ATTACHMENT 2

RISK IMPACT ASSESSMENT OF EXTENDING CONTAINMENT TYPE "A" TEST INTERVAL FOR NMP2

(2NER-PR-003)

Nine Mile Point Nuclear Station, LLC
June 29, 2009

Constellation Energy Group

Nine Mile Point
Nuclear Station

NUCLEAR ENGINEERING REPORT
NINE MILE POINT UNIT 2

Risk Impact Assessment of
Extending Containment Type "A" Test Interval for NMP2

2NER-PR-003

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1 Purpose of the Analysis

1.1 Purpose

The purpose of this analysis is to provide a risk assessment of extending the currently allowed containment Type A (integrated leak rate test - ILRT) interval to a permanent fifteen years. The extension would allow for substantial cost savings as the Type A test could be deferred for additional scheduled refueling outages for Nine Mile Point Unit 2 (NMP2). The risk assessment follows the guidelines from NEI 94-01, Revision 2-A [1], the methodology described in EPRI 1009325 Revision 2-A [27], the NRC regulatory guidance on the use of Probabilistic Risk Assessment (PRA) as stated in Regulatory Guide 1.200 as applied to Type A test interval extensions, and risk insights in support of a request for a plant's licensing basis as outlined in Regulatory Guide (RG) 1.174 [4]. In addition, the methodology used for Calvert Cliffs to estimate the likelihood and risk implications of corrosion-induced leakage of steel liners going undetected during the extended test interval [5] has been used as incorporated in the EPRI methodology.

1.2 Background

Revisions to 10CFR50, Appendix J (Option B) allow individual plants to extend the Type A surveillance testing frequency requirement from three in ten years to at least once in ten years. The revised Type A test frequency is based on an acceptable performance history defined as two consecutive periodic Type A tests at least 24 months apart in which the calculated performance leakage rate was less than the limiting containment leakage rate of 1La. The basis for the current 10-year test interval is provided in Section 11.0 of NEI 94-01, Revision 0, and was established in 1995 during development of the performance-based Option B to Appendix J. Section 11.0 of NEI 94-01 states that NUREG-1493, "Performance-Based Containment Leak Test Program," September 1995 [6], provides the technical basis to support rulemaking to revise leakage rate testing requirements contained in Option B to Appendix J. The basis consisted of qualitative and quantitative assessments of the risk impact (in terms of increased public dose) associated with a range of extended leakage rate test intervals. To supplement the NRC's rulemaking basis, NEI undertook a similar study. The results of that study are documented in Electric Power Research Institute (EPRI) Research Project Report TR-104285, "Risk Impact Assessment of Revised Containment Leak Rate Testing Intervals."[2]

NUREG-1493 [6] analyzed the effects of containment leakage on the health and safety of the public and the benefits realized from the containment leak rate testing. In that analysis, it was determined that for a representative BWR plant (i.e., Peach Bottom), increasing the containment leakage rate from the nominal 0.5 percent per day to 5 percent per day results in a small increase in total population exposure. In addition, increasing the leakage rate to 50 percent per day increases the total population risk by less than 1 percent. Consequently, it is desirable to show that extending the Type A test interval will not lead to a significant increase in risk for NMP2.

The Guidance provided in Appendix H of EPRI 1009325 Revision 2-A [27] (also identified as EPRI 1018243) for performing risk impact assessments in support of Type A test extensions builds on the EPRI Risk Assessment methodology described in EPRI TR-104285. This methodology of EPRI 1009325 is followed to determine the appropriate risk information for use in evaluating the impact of the proposed Type A test interval changes.

It should be noted that containment leak-tight integrity is also verified through periodic inservice inspections conducted in accordance with the requirements of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Section XI. More specifically, Subsection IWE provides the rules and requirements for inservice inspection of Class MC pressure-retaining components and their integral attachments, and of metallic shell and penetration liners of Class CC pressure-retaining components and their integral attachments in light-water cooled plants. 10CFR50.55a(b)(2)(ix)(E) requires that a general visual examination as required by Subsection IWE must be performed once each inspection interval. The guidance in NEI 94-01 Revision 2-A indicates that general visual examinations must be conducted prior to each Type A test and at least three other outages before the next Type A test if the test interval is being extended to 15 years. These requirements will not be changed as a result of the extended Type A test interval. In addition, Appendix J, Type B local leak tests performed to verify the leak-tight integrity of containment penetration bellows, airlocks, seals, and gaskets, and Type C local leak test performed to verify leak-tight integrity if containment isolation valves are also not affected by the change to the Type A test frequency.

1.3 Criteria

The acceptance guidelines in RG 1.174 [4] are used to assess the acceptability of this extension of the Type A test interval beyond that established during the Option B rulemaking of Appendix J. RG 1.174 defines very small changes in the risk-acceptance guidelines as increases in core damage frequency (CDF) less than 1E-6 per reactor year and increases in large early release frequency (LERF) less than 1E-7 per reactor year. Since the Type A test interval does not significantly impact CDF, the relevant criterion is the change in LERF. RG 1.174 also defines small changes in LERF as below 1E-6 per reactor year. RG 1.174 discusses defense-in-depth and encourages the use of risk analysis techniques to help ensure and show that key principles, such as the defense-in-depth philosophy, are met. Therefore, the increase in the conditional containment failure probability (CCFP) that helps to ensure that the defense-in-depth philosophy is maintained is also calculated.

Regarding CCFP, changes of up to 1.1% have been accepted by the NRC for the one-time requests for extension of Type A test intervals, and a CCFP of 1/10 (10%) has been approved for application to evolutionary light water designs [27]. Based on the criteria stated in EPRI 1009325 Revision 2-A, a change in the CCFP of up to 1.5% is considered to be small.

In addition, the total annual risk (person rem/yr population dose) is examined to demonstrate the relative change in this parameter. Based on the criteria stated in EPRI 1009325 Revision 2-A, a very small population dose is defined as an increase from the baseline Type A test interval (3 tests per 10 years) dose of ≤ 1.0 person-rem per year or 1% of the total baseline dose, whichever is less restrictive for the risk impact assessment of the proposed extended Type A test interval.

In addition, EPRI 1009325 Revision 2-A requires that ECCS NPSH requirements be assessed with regard to determining whether containment over pressure is required in various accident scenarios. The NMP2 ECCS pumps are capable of pumping saturated fluids and containment over pressure is not required in the PRA for ECCS pumping success. As a result, Type A test interval changes have an insignificant impact on CDF and LERF is the proper risk metric to be considered.

2 Methodology

A simplified bounding analysis approach consistent with the EPRI approach is used for evaluating the NMP2-specific change in risk associated with increasing the Type A test interval to fifteen years. EPRI 1009325 Revision 2-A [27] provides a generally applicable assessment of the risk involved in extension of Type A test intervals to permanent 15-year intervals. Appendix H of the EPRI report provides guidance for performing plant-specific supplemental risk impact assessments. The approach included in this guidance document is used in the NMP2 assessment to determine the estimated increase in risk associated with the Type A test interval extension. This EPRI document includes the bases for the values assigned in determining the probability of leakage for the EPRI Class 3a and 3b scenarios in this analysis as described in Section 5.

This analysis uses results from a Level 2 analysis of core damage scenarios from the current NMP2 PRA model and subsequent containment response resulting in various fission product release categories (including no or negligible release).

The six general steps of this assessment are as follows:

1. Quantify the baseline risk in terms of the frequency of events (per reactor year) for each of the eight containment release scenario types identified in the EPRI report.

2. Develop plant-specific person-rem (population dose) per reactor year for each of the eight containment release scenario types from plant specific consequence analyses.

