JANUARY 23, 2003 NRC MEETING
RI-ISI RELIEF REQUEST
CLARIFICATION ON THE USE OF SUB-SEGMENTS

Meeting Agenda

Kick-Off and Introductions...........*Bud Gerling, Regulatory Affairs Supervisor*
Palisades Nuclear Plant

Palisades Application
of Methodology.........................*Mike Carlson, Programs Engineering Manager*
Palisades Nuclear Plant

Westinghouse Overview
of Methodology.........................*Paul Stevenson, Principal Engineer*
Westinghouse Electric Company LLC

Palisades Responses to Clarification Request

Summary of Requested
Item #1...................................*Bruce Bishop, Principal Engineer*
Westinghouse Electric Company LLC

Summary of Requested
Item #2...................................*Dick Haessler, Principal Engineer*
Westinghouse Electric Company LLC

Summary of Requested
Item #3...................................*Mark Cimock, Senior Engineer*
Palisades Nuclear Plant

Conclusion..............................*Mike Carlson, Programs Engineering Manager*
Palisades Nuclear Plant

ATTACHMENT

PALISADES RISK-INFORMED INSERVICE INSPECTION PROJECT CHRONOLOGY

- October 1999: Project Kickoff / Expert Panel Scoping Session.
- Development of engineering analyses (EAs) for segment definitions and associated direct and indirect consequences.
- Development of Win-SRRA failure probability analyses.
- Performance of CDF/LERF analyses for all direct and indirect consequences on all segments modeled in the PSA.
- Performance of risk ranking analysis.
- October 2000: Expert Panel Risk Ranking Meetings for categorization of high safety significant (HSS) and low safety significant (LSS) segments.
- Change in (Delta) risk analysis.
- Statistical selection of number of welds to be inspected (Perdue Analysis).
- Revision (by Palisades) due to segmentation/consequence changes on select systems. Revisions performed on:
  - Segmentation/Consequence analysis.
  - CDF/LERF analysis.
  - Risk Ranking analysis (Expert Panel reconvened).
  - Delta Risk analysis.
  - Perdue analysis.
- Selection of inspection locations and methods by Engineering Sub-Panel.
- March 2002: RI-ISI submittal to the NRC.
- May 2002: Request for additional information (RAI) issued by NRC.
- August 2002: Palisades response to May RAI.
- September 2002: NRC Audit of Palisades RI-ISI Program.
- October 2002: NRC submits draft of Request for Clarification on the Use of Sub-Segments in the RI-ISI Relief Request
- January 2003: Palisades, Westinghouse, and NRC meeting to discuss open Request for Clarification on pipe segment modeling.

OVERVIEW OF WESTINGHOUSE OWNERS GROUP APPLICATION OF RISK-INFORMED METHODS TO PIPING INSERVICE INSPECTION (WCAP14572 REVISION 1-NP-A) RELEVANT TO TODAY'S DISCUSSION

a) The methodology identified in WCAP-14572 is a risk-informed methodology incorporating both quantitative and qualitative (i.e. deterministic) aspects.

b) The quantitative portion of the process uses best estimates that in some cases, may be conservative but not overly conservative.

c) Segments are defined primarily on the direct consequences associated with a postulated piping failure.

d) Failure probabilities are calculated for each segment for use in generating a piping core damage frequency (CDF), large early release frequency (LERF), risk reduction worth (RRW) and other risk metrics to help determine the safety significance of each segment.

e) All segments determined to be high safety significant by the expert panel receive examination.

f) For high safety significant segments, 100% of all welds subjected to an active failure mechanism, or analyzed as being highly susceptible to an active failure mechanism are examined.

g) The Perdue model analysis is used only on those welds in high safety significant segments where there is no active failure mechanism and the welds were not analyzed as being highly susceptible to an active failure mechanism. The Perdue Model is not used for socket welds.

h) Westinghouse provided training, technical review of Palisades' work, and worked closely with Palisades throughout their RI-ISI program to assure that Palisades correctly applied the methodology in WCAP-14572.

Requested Item

1. *For the failure probability estimation for segments that were subdivided, please provide the definitions used to identify sub-segments. Also please explain how the failure probability estimates are developed for a segment that has been divided into sub-segments and how your methodology comports with the approved methodology.*

Summary of Palisades Response

a) Sub-segments within a segment are defined based on having the same consequence but having different pipe sizes.

b) The segment probability is the highest value of the failure probabilities estimated for all its sub-segments.

c) Palisades application of the methodology fully comports with the approved methodology for the following reasons:

- SRRA calculations on the sensitivity of pipe size, including the presence of butt or socket welds, are performed to ensure excessive conservatism does not unrealistically impact the risk categorization of the segment.
- When multiple degradation mechanisms exist in a sub-segment, limiting input values for each mechanism are combined.
- The failure probability for the segment is characterized as the highest sub-segment value, which is the worst-case situation in each segment.
- The results of the SRRA calculations for sub-segments and segments are reviewed by the engineering team relative to being reasonable and consistent with operating experience.
- Use of the same four considerations in sub-segment failure probability (configuration, components, materials/chemistry and loads) also insures that excessive conservatism is not applied to the selection of inspection locations.
- All requirements and guidance on probability estimation by the engineering team with the SRRA tool in the approved WCAP Report, its Supplement and the NRC-SE are fully considered.

Requested Item

2. *For the Perdue method application on segments that were subdivided, please provide the definitions used to identify sub-segments. Also please explain how the Perdue input parameters are developed for a segment that has been divided into sub-segments, how the results are used to determine the number of locations for inspection in the segment, and how your methodology comports with the approved methodology.*

Summary of Palisades Response

The Perdue Model is used to aid in the determination of the number of inspection locations for segments determined to be high safety significant by the plant RI-ISI expert panel. Palisades segments were divided into sub-segments (or lots) during the Perdue Model evaluation using the following cases:

Case A

Segment has one pipe size, active failure mechanism postulated – susceptible locations are selected for inspection. Active failure mechanisms are removed from the Perdue Model inputs. The Perdue Model is used for remaining locations.

