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Subject: **Additional Information Related to Response to NRC Request for Additional Information Letter No. 56 – DCD Chapter 17 – RAI Numbers 17.1-1, 17.2-1, and 17.4-1 through 17.4-12 — NEDO-33289, "NP-2010 COL Demonstration Project Reliability Assurance Program Plan," October 2006**

Enclosure 1 contains NEDO-33289, "NP-2010 COL Demonstration Project Reliability Assurance Program Plan," October 2006, as requested by the NRC in an e-mail dated October 23, 2006. The purpose of the Reliability Assurance Program is to ensure that plant safety, as estimated by the PRA, is maintained as the detailed design evolves through the implementation and procurement phases and that pertinent information is provided in the design documentation to the COL applicant so that equipment reliability, as it affects plant safety, can be maintained through operation and maintenance during the entire plant life. GE's original response to the subject RAIs was transmitted via the Reference 1 letter.

If you have any questions about the information provided here, please let me know.

D068

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

Reference:

1. MFN 06-368, Letter from David Hinds to U.S. Nuclear Regulatory Commission, *Response to NRC Request for Additional Information Letter No. 56 – DCD Chapter 17 – RAI Numbers 17.1-1, 17.2-1, and 17.4-1 through 17.4-12,* October 6, 2006

Enclosure:

1. MFN 06-368, Supplement 1 – NEDO-33289, "NP-2010 COL Demonstration Project Reliability Assurance Program Plan," October 2006

cc: AE Cubbage USNRC (with enclosures)
GB Stramback GE/San Jose (with enclosures)
eDRF 0060-4184

ENCLOSURE 1

MFN 06-368, Supplement 1

NEDO-33289, "NP-2010 COL Demonstration Project Reliability Assurance Program Plan," October 2006

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Wilmington, NC 28401

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NP-2010 COL Demonstration Project
Reliability Assurance Program Plan

Prepared for:

Dominion Nuclear North Anna, LLC
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Contents

1 Overview

1.1 Introduction

Reliability Assurance is a continuous process with the goal of assuring that a high level of plant safety, as estimated by the PRA, is preserved. As the detailed design evolves through the implementation and procurement phases and pertinent information is provided in the design documentation to the COL applicant, equipment reliability is assured and is maintained during the entire plant life.

The Reliability Assurance Program (RAP) is designed to achieve this objective by bridging the gap between Technical Specification (TS) safety limits, which are deterministic, and the NRC plant nuclear safety goals, which are probabilistic and more encompassing. TS surveillance requirements control SSCs that mitigate design-basis accidents and challenge the fission product barriers. PRA experience has shown that the plant's Technical Specifications control the key safety functions, but this is a subset of the overall risk profile of the plant. Therefore, PRA results, such as importance analyses, are used in conjunction with these deterministic results, and operating experience, to comprise the necessary elements of a RAP that effectively addresses the important elements of plant nuclear safety.

An effective RAP utilizes the following processes: Classification of risk significance; Assignment of reliability assurance activities; Monitoring and feedback; and Implementation of reliability assurance activities (this is performed by the plant organization and is not described in this document. The RAP is adaptable to lessons learned and new operating experience so that risk significance is re-evaluated and the necessary reliability assurance activities are adjusted accordingly. The RAP is integrated into the engineering design program, using the design control and PRA procedures.

The key RAP products that are developed and maintained are a list of risk-significant PRA insights and assumptions; a list of risk-significant SSCs; and system design reliability assessments. These products are used to ensure that risk insights are incorporated into the plant design, and to preserve the integrity of the PRA model by ensuring that important PRA model assumptions are maintained, so that the PRA model is a reasonable reflection of the as-built and as-operated plant. Each product is updated with changes to plant design and the PRA model.

The RAP is developed in four phases, corresponding to COL application process, and based on the level of detail that is available during the design, construction, and operating phases. The Design Certification Application D-RAP phase defines the program structure, including guidance for procedures and activities that will be implemented in the future phases of the RAP. In this phase, a preliminary, generic PRA model is developed, along with a list of PRA insights and assumptions. Also, baseline design reliability assessments for each PRA system are performed in the DCD Applicant phase. The COL Application D-RAP phase identifies the list of risk-significant SSCs within the scope of the RAP based on plant-specific

PRA results and insights. These results are evaluated using an expert panel process to establish dominant failure modes and recommended operations, maintenance and monitoring strategies. The COL Holder D-RAP phase incorporates recommended operations, maintenance and monitoring strategies into the Operations phase of the RAP to assure that such SSCs can be expected to operate throughout plant life with reliable performance that is consistent with the PRA. During the operations phase, the RAP is implemented through the COL Holder's Maintenance Rule Program and other processes, such as Quality Assurance, In-Service-Inspection and Testing, and Corrective Action Program.