3. Evaluate the risk impact (i.e., the change in containment release scenario type frequency and population dose) of extending the Type A test interval to fifteen years.

4. Determine the change in risk in terms of Large Early Release Frequency (LERF) in accordance with RG 1.174 [4] and compare with the acceptance guidelines of RG 1.174.

5. Determine the impact on the Conditional Containment Failure Probability (CCFP).

6. Evaluate the sensitivity of the results to assumptions in the liner corrosion analysis, external events, and the fractional contribution to LERF of increased large isolation failures (due to liner breach).

3 Ground Rules

The following ground rules are used in the analysis consistent with EPRI 1009325 Revision 2-A:

- The technical adequacy of the NMP2 PRA is consistent with the requirements of Regulatory Guide 1.200 Rev 1 as is relevant to this Type A test interval extension.

- The NMP2 Level 1 and Level 2 internal events PRA models provide representative results.

- It is appropriate to use the NMP2 internal events PRA model as a gauge to effectively describe the risk change attributable to the Type A test interval extension. It is reasonable to assume that the impact from the extension (with respect to percent increases in population dose) will not substantially differ if fire and seismic events were to be included in the calculations.

- Dose results for the containment failures modeled in the PRA can be characterized by information provided in NUREG/CR-4551 [7]. They are estimated by scaling the NUREG/CR-4551 results by population differences for Nine Mile Point Station compared to the NUREG/CR-4551 reference plant. Using this reference plant is judged reasonable as it was also used for another Mark II BWR as an example in EPRI 1009325 Revision 2-A.

- Accident classes describing radionuclide release end states are defined consistent with EPRI methodology and are summarized in Section 4.2.

- The representative containment leakage for Class 1 sequences is 1La. Class 3 accounts for increased leakage due to Type A inspection failures.

- The representative containment leakage for Class 3a sequences is 10La.

- The representative containment leakage for Class 3b sequences is 100La.

- The Class 3b sequences can be conservatively categorized as LERF.

- The impact on population doses from containment bypass scenarios is not altered by the proposed Type A test interval extension, but is accounted for in the EPRI methodology as a separate entry for comparison purposes. Since the containment bypass contribution to population dose is fixed, no changes on the conclusions from this analysis will result from this separate categorization.

- The reduction in Type A test frequency does not impact the reliability of containment isolation valves to close in response to a containment isolation signal.

- The NMP2 PRA does contain external events included from the IPEEE; however, these event models have not been updated and maintained. Still, the sensitivity of the Class 3b contribution to LERF from external events is evaluated using the NMP2 PRA to provide an order of magnitude estimate for contribution of external events to the impact of the changed Type A test interval.

4 Inputs

This section summarizes general resources available as input (Section 4.1) and the plant specific resources required (Section 4.2).

4.1 General Resources

Various industry studies on containment leakage risk assessment are available and support the final methodology in EPRI 1009325 Revision 2-A [27]. Each of the following documents is summarized in further detail in EPRI 1009325:

1. NUREG/CR-3539 [10]
2. NUREG/CR-4220 [11]
3. NUREG-1273 [12]
4. NUREG/CR-4330 [13]
5. EPRI TR-105189 [14]
6. NUREG-1493 [6]
7. EPRI TR-104285 [2]
8. NUREG-1150 [15] and NUREG/CR-4551 [7]
9. NEI Interim Guidance [3][20]
10. Calvert Cliffs liner corrosion analysis [5]
11. EPRI Report No. 1009325, Revision 2-A, Appendix H [27]

4.2 Plant Specific Inputs

The plant-specific information used to perform the NMP2 Type A test interval extension risk assessment includes the following:

- Level 1 Model results [17]
- Level 2 Model results [17]
- Release category definitions used in the Level 2 Model [18]
- Population within a 50-mile radius [19]
- Type A test results demonstrate adequacy of the administrative and hardware issues [28]. The two most recent Type A tests at NMP2 have been successful, so the current Type A test interval requirement is 10 years.
- Containment failure probability data [18]

<u>Level 1 Model</u>
The Level 1 PRA model that is used for NMP2 is characteristic of the as-built plant. The current Level 1 model is a linked fault tree model, and was quantified with a total Core Damage Frequency (CDF) = 8.4E-6/yr (1E-12 truncation).

Level 2 Model

The Level 2 Model that is used for NMP2 was developed to calculate the LERF contribution (Release Category H-E) as well as the other release categories evaluated in the model. Table 1 summarizes the NMP2 Level 2 results (1E-13 truncation) in terms of release category [17, 18].

Table 1: Level 2 PRA Release Categories and Frequencies

Release Category	Definition of Release	Events/yr
OK	Containment Intact	3.09E-06
LL-L	Low-Low Magnitude and Late Timing	2.49E-08
LL-I	Low-Low Magnitude and Intermediate Timing	1.74E-06
LL-E	Low Magnitude and Early Timing	9.55E-10
L-L	Low Magnitude and Late Timing	0.00
L-I	Low Magnitude and Intermediate Timing	2.50E-07
L-E	Low Magnitude and Early Timing	1.51E-06
M-L	Medium Magnitude and Late Timing	0.00
M-I	Medium Magnitude and Intermediate Timing	8.23E-07
M-E	Medium Magnitude and Early Timing	2.48E-07
H-L	High Magnitude and Late Timing	0.00
H-I	High Magnitude and Intermediate Timing	2.34E-07
H-E	High Magnitude and Early Timing	4.43E-07
	Total Release Category Frequency	**8.37E-06**

Population Dose Calculations

The population dose is calculated by using data provided in NUREG/CR-4551 and adjusting the results for NMP2. Each of the release categories from Table 1 is associated with an applicable Collapsed Accident Progression Bin (APB) from NUREG/CR-4551 (see below). The collapsed APBs are characterized by 5 attributes related to the accident progression. Unique combinations of the 5 attributes result in a set of 10 bins that are relevant to the analysis. The definitions of the 10 collapsed APBs are provided in NUREG/CR-4551 [7] and are reproduced in Table 2 for references purposes. Table 3 summarizes the calculated population dose for Peach Bottom associated with each APB from NUREG/CR-4551 [7]. The EPRI approach was used in lieu of the level 3 PRA model that was developed for the NMP License Renewal Application [29] because the level 3 model has not been maintained since its creation. It has not been updated to the same level of quality as the level 1 and level 2 PRA (RG 1.200) and has not been updated since the License Renewal Application for which it was developed.