Case B

Segment has more than one pipe size, no active failure mechanism postulated – first approach is to use conservative input parameters and run the Perdue Model on all welds. If the results are too conservative, then subdivide the segment into lots by pipe size, run the Perdue Model on each pipe size, and multiply confidences of each lot to check against the acceptance criteria.

Case C

Segment has more than one pipe size, active failure mechanism postulated – susceptible locations are selected for inspection. For the remaining locations, active failure mechanisms are removed from the Perdue Model inputs and the first approach is to use conservative input parameters and run the Perdue Model on all remaining welds. If the results are too conservative, then subdivide the segment into lots by pipe size, run the Perdue Model on each pipe size, and multiply confidences of each lot to check against the acceptance criteria.

The above cases used in the Palisades RI-ISI program are consistent with the methodology described in WCAP-14572, Section 3.7.

Requested Item

3. *If you were to apply the failure probability estimation and the Perdue methodology to the entire segment for all segments, as opposed to sub-segments, how would the total number of inspections required in the RI-ISI program change?*

Summary of Palisades Response

The total number of inspections would not change.

Program specific data was evaluated to address this request. There are 193 segments that contain multiple pipe diameters and have some variation in the SRRA input parameters. All of the segments with SRRA input parameters that vary fall into one of three categories:

1. Only variation in inputs are pipe size and wall thickness (119 segments)

The only variations in the inputs are those associated with the actual physical makeup of the pipe. All other SRRA inputs are the same for each sub-segment.

2. Variations are all related to pipe and weld geometries (65 segments)

The more limiting inputs were consistently applied to the small-bore socket-welded sections of these segments. Numerous examples show that reevaluating the large bore sections of the pipe with the most limiting inputs would raise the failure probabilities for those sub-segments. However, in each example, the original limiting failure probability (for the small bore piping) associated with the segment remained the highest value and would still be chosen to represent the segment. Based on the evidence from the examples, applying the failure probability estimates to the entire segment as opposed to sub-segments for those in this category would not increase the number of inspections.

3. Variations are based on engineering judgment regarding potential degradation mechanisms (nine segments)

The justification for the variation in the inputs for these segments is sound and well documented. The decisions for the inputs were based on known and studied conditions specific to each section of the pipe. Additionally, because the segments in this category are low safety significant (LSS) and the most conservative failure probabilities of the sub-segments were used, had the segments in this category been split, the new segments would have also been LSS and there would have been no change to the number of inspections.

ENCLOSURE

NUCLEAR MANAGEMENT COMPANY, LLC
PALISADES NUCLEAR PLANT
DOCKET 50-255

REQUEST FOR CLARIFICATION ON THE USE OF SUB-SEGMENTS IN THE RISK-INFORMED INSERVICE INSPECTION RELIEF REQUEST PALISADES NUCLEAR PLANT 45-DAY RESPONSE

22 Pages Total

REQUEST FOR CLARIFICATION ON THE USE OF SUB-SEGMENTS
IN THE RISK-INFORMED INSERVICE INSPECTION RELIEF REQUEST
PALISADES NUCLEAR PLANT 45 DAY RESPONSE

Introduction

During a September 12-13, 2002, site audit of the risk-informed documentation to support your inservice inspection relief request, we noted that numerous segments were divided into sub-segments, failure probability estimates were developed for one or more of the sub-segments, and the failure probability estimates of one of the sub-segments was used for the entire segment. Page 71 of the WCAP states the following.

> *"The failure probability of a segment is characterized by the failure potential (probability or frequency as appropriate) of the worst case situation in each segment (not a selected weld in each segment). This is calculated by the SRRA code by inputting the conditions (typically, the most limiting or bounding) for the entire piping segment. Essentially, the piping failure probability is a representation or characterization of the piping segment."*

Our understanding is that your methodology applies this guidance to individual sub-segments but not to the entire segment and therefore deviates from the approved methodology.

There was also some discussion of your application of the Perdue methodology. We were informed that the Perdue methodology is also applied independently to individual sub-segments. Pages 170 and 171 of the WCAP discuss application of the Perdue methodology. The relevant text is provided below.

> *"Segment #: This is the name for the lot from which a sample of structural elements (such welds, pipe elbows, branch connections, etc.) is to be taken. Generally, each piping segment is defined as a lot. However, segments that are similar (e.g., all the cold legs on each reactor coolant loop with the same postulated failure mechanism) may be combined to define a lot.*
>
> *Number of Welds or Elements: This is the number of structural elements in the lot.*
>
> *Probability of a Flaw (@specified year/weld): The probability of an unacceptable flaw in the segment's 'most likely to fail' weld (or typical weld, if they are viewed as clones) at the current age of the weld (usually the current age of the plant unless the pipe has been repaired or replaced). An unacceptable flaw is defined by the ASME Section XI Code. This has been defined as a/t > 0.10 and is obtained from the probabilistic fracture mechanics code (e.g., SRRA)."*

Our understanding is that your methodology applies this guidance to individual sub-segments but not to the entire segment and therefore deviates from the approved methodology

At the exit meeting of the audit, we noted that supplemental information regarding the use of sub-segments will be needed to complete the review of the relief request. We therefore request the following information.

Requested Item

1. *For the failure probability estimation for segments that were subdivided, please provide the definitions used to identify sub-segments. Also please explain how the failure probability estimates are developed for a segment that has been divided into sub-segments and how your methodology comports with the approved methodology.*

Response

Failure consequences were used as the primary factor to initially divide segments into sub-segments. This method led to some individual piping segments consisting of piping with a variety of pipe diameters. For example: a four-inch diameter pipe with a two-inch diameter branch line may be part of the same piping segment if a failure at any portion of the segment would result in the same consequences. For multiple pipe size segments, sub-segments were defined by the pipe size for the failure probability analysis.

The failure probability estimates were developed for a segment that has been divided into sub-segments using the Westinghouse Structural Reliability And Risk Assessment Model (Win-SRRA). Some of the input parameters used by the Win-SRRA code vary if the diameter of the pipe varies (e.g. nominal pipe size, thickness to outer diameter ratio). Failure probability estimates for segments made up of multiple pipe sizes were determined by performing multiple Win-SRRA cases. In instances with multiple cases, resulting in multiple failure probability estimates, the highest failure probability associated with the segment was then used to represent the segment.