NUREG 0800 states that the NRC will verify the design phase RAP implementation by assessing the following:

- Verification that the design phase RAP evaluated and approved during the design stage is being implemented during procurement, fabrication, construction, and preoperational testing.
- Evaluation of modifications to the design of risk-significant SSCs during the construction stage, thereby ensuring that new information is factored into the PRA or other sources to assure risk significance evaluations and prioritizations are maintained.
- Evaluation of revisions to the plant- or site-specific PRA.
- Verification that the list of SSCs designated as risk significant for the COL holder during the construction stage is appropriately revised.
- Verification that dominant failure modes consider any changes to site-specific elements, any new industry experience and analytical models.

Accordingly, the ESBWR RAP provides the process, controls, and documentation to satisfy the verification requirements.

1.2 Purpose

The purpose of the RAP is to ensure that plant safety, as estimated by the PRA, is maintained as the detailed design evolves through the implementation and procurement phases and that pertinent information is provided in the design documentation to the COL applicant so that equipment reliability, as it affects plant safety, can be maintained through operation and maintenance during the entire plant life.

1.3 Scope

The scope of the ESBWR RAP includes risk-significant SSCs, both safety-related and nonsafety related, that provide defense-in-depth or result in significant improvement in the

PRA evaluations. A list of risk-significant SSCs within the scope of the RAP is developed and maintained for use in the operations phase of the RAP. This information forms the basis for the Maintenance Rule program, which ensures that risk-significant SSCs operate throughout plant life with reliable performance that is consistent with the PRA.

The scope of the RAP during normal operations is implementation of the Maintenance Rule program. This includes updating the PRA model and the Maintenance Rule program using the monitoring, feedback, and periodic updating processes described in the RAP. No regulatory submittals are required. Program information is documented and is available for NRC inspection.

1.4 Objectives

The objectives of the RAP are to provide reasonable assurance of the following:

- The plant is designed, constructed, and operated consistent with risk-significant PRA assumptions and insights for SSCs.
- Risk-significant SSCs will not degrade to an unacceptable level during plant operations.
- The frequency of transients posing challenges to risk-significant SSCs will be minimized.
- Risk-significant SSCs will function reliably when challenged

2 Reliability Assurance Program Description

2.1 Design Organization

The GE ESBWR Engineering Section is an integrated design and engineering organization that is responsible for formulating and implementing the RAP. The Manager, ESBWR Engineering is responsible for the design and licensing of the ESBWR, and for development of the D-RAP. The COL applicant is responsible for implementing the operations phase of the RAP.

The ESBWR Engineering organization is responsible for the design analysis and PRA engineering that is necessary to support the development of the RAP. PRA personnel are directly involved with the design organization and keep the design staff cognizant of risk-significant items, program needs, and project status. PRA personnel participate in the design change control process, which includes providing RAP related inputs in the design process.

2.2 Design Controls

GE ESBWR engineering design procedural controls are applied to the RAP. Specific procedures provide guidance on the design process, control of design changes, and storage and retrieval controls.

The design control procedure defines the process for performing, documenting, and verifying design activities. This includes developing or modifying the design of systems, engineering evaluations, analyses, calculations and document preparation, (e.g., specifications, drawings, reports.)

The procedure for design change control defines the process for evaluating design changes in engineering controlled documents to ensure that the total effect is considered before a change is approved, and the affected documents are identified and changed accordingly. The procedure provides authority for a change and identifies the pertinent interfaces and organizations responsible for these interfaces, including PRA review, and provides accurate and traceable records of a change. If a proposed change could affect the safety, availability or capacity factor of the ESBWR plant, system reliability is analyzed. A reliability study may include, but is not limited to, failure modes and effects analysis; PRA fault tree and importance analysis; common cause failure analysis; or analysis of operating experience. A safety assessment is required to be performed if the proposed change is the result of a deviation, a failure to comply, or an inadequacy in the original design, which could lead to a significant safety hazard or a Technical Specification safety limit violation. In addition certain changes, such as ones required to correct a condition that is hazardous to the health and safety of the public or plant personnel, or changes that improve or

degrade system or plant operational availability, require approval by a formal Change Control Board.

