Program Management Office
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Project 694

April 17, 2017

OG-17-114

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Subject: PWR Owners Group, Risk Management Committee
Submittal of Revisions to PWROG-14001-P/NP, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal," per PA-RMSC-1463

References:

1. PWR Owners Group Submittal of PWROG-14001-P/NP, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal," OG-14-211, dated July 3, 2014.
2. NRC Letter for Transmittal of the Draft Safety Evaluation for Pressurized Water Reactor Owners Group Topical Report PWROG-14001-P, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal," dated December 23, 2016 (TAC NO. MF4397)
3. PWR Transmittal of Comments on the Draft Safety Evaluation Regarding PWROG-14001-P/NP, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal," OG-17-24, dated January 20th, 2017.

The Advisory Committee on Reactor Safety (ACRS) provided a number of inquiries on topical report PWROG-14001-P/NP at the February 6th, 2017 subcommittee meeting. Additional information was requested on the following:

- Inadvertent Actuation of the Generation III Shutdown Seal (SDS)
- Human Reliability Analysis (HRA) Dependency on the Operator Action to trip the Reactor Coolant Pumps (RCPs)
- RCP Shaft Sleeve O-ring Failure

VERIFIED TRUE COPY
BRIAN BEAVEY

Enclosure 1 provides the additional text that will be added to the approved version of the topical report which addresses the ACRS subcommittee inquiries. The revisions will be included in the approved version of the topical report after the Final Safety Evaluation (FSE) is issued.

Enclosed are:

- Three copies of Revisions to Topical Report PWROG-14001-P/PWROG-14001-NP, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal," LTR-RAM-17-17 (Proprietary and Non-Proprietary). (Enclosure 1)

Also enclosed is Westinghouse letter CAW-17-4569 (Enclosure 2), the accompanying affidavit, Proprietary Information Notice, and Copyright Notice.

The enclosed revisions (Enclosure 1) contain information proprietary to Westinghouse Electric Company LLC; it is supported by an affidavit signed by Westinghouse, owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b) (4) of Section 2.390 of the Commission's regulations.

It is respectfully requested that this information which is proprietary to Westinghouse, be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the information identified above or the supporting Westinghouse affidavit should be directed to: Mr. J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania, 16066.

Correspondence related to this transmittal should be addressed to:

Mr. W. Anthony Nowinowski, Program Manager
PWR Owners Group, Program Management Office
Westinghouse Electric Company
1000 Westinghouse Drive
Suite 380
Cranberry Township, Pennsylvania 16066

If you have any questions, please do not hesitate to contact me at (205) 992-7037 or Mr. W. Anthony Nowinowski, Program Manager of the PWR Owners Group, Program Management Office at (412) 374-6855.

Sincerely yours,

Norman J. Stringfellow

Jack Stringfellow
Chairman and Chief Operating Officer
PWR Owners Group

NJS:WAN

Enclosure 1: PWROG Revisions to PWROG-14001-P/NP, LTR-RAM-17-17 (Proprietary and Non-Proprietary)
Enclosure 2: Affidavit for Withholding, CAW-17-4569 (Non-Proprietary)

cc: PWROG PMO
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CAW-17-4569

April 11, 2017

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-RAM-17-17 P-Attachment, Revision 0, "Revisions to Topical Report PWROG-14001-P/PWROG-14001-NP, Revision 1, 'PRA Model for the Generation III Westinghouse Shutdown Seal' " (Proprietary)

The Application for Withholding Proprietary Information from Public Disclosure is submitted by Westinghouse Electric Company LLC ("Westinghouse"), pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Nuclear Regulatory Commission's ("Commission's") regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-17-4569 signed by the owner of the proprietary information, Westinghouse. The Affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying Affidavit by Pressurized Water Reactor Owners Group (PWROG).