For each case, the Win-SRRA code required 18 input parameters associated with the piping. For segments with multiple pipe sizes, some of the input parameters varied from case to case even though they represented the same segment. Different pipe diameters required different inputs for a number of the parameters. Other inputs also varied based on expert engineering judgment. Palisades subject matter experts in in-service inspection (ISI), non-destructive examination (NDE), materials, and pipe stress analysis worked together to develop the input parameters for each Win-SRRA code case run. Therefore, each case represented a sub-segment and was evaluated for the expected conditions for the sub-segment.

Following the Westinghouse Owners Group WCAP-14572, "Westinghouse Owners Group Application of Risk-Informed Methods to Piping Inservice Inspection Topical Report," Revision 1-NP-A and WCAP-14572, Supplement 1, "Westinghouse Structural Reliability and Risk Assessment (SRRA) Model for Piping Risk-Informed Inservice Inspection," Revision 1-NP-A (referred to as "WCAP-14572" for the remainder of this document) methodology, the group developed limiting inputs for evaluation of each segment or sub-segment. Input parameters varied for separate portions of the same segment for one of two reasons. One reason was that many segments contained multiple weld geometries (both butt and socket-welds). In these segments specific geometries were reviewed. Different parameters to accurately model the geometry were input. Basic design practice would also suggest using more limiting inputs for dead weight and thermal stress, and design limiting stress for small bore (socket-welded) piping, where spacing tables were utilized in the routing design versus actual analysis results. The other reason was that input parameters for sub-segments varied slightly based on engineering judgment. For these cases the inputs were developed by plant subject matter experts and were based on observed and recorded conditions. The basis for each judgment is documented in the Palisades Win-SRRA engineering analyses. Though the input parameters for different cases of the same segment may vary, the parameters that were chosen for each case were the most limiting for that section of the piping segment. The limiting failure probability estimates associated with each pipe size for each segment are based on the realistic limiting inputs associated with that section of piping. For segments with multiple line sizes, multiple failure probabilities were determined. In every case the most limiting (highest) failure probability associated with the segment was used to represent the segment.

As shown in figure 3.5-1 and the accompanying text in the approved WCAP-14572, failure probability estimation is the responsibility of the engineering team based upon their knowledge of the pertinent information at their plant and any potential concerns identified in industry experience at other plants. For example, recent PWR plants have evaluated the increased potential for stress corrosion cracking at the reactor vessel outlet nozzle weld based upon the leak at V. C. Summer. The SRRA tool is used to quantify the effects of the engineering team's input on the calculated leak and break probabilities.

The second concern of the summary and conclusions of the Nuclear Regulatory Commission (NRC) safety evaluation (SE) (Section A.25 on page A-21) for the SRRA tool (supplement 1 to the approved WCAP-14572) endorses this position via the following:

> "The results of SRRA calculations should always be reviewed to ensure that they are reasonable and consistent with plant operating experience. Data from plant operation should be used to review and refine inputs to calculations."

Nuclear Management Company's (NMC's) application of the methodology, taking the limiting SRRA probabilities from the sub-segments of different sizes in a segment, comports with the NRC approved methodology.

The fifth concern in the previously cited section of the NRC SE recommends:

> "The simplified nature of the SRRA code has resulted in a number of conservative assumptions and inputs being used in applications of the code. It is therefore recommended that sensitivity calculations be performed to ensure that excessive conservatism does not unrealistically impact the categorization and selection of piping locations to be inspected."

NMC's application of the methodology on how the degradation mechanisms in the different sized sub-segments are to be "combined" fully comports with the approved methodology as stated in the last paragraph of Section 3.2.3, "Piping Failure Potential", of the NRC SE and in Section 3.2, "Simplified and Detailed Input", in the WCAP-14572 Supplement for SRRA:

> "If more than one degradation mechanism is present in a given piping segment, then the limiting input values for each mechanism should be combined so that a limiting failure probability is calculated for risk ranking."

As indicated on page 84 in Section 3.5.6, "Failure Probability Determination", of the approved WCAP-14572, combining degradation mechanisms does not imply adding the failure probabilities for each mechanism. Typically, one degradation mechanism will dominate the failure probability in the segment by several orders of magnitude. However, because of uncertainties, the engineering team may not know which of the potential degradation mechanisms will dominate, especially if there are sub-segments of different nominal pipe size in the segment. Multiple nominal pipe sizes in a single segment arise due to the establishment of initial segment boundaries based on consequence considerations as detailed on page 57 of the approved WCAP-14572. An appropriate tool must be used to determine the failure impact of the potential degradation mechanisms to determine the dominant mechanism for the segment. As noted, the SRRA tool was used in the calculation of failure probability estimates at Palisades. As detailed in the supplement to the WCAP-14572, multiple factors must be considered in determining the piping failure including:

1. degradation mechanisms,
2. pre-service construction and inspection history and practice,
3. and physical routing and configuration.

Table 3.5-1 of the WCAP-14572 and the WCAP-14572 supplement provide guidelines for items to consider. In section 3.5.4, the estimated failure probability is identified as being dependent on and significantly influenced by the following four items: configuration, components, materials/chemistry and loads.

A degradation mechanism's affect may vary based on the different physical configurations of the weld(s). Socket-welds are particularly noted as having low resistance to sustained vibration. It is also noted in this section that interactions among the factors are common. Distinction is made in the discussion between component dependent failure modes, which are generally noted as localized within a segment and materials dependent or operational dependent mechanisms, which may be present throughout the entire segment. This directly supports the opening paragraphs of section 3.5 of the WCAP-14572, which identified that:

> "The failure probability of a segment is characterized by the failure potential (probability or frequency as appropriate) of the worst case situation in each segment (not a single selected weld in each segment)."