Table 2: Summary Accident Progression Bin (APB) Descriptions

Collapsed APB Number	Description
1	CD, VB, Early CF, WW Failure, RPV Pressure > 200 psi at VB Core damage occurs followed by vessel breach. The containment fails early in the wetwell (i.e., either before core damage, during core damage, or at vessel breach) and the RPV pressure is greater than 200 psi at the time of vessel breach (this means Direct Containment Heating (DCH) is possible).
2	CD, VB, Early CF, WW Failure, RPV Pressure < 200 psi at VB Core Damage occurs followed by vessel breach. The containment fails early in the wetwell (i.e., either before core damage, during core damage, or at vessel breach) and the RPV pressure is less than 200 psi at the time of vessel breach (this means DCH is not possible).
3	CD, VB, Early CF, DW Failure, RPV Pressure > 200 psi at VB Core damage occurs followed by vessel breach. The containment fails early in the drywell (i.e., either before core damage, during core damage, or at vessel breach) and the RPV pressure is greater than 200 psi at the time of vessel breach (this means DCH is possible).
4	CD, VB, Early CF, DW Failure, RPV Pressure < 200 psi at VB Core Damage occurs followed by vessel breach. The containment fails early in the drywell (i.e., either before core damage, during core damage, or at vessel breach) and the RPV pressure is less than 200 psi at the time of vessel breach (this means DCH is not possible).
5	CD, VB, Late CF, WW Failure, N/A Core Damage occurs followed by vessel breach. The containment fails late in the wetwell (i.e., after vessel breach during Molten Core-Concrete Interaction (MCCI)) and the RPV pressure is not important since, even if DCH occurred, it did not fail containment at the time it occurred.
6	CD, VB, Late CF, DW Failure, N/A Core Damage occurs followed by vessel breach. The containment fails late in the drywell (i.e., after vessel breach during MCCI) and the RPV pressure is not important since, even if DCH occurred, it did not fail containment at the time it occurred.
7	CD, VB, No CF, Vent, N/A Core Damage occurs followed by vessel breach. The containment never structurally fails, but is vented sometime during the accident progression. RPV pressure is not important (characteristic 5 is N/A) since, even if it occurred, DCH does not significantly affect the source term as the containment does not fail and the vent limits its effect.
8	CD, VB, No CF, N/A, N/A Core damage occurs followed by vessel breach. The containment never fails structurally (characteristic 4 is N/A) and is not vented. RPV pressure is not important (characteristic 5 is N/A) since, even if it occurred, DCH did not fail containment. Some nominal leakage from the containment exists and is accounted for in the analysis so that while the risk will be small it is not completely negligible.
9	CD, No VB, N/A, N/A, N/A Core damage occurs but is arrested in time to prevent vessel breach. There are no releases associated with vessel breach or MCCI. It must be remembered, however, that the containment can fail due to overpressure or venting even if vessel breach is averted. Thus, the potential exists for some of the in-vessel releases to be released to the environment.
10	No CD, N/A, N/A, N/A, N/A Core damage did not occur. No in-vessel or ex-vessel release occurs. The containment may fail on overpressure or be vented. The RPV may be at high or low pressure depending on the progression characteristics. The risk associated with this bin is negligible.

Table 3: Calculation of Peach Bottom Population Dose Risk at 50 Miles

Collapsed Accident Progression (APB) Number	Fractional APB Contributions to Risk (MFCR) (1)	NUREG/CR-4551 Population Dose Risk at 50 miles (From a total of 7.9 person-rem/yr, mean) (2)	NUREG/CR-4551 Collapsed Bin Frequencies (per year) (3)	NUREG/CR-4551 Population Dose at 50 miles (Person-rem) (4)
1	0.021	0.1659	9.55E-8	1.74E+6
2	0.0066	0.05214	4.77E-8	1.09E+6
3	0.556	4.3924	1.48E-6	2.97E+6
4	0.226	1.7854	7.94E-7	2.25E+6
5	0.0022	0.01738	1.30E-8	1.34E+6
6	0.059	0.4661	2.04E-7	2.28E+6
7	0.118	0.9322	4.77E-7	1.95E+6
8	0.0005	0.00395	7.99E-7	4.94E+3
9	0.01	0.079	3.86E-7	2.05E+5
10	0	0	4.34E-8	0
Totals	1.0	7.9	4.34E-6	

(1) Mean Fractional Contribution to Risk calculated from Table 5.2-3 of NUREG/CR-4551

(2) The total population dose risk (PDR) at 50 miles from internal events in person-rem is provided in Table 5.1-1 of NUREG/CR-4551. The contribution for a given APB is the product of the total PDR50 and the fractional APB contribution.

(3) NUREG/CR-4551 provides the conditional probabilities of the collapsed APBs in Figure 2.5-6. These conditional probabilities are multiplied by the total internal CDF to calculate the collapsed APB frequency.

(4) Obtained from dividing the population dose risk shown in the third column of this table by the collapsed bin frequency shown in the fourth column of this table.

The person-rem results in Table 3 can be used as an approximation of the dose for the NMP2 site if it is corrected for allowable containment leak rate (La), reactor power level and the population density surrounding NMP2 [27].

- Leak rate adjustment = La of NMP2 (%w/o/day) ÷ La of Peach Bottom
  = 1.1 ÷ 0.5
  = 2.20
  La for Peach Bottom is 0.5%w/o/day
  La for NMP2 is 1.1%w/o/day based on Technical Specification 5.5.12
  This is applicable only to those APBs affected by normal leakage

- Power level adjustment = Proposed upated power at NMP2 (MWt) ÷ Rated power at Peach Bottom
  = 3988 MWt ÷ 3293 MWt
  = 1.211
  The rated power level for Peach Bottom is 3293 MWt
  The proposed uprated power level for NMP2 is 3988 MWt

- Population density adjustment = NMP2 population ÷ Peach Bottom population
  = 914,688 / 3.2E+06
  = 0.286

The total population within a 50-mile radius of NMP2 is 914,668 [19]. This population value is compared to the population value that is provided in NUREG/CR-4551 in order to get a "Population Dose Factor" that can be applied to the APBs to get dose estimates for NMP2. Peach Bottom Population from NUREG/CR-4551 is 3.2E+06, as referenced in the EPRI 1009325 Rev 2-A.

The factors developed above are used to adjust the population dose for the surrogate plant (Peach Bottom) for NMP2. For intact containment end states, the total population dose factor is as follows:

FIntact = FPopulation * FPower Level * FLeakage

FIntact = 0.286 * 1.211 * 2.20

FIntact = 0.76

For EPRI accident classes not dependent on containment leakage, the population dose factor is as follows:

FOthers = FPopulation * FPower Level

FOthers = 0.286 * 1.211

FOthers = 0.35

The difference in the doses at 50 miles is assumed to be in direct proportion to the difference in the population within 50 miles of each site. The above adjustments provide an approximation for NMP2 of the population doses associated with each of the release categories from NUREG/CR-4551.

Table 4 shows the results of applying the population dose factor to the NUREG/CR-4551 population dose results at 50 miles to obtain the adjusted population dose at 50 miles for NMP2.

Table 4: Calculation of NMP2 Population Dose Risk at 50 Miles

Peach Bottom Accident Progression Bin #	NUREG/CR-4551 Population Dose at 50 miles (Person-rem)	Bin Multiplier used to obtain NMP2 Population Dose	NMP2 Adjusted Population Dose at 50 miles (Person-rem)
1	1.74E+6	0.35	6.09E+5
2	1.09E+6	0.35	3.82E+5
3	2.97E+6	0.35	1.04E+6
4	2.25E+6	0.35	7.88E+5
5	1.34E+6	0.35	4.69E+5
6	2.28E+6	0.35	7.98E+5
7	1.95E+6	0.35	6.83E+5
8	4.94E+3	0.76	3.75E+3
9	2.05E+5	0.35	7.18E+4
10	0	0.35	0.0

Application of NMP2 PRA Results to NUREG/CR-4551 Level 3 Output

A major factor related to the use of NUREG/CR-4551 in this evaluation is that the results of the NMP2 PRA Level 2 model are not defined in the same terms as reported in NUREG/CR-4551. In order to use the Level 3 model presented in that document, it was necessary to match the NMP2 PRA Level 2 release categories to the collapsed APBs. The assignments are shown in Table 5, along with the corresponding EPRI classes (see below).

