for the overall ARTCC systems risk models, using the FAA maintenance management system (MMS) wherever possible, complemented by published generic data to meet the risk assessment data needs.

In the aerospace field, Ms. Collins assisted in 2003 with the documentation of risk modeling performed for NASA Langley Research Center in support of future planning for the Integrated Space Transportation System (ISTP), considering the issues of shuttle reliability and the risk associated with alternative space transportation vehicles to meet the needs of the International Space Station. She also helped construct a mission flow diagram and event sequence diagrams for the proposed Mars ARES mission for NASA Langley. Previously, she supported the efforts of NASA Glenn (then Lewis) Research Center, Martin Marietta Space Launch Systems, and General Dynamics Space Systems Division in the construction of a Databook for the Titan IV/Cassini RTG Safety Study. For this effort, she compiled guidelines for the use of a structured interview technique which she helped develop for obtaining data estimates from subject matter experts, which has been successfully utilized during an Air Force Reliability Study and was to be implemented on the Titan IV/Cassini RTG Safety Study for NASA Lewis Research Center and the Space Shuttle Risk Assessment for NASA Headquarters. This method was previously used to obtain component unavailability data estimates from the experience base of nuclear plant personnel from the Davis-Besse and the Crystal River Unit 3 plants.

Ms. Collins has compiled generic component-level data to estimate the reliability of orbital replaceable units (ORUs) for a study on the maintainability of the proposed Space Station Freedom. Ms. Collins participated in the construction of data sets on solid and liquid rocket launch and failure histories for use in quantifying Space Shuttle subsystem failure probabilities for the Galileo RTG risk assessment for the NASA Headquarters Code Q reliability office. In this capacity, she evaluated past performance to estimate the relative contribution of subsystems to launch vehicle failure and identify failure modes, where possible. She also supported the development of reporting and presentation materials for deliverables related to SAIC's risk analyses of the proposed Mars Sample Return mission. She also assisted in the reporting and analysis for a private sector (proprietary) client on satellite system failure modes and effects.

Ms. Collins also served as a Cost Account Manager for the National Ignition Facility (NIF) large-scale experimental laser project designed and under construction by Lawrence Livermore National Laboratory (LLNL) for the DOE for an estimated total cost of $1.1B. In this capacity, she was responsible for supporting the NIF system design engineers in their development of projected budgets and activity schedules across the entire project life (FY1997 through 2003). These budgets (in Excel spreadsheet form) were then input to the LLNL overall project budget calculation system resident on a mainframe. Ms. Collins would then provide task-specific cost estimate outputs by fiscal month for project management by the system engineers, update or revise the information as needed, and produce input to NIF cost reporting to DOE.

For the chemical process industry, Ms. Collins served as the prime liaison with the American Institute of Chemical Engineers (AIChE) in the production of their 1989 Guidelines for Process Equipment Reliability Data with Data Tables. On this project, Ms. Collins assisted the AIChE committee in the development of a structured hierarchy (or taxonomy) for process industry equipment based on reliability and engineering principles, the writing and production of text, the construction of the data base and data tables in camera-ready format, and the documentation of committee decision-making and guideline text revisions.

Project Manager 1993-1995
Jobson Beer Handbook, Adams/Jobson Publishing Company

Ms. Collins worked as an independent consultant to Adams/Jobson Publishing Company in New York City as Project Manager for the inaugural edition of the Jobson Beer Handbook in 1993. For this handbook, she analyzed the available data and developed a linked spreadsheet system for calculating malt beverage shipment trend data by supplier, state, and brand for the years 1988 through 1992. The initial volume, and Ms. Collins' work on it, was so well received that she was requested to return the following years to update the information for the 1994 and 1995 Handbooks.