Consider the following two hypothetical examples based on typical situations experienced by plant engineering teams for SRRA input:

Example 1: Significant Differences in Pipe Sizes and Potential Degradation Mechanisms

In this example segment for high temperature and pressure piping, a six-inch sub-segment extends some distance from a check valve to a tee, where the flow is split into two, three-inch sub-segments that each extend to a pump. Because of a concern for water hammer that has occurred in this system at other plants, a one-inch sub-segment was added at the high-points (near each pump) of the three-inch piping to periodically vent the system. If the check valve leaked, then the weld in the six-inch sub-segment closest to the valve could experience thermal stratification. Although there is no evidence that the check valve is leaking, it has happened in similar plants so a high fatigue stress range and number of cycles for stratification is selected by the team for the simplified SRRA input. Because of the geometric layout of the piping, a weld in the three-inch portion would see the highest water-hammer loading, which the team estimated only had a one-percent chance of occurring due to the corrective actions that had already been implemented. Another weld in the same size piping also had a pre-service inspection indication that was small enough that a repair was not required per the American Society of Mechanical Engineers (ASME) code. Because some imbalance of the pump was observed after the one-inch vent was installed, there is a concern for the potential effects of vibration in the three-inch pipe welds, but particularly in the one-inch pipe socket-welds nearest to the pumps. All the piping in the segment is subject to fatigue loading due to normal heat-up and cool-down and periodic pump testing. The consequence is loss of inventory and the system disabling leak rate has been conservatively assumed to be two gallons per minute (gpm) for all three pipe sizes in the segment.

The assumed SRRA large-leak probabilities after 40 years are as follows (the numbers given in this example are approximations based on expert engineering judgement):

a) 3.3E-05 for the six-inch pipe with thermal stratification,
b) 1.5E-05 for the three-inch pipe with one-flaw, vibration (input corrected for size by SRRA Program) and a one-percent chance of a severe water hammer,
c) 5.0E-04 for one-inch pipe with vibration (correction factor of one),
d) 4.0E-02 for one-inch pipe with thermal stratification, one-flaw, vibration and a one-percent chance of a severe water hammer.

The SRRA probability of 5.0E-04 should be selected by the engineering team for risk ranking because the probability of option d) is unduly conservative relative to plant and industry experience. The SRRA input for option d) would also be unrealistic relative to assuming the same six-inch stratification loading near the check valve in the one-inch line far away from the valve and the worst three-inch water hammer loading in a one-inch branch line.

Example 2: Small Differences in Pipe Sizes and Potential Degradation Mechanisms

In this example segment for moderate temperature and pressure, three different pipe sizes are also used (nominal pipe size of one, one and a half and two-inch). All the piping in the segment is subject to fatigue loading due to normal heat-up and cool-down and relatively high seismic (SSE) loading for the design-limiting event. The consequence is loss of the system function and disabling leak rate has been conservatively assumed to be ten-percent of the flow through the largest of the three pipe sizes in the segment.

The assumed SRRA large-leak probabilities after 40 years are as follows (the numbers given in this example are approximations based on expert engineering judgement):

a) 8.9E-05 for the two-inch pipe with its fatigue and SSE loading,
b) 1.2E-06 for the one-and-a-half inch pipe with its fatigue and SSE loading,
c) 7.5E-07 for one-inch pipe with its fatigue and SSE loading,
d) 9.1E-05 for the two-inch pipe with the highest fatigue and highest SSE loading independent of pipe size.

The SRRA probability of 9.1E-05 could be selected by the engineering team for risk ranking because the probability of option d) is not overly conservative relative to plant and industry experience and the SRRA input would still be realistic relative to the uncertainties in the actual loading for the different pipe sizes (i.e. the difference between the SRRA calculated probability values of 8.9E-05 and 9.1E-05 is not statistically significant).

It is NMC's position that assessing the unique input parameters based on the configuration, components, materials/chemistry, and loads by distinct quantification of all of the potential degradation in regards to localized and generalized degradation mechanisms in the entire segment fully comports with the SE requirement to:

"...ensure that excessive conservatism does not unrealistically impact the categorization and selection of piping locations to be inspected".

The consistency in the items used in determining the critical location or locations for inspection is supported by the requirement in WCAP-14572 Section 3.7.3. This section identifies that the selection of inspection location be based on the postulated failure mechanisms and the loading conditions for the piping segment considering the same four items as in the determination of piping failure, namely: configuration, components, materials/chemistry and loads.

Furthermore, the inspection is not limited to a single degradation mechanism but must consider all possible mechanisms contributing to the potential pipe failure for a given segment at the most likely location of occurrence.

It is NMC's conclusion that the process followed in sub-dividing consequence defined segments fully supports the directive to apply all possible degradation mechanisms at a single weld and ensure that there is no excessive conservatism on the piping categorization or selection of inspection location.

Requested Item

2. *For the Perdue method application on segments that were subdivided, please provide the definitions used to identify sub-segments. Also please explain how the Perdue input parameters are developed for a segment that has been divided into sub-segments, how the results are used to determine the number of locations for inspection in the segment, and how your methodology comports with the approved methodology.*

Response

The Perdue Model is used to aid in the determination of the number of inspection locations for segments determined to be high safety significant by the plant risk-informed inservice inspection (RI-ISI) expert panel. Segments were divided into sub-segments (or lots) during the Perdue Model evaluation using the following cases:

Case A: There is an identified active degradation mechanism and the segment is placed in Region 1 of WCAP-14572 Figure 3.7-1.

For this case, the piping in the segment is the same nominal diameter. One lot consists of the welds/locations susceptible to the degradation mechanism (Region 1A). Each susceptible location is included in the inspection program if it is not already part of an augmented inspection program. Welds/locations, which are included in an augmented program, remain in that program and are inspected in accordance with that program. The other lot consists of the remainder of the welds in the segment (Region 1B). These are evaluated with the Perdue Model based on SRRA parameters, which exclude the active degradation mechanism. The total number of inspections for the segment is the sum of the susceptible locations plus the number of inspections required to achieve a 95% confidence using the Perdue Model (a minimum of one location is specified even if the Perdue Model shows 100% confidence with no ISI). This comports with the description of segments in Region 1 on page 168 of WCAP-14572.

Case B: There is no identified active degradation mechanism and the segment has been placed in Region 2 of WCAP-14572 Figure 3.7-1.