Table 5: EPRI Class Dose and Frequency Assignment

EPRI Class	EPRI Description	Leakage Basis	Peach Bottom APB for Dose (NUREG/CR-4551)	NMP2 Level 2 Release Category Frequency (or other)
1	No Containment Failure	La	8	OK (Intact) – 3a – 3b
2	Large Containment Isolation Failure	Plant value	3 (highest dose)	Containment Isolation failure (H-E with IS=F)
3a	Small pre-existing failure	10 La	10 x Dose of APB 8	By methodology (CDF-(H-E)*0.0092)
3b	Large pre-existing failure	100 La	100 x Dose of APB 8	By methodology (CDF-(H-E)*0.0023)
4	Small Isol failure – Type B	NA	NA	NA
5	Small Isol failure – Type C	NA	NA	NA
6	Cont Isol failure – Dep failure	NA	NA	NA
7	Severe Accident Sequences	Plant value (weighted average)	Weighted Average	Weighted Average of Subcategories (7a, 7b, 7c, 7d, 7e)
7a	Subcategory (not EPRI)		3 (highest dose)	H-E without IS=F and V
7b	Subcategory (not EPRI)		6 (high dose, late DW failure)	H-M & H-L
7c	Subcategory (not EPRI)		1 (WW failure early)	M-E
7d	Subcategory (not EPRI)		2 (WW failure late)	M-I & M-L
7e	Subcategory (not EPRI)		9 (CD, no Vessel Breach)	L & LL
8	Containment Bypass	Plant value	3 (highest dose)	H-E Class V Scenarios

Release Category Definitions

Table 6 defines the accident classes used in the Type A test interval extension evaluation, which are consistent with the EPRI methodology [27]. These containment failure classifications are used in this analysis to determine the risk impact of extending the containment Type A test interval as described in Section 5 of this report.

Table 6: EPRI Containment Failure Classification

Class	Description
1	Containment remains intact including accident sequences that do not lead to containment failure in the long term. The release of fission products (and attendant consequences) is determined by the maximum allowable leakage rate values L_a, under Appendix J for that plant
2	Containment isolation failures (as reported in the IPEs) include those accidents in which there is a failure to isolate the containment.
3	Independent (or random) isolation failures include those accidents in which the pre-existing isolation failure to seal (i.e., provide a leak-tight containment) is not dependent on the sequence in progress.

Class	Description
4	Independent (or random) isolation failures include those accidents in which the pre-existing isolation failure to seal is not dependent on the sequence in progress. This class is similar to Class 3 isolation failures, but is applicable to sequences involving Type B tests and their potential failures. These are the Type B-tested components that have isolated but exhibit excessive leakage.
5	Independent (or random) isolation failures include those accidents in which the pre-existing isolation failure to seal is not dependent on the sequence in progress. This class is similar to Class 4 isolation failures, but is applicable to sequences involving Type C tests and their potential failures.
6	Containment isolation failures include those leak paths covered in the plant test and maintenance requirements or verified per in service inspection and testing (ISI/IST) program.
7	Accidents involving containment failure induced by severe accident phenomena. Changes in Appendix J testing requirements do not impact these accidents.
8	Accidents in which the containment is bypassed (either as an initial condition or induced by phenomena) are included in Class 8. Changes in Appendix J testing requirements do not impact these accidents.

4.3 Impact of Extension on Detection of Failures that Lead to Leakage

The Type A test can detect a number of component failures such as liner breach, failure of certain bellows arrangements and failure of some sealing surfaces, which can lead to leakage. The proposed Type A test interval extension may influence the conditional probability of detecting these types of failures. To ensure that this effect is properly accounted for, the EPRI Class 3 accident class as defined in Table 6 is divided into two sub-classes, Class 3a and Class 3b, representing small and large leakage failures, respectively.

The probability of the EPRI Class 3a and 3b failures is determined consistent with the EPRI Guidance [27]. For Class 3a, the probability is based on the maximum likelihood estimate of failure (arithmetic average) from the available data (i.e., 2 "small" failures in 217 tests leads to 2/217 = 0.0092). For Class 3b, Jeffreys non-informative prior distribution is assumed for no "large" failures in 217 tests (i.e., 0.5 / (217+1) = 0.0023).

In a follow on letter [20] to their interim guidance document [3], NEI issued additional information concerning the potential that the calculated delta LERF values for several plants may fall above the "very small change" guidelines of NRC Regulatory Guide 1.174. This additional NEI information includes a discussion of conservatisms in the quantitative guidance for delta LERF. NEI describes ways to demonstrate that, using plant-specific calculations, the delta LERF is smaller than that calculated by the simplified method.

The supplemental information states:

> *The methodology employed for determining LERF (Class 3b frequency) involves conservatively multiplying the CDF by the failure probability for this class (3b) of accident. This was done for simplicity and to maintain conservatism. However, some plant-specific accident classes leading to core damage are likely to include individual sequences that either may already (independently) cause a LERF or could never cause a LERF, and are thus not associated with a postulated large Type A containment leakage path (LERF). These contributors can be removed from Class 3b in the evaluation of LERF by multiplying the Class 3b probability by only that portion of CDF that may be impacted by type A leakage.*

The application of this additional guidance to the analysis for NMP2, as detailed in Section 5, involves the following:

- The LERF sequences (Class 2, Class 8 and H-E portion of Class 7) are subtracted from the CDF that is applied to Class 3b. To be consistent, the same change is made to the Class 3a CDF, even though these events are not considered LERF. Class 2 and Class 8 events refer to sequences with either large pre-existing containment isolation failures or containment bypass events. These sequences are already considered to contribute to LERF in the NMP2 Level 2 PRA analysis.

- Class 1 accident sequences may involve availability and or successful operation of containment sprays. It could be assumed that, for calculation of the Class 3b and 3a frequencies, the fraction of the Class 1 CDF associated with successful operation of containment sprays can also be subtracted. However, this has been conservatively neglected in this evaluation. Also, other sequences that have the potential to never be LERF (e.g., late core damage) have conservatively not been deleted from Class 3b.

Consistent with the methodology [27], the change in the leak detection probability can be estimated by comparing the average time that a leak could exist without detection. For example, the average time that a leak could go undetected with a three-year test interval is 1.5 years (3 yr / 2), and the average time that a leak could exist without detection for a ten-year interval is 5 years (10 yr / 2). This change would lead to a non-detection probability that is a factor of 3.33 (5.0/1.5) higher for the probability of a leak that is detectable only by Type A testing. Correspondingly, an extension of the Type A test interval to fifteen years can be estimated to lead to a factor of 5.0 (7.5/1.5) increase in the non-detection probability of a leak.

It should be noted that using the methodology discussed above is conservative compared to previous submittals (e.g., the IP3 request for a one-time Type A test interval extension that was approved by the NRC [9]) because it does not factor in the possibility that the failures could be detected by other tests (e.g., the Type B local leak rate tests that will still occur). Eliminating this possibility conservatively over-estimates the factor increases attributable to the Type A test interval extension.

4.4 Impact of Extension on Detection of Steel Liner Corrosion

An estimate of the likelihood and risk implications of corrosion-induced leakage of the steel liners occurring and going undetected during the extended Type A test interval is evaluated using the methodology from the Calvert Cliffs liner corrosion analysis [5]. The Calvert Cliffs analysis was performed for a concrete cylinder and dome and a concrete basemat, each with a steel liner. The NMP2 containment is a pressure-suppression BWR Mark II type. The drywell is a steel-lined reinforced concrete vessel, and the suppression chamber is a stainless steel clad, steel-lined reinforced concrete vessel.