Several design control procedures provide guidance for developing a high quality process for reliability assurance. The documentation procedure establishes the requirements and responsibilities for the preparation, approval, and issue of documents controlled by the engineering design organizations. The quality assurance records procedure provides requirements for quality assurance record retention. The self-assessment, corrective action and audits procedure specify the responsibilities for performing self-assessments; internal audits of the engineering organization; and prompt identification, documentation, and corrective actions on conditions that are adverse to quality.

2.3 RAP Procedure

In addition to the standard engineering design processes and quality controls, specific guidance is used to define and implement an effective RAP. The RAP procedure describes the processes for identifying and prioritizing risk significance, implementing reliability assurance strategies, and monitoring program effectiveness. It is described below, and it is used in conjunction with the PRA procedures and the Expert Panel Process to incorporate reliability assurance into each aspect of the design, construction, testing, and operation of the ESBWR.

3 RAP Implementation

RAP is designed to provide sufficient documentation to conclude that reliability assurance is provided during all phases of the design and operation of the ESBWR. This section outlines the responsibilities and products that are developed during the successive phases of plant design through normal operations.

3.1 Phase I – Design Certification Application D-RAP

In this initial RAP phase preliminary PRA information is incorporated into the plant design. The PRA is a generic model, i.e., plant-specific details on ultimate heat sink and switchyard are not available. The PRA data is based on generic estimates for initiating event frequencies, failure rates, and human error probabilities. The products that are developed in the DCD Applicant phase are system design reliability assessments, which are based upon:

- A preliminary list of risk-significant PRA insights and assumptions.
- A preliminary list of risk-significant SSCs.

The assessment identifies key risk-informed information that is provided to the system engineer to ensure that it is incorporated into the final system design. The processes for identifying and prioritizing SSCs are described in Section 4.

3.2 Phase II – COL Application D-RAP

In this phase, the PRA model is updated to contain plant-specific details; however, the data is still based on generic estimates. Specific design details are still being developed and they will be incorporated into the PRA update process described in Section 5. The DCD Applicant and COL Applicant have joint responsibility for creating an expert panel. The panel will evaluate the PRA information, in concert with traditional engineering evaluations, sensitivity studies, PRA insights/assumptions, operational experience, and current regulatory requirements. The evaluation provides the initial comprehensive list of risk-significant SSCs.

In addition, the expert panel will use this evaluation to develop reliability assurance strategies for procurement and construction and pre-operational testing.

3.3 Phase III – COL Holder D-RAP

The PRA model is updated to contain plant-specific design details and estimated human error probabilities that are based on the development of plant operating procedures. The COL Holder has responsibility for updating the list of risk-significant SSCs, and for developing the Maintenance Rule program.

3.4 Phase IV – Operations

The PRA is now a comprehensive, (but inexperienced) model. The PRA model and the key products are updated through the normal procedural controls. The RAP is integrated primarily into the Maintenance Rule Program, however some elements may also be included in the Appendix B Program, ISI / IST Program and other risk-informed programs. For example, non-safety significant SSC design and operational errors will be addressed by Appendix B (as discussed in SECY 95-132).

4 Description of RAP Procedure

The purpose of the procedure is to provide guidance and controls for the essential elements of a RAP, which are described below.

4.1 Classification of Risk Significance

4.1.1 PRA Insights and Assumptions

Some risk information in the design phase PRA model is based on assumptions because certain details have not been created. Therefore, the design phase PRA uses assumptions (typically they are conservative) in the areas of design requirements, bounding analyses, generic failure rates, deterministic success criteria, physical layout of equipment, etc. to compensate for this gap. In order to ensure that the PRA model reflects the as-built plant, it is necessary to ensure that these PRA assumptions are preserved in the actual design, and that changes to assumptions are adequately assessed when design details are finalized in the construction and startup of the plant. Therefore, the PRA risk insights and assumptions are evaluated in order to identify key design details that have a significant effect on the PRA model.