Correspondence with respect to the proprietary aspects of the Application for Withholding or the Westinghouse Affidavit should reference CAW-17-4569 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

James A. Gresham, Manager
Regulatory Compliance

CAW-17-4569

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

I, James A. Gresham, am authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC ("Westinghouse") and declare that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

Executed on: 4/11/17

James A. Gresham, Manager
Regulatory Compliance

(1) I am Manager, Regulatory Compliance, Westinghouse Electric Company LLC ("Westinghouse"), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Nuclear Regulatory Commission's ("Commission's") regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitute Westinghouse policy and provide the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of

Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, (e.g., by optimization or improved marketability).

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(iii) There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iv) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, is to be received in confidence by the Commission.

(v) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(vi) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in LTR-RAM-17-17 P-Attachment, Revision 0, "Revisions to Topical Report PWROG-14001-P/PWROG-14001-NP, Revision 1, 'PRA Model for the Generation III Westinghouse Shutdown Seal' " (Proprietary), for submittal to the Commission, being transmitted by PWROG letter OG-17-114. The proprietary information as submitted by Westinghouse is that associated with requests for review and approval of Topical Report PWROG-14001 and may be used only for that purpose.

(a) This information is part of that which will enable Westinghouse to support the Final Safety Evaluation for Topical Report PWROG-14001.

(b) Further, this information has substantial commercial value as follows:

(i) Westinghouse plans to sell the use of similar information to its customers for the purpose of marketing the Generation III shutdown seal.

(ii) Westinghouse can sell support and defense of industry guidelines and acceptance criteria for plant-specific applications.

(iii) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and non-proprietary versions of a document, furnished to the NRC associated with requests for review and approval of Topical Report PWROG-14001and may be used only for that purpose.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the Affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

Letter for Transmittal to the NRC

The following paragraphs should be included in your letter to the NRC Document Control Desk:

Enclosed is:

1. LTR-RAM-17-17 P-Attachment/LTR-RAM-17-17 NP-Attachment, Revision 0, "Revisions to Topical Report PWROG-14001-P/PWROG-14001-NP, Revision 1, 'PRA Model for the Generation III Westinghouse Shutdown Seal' " (Proprietary/Non-Proprietary)

Also enclosed are the Westinghouse Application for Withholding Proprietary Information from Public Disclosure CAW-17-4569, accompanying Affidavit, Proprietary Information Notice, and Copyright Notice.

The subject document was prepared and classified as Westinghouse Proprietary Class 2. Westinghouse requests that the document be considered proprietary in its entirety. As such, a non-proprietary version will not be issued.

As Item 1 contains information proprietary to Westinghouse Electric Company LLC ("Westinghouse"), it is supported by an Affidavit signed by Westinghouse, the owner of the information. The Affidavit sets forth the basis on which the information may be withheld from public disclosure by the Nuclear Regulatory Commission ("Commission") and addresses with specificity the considerations listed in paragraph (b)(4) of Section 2.390 of the Commission's regulations.

Accordingly, it is respectfully requested that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the item listed above or the supporting Westinghouse Affidavit should reference CAW-17-4569 and should be addressed to James A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 3 Suite 310, Cranberry Township, Pennsylvania 16066.

Revisions to Topical Report PWROG-14001-P/PWROG-14001-NP, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal."

April 12, 2017

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***Electronically approved records are authenticated in the Electronic Document Management System.**

Inadvertent Actuation

The following text will be added to Subsection 2.5.5.6 of TR PWROG-14001-P/PWROG-14001-NP (Reference 1).

The design of the SDS assembly provides additional defenses against inadvertent actuation of the SDS. This is accomplished by providing margins between the design specifications and the expected operational conditions as well as assuring that catastrophic component failure does not lead to inadvertent actuation. Consensus judgment from an expert panel comprised of senior Westinghouse subject matter experts in design, field services, plant operations, and probabilistic risk assessment was used to develop an estimate of the probability of an inadvertent actuation using proven PRA methodologies. The resulting frequency of inadvertent actuation, based on the consensus expert judgment process, is [ ]^{a,c}. A detailed evaluation and additional discussion on inadvertent actuation is provided in Appendix A.

The following text will be added as Appendix A in TR PWROG-14001-P/PWROG-14001-NP (Reference 1).