The following approach is used to determine the change in likelihood, due to extending the Type A test interval, of detecting corrosion of the containment steel liner. This likelihood is then used to determine the resulting change in risk. Consistent with the Calvert Cliffs analysis, the following issues are addressed:

- Differences between the containment basemat and other regions of the containment
- The historical steel liner flaw likelihood due to concealed corrosion
- The impact of aging
- The corrosion leakage dependency on containment pressure
- The likelihood that visual inspections will be effective at detecting a flaw

Assumptions

- Consistent with the Calvert Cliffs analysis, a half failure is assumed for basemat concealed liner corrosion due to the lack of identified failures (see Table 7, Step 1).
- The two corrosion events used to estimate the liner flaw probability in the Calvert Cliffs analysis are assumed to be applicable to the NMP2 containment analysis. These events, one at North Anna Unit 2 and one at Brunswick Unit 2 were initiated from the non-visible (backside) portion of the containment liner (see Table 7, Step 1).
- Consistent with the Calvert Cliffs analysis, the estimated historical flaw probability is also limited to 5.5 years to reflect the years since September 1996 when 10 CFR 50.55a started requiring visual inspection. Additional success data was not used to limit the aging impact of this corrosion issue, even though inspections were being performed prior to this date (and have been performed since the time frame of the Calvert Cliffs analysis), and there is no evidence that additional corrosion issues were identified (See Table 7, Step 1).
- Consistent with the Calvert Cliffs analysis, the steel liner flaw likelihood is assumed to double every five years. This is based solely on judgment and is included in this analysis to address the increased likelihood of corrosion as the steel liner ages (See Table 7, Steps 2 and 3). Sensitivity studies are included that address doubling this rate every ten years and every two years.
- In the Calvert Cliffs analysis, the likelihood of the containment atmosphere reaching the outside atmosphere given that a liner flaw exists was estimated as 1.1% for the cylinder and dome and 0.11% (10% of the cylinder failure probability) for the basemat. These values were determined from an assessment of the probability versus containment pressure, and the selected values are consistent with a pressure that corresponds to the Type A test target pressure of ~40 psig. For NMP2, the containment failure probabilities are less than these values at 40 psig [18]. Sensitivity studies are included that increase and decrease the probabilities by an order of magnitude (See Table 7, Step 4).

- Consistent with the Calvert Cliffs analysis, the likelihood of leakage escape (due to crack formation) in the basemat region is considered to be less likely than the containment cylinder and dome region (See Table 7, Step 4).

- Consistent with the Calvert Cliffs analysis, a 5% visual inspection detection failure likelihood given the flaw is visible and a total detection failure likelihood of 10% is used. To date, all liner corrosion events have been detected through visual inspection (See Table 7, Step 5). Sensitivity studies are included that evaluate total detection failure likelihood of 5% and 15%, respectively.

- Consistent with the Calvert Cliffs analysis, all non-detectable containment failures are assumed to result in early releases. This approach avoids a detailed analysis of containment failure timing and operator recovery actions.

Table 7: Steel Liner Corrosion Base Case

<table>
<tr><th>Step</th><th>Description</th><th colspan="2">Containment Cylinder and Dome</th><th colspan="2">Containment Basemat</th></tr>
<tr><td>1</td><td>Historical Steel Liner Flaw Likelihood
Failure Data: Containment location specific (consistent with Calvert Cliffs analysis)</td><td colspan="2">Events: 2
2/(70 * 5.5) = 5.2E-3</td><td colspan="2">Events: 0 (assume half failure)
0.5/(70 * 5.5) = 1.3E-3</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Age Adjusted Steel Liner Flaw Likelihood
During 15-year interval, assume failure rate doubles every five years (14.9% increase per year). The average for 5th to 10th year is set to the historical failure rate (consistent with Calvert Cliffs analysis)</td><td>Year
1
avg 5-10
15</td><td>Failure Rate
2.1E-3
5.2E-3
1.4E-2</td><td>Year
1
avg 5-10
15</td><td>Failure Rate
5.1E-4
1.3E-3
3.6E-3</td></tr>
<tr><td colspan="2">15 year average = 6.4E-3</td><td colspan="2">15 year average = 1.6E-3</td></tr>
<tr><td>3</td><td>Flaw Likelihood at 3, 10, and 15 years
Uses age adjusted liner flaw likelihood (Step 2), assuming failure rate doubles every five years (consistent with Calvert Cliffs analysis – See Table 6 of Reference [5]).</td><td colspan="2">0.71% (1 to 3 years)
4.14% (1 to 10 years)
9.66% (1 to 15 years)
(Note that the Calvert Cliffs analysis presents the delta between 3 and 15 years of 8.7% to utilize in the estimation of the delta-LERF value. For this analysis, however, the values are calculated based on the 3, 10, and 15 year intervals consistent with the desired presentation of the results.</td><td colspan="2">0.18% (1 to 3 years)
1.03% (1 to 10 years)
2.41% (1 to 15 years)
(Note that the Calvert Cliffs analysis presents the delta between 3 and 15 years of 2.2% to utilize in the estimation of the delta-LERF value. For this analysis, however, the values are calculated based on the 3, 10, and 15 year intervals consistent with desired presentation of the results.</td></tr>
</table>

Step	Description	Containment Cylinder and Dome	Containment Basemat
4	Likelihood of Breach in Containment Given Steel Liner Flaw The failure probability of the cylinder and dome is assumed to be 1% (compared to 1.1% in the Calvert Cliffs analysis). The basemat failure probability is assumed to be a factor of ten less, 0.1%, (compared to 0.11% in the Calvert Cliffs analysis).	1%	0.1%
5	Visual Inspection Detection Failure Likelihood Utilizes assumptions consistent with Calvert Cliffs analysis	**10%** 5% failure to identify visual flaws plus 5% likelihood that the flaw is not visible (not through-cylinder but could be detected by Type A test) All events have been detected through visual inspection. 5% visible failure detection is a conservative assumption.	**100%** Cannot be visually inspected.
6	Likelihood of Non-Detected Containment Leakage (Steps 3 * 4 * 5)	**0.00071% (at 3 years)** 0.71% * 1% * 10% **0.0041% (at 10 years)** 4.1% * 1% * 10% **0.0097% (at 15 years)** 9.7% * 1% * 10%	**0.00018% (at 3 years)** 0.18% * 0.1% * 100% **0.0010% (at 10 years)** 1.0% * 0.1% * 100% **0.0024% (at 15 years)** 2.4% * 0.1% * 100%

The total likelihood of the corrosion-induced, non-detected containment leakage is the sum of Step 6 for the containment cylinder and dome and the containment basemat as summarized below for NMP2.

Total Likelihood of Non-Detected Containment Leakage Due To Corrosion for NMP2:
At 3 years: 0.00071% + 0.00018% = 0.00089%
At 10 years: 0.0041% + 0.0010% = 0.0052%
At 15 years: 0.0097% + 0.0024% = 0.012%

The above factors are applied to those core damage accidents that are not already independently LERF or that could never result in LERF. For example, the 3-in-10 year case is calculated as follows:

- Per Table 9, the EPRI Class 3b frequency is 1.82E-8/yr. As discussed in Section 5.1, this is the NMP2 CDF associated with accidents that are not independently LERF [CDF – (H-E) = 7.93E-6] times the conditional probability of Class 3b (0.0023).

- The increase in the base case Class 3b frequency due to the corrosion-induced concealed flaw issue is calculated as 7.93E-6 [CDF – (H-E)] * 8.9E-6 = 7.1E-11/yr, where 8.9E-6 as shown above is the cumulative likelihood of non-detected containment leakage due to corrosion at 3 years.

- The 3-in-10 year Class 3b frequency including the corrosion-induced concealed flaw issue is calculated as 1.82E-8/yr + 7.1E-11/yr= 1.83E-8/yr.