A list of risk-significant PRA insights and assumptions is developed to provide assurance that the PRA model reflects the as-built and as-operated plant. The risk-significant PRA insights and assumptions relate to design requirements, reliability and availability requirements, or operator actions that are necessary to support safety function success.

The list of risk-significant PRA insights and assumptions is controlled and maintained in accordance with PRA procedural controls, and interfaces within the engineering design control procedures.

4.1.2 Risk-Significant SSCs

A list of risk-significant SSCs is developed in stages. First, a preliminary list is developed based on the generic PRA information available in the design certification phase. As the design progresses, the list of risk significant SSCs is enhanced by using a blended approach that applies the best information from PRA results with defense-in-depth principles and operating experience. An expert panel, with collective knowledge and experience in operations and maintenance processes, evaluates this information.

The list of risk-significant SSCs is also maintained with appropriate configuration controls by the PRA procedures, and is the basis for developing reliability assurance operational strategies and for the site Maintenance Rule program.

4.1.3 Risk-Significance Methods

Typically, a blended approach of quantitative and qualitative results is employed to describe risk. The PRA results are compiled from several PRA scenarios that envelope the overall risk profile of the plant. The level 1 PRA evaluates accident sequences from initiating events and failures of safety functions that lead to core damage. An assessment is performed for operating and shutdown conditions. The external events analysis considers events whose cause is external to systems associated with at-power or shutdown plant operations, including internal flooding, fire, high winds, and seismic events. The seismic events are analyzed using a seismic margins approach that provides qualitative conclusions on the ability of ESBWR SSCs to cope with seismic events. The other external events are quantified using the Level 1 PRA. The Level 1 results are further evaluated with respect to their effects on containment failure and radiological release probabilities in the Level 2 analyses.

Risk significance can be measured for each of these PRA scenarios. For example, Level 1 basic events representing component failures are identified as risk-significant if their importance values for Risk Achievement Worth (RAW) are greater than or equal to 5.0, or Fussell-Vesely Importance (FVI) are greater than or equal to .01. However, when evaluating the risk significance of a basic event or an initiating event relative to the overall risk profile, it is necessary to consider the differences that exist in calculating the various PRA scenarios to ensure that the risk is evaluated on a common basis. The shutdown risk importance is based on a relatively short time period, as compared to an operating cycle, and should be adjusted to an annual basis. Some PRA scenarios, such as Fire scenarios, use a screening approach with highly conservative values. Seismic scenarios are not quantified. Therefore, judgment must be applied when comparing these types of risk insights. Level 2 risk significance is determined either quantitatively, or qualitatively by identifying the dominant contributors to severe accidents and offsite release of fission products. The analysis, which is performed by the expert panel, includes the evaluation of severe accident phenomena and fission product source terms, and containment integrity strategies including pressure suppression, decay heat removal, and hydrogen generation.

Another measure of risk significance is derived from the NRC safety goals. SSCs that are relied upon under power-operating and shutdown conditions to meet the NRC's safety goal guidelines of a CDF of less than 1.0E-4 per reactor year and LRF of less than 1.0E-6 per reactor year are risk-significant. In addition, SSCs that are needed to meet the containment performance goal, including containment bypass, during severe accidents are also risk-significant.

The expert panel may assess component operating history and industry operating experience when it can be applied to assessing risk significance. Operating experience identifies previous failures of components in similar applications, and also reveals situations where inappropriate human actions have led to functional failures of SSCs.

Any SSC, human error probability, initiating event that is determined to be risk significant is included in the list of risk-significant SSCs.

4.2 Assignment of Risk-Significant Insights Into Reliability Assurance Activities

A two-step approach is used to translate risk insights from the list of risk-significant SSCs into strategies for reliability assurance. The first step involves identifying the dominant failure modes of risk-significant SSCs and their effects on safety functions. The second step is to identify specific operations and maintenance strategies to address the dominant failure modes, so that equipment performance is consistent with the PRA.

4.2.1 Evaluate Risk Information

In the first step, the design engineer evaluates the design of a component, train or system to identify dominant failure modes and their effects.

Inputs may include PRA importance analysis, root cause analysis, failure modes and effects analysis, and review of operating experience.