For this case, there are multiple pipe sizes in the segment. The Perdue Model inputs are specific to the pipe material and size. The first approach is to combine the most limiting inputs from each pipe size, use the total number of welds in the segment, and analyze the segment as one lot. Alternatively, if this is so conservative that a 95% confidence level cannot be achieved, then each pipe size is analyzed separately with the appropriate number of welds and the appropriate SRRA results. This divides the segment into lots according to pipe size. The confidence values of each lot are multiplied together to get the confidence for the segment. The resulting confidence level must be greater than or equal to 95% for the Perdue Model evaluation to be acceptable. The total number of inspections for the segment is the number of inspections required to achieve a 95% confidence using the Perdue Model. A minimum of one location is specified even if the Perdue Model shows 100% confidence with no ISI. This comports with the description of segments in Region 2 on page 168 of WCAP-14572 and with the description of dividing a segment into multiple lots on pages 174 and 175.

Case C: There is an active degradation mechanism and the segment has been placed in Region 1 of WCAP-14572 Figure 3.7-1.

For this case, there are multiple pipe sizes in the segment. One lot consists of the welds/locations susceptible to the degradation mechanism (Region 1A). Each susceptible location is included in the inspection program if it is not already part of an augmented inspection program. Welds/locations, which are included in an augmented program, remain in that program and are inspected in accordance with that program. For the Perdue Model evaluation of the non-susceptible welds/locations (Region 1B), the steps followed are the same as in Case B above. The first approach is to combine the most limiting inputs from each pipe size after removing the active degradation mechanism, use the total number of welds minus the number of susceptible welds, and analyze the segment as one lot. If this is too conservative, then each pipe size is analyzed separately with the appropriate number of welds and the appropriate SRRA results. The confidence values of each lot are multiplied together to get the confidence for the segment. The resulting confidence level must be greater than or equal to 95% for the Perdue Model evaluation to be acceptable. The total number of inspections for the segment is the sum of the susceptible locations plus the number of inspections required to achieve a 95% confidence using the Perdue Model (a minimum of one location is specified even if the Perdue Model shows 100% confidence with no ISI). This comports with the description of segments in Region 1 on page 168 of WCAP-14572 and with the description of dividing a segment into multiple lots on pages 174 and 175.

Individual Perdue Model inputs are specific to the pipe material and size. Therefore, segments with multiple sizes must be evaluated in one of the three ways discussed. In all three approaches the method for evaluating segments with the Perdue Model fully comports with the approved methodology.

Requested Item

3. If you were to apply the failure probability estimation and the Perdue methodology to the entire segment for all segments, as opposed to sub-segments, how would the total number of inspections required in the RI-ISI program change?

Response

NMC and Westinghouse are in concurrence that the approved WCAP-14572 methodology in application of failure probabilities and in the application of the Perdue methodology to piping segments was followed by Palisades. Both parties agree that the responses prepared for the first two questions support and clarify this position.

Program specific data were evaluated to approximate how the number of inspections would change if failure probability estimates for sub-segments were evaluated with the most limiting Win-SRRA inputs for all portions of the segment. There are 193 segments that consist of multiple pipe diameters and have some variation in the input parameters. All of the segments with input parameters that vary fall into one of three categories:

1. **Only variation in inputs are pipe size and wall thickness (119 segments)**
2. **Variations are all related to pipe and weld geometries (65 segments)**
3. **Variations are based on engineering judgment regarding potential degradation mechanisms (nine segments)**

For segments in the first category, the only variations in the inputs are those associated with differences in the actual physical makeup of the pipe (nominal pipe size and thickness to outer diameter ratio). There are 18 input parameters for each Win-SRRA case run. For these segments, the other 16 input parameters were the same for all pipe size failure probability estimations. The limiting case for each of the 119 segments in this category is the absolute limiting case for the segment, therefore, there would be no change to the number of inspections. The Perdue Model was applied to the high safety significant (HSS) segments as described in the response to question 2, except in cases where it was not applicable such as socket-welded piping. Thus, for this category, there would have been no changes to the number of inspections.

There are 65 segments in category two. All 65 segments include both small bore (socket-weld) and large bore (butt-weld) piping. All had variations in the Win-SRRA inputs due to pipe size differences or weld geometry differences. The small-bore socket welded piping consistently had more limiting Win-SRRA inputs

for DW/Thermal Stress and Design Limiting Stress. A sample of four of the segments was reevaluated to run the Win-SRRA code on the larger bore piping with the more limiting inputs associated with the small bore portions of the segments. The failure probability for the large bore piping did increase in every case. However, the original failure estimates generated for the small bore piping were still the highest overall in each of the four segments. The failure probabilities used to represent the segments in this category represent the most limiting inputs associated with those segments. Examples have shown that applying failure estimates for the entire segments as opposed to sub-segments for segments in this category would not have changed the number of inspections. As identified on page 178 of WCAP-14572, Revision 1-NP-A, the Perdue Model should not be used for socket-welded piping. For the HSS segments in this category, at least a portion of the piping is socket-welded. The SRRA runs associated with the socket-welded piping should not be used for the Perdue Model inputs. For the portions of the segments in this category that are not socket-welded, the SRRA runs representing the non-socket-welded portions of the segment were used to determine the number of inspections. In determining the number of inspections using the Perdue Model, it would be inappropriate to use inputs for the socket-welded piping. Thus the appropriate inputs were used for the Perdue Model for the segments in this category and, therefore, there would be no change to the number of inspections.

For segments in the third category, an evaluation using the most limiting Win-SRRA inputs was not performed. The decisions for the inputs that were used were based on known and studied conditions specific to each section of the pipe. A number of the segments in this category had variations in the flow accelerated corrosion (FAC) inputs for different sub-segments of the same segment. The inputs selected for FAC for each of the sub-segments are in accordance with the rankings developed in the Palisades FAC Program for that portion of the system piping. The failure estimates generated for the cases are realistic and reflect known conditions in the piping. In this and similar cases there is actual plant specific data that was used to develop the Win-SRRA inputs.