5 Results

The application of the approach based on the guidance contained in Appendix H of EPRI 1009325 Revision 2-A [27] and previous risk assessment submittals on this subject [5, 8, 21, 22, 23] have led to the following results described in this section. The results are displayed according to the eight accident classes defined in the EPRI report. Table 8 lists these accident classes.

The analysis performed examined NMP2-specific accident sequences in which the containment remains intact or the containment is impaired. Specifically, the break down of the severe accidents contributing to risk was considered in the following manner:

- Core damage sequences in which the containment remains intact initially and in the long term (EPRI Class 1 sequences).
- Core damage sequences in which containment integrity is impaired due to random isolation failures of plant components other than those associated with Type B or Type C test components. For example, liner breach or bellows leakage (EPRI Class 3 sequences).
- Core damage sequences in which containment integrity is impaired due to containment isolation failures of pathways left "opened" following a plant post-maintenance test. For example, a valve failing to close following a valve stroke test (EPRI Class 6 sequences). This class is not specifically examined since it will not significantly influence the results of this analysis.
- Accident sequences involving containment bypassed (EPRI Class 8 sequences), large containment isolation failures (EPRI Class 2 sequences), and small containment isolation "failure-to-seal" events (EPRI Class 4 and 5 sequences) are accounted for in this evaluation as part of the baseline risk profile. However, they are not affected by the Type A test interval change.
- Class 4 and 5 sequences are impacted by changes in Type B and C test intervals; therefore, changes in the Type A test interval do not impact these sequences.

Table 8: EPRI Accident Classes

Accident Classes (Containment Release Type)	Description
1	No Containment Failure
2	Large Isolation Failures (Failure to Close)
3a	Small Isolation Failures (liner breach)
3b	Large Isolation Failures (liner breach)
4	Small Isolation Failures (Failure to seal –Type B)
5	Small Isolation Failures (Failure to seal—Type C)
6	Other Isolation Failures (e.g., dependent failures)
7	Failures Induced by Phenomena (Early and Late)
8	Bypass (Interfacing System LOCA)
CDF	All CET End states (including very low and no release)

The steps taken to perform this risk assessment evaluation are as follows:

Step 1 - Quantify the base-line risk in terms of frequency per reactor year for each of the eight accident classes presented in Table 8.

Step 2 - Develop plant-specific person-rem dose (population dose) per reactor year for each of the eight accident classes.

Step 3 - Evaluate risk impact of extending Type A test interval from 3 to 15years and from 10 to 15 years.

Step 4 - Determine the change in risk in terms of Large Early Release Frequency (LERF) in accordance with RG 1.174.

Step 5 - Determine the impact on the Conditional Containment Failure Probability (CCFP)

5.1 Step 1 – Quantify the Base-Line Risk

As previously described, the extension of the Type A interval does not influence those accident progressions that involve large containment isolation failures, Type B or Type C testing, or containment failure induced by severe accident phenomena.

For the assessment of Type A test interval impacts on the risk profile, the potential for pre-existing leaks is included in the model (These events are represented by the EPRI Class 3 sequences). The question on containment integrity is modified to include the probability of a liner breach or bellows failure (due to excessive leakage) at the time of core damage. Two failure modes are considered for the Class 3 sequences. These are Class 3a (small breach) and Class 3b (large breach).

The frequencies for the severe accident classes defined in Table 8 are developed for NMP2 by first determining the frequencies for Classes 1, 2, 7 and 8 using the categorized sequences and the identified correlations shown in Table 5, determining the frequencies for Classes 3a and 3b, and then determining the remaining frequency for Class 1. Furthermore, adjustments were made to the Class 3b and hence Class 1 frequencies to account for the impact of undetected corrosion of the steel liner per the methodology described in Section 4.4.

The total frequency of the categorized sequences is 8.4E-6/yr the same as total CDF. Table 9 contains the frequencies from the categorized sequences. The results are summarized below and in Table 10.

Table 9: NMP2 Categorized Accident Classes and Frequencies

EPRI Class	NMP2 Frequency (per yr)	NMP2 Basis (release category)
1	3.00E-06	OK – EPRI 3a – EPRI 3b
2	2.95E-07	IS=F contribution from H-E
3a	7.29E-08	[CDF – (H-E)] times 0.0092
3b	1.82E-08	[CDF – (H-E)] times 0.0023
7	4.97E-06	CDF – OK – (IS=F contribution) – (Class V contribution)
8	1.60E-08	Class V contribution from H-E

Class 1 Sequences – This group consists of all core damage accident progression bins for which the containment remains intact (modeled as Technical Specification Leakage). The frequency per year is determined from the Level 2 Release Category OK listed in Table 1, minus the EPRI Class 3a and 3b frequency, calculated below.

Class 2 Sequences – This group consists of all core damage accidents for which a failure to isolate the containment occurs. The frequency per year for these sequences is obtained from the Release Category H-E, but only includes the contribution from failure of top event IS (containment isolation failure).

Class 3 Sequences – This group consists of all core damage accident progression bins for which a pre-existing leakage in the containment structure (e.g., containment liner) exists. The containment leakage for these sequences can be either small (in excess of design allowable but <10La) or large (>100La).

The respective frequencies per year are determined as follows:

$PROB_{class\_3a}$ = probability of small pre-existing containment liner leakage
= 0.0092 [see Section 4.3]

$PROB_{class\_3b}$ = probability of large pre-existing containment liner leakage
= 0.0023 [see Section 4.3]

As described in Section 4.3, additional consideration is made to not apply these failure probabilities on those cases that are already LERF scenarios (i.e., the Class 2 and Class 8 contributions and H-E portion of Class 7).

CLASS_3A_FREQUENCY = 0.0092 * [CDF - Class 2 - Class 8 – (H-E part of Class 7)]
= 0.0092 * [CDF – (H-E)]
= 7.3E-8/yr

CLASS_3B_FREQUENCY = 0.0023 * [CDF - Class 2 - Class 8 – (H-E part of Class 7)]
=0.0023 * [CDF – (H-E)]
=1.8E-8/yr

For this analysis, the associated containment leakage for Class 3A is $10L_a$ and for Class 3B is $100L_a$. These assignments are consistent with the guidance provided in EPRI 1009325 Revision 2-A [27].

Class 4 Sequences – This group consists of all core damage accident progression bins for which containment isolation failure-to-seal of Type B test components occurs. Because these failures are detected by Type B tests which are unaffected by the Type A test, this group is not evaluated further in the analysis.

Class 5 Sequences – This group consists of all core damage accident progression bins for which a containment isolation failure-to-seal of Type C test components occurs. Because the failures are detected by Type C tests which are unaffected by the Type A test, this group is not evaluated further in this analysis.

Class 6 Sequences – This group is similar to Class 2. These are sequences that involve core damage accident progression bins for which a failure-to-seal containment leakage due to failure to isolate the containment occurs. These sequences are dominated by misalignment of containment isolation valves following a test/maintenance evolution. Consistent with guidance provided in EPRI 1009325 Revision 2-A [27], this accident class is not explicitly considered since it has a negligible impact on the results.

Class 7 Sequences – This group consists of all core damage accidents in which containment failure induced by severe accident phenomena occurs (e.g., overpressure). For this analysis, the frequency is determined by subtracting the EPRI Class 1, 2, and 8 frequencies from total CDF.

Class 8 Sequences – This group consists of all core damage accidents in which containment bypass occurs. For this analysis, the frequency is determined from Release Category H-E, but only includes the contribution from Class V Level 1 core damage scenarios.

Summary of Accident Class Frequencies

In summary, the accident sequence frequencies that can lead to radionuclide release to the public have been derived consistent with the definitions of accident classes defined in EPRI 1009325 Revision 2-A [27]. Table 10 summarizes these accident frequencies by accident class for NMP2.