This appendix contains a detailed evaluation and discussion on the probability of an inadvertent actuation of the SDS. Inadvertent actuation of the SDS while the RCP is in operation will damage the SDS and prevent the SDS from performing its function, should it be needed following a loss of seal cooling. As a consequence of the significance of the event, and the low likelihood of detection given premature actuation, considerable effort has gone into including design features to prevent inadvertent actuation. In order to quantify the likelihood of inadvertent actuation of the SDS an expert panel comprised of senior Westinghouse subject matter experts in design, field services, plant operations, and probabilistic risk assessment was convened to perform a failure modes and effects analysis of the SDS and to develop an estimate of the probability of an inadvertent actuation using proven PRA methodologies. The following discussion describes the events that could lead to an inadvertent actuation of the SDS, the expected consequences, and the assigned probabilities.

Fault Tree Model for Inadvertent Actuation

To systematically assess the frequency of inadvertent actuation of the SDS, a fault tree model was developed. Subsequently, numerical probabilities were assigned to the fault tree basic events and the fault tree was quantified to yield a frequency of inadvertent actuation.

The fault tree model structure and numerical assignments of associated basic event probability were based on the engineering judgment of a group of experienced Westinghouse engineers who considered their own background as well as input from other subject matter experts. The full fault tree structure is shown in Figure A-1 and includes the following possible causes of inadvertent actuation:

- [ ]^{a,c}
- [ ]^{a,c}
- [ ]^{a,c}
- [ ]^{a,c}

Inadvertent actuation is defined as any failure of the SDS or SDS components that would result in the actuation of the SDS at seal leak-off temperatures below [ ]^{a,c}. Seal leak-off temperatures above [ ]^{a,c} are indicative of loss of all seal cooling conditions for which the SDS is designed to actuate. Therefore, by definition, if the seal leak-off temperature exceeds this value and the SDS actuates, actuation of the SDS is not inadvertent. Therefore, by definition, inadvertent actuation is only considered possible when the SDS actuates without a prior loss of all seal cooling accident to the affected RCP. If a loss of all seal cooling accident occurs, and the SDS actuates prior to reaching its actuation temperature, this occurrence is not considered inadvertent. This type of failure is considered a random failure of the SDS.

[

]^{a,c}

Figure A-1: Inadvertent Actuation Fault Tree

Fault Tree Quantification

The assignment of numerical values to the basic events in the fault tree was performed by the expert panel consensus process. The assignment of numerical values considered the SDS design and quality control, as well as, extensive testing and analysis that have been performed to prevent inadvertent actuation of the SDS as described in TR-FSE-14-1-P, Revision 1 (Reference 3). The guidelines for the assignment of numerical values to the basic events in the fault tree and the basis for the assignment is described below.

A set of criteria was developed for translating engineering judgment into quantifiable values. The criteria are similar to the guidelines for probability assignment used in NUREG/CR-6771. The Table A-1 criteria were provided to expert panel members for use in assigning probabilities to physical events such as component failures of relevance to the inadvertent actuation failure mode.

Table A-1: Guidelines for Assigning Conditional Probabilities to Physical Events

Value	***Description***
1.0E-01	*The indicated outcome is UNLIKELY but it cannot be supported by analysis or testing. It is a credible outcome, considering uncertainties, such that it could occur during the plant lifetime.*
5.0E-02	*The indicated outcome is HIGHLY UNLIKELY. Analyses or testing have not been done directly or cannot rule it out completely. However, arguments in favour of this outcome are not supported by available testing or analysis.*
1.0E-02	*The indicated outcome is VERY UNLIKELY. Available testing or analyses show that the outcome did not occur. Consideration of these uncertainties might lead to this outcome but no analytical or experimental support can be found.*
1.0E-03	*The indicated outcome is EXTREMELY UNLIKELY. Available testing or analyses show that the outcome did not occur and consideration of the uncertainties cannot reasonably be found to lead to this outcome event when no analytical or experimental support can be found.*
1.0E-04	*The indicated outcome is ALMOST IMPOSSIBLE. No analysis or testing is available to support this result even considering relevant uncertainties. It has credibility only if a number of unsupported (but not demonstrably incorrect) assumptions are made. All available analysis and experiments support alternate outcomes.*

Some of the fault tree entries require an estimation of the probability that an out-of-specification item would not be detected in the Westinghouse or supplier quality program. It was assumed that all components will be procured and shipped under the Westinghouse Quality Assurance Program and that all suppliers would have an approved quality program that is acceptable under the Westinghouse Quality Assurance Program. The Table A-2 criteria were provided to expert panel members for use in assigning probabilities to non-compliances under the vendor and Westinghouse Quality control programs that would contribute to events that could impact SDS inadvertent actuation.