Program Administrator 1979-1982
Nuclear Standards Department, American National Standards Institute (ANSI)

Ms. Collins served as Program Administrator for the Nuclear Standards Department at the American National Standards Institute. Her responsibilities included the monitoring of standards development progress, coordinating the technical societies involved in the standards writing process to alleviate redundancy and conflict, and interface with project chairmen to assist in the smooth completion of draft and final standards writing and ANSI approval. Her duties included the coordination of international standards in the nuclear field which required contact with overseas agencies and personnel. Ms. Collins frequently traveled nationwide to standards-related meetings to keep abreast of standards progress and to represent ANSI by clarifying its role in the standards development process.

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2. Collins, E.P. and Najafi, B., "Use of Process Incident Data for Accident Sequence Precursor Analysis," American Institute of Chemical Engineers 2016 Spring Meeting, 12th Global Congress on Process Safety (GCPS), 10-14 April 2016, Houston, TX.
3. Amico, P. and Collins, E.P., "Modeling Main Control Room Abandonment in Fire PRAs," 2015 International Topical Meeting on Probabilistic Safety Assessment and Analysis (PSA 2015), Sun Valley, ID, 26–30 April 2015.
4. Garvey, M, Joglar, F., and Collins, E.P., "HRA for Detection and Suppression Activities in Response to Fire Events," to be presented at the 2014 Reliability, Availability, Maintainability Symposium (RAMS), 27-30 January 2014, Colorado Springs, CO.
5. Garvey, M, Joglar, F., and Collins, E.P., "Human Reliability Analysis for Detection and Suppression Activities in Response to Fire Events," International System Safety Conference (ISSC 2013), 11–16 August 2013, Boston, MA.
6. Collins, E.P., Williams, C.A., and Macheret, P., "PRA Database Update Process Concepts," 10th International Probabilistic Safety Assessment & Management Conference (PSAM 10), 7-11 June 2010, Seattle, WA.
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8. Cooper, S.E. et al, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines," 10th International Probabilistic Safety Assessment & Management Conference (PSAM 10), 7-11 June 2010, Seattle, WA.

9. Cooper, S.E. et al, "EPRI/NRC-RES Fire Human Reliability Analysis Guidelines," 2009 ANS Winter Meeting, 15-19 November 2009, Washington, DC.
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11. Fragola, J.R. and Collins, E.P., "The Value of a Space Precursor Analysis Program: A Saturn Example", 2003 ASME Congress, 21 November 2003, Washington, DC.
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13. Dougherty, E.M. and Collins, E.P., "A Technical Note: Assessing the Reliability of Skilled Performance", Reliability Engineering and System Safety, Vol. 51, pgs 35-42, Elsevier, The Netherlands, 1996.
14. Collins, E.P. and Fragola, J.R., "Advances in Human Error Evaluation", 1995 Reliability, Availability, Maintainability Symposium (RAMS), January 1995, Washington, DC.
15. Collins, E.P., "Process Safety Analysis and Management using the IRISH™ Methodology", Society for Risk Analysis-Europe Fourth Conference, October 1993, Rome, Italy.
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17. Collins, E.P., "Reliability, Availability, Maintainability (RAM) Data Collection and Analysis", Tutorial for the 16th Inter-RAM Conference, May 1989, Monterey, CA.
18. Levy, I.S., Wreathall, J., DeMoss, G., Wolford, A., Collins, E.P. and Jarrell, D.B., Prioritization of TIRGALEX - Recommended Components for Further Aging Research, NUREG/CR-5248, November 1988.
19. Fernandez, R.A., Dougherty, E.M., Fragola, J.R., and Collins, E.P, "Human Reliability and Recovery Analysis for the Garoña PRA", Presented at Spanish Nuclear Society meeting on Human Reliability Analysis Methods, April 1987, Madrid, Spain.
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21. Collins, E.P., "Data Bases and their Applicability to Reliability Assessment", 13th Inter-RAM Conference, June 1986, Syracuse NY.
22. Fragola, J. R. and Collins, E. P., "Human Reliability Data Framework Development and Application", ANS Annual Meeting Transactions Vol. 49, TANSAO 49 1-474 (1985), June 1985, Boston, MA.