Table 10: Radionuclide Release Frequencies as a Function of Accident Class (Base Case)

Accident Classes (Containment Release Type)	Description	Frequency (per year)	
		Base Case	Base Case Plus Corrosion (1)
1	No Containment Failure	3.00E-6	3.00E-6
2	Large Isolation Failures (Failure to Close)	2.95E-7	2.95E-7
3a	Small Isolation Failures (liner breach)	7.29E-8	7.29E-8
3b	Large Isolation Failures (liner breach)	1.82E-8	1.83E-8
4	Small Isolation Failures (Failure to seal –Type B)	NA	NA
5	Small Isolation Failures (Failure to seal—Type C)	NA	NA
6	Other Isolation Failures (e.g., dependent failures)	NA	NA
7	Failures Induced by Phenomena (Early and Late)	4.97E-6	4.97E-6
8	Bypass (Interfacing System LOCA)	1.60E-8	1.60E-8
CDF	All CET end states	8.37E-6	8.37E-6

(1) Based on data developed in Section 4.4

5.2 Step 2 – Develop Plant-Specific Person-Rem Dose

Plant-specific release analyses were performed to estimate the person-rem doses to the population within a 50-mile radius from the plant. The releases are based on information provided by NUREG/CR-4551 with adjustments made for the site demographic and plant design differences compared to the reference plant, as described in Section 4.2, and summarized in Table 4. The results of applying these releases to the EPRI containment failure classification are as follows:

Table 11: NMP2 Dose Estimates for Population within 50 Miles

EPRI Class	Class Description	NMP2 Population Dose (1)	NMP2 Frequency (2)	Dose Rate (person-rem/yr) (3)
1	No Containment Failure (4)	3.75E+3	3.00E-6	1.13E-2
2	Containment Isolation Failure (5)	1.04E+6	2.95E-7	3.07E-1
3a	Small Pre-existing Leak (6)	3.75E+4	7.29E-8	2.74E-3
3b	Large Pre-existing Leak (7)	3.75E+5	1.82E-8	6.85E-3
7	Containment Failure – Severe Accident (8)	2.72E+5	4.97E-6	1.04
8	Containment Bypass (9)	1.04E+6	1.60E-8	1.67E-2
Totals		**NA**	**8.37E-6**	**1.39**

(1) Population dose taken from Table 4
(2) Frequency taken from Table 9
(3) Dose rate calculated by multiplying column 3 by column 4
(4) Population dose based on "no containment failure" APB 8 from NUREG/CR-4551
(5) Class 2 population dose based on NMP2 H-E set equal to APB 3 from NUREG/CR-4551
(6) Pre-existing small leak population dose is equal to 10 times EPRI Class 1 population dose
(7) Pre-existing large leak population dose is equal to 100 times EPRI Class 1 population dose
(8) Class 7 population dose and frequency are developed as follows

NMP2 Release Frequency		NUREG/CR-4551 APB	NMP2 Population Dose (person-rem)	Does Rate (person-rem/yr)
H-E (a)	1.31E-7	3	1.04E+6	1.37E-1
H-I + H-L	2.34E-7	6	7.98E+5	1.87E-1
M-E	2.48E-7	1	6.09E+5	1.51E-1
M-I + M-L	8.23E-7	2	3.82E+5	3.14E-1
L + LL	3.53E-6	9	7.18E+4	2.53E-1
Total	**4.97E-6**	**NA**	**2.10E+5(b)**	**1.04**

(a) Excludes EPRI Class 2 (H-E with IS=F) and 8 (H-E Class 5)
(b) Frequency-weighted population dose for EPRI class 7 obtained by dividing total population dose rate by the total release frequency

(9) Class 8 population dose based on NMP2 H-E set equal to APB 3 from NUREG/CR-4551

In summary, the population dose estimates derived for use in the risk evaluation per the EPRI methodology [27] are provided in Table 11.

The above dose estimates, when combined with the results presented in Table 10, yield the NMP2 baseline mean consequence measures for each accident class. These results are presented in Table 12.

Table 12: NMP2 Annual Dose as a Function of Accident Class for Type A Test Required 3/10 Years

Accident Classes (Containment Release Type)	Description	Person-Rem (50 miles)	EPRI Methodology		EPRI Methodology Plus Corrosion		Change Due to Corrosion Person-Rem/yr(1)
			Frequency (per Rx-yr)	Person-Rem/yr (50 miles)	Frequency (per Rx-yr)	Person-Rem/yr (50 miles)	
1	No Containment Failure (2)	3.75E+3	3.00E-6	1.13E-2	3.00E-6	1.13E-2	-2.65E-7
2	Large Isolation Failures (Failure to Close)	1.04E+6	2.95E-7	3.07E-1	2.95E-7	3.07E-1	0.00
3a	Small Isolation Failures (liner breach)	3.75E+4	7.29E-8	2.74E-3	7.29E-8	2.74E-3	0.00
3b	Large Isolation Failures (liner breach)	3.75E+5	1.82E-8	6.85E-3	1.83E-8	6.87E-3	2.65E-5
7	Failures Induced by Phenomena (Early and Late)	2.10E+5	4.97E-6	1.04	4.97E-6	1.04	0.00
8	Bypass (Interfacing System LOCA)	1.04E+6	1.60E-8	1.67E-2	1.60E-8	1.67E-2	0.00
CDF	All Classes		8.37E-6	1.39	8.37E-6	1.39	2.62E-5

1) Only release Classes 1 and 3b are affected by the corrosion analysis.
2) Characterized as $1L_a$ release magnitude consistent with the derivation of the Type A test non-detection failure probability. Release classes 3a and 3b include failures of containment to meet the Technical Specification leak rate.

5.3 Step 3 – Evaluate Risk Impact of Extending Type A Test Interval From 10 to 15 Yrs

The next step is to evaluate the risk impact of extending the test interval from its current ten-year value to fifteen-years. To do this, an evaluation must first be made of the risk associated with the ten-year interval since the base case applies to a 3-year interval (i.e., a simplified representation of a 3-in-10 interval).

Risk Impact Due to 10-year Test Interval

As previously stated, Type A tests impact only Class 3 sequences. For Class 3 sequences, the release magnitude is not impacted by the change in test interval (a small or large breach remains the same, even though the probability of not detecting the breach increases). Thus, only the frequency of Class 3a and 3b sequences is impacted. The risk contribution is changed based on the methodology described in Section 4.3 by a factor of 3.33 compared to the base case values. The results of the calculation for a 10-year interval are presented in Table 13.

Risk Impact Due to 15-Year Test Interval

The risk contribution for a 15-year interval is calculated in a manner similar to the 10-year interval. The difference is in the increase in probability of leakage in Classes 3a and 3b. For this case, the value used in the analysis is higher by a factor of 5.0 compared to the 3-year interval value, as described in Section 4.3. The results for this calculation are presented in Table 14.