Table A-2: Guidelines for Assigning Conditional Probabilities to Quality Program Events	
Value	***Description***
1.0E-01	*The indicated outcome is UNLIKELY. Quality program is based on observations by Westinghouse that are not completely independent from supplier quality checks or a supplier on the Westinghouse Quality Supplier List with whom issues have occurred in the past.*
1.0E-02	*The indicated outcome is VERY UNLIKELY. Quality program is based on testing or observations by Westinghouse that are not completely independent from supplier quality checks or a supplier on the Westinghouse Quality Supplier List with whom little (or no) experience has accumulated.*
1.0E-03	*The indicated outcome is EXTREMELY UNLIKELY. Quality program is based on independent testing by Westinghouse or a supplier on the Westinghouse Quality Supplier List with whom experience has accumulated.*
1.0E-04	*The indicated outcome is ALMOST IMPOSSIBLE. Quality program is based on no human interactions or decisions.*

The criteria above provide a basis for qualifying the fault tree based on engineering judgment by an expert panel to provide an estimate of the yearly frequency of inadvertent actuation of the SDS during normal operation on a per pump-year basis.

This section provides the numerical value assigned to each of the basic events identified in the fault tree along with the basis for that assignment as developed by the expert panel.

[ ]^{a,c}

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Conclusions

The resulting frequency of inadvertent actuation, based on the consensus judgment process, is [ ]^{a,c}. The resulting inadvertent actuation frequency is dependent on the number of RCPs (i.e., the number of RCS loops) and the time the RCPs will operate. The other failure modes discussed in Section 2.5 are also on a per-pump basis. Consistent with SY-A15 of the ASME/ANS Standard, the calculated value for inadvertent actuation can be screened from the fault tree model since the value is greater than two orders of magnitude lower than the proposed failure frequency of the SDS. Therefore, the inadvertent actuation failure mode should not be included in the fault tree model for the SDS.

Update to Discussion on HRA Dependency for Operator Action to Trip the RCPs

In discussion of the PRA model for the SDS, it was noted that there was a need to expand the discussion on the operator action to trip the RCPs. The current text focuses on the modeling of an uncomplicated single operator action to trip the RCPs whose consequence would change dependent on the time the action was completed. The discussion did not consider the potential that the action could fail due to hardware/equipment failures. Should the operator attempt to trip the RCPs and fail due to hardware failures, the operator may then potentially recover by manually opening the reactor pump trip breakers. The model implicitly assumes that failure of the operator to take the initial action in the required time cannot be recovered. The following information will be added to the current text in Subsection 2.5.5.5 of TR PWROG-14001-P/PWROG-14001-NP (Reference 1).

When evaluating the operator action to trip the RCPs, analysts should consider the relevance of hardware/equipment failures and whether or not the operator action to trip the RCPs is dominant as compared to the hardware/equipment failures. Analysts should refer to the screening criteria provided in the SY supporting requirement of the ASME/ANS PRA Standard when determining whether or not to include hardware/equipment failures as part of the operator action to trip the RCPs. In addition, any dependency analysis for the operator action to trip the RCPs, and subsequent recovery actions to trip the RCPs by alternate means, should be done in accordance with the HR supporting requirement of the ASME/ANS PRA Standard.

Update to Discussion on O-ring Failure Mode in the Model 93A RCP

In the discussion of the PRA model for the SDS, it was noted in Subsection 2.5.1 of PWROG-14001-P/PWROG-14001-NP (Reference 1) that "In construction of the PRA model, [ ]^{a,c}." The following discussion expands on the basis for not developing a model 93A RCP seal specific PRA model. The following information will be added to the end of Subsection 2.2.3 of TR PWROG-14001-P/PWROG-14001-NP (Reference 1).