Additionally, all nine segments in the third category ended up as low safety significant (LSS). If the segments had been divided up and evaluated as individual segments, none of the additional segments would have ended up HSS. The inputs associated with each sub-segment were limiting for that section of the pipe. The most limiting failure probabilities were then used to represent the segment. If the segments were split, the failure probabilities would be the same or lower than the failure probabilities used for the nine segments and the risk reduction worth (RRW) for the sub-segments would be the same or lower than the RRW for the nine segments. Since the nine segments were categorized as LSS, it is reasonable to assume that the sub-segments would also be made LSS. Because the segments are LSS there are no inspections required as part of the RI-ISI program. Thus there would be no change in the number of inspections for

these nine segments. For each of the three categories of segments with multiple sizes, there is no change to the number of inspections. NMC would expect no changes to the number of inspections.

The following attachment provides additional information to further clarify response 3.

ATTACHMENT

NUCLEAR MANAGEMENT COMPANY, LLC
PALISADES NUCLEAR PLANT
DOCKET 50-255

ADDITIONAL INFORMATION TO FURTHER CLARIFY RESPONSE 3

Palisades risk-informed inservice inspection (RI-ISI) program divided the plant piping systems into 799 segments. To determine failure probability estimates, the Westinghouse Structural Reliability And Risk Assessment Model (Win-SRRA) code was used. Since some of the input parameters for the code reflect the physical characteristics of the pipe (e.g. nominal pipe size), each segment that was made up of more than one pipe diameter required more than one set of Win-SRRA input parameters. There are 193 segments that contain multiple pipe diameters and thus have some variation in the input parameters. All of the segments with inputs parameters that vary fall into one of three categories:

4. Only variation in inputs are pipe size and wall thickness (119 segments)
5. Variations are all related to pipe and weld geometries (65 segments)
6. Variations are based on engineering judgment regarding potential degradation mechanisms (nine segments)

CATEGORY 1

Table 3.1 shows the Win-SRRA input parameters for a segment in category one. The only parameters listed in the table are those with different inputs for the sub-segments. Inputs not listed in the table are identical for both sub-segments.

Table 3.1 Category 1 Segment CSW-004

Win-SRRA Input Parameters	Sizes		Reason For Input Variation
	16-inch	24-inch	
Nominal Pipe Size (inches)	16	24	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.023	0.016	Physical characteristic of pipe

Table 3.2 shows the results of the Win-SRRA runs generated for the two sub-segments (one twenty-four-inch and one sixteen-inch) that make up CSW-004. Small leak probabilities are provided because they are used for comparison with experience while large leak probabilities are provided because they are used for risk ranking.

Table 3.2 Segment CSW-004 SRRA Results

Win-SRRA Case Results	Failure Probability	
	Without ISI	With ISI
CSW-004 (16-inch) small leak	4.40E-3	1.86E-4
CSW-004 (16-inch) large leak	4.40E-3	1.86E-4
CSW-004 (24-inch) small leak	4.20E-3	1.07E-4
CSW-004 (24-inch) large leak	4.20E-3	1.07E-4

In the above example, the differences in the inputs to develop failure estimates are all specifically related to the physical makeup of the piping. The other 16 input parameters for the segment were the same for both pipe size failure probability estimations. Applying failure estimates for the entire segments as opposed to sub-segments for segments in this category would not have changed the number of inspections.

CATEGORY 2

Table 3.3 lists the Win-SRRA input parameters for a segment from category 2. The only parameters listed in the table are those with different inputs for the sub-segments. For these cases, all the variations in the inputs are due to pipe size differences or weld geometry differences.

Table 3.3 Category 2 Segment BLD-009

Win-SRRA Input Parameters	Pipe Sizes		Reason For Input Variation
	2-inch	4-inch	
Nominal Pipe Size (inches)	2	4	Nominal Pipe Size
Thickness to O.D. Ratio (inches)	0.092	0.075	Thickness to O.D. Ratio
Design Limiting Stress	0.26	0.1	Medium (0.26) value recommended for small bore piping.

Table 3.4 below shows the results of the Win-SRRA runs generated for the two sub-segments (one two-inch and one four-inch) that make up BLD-009. The table also shows the results of the four-inch portion of the segment evaluated with the most limiting dead weight (DW), thermal stress and design limiting stress inputs.

Table 3.4 Segment BLD-009 SRRA Results

Win-SRRA Case Results	Failure Probability	
	Without ISI	With ISI
BLD-009 (2-inch) small leak	1.50E-4	5.55E-7
BLD-009 (2-inch) large leak	5.63E-5	5.38E-5
BLD-009 (4-inch) small leak	3.28E-5	3.51E-7
BLD-009 (4-inch) large leak	2.67E-7	1.71E-9
The results below are revised. The inputs for DW & Thermal Stress and Design Limiting Stress were increased to match the inputs for the 2-inch case.		
BLD-009R (4-inch) small leak	3.28E-5	3.51E-7
BLD-009R (4-inch) large leak	5.36E-5	5.26 E-5

The example from category two (Table 3.3) is a segment that consists of two different pipe diameters. The four-inch diameter piping consists of all butt-welds. The two inch piping in the segment is small bore piping and all welds associated with it are socket-welds. Due to differences in the specific geometries between socket-welds and butt-welds, more limiting inputs for DW, thermal stress and design limiting stress were recommended for the small bore piping.

The results of applying the most limiting Win-SRRA inputs to each pipe size in the segment have no impact for this segment. The most limiting inputs were applied to the small bore piping originally. Applying the same, higher values for DW, thermal stress and design limiting stress to the large bore piping does increase the large leak failure probability for that portion of the segment. However, the original failure probabilities associated with the two-inch section are still the highest overall, and would be selected to represent the segment.

There are 65 segments that fit into category two. All 65 segments include both small bore (socket-weld) and large bore (butt-weld) piping. The more limiting Win-SRRA inputs were consistently applied to the small bore piping. A sample of four of the segments were reevaluated to run the Win-SRRA code on the larger bore piping with the more limiting inputs associated with the small bore portions of the segments. The failure probability for the large bore piping did increase in every case. However, the original failure estimates generated for the small bore piping were still the highest overall in each of the four segments. Additional examples from this category are included below.