In addition, equipment performance information, including vendor manuals, ASME Section XI, technical specifications, Regulatory Treatment of Non-Safety Systems (RTNSS), and other regulatory requirements are reviewed to identify important safety functions.

The design engineer analyzes this information to identify dominant failure modes, such as single failures, latent failures not detected by routine monitoring, common cause failures, or failures that could cascade into more significant safety functional failures. This information is incorporated into the baseline and routine design reliability assessments, which are described in this document.

4.2.2 Identify Reliability Assurance Strategies

Collectively, the design engineer and the expert panel identify operational reliability assurance strategies for all phases of design and construction that are realistic and achievable. Risk insights may be applied in each phase of development, as indicated by the following examples of items for consideration:

- Procurement and Fabrication
    - Incorporate Risk-Significant Insights into Procurement Specifications, when applicable. Risk-significant components, especially those that are unique to the ESBWR design, are procured with the reliability that is assumed in the PRA. If a component's reliability deviates significantly from the assumed PRA value, it must be evaluated to determine if a PRA model change or a design change is warranted.

- Construction
    - Monitor Design Changes. Changes that affect functional characteristics of major components might affect the PRA model.
    - Assess physical layout of SSCs with respect to adverse interactions, fire and flood separation
- Pre-Operational Testing
    - Validate risk-significant PRA assumptions by tests, if applicable.
- Operations
    - Maintenance Rule implementation
    - Operator training and procedures
        - Preventive and predictive maintenance (including test and maintenance unavailabilities used in the PRA model)
    - Surveillance testing
    - Component performance
    - Initiating event experience
    - Human factors.

4.2.3 Determine Risk Significance Commensurate With Safety

Safety-related SSCs are already controlled by plant Technical Specifications. If a non-safety SSC is shown through operating experience or PRA to be significant to public health and safety, then its performance should be implemented and controlled by Technical Specifications, in accordance with 10 CFR 50.36. In this case, "significant to public health and safety" equates to an SSC that is required to meet the NRC Safety Goals. If an SSC is found to be risk significant but is not required for meeting the NRC Safety Goals, then performance controls should be implemented through the RAP. If the SSC is not risk significant, then normal controls should be implemented through the site Maintenance Rule and corrective action programs.

4.3 Monitor and Feedback Processes

Throughout all phases of the RAP, processes are in place to monitor and refine the elements of the program. The following processes for monitoring and feedback are essential elements of a RAP.

4.3.1 Design Reliability Assessment

A design reliability assessment is a process in which the design engineer builds quality and reliability into the SSC, while ensuring that the basis for SSC design is properly modeled in the PRA. Due to the preliminary nature of the PRA model during the design phase, the model relies on generic information, bounding assumptions, or design requirements as a basis for model development. This design assessment can be performed for changes that occur during the plant design phase, as well as during normal plant operations.

The design engineer uses a systematic method to evaluate the proposed design details with respect to PRA insights. The evaluation considers reliability concepts, such as redundancy, diversity, human factors, spatial interactions, external events, etc., to enhance the system design. The assessment uses the list of PRA insights and assumptions. If the assessment reveals that the proposed design could conflict with risk-significant results and insights calculated in the PRA, or could cause significant unavailability of a safety function, then a design change is pursued.

Proposed design changes are processed by the design change control procedure, which requires PRA review. If a design change affects the PRA model, then it is revised in accordance with the PRA update process described in the PRA procedure.

A baseline design reliability assessment is performed for each system modeled in the PRA. The assessment is maintained in the document control program, and may be updated with future design reliability assessments as necessary.

4.3.2 Operations and Maintenance Reliability Assessment

After initial fuel load and thereafter, the RAP is implemented in plant programs, such as the Maintenance Rule program. A procedure is developed by the COL holder to implement a Maintenance Rule program with the following scope:

- Selection of Structures, Systems, and Components (SSCs) for inclusion.
- Establishing and applying safety significant criteria.
- Setting performance monitoring criteria.
- Trending the performance of applicable SSCs to demonstrate the effectiveness of maintenance activities.
- Taking corrective action when SSC performance degrades.
- Periodically assessing program performance.
- Maintenance Rule a(4) assessment of real-time risk profile, (i.e., actual versus scheduled risk.)

5 Description of PRA Procedures

PRA procedures include the following elements: control of inputs, methods, and documentation; model development; processing changes to the PRA model, e.g., design changes; and, PRA applications. These processes are outlined below.