The Model 93A RCP SDS configuration includes a [ ]^{a,c} This implementation differs from the other Westinghouse RCP designs that use the SDS to [ ]^{a,c}. However, while the Model 93A RCP has [ ]^{a,c}. The use of the [ ]^{a,c} was largely based on a review of the test program data, and the inherent conservatism regarding how the baseline failure probabilities were determined. These considerations are presented below.

The overall approach of the SDS endurance qualification program was to efficiently demonstrate the high reliability of the SDS function for an [ ]^{a,c}. For purposes of qualification testing, the most limiting [ ]^{a,c} were identified. Of particular note was the SDS endurance testing performed on the Westinghouse model 93A-1 pump configuration. This configuration has the [ ]^{a,c}. Another important feature of the SDS qualification testing was that the testing was [ ]^{a,c}. Specifically, the seal ring endurance tests typically lasted between [ ]^{a,c}. Furthermore, it was assumed for purposes of the PRA, that the SDS [ ]^{a,c}. In most situations, loss of seal cooling events will be followed by a prompt plant shutdown and a rapid cooldown which would reduce the RCS pressure and temperature to [ ]^{a,c},

significantly reducing the challenge to the SDS within hours of the initiating event. Thus, the SDS seal failure probability [ ]^{a,c} given a loss of seal cooling can be considered bounding.

As discussed above, the Model 93A RCP includes an [ ]^{a,c}. Separate qualification tests were performed for these O-rings. O-rings can significantly degrade under exposure to high temperatures. The reliability of the O-ring was separately investigated in two test programs. One test program included [ ]^{a,c}. Each test involved two O-rings. These tests exposed the [ ]^{a,c}. The endurance test was continued for [ ]^{a,c}. The pressure profile was intended to bound the maximum pressure/pressurizer heat losses. Following each endurance test, a [ ]^{a,c}. O-ring failure was noted by the [ ]^{a,c}. The O-ring failure pressure was recorded and a pressure "survivability margin" was determined. The [ ]^{a,c} temperature environment was maintained during [ ]^{a,c}. These tests demonstrated the ability of the seal to survive harsh conditions for a timespan of a [ ]^{a,c} with sufficient residual strength to maintain sealing capability to pressures above [ ]^{a,c}. Following this test program, Westinghouse conducted an additional [ ]^{a,c}. As with the earlier test program, the pressure profile included a [ ]^{a,c}. The O-rings maintained their sealing capability throughout both test programs. In total, O-ring experiments included a total exposure time of approximately [ ]^{a,c}.

Analyses of the model 93A seal heatup following actuation of the SDS indicates that the reduced RCS leakage into the seal results in a relatively slow seal heatup process, requiring approximately [ ]^{a,c}. It is recognized that the ERGs instruct the operator to cooldown the RCS shortly after the onset of the loss of seal cooling. RCS cooldown will likely commence well in advance of the sealing ring temperature reaching its maximum asymptotic temperature of [ ]^{a,c}. It is estimated that when a realistic cooldown is credited, the effective O-ring exposure temperature would be generally bounded by [ ]^{a,c}. Applying an Arrhenius based acceleration factor based on the properties of the O-ring material it can be estimated that the effective duration of the seals at the anticipated post SDS actuation condition to be closer to [ ]^{a,c}. These considerations result in an effective [ ]^{a,c}. Therefore, failure of the [ ]^{a,c}. Given the fact that both the seal ring and O-ring failures are based on bounding data, it was judged that creating a second seal model to capture this failure mode was unnecessary. As a result of the bounding nature of the SDS failure probability, particularly as it applies to the Model 93A with [ ]^{a,c}, no adjustment to the baseline PRA value for failure to seal was warranted. Furthermore, it was judged that this approach reduces model complexity, maintains consistency among the PRAs; and simplifies model implementation.

References:

1. PWROG-14001-P/NP, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal," July 2014.