Example 1: Category 2 Segment CBA-001

Win-SRRA Input Parameters	Pipe Sizes		Reason For Input Variation
	1-inch	4-inch	
Nominal Pipe Size (inches)	1	4	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.101	0.027	Physical characteristic of pipe
Dead Weight & Thermal Stress Level	0.11	0.05	Medium (0.11) value recommended for small bore piping.
Design Limiting Stress	0.26	0.1	Medium (0.26) value recommended for small bore piping.

Win-SRRA Case Results	Failure Probability	
	Without ISI	With ISI
CBA-001 (1-inch) large leak	2.52E-3	2.74E-5
CBA-001 (4-inch) large leak	9.67E-4	1.59E-4
The results below are revised. The inputs for DW & Thermal Stress and Design Limiting Stress were increased to match the inputs for the 2-inch case.		
CBA-001R (4-inch) large leak	1.30E-3	1.86E-5

Example 2: Category 2 Segment AFW-002

Win-SRRA Input Parameters	Sizes			Reason For Input Variation
	2-inch	3-inch	6-inch	
Nominal Pipe Size (inches)	2	3	6	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.092	0.062	0.065	Physical characteristic of pipe
Initial Flaw Conditions	12.8	1	1	3-inch and 6-inch butt-welds received past NDE (X-Ray) exams, 2-inch Socket-welds have not.
Dead Weight & Thermal Stress Level	0.11	0.05	0.05	Medium (0.11) value recommended for small bore piping.
Design Limiting Stress	0.26	0.1	0.1	Medium (0.26) value recommended for small bore piping.

Win-SRRA Case Results	Failure Probability	
	Without ISI	With ISI
AFW-002 (2-inch) large leak	2.64E-4	4.23E-5
AFW-002 (3-inch) large leak	3.99E-5	2.00E-7
AFW-002 (6-inch) large leak	4.31E-7	1.57E-9
The results below are revised. The inputs for DW & Thermal Stress and Design Limiting Stress were increased to match the inputs for the 2-inch case.		
AFW-002R (3-inch) large leak	2.49E-5	2.64E-6
AFW-002R (6-inch) large leak	8.87E-6	8.19E-6

Example 3: Category 2 Segment CCS-021

Win-SRRA Input Parameters	Pipe Sizes		Reason For Input Variation
	1-inch	10-inch	
Nominal Pipe Size (inches)	1	10	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.136	0.034	Physical characteristic of pipe
Dead Weight & Thermal Stress Level	0.11	0.05	Medium (0.11) value recommended for small bore piping.
Design Limiting Stress	0.26	0.1	Medium (0.26) value recommended for small bore piping.

Win-SRRA Case Results	Failure Probability	
	Without ISI	With ISI
CCS-021 (1-inch) large leak	2.25E-5	2.21E-5
CCS-021 (10-inch) large leak	7.37E-11	2.75E-12
The results below are revised. The inputs for DW & Thermal Stress and Design Limiting Stress were increased to match the inputs for the 2-inch case.		
CCS-021R (10-inch) large leak	6.95E-6	6.95E-6

The most limiting inputs for the segments in category two were always applied to the small bore piping. Applying failure probability estimates to the entire segment for these segments, as opposed to sub-segments would not change the number of inspections for the program.

CATEGORY 3

The last of the three categories includes the segments whose Win-SRRA inputs varied at different portions of the segment based on engineering judgment regarding potential degradation mechanisms. There are only nine segments in this category representing approximately one percent of the entire population of segments. Each segment and the inputs associated with it are discussed below on a case-by-case basis.

Three of the segments in this category are main feedwater (MFW) segments. In all three cases the input that varied for different portions of the segment were associated with flow accelerated corrosion (FAC), which is reflected in the material wastage potential (MWP) input.

Tables 3.5 and 3.6 show the Win-SRRA input parameters for the three MFW segments. The only parameters listed in the table are ones with different inputs for the sub-segments. Inputs not listed in the table are identical for the multiple sized cases of the same segment.

Table 3.5 Category 3 Segment MFW-002

Win-SRRA Input Parameters	Pipe Sizes			Reason For Input Variation
	6-inch	8-inch	18-inch	
Nominal Pipe Size (inches)	6	8	18	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.065	0.058	0.064	Physical characteristic of pipe
Material Wastage Potential	0.05	0.1	0.1	FAC values are in accordance with known and documented FAC values in piping system.

Table 3.6 Category 3 Segments MFW-007A and MFW-008A (inputs are identical)

Win-SRRA Input Parameters	Pipe Sizes						Reason For Input Variation
	6-inch	8-inch	10-inch	10-inch(a)	16-inch	18-inch	
Nominal Pipe Size (inches)	6	8	10	10	16	18	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.042	0.037	0.047	0.055	0.041	0.047	Physical characteristic of pipe
Material Wastage Potential	0.05	0.05	0.05	0.05	0.05	0.1	FAC values are in accordance with known and documented FAC values in piping system.

(There are two different 10-inch pipe classes for these segments. One is EB-9 and the other is EBD-901. The 10-inch(a) is the EBD-901 portion.)

Palisades MFW system piping is susceptible to FAC. Piping for the system is currently in the Palisades FAC Program and the effects of FAC in MFW piping have been studied at Palisades since 1988. The inputs selected for FAC for each of the sub-segments are in accordance with the rankings developed in the Palisades FAC Program for that portion of the system piping. The inputs are also slightly conservative since all MFW piping was given, at a minimum, a medium (0.05) FAC value. If a high FAC value had been input into one sub-segment only because a different sub-segment (of the same segment) had a high input, it would work to defeat the purpose of having a risk-informed approach. In this case the inputs are based on known plant specific data that is generated from a program whose purpose is to check and evaluate piping for FAC. These realistic inputs provide valuable risk insights that are lost if excessively conservative inputs are used in their place.

Table 3.7 below shows the Win-SRRA input parameters for two BLD segments. The segments are nearly identical segments, one each from the two BLD piping trains.

Table 3.7 Category 3 Segments BLD-001 and BLD-002 (inputs are identical)

Win-SRRA Input Parameters	Pipe Sizes		Reason For Input Variation
	1-inch	4-inch	
Nominal Pipe Size (inches)	1	4	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.136	0.075	Physical characteristic of pipe
Dead Weight & Thermal Stress Level	0.11	0.17	Medium (0.11) value recommended for small bore piping.
Design Limiting Stress	0.26	0.1	Medium (0.26) value recommended for small bore piping.
Material Wastage Potential	0.001	0.05	FAC values are in accordance with known and documented FAC values in piping system.