5.1 PRA Model Controls

The PRA model is maintained as controlled engineering analysis. In order to maintain a PRA model that reasonably reflects the as-built and as-operated characteristics of the plant, controls are implemented to:

- Monitor PRA inputs and collect new information.
- Maintain and upgrade the PRA model.
- Ensure that cumulative impacts of pending changes are considered in PRA applications.
- Evaluate the impact of PRA changes on previously implemented risk-informed applications.
- Maintain configuration control of the computational methods used to support the PRA model.
- Document the PRA model and the procedures that implement these controls.

5.2 PRA Model Development

Similar to the RAP, the PRA model must be developed in phases, in parallel with the design of the ESBWR. PRA information is used to evaluate and improve the design, operation, and maintenance of a system or function. When sufficient design detail is developed, a Design-Phase PRA model is also developed. It models the generic ESBWR plant, i.e., without site-specific characteristics, such as transmission system or cooling water design. When site-specific design details are available, a Plant-Specific PRA model is developed. Two key products are developed from the PRA for the RAP: 1) a list of risk-significant PRA insights and assumptions, and 2) a list of risk-significant SSCs. These products are maintained and updated as the PRA model and site design evolve. Updated risk-significant insights are identified to show that key assumptions from the Design Certification PRA model have been maintained or improved upon in the Construction PRA model. Differences in risk insights include changes, either detrimental or beneficial, to significant cutsets relative to CDF, significant accident sequences, and significant containment challenges. A systematic screening approach is used to ensure that all significant differences are identified. The COL Applicant is then responsible for showing the overall effect of the changes, and that risk-

significant PRA assumptions and insights are maintained such that the PRA model reflects the as-built, as-operated plant.

In order to ensure that the Plant-Specific PRA model maintains the appropriate scope, level of detail and technical adequacy, it is peer-reviewed using the guidance in ASME RA-S-2002, "Standard for Probabilistic Risk Assessment for Nuclear Power Plant Applications." Findings from the peer review, i.e., facts and observations are identified and incorporated into the PRA model or dispositioned.

5.3 PRA Model Changes

When a pending change is provided from the design engineer to the PRA engineer, the effects of the change on CDF and LRF are estimated. As a result of the estimate, one of the following should occur: (a) If the impact is judged to have a significant effect on the PRA model, a PRA model update is implemented promptly (commensurate with the safety significance of the pending change) without waiting for the normal update cycle. (b) If the impact is judged to be small, the incorporation of the change occurs in the next scheduled model update, and the identified change is documented in a change control process. (c) If the change has no impact, then no further action is required.

The PRA model is updated to reflect plant design, operational, and PRA modeling changes, consistent with NRC-endorsed standards in existence 1 year prior to issuance of the update, which will be every other fuel cycle, not to exceed 5 years. When the PRA model is updated, the list of risk-significant SSCs is updated and fed back to the appropriate engineering organization.

5.4 PRA Applications

Risk-informed applications will be administered and controlled by the licensee during normal plant operations.

6 Description of Expert Panel

An expert panel is formed to evaluate quantitative and qualitative inputs relative to risk-significance and make the overall determination on the risk-significance of the SSC, process, or condition being evaluated within the RAP. This provides the basis for an effective allocation of resources commensurate with nuclear safety.

The expert panel is comprised of individuals who collectively possess knowledge in the following areas:

- Plant design.
- System operation.
- PRA concepts.
- As the project progresses, individuals knowledgeable in predictive and preventive maintenance and surveillance testing should be added to the Panel.

Expert Panel members are trained on the following concepts:

- Maintenance Rule program.
- PRA concepts such as CDF, LRF and Importance factors.
- Limitations of the PRA.
- Use of industry operating experience.

The Expert Panel provides an integrated decision-making process that is systematic, repeatable, and technically defensible. In documenting the findings, the Panel should account for probabilistic and traditional engineering considerations. Probabilistic analyses should include a discussion of the limitations or uncertainties in the risk models. It is expected that documentation of the Expert Panel process will reside within the configuration controls of the process or program being evaluated. Ultimately, the Expert Panel process is incorporated into the COL Holder's program for compliance to 10 CFR 50.65, the Maintenance Rule.