Portions of the Palisades BLD piping are susceptible to FAC. Piping for the system is currently in the Palisades FAC Program and the effects of FAC in BLD piping has been studied since 1988. The inputs selected for FAC for each of the sub-segments are in accordance with the rankings developed in the Palisades FAC Program for that portion of the system piping. The failure estimates generated for the cases are realistic and reflect known conditions in the piping. Using only the worst of the input values for each size would be overly conservative and not produce realistic results.

Table 3.8 lists the Win-SRRA input parameters for segment BLD-008. The two sub-segments for BLD-008 have inputs that vary for pipe size differences, weld geometry differences, and thermal stratification potential differences.

Table 3.8 Category 3 Segment BLD-008

Win-SRRA Input Parameters	Pipe Sizes		Reason For Input Variation
	¾-inch	4-inch	
Nominal Pipe Size (inches)	¾	4	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.147	0.075	Physical characteristic of pipe
Dead Weight & Thermal Stress Level	0.11	0.17	Medium (0.11) value recommended for small bore piping.
Design Limiting Stress	0.26	0.1	Medium (0.26) value recommended for small bore piping.
Fatigue Stress Range	0.3	0.5	4-inch section has higher value due to its interface with the steam generator.
Low Cycle Fatigue Frequency	5	10	4-inch section has higher value due to its interface with the steam generator.

Segment BLD-008 interfaces with the steam generator and has thermal stratification stress potential. The ¾-inch branch line on the segment is not near the generator and has significantly less thermal stratification stress potential. The inputs for both flow stress level and fatigue cycle frequency account for the potential stratification near the generator for the four-inch section. Applying the same limiting inputs for both line sizes associated with the segment would be unrealistic and overly conservative (similar to example 1 in the response to question 1).

Table 3.9 lists the Win-SRRA input parameters for a segment from the heaters and extraction drain system (HED). The only parameters listed in the table are the ones with different inputs for the sub-segments. For these cases, all the variations in the inputs are due to FAC.

Table 3.9 Category 3 Segment HED-004

Win-SRRA Input Parameters	Pipe Sizes					Reason For Input Variation
	3-inch	4-inch	8-inch	12-inch	16-inch	
Nominal Pipe Size (inches)	3	4	8	12	16	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.062	0.053	0.037	0.029	0.023	Physical characteristic of pipe
Material Wastage Potential	0.2	0.1	0.1	0.2	0.2	FAC values are in accordance with known and documented FAC values in piping system.

Portions of the HED piping are susceptible to FAC. Piping for the system is currently in the Palisades FAC Program and the effects of FAC in HED piping has been studied since 1988. The Win-SRRA inputs for material wastage are in line with the predicted component wear rates of the Palisades FAC Program. The failure estimates generated for the cases are realistic and reflect known conditions in the piping. Using only the worst of the input values for each size would be overly conservative and not produce realistic results for the 4-inch and 8-inch portions of the piping.

Table 3.10 shows the variation in the Win-SRRA inputs between the sub-segments for two pressurizer (PZR) segments. The segments are nearly identical segments; each one is isolated from the primary coolant system (PCS) by a normally closed power-operated relief valve (PORV).

Table 3.10 Category 3 Segments PZR-011 and PZR-012 (inputs are identical)

Win-SRRA Input Parameters	Pipe Sizes		Reason For Input Variation
	¾-inch	4-inch	
Nominal Pipe Size (inches)	¾	4	Physical characteristic of pipe
Thickness to O.D. Ratio (inches)	0.147	0.097	Physical characteristic of pipe
Fatigue Stress Range	0.3	0.5	4-inch section has higher value due to its interface with the PCS.
Low Cycle Fatigue Frequency	5	10	4-inch section has higher value due to its interface with the PCS.

NOTE: DW/Thermal Stress & Design Limiting Stress inputs were the same for both segments.

Comment: Clarification required since this case is unique from other examples where we used different values for the small bore socket weld. The more conservative values were use for both in the original, thus no change.

Similar to segment BLD-008, the four-inch section of the segments is susceptible to thermal stratification. The four-inch sections of the segment are separated from the PCS by normally closed valves that have been known to leak. Due to the location on the segments of the ¾-inch branch lines, they are much less susceptible to the thermal stratification. The inputs reflect the actual piping conditions and are realistic. Using only the worst of the input values for each size would be overly conservative and not produce realistic results.

SUMMARY

For two of the three categories of segments with multiple Win-SRRA inputs parameters, applying the failure probability estimates to the entire segment as opposed to sub-segments would not increase the number of inspections. For segments in the first category, the inputs to determine the failure estimates are the same for each pipe size. The only variations in the inputs are those associated with the actual physical makeup of the pipe. For segments in category two, the more limiting inputs were consistently applied to the small bore socket-welded sections of the segments. Numerous examples show that reevaluating the large bore sections of the pipe with the most limiting inputs would raise the failure probabilities for those sub-segments. However, in each example, the original limiting failure probability (for the small bore piping) associated with the segment remained the highest value and would still be chosen to represent the segment. Based on the evidence from the examples, applying the failure probability estimates to the entire segment as opposed to sub-segments for those in category two would not increase the number of inspections.

Comment:

As discussed in the response to question one of the request for additional information (RAI), applying the most conservative SRRA inputs for various pipe sizes in a weld may result in excessive conservatism in the SRRA failure probability for that segment and therefore should not be considered. Applying the worst case inputs associated with any part of the segment to all portions of the segment might change the number of inspections for segments in category three. However, any additional inspections would be the result of using overly conservative and unrealistic data and therefore, are inappropriate. The justification for the variation in the inputs for these segments is sound and well documented. The decisions for the inputs were based on known and studied conditions specific to each section of the pipe.

Because the segments in this category are low safety significant (LSS) and the most conservative failure probabilities of the sub-segments were used, had the segments in this category been split, the new segments would have also been LSS and there would have been no change to the number of inspections.