Table 13: NMP2 Annual Dose as a Function of Accident Class for Type A Test Required 1/10 Years

Accident Classes (Containment Release Type)	Description	Person-Rem (50 miles)	EPRI Methodology		EPRI Methodology Plus Corrosion		Change Due to Corrosion Person-Rem/yr(1)
			Frequency (per Rx-yr)	Person-Rem/yr (50 miles)	Frequency (per Rx-yr)	Person-Rem/yr (50 miles)	
1	No Containment Failure (2)	3.75E+3	2.79E-6	1.05E-2	2.79E-6	1.05E-2	-1.55E-6
2	Large Isolation Failures (Failure to Close)	1.04E+6	2.95E-7	3.07E-1	2.95E-7	3.07E-1	0.00
3a	Small Isolation Failures (liner breach)	3.75E+4	2.43E-7	9.12E-3	2.43E-7	9.12E-3	0.00
3b	Large Isolation Failures (liner breach)	3.75E+5	6.07E-8	2.28E-2	6.11E-8	2.30E-2	1.55E-4
7	Failures Induced by Phenomena (Early and Late)	2.10E+5	4.97E-6	1.04	4.97E-6	1.04	0.00
8	Bypass (Interfacing System LOCA)	1.04E+6	1.60E-8	1.67E-2	1.60E-8	1.67E-2	0.00
CDF	All Classes		8.37E-6	1.41	8.37E-6	1.41	1.53E-4

1) Only release classes 1 and 3b are affected by the corrosion analysis.

2) Characterized as $1L_a$ release magnitude consistent with the derivation of the Type A test non-detection failure probability. Release classes 3a and 3b include failures of containment to meet the Technical Specification leak rate.

Table 14: NMP2 Annual Dose as a Function of Accident Class for Type A Test Required 1/15 Years

Accident Classes (Containment Release Type)	Description	Person-Rem (50 miles)	EPRI Methodology		EPRI Methodology Plus Corrosion		Change Due to Corrosion Person-Rem/yr(1)
			Frequency (per Rx-yr)	Person-Rem/yr (50 miles)	Frequency (per Rx-yr)	Person-Rem/yr (50 miles)	
1	No Containment Failure (2)	3.75E+3	2.64E-6	9.90E-3	2.64E-6	9.90E-3	-3.57E-6
2	Large Isolation Failures (Failure to Close)	1.04E+6	2.95E-7	3.07E-1	2.95E-7	3.07E-1	0.00
3a	Small Isolation Failures (liner breach)	3.75E+4	3.65E-7	1.37E-2	3.65E-7	1.37E-2	0.00
3b	Large Isolation Failures (liner breach)	3.75E+5	9.12E-8	3.42E-2	9.21E-8	3.46E-2	3.57E-4
4	Small Isolation Failures (Failure to seal type B)	2.10E+5	4.97E-6	1.04	4.97E-6	1.04	0.00
8	Bypass (Interfacing System LOCA)	1.04E+6	1.60E-8	1.67E-2	1.60E-8	1.67E-2	0.00
CDF	All Classes		8.37E-6	1.42	8.37E-6	1.42	3.54E-4

1) Only release classes 1 and 3b are affected by the corrosion analysis.
2) Characterized as $1L_a$ release magnitude consistent with the derivation of the Type A test non-detection failure probability. Release classes 3a and 3b include failures of containment to meet the Technical Specification leak rate.

5.4 Step 4 – Determine Change in Risk in Terms of LERF

The risk increase associated with extending the Type A test interval involves the potential that a core damage event that normally would result in only a small radioactive release from an intact containment could in fact result in a larger release due to the increase in probability of failure to detect a pre-existing leak. With strict adherence to the EPRI guidance, 100% of the Class 3b contribution would be considered LERF.

Regulatory Guide 1.174 provides guidance for determining the risk impact of plant-specific changes to the licensing basis. RG 1.174 defines very small changes in risk as resulting in increases of core damage frequency (CDF) below 10^{-6}/yr and increases in LERF below 10^{-7}/yr, and small changes in LERF as below 10^{-6}/yr. Because the Type A test interval does not impact CDF, the relevant metric is LERF.

For NMP2, 100% of the frequency of Class 3b sequences can be used as a conservative first-order estimate to approximate the potential increase in LERF from the Type A test interval extension (consistent with the EPRI guidance methodology). Based on a ten-year test interval from Table 13 the Class 3b frequency is 6.07E-8/yr; and, based on a fifteen-year test interval from Table 14, it is 9.12E-8/yr. Thus, the increase in the overall probability of LERF due to Class 3b sequences that is due to increasing the Type A test interval from 3 to 15 years is 7.3E-8/yr. Similarly, the increase due to increasing the interval from 10 to 15 years is 3.1E-8/yr. As can be seen, even with the conservatisms included in the evaluation (per the EPRI methodology), the estimated change in LERF is below the threshold criteria for a very small change.

5.5 Step 5 – Determine Impact on Conditional Containment Failure Probability

Another parameter that the NRC guidance in RG 1.174 states can provide input into the decision-making process is the change in the conditional containment failure probability (CCFP). The change in CCFP is indicative of the effect of the Type A test interval on all radionuclide releases, not just LERF. The CCFP can be calculated from the results of this analysis. In this assessment, the CCFP is defined such that containment failure includes all radionuclide release end states other than the intact state. The conditional part of the definition is conditional given a severe accident (i.e., core damage).

The change in CCFP is calculated as a basis for demonstrating that the proposed change is consistent with the defense-in-depth philosophy. The change in CCFP is calculated by using the method specified in the EPRI 1009325 Revision 2-A [27] as follows:

$$CCFP = [1 - (\text{Class 1 frequency} + \text{Class 3a frequency}) / CDF] * 100\%$$

$$CCFP_3 = 63.27\%$$

$$CCFP_{10} = 63.78\%$$

$$CCFP_{15} = 64.14\%$$

$$\Delta CCFP = CCFP_{15} - CCFP_{3} = 0.87\%$$

$$\Delta CCFP = CCFP_{15} - CCFP_{10} = 0.36\%$$

The change in CCFP of less than 1% by extending the Type A test interval to 15 years from the original 3-in-10 year requirement is judged to be insignificant.

5.6 Summary of Results

The results from this Type A test interval extension risk assessment for NMP2 are summarized in Table 15.

Table 15: Summary of NMP2 Results for the Type A Test Interval Change

EPRI Class	DOSE Per-Rem	Base Case 3 in 10 Years		Extend to 1 in 10 Years		Extend to 1 in 15 Years	
		CDF	**Per-Rem/Yr**	**CDF**	**Per-Rem/Yr**	**CDF**	**Per-Rem/Yr**
1	3.75E+3	3.00E-6	1.13E-2	2.79E-6	1.05E-2	2.64E-6	9.90E-3
2	1.04E+6	2.95E-7	3.07E-1	2.95E-7	3.07E-1	2.95E-7	3.07E-1
3a	3.75E+4	7.29E-8	2.74E-3	2.43E-7	9.12E-3	3.65E-7	1.37E-2
3b	3.75E+5	1.82E-8	6.85E-3	6.07E-8	2.28E-2	9.12E-8	3.42E-2
7	2.10E+5	4.97E-6	1.04	4.97E-6	1.04	4.97E-6	1.04
8	1.04E+6	1.60E-8	1.67E-2	1.60E-8	1.67E-2	1.60E-8	1.67E-2
Total		8.37E-6	1.39	8.37E-6	1.41	8.37E-6	1.42
ILRT Dose Rate from 3a and 3b		9.58E-3		3.19E-2		4.79E-2	
Delta Total Dose Rate	From 3 yr	N/A		2.15E-2		3.70E-2	
	From 10 yr	N/A		N/A		1.54E-2	
% change in dose rate from base	From 3 yr	N/A		1.55%		2.67%	
	From 10 yr	N/A		N/A		1.10%	
3b Frequency (LERF)		1.82E-8		6.07E-8		9.12E-8	
Delta LERF	From 3 yr	N/A		4.25E-8		7.29E-8	
	From 10 yr	N/A		N/A		3.05E-8	
CCFP %		63.27%		63.78%		64.14%	
Delta CCFP %	From 3 yr	N/A		0.51%		0.87%	
	From 10 yr	N/A		N/A		0.36%	

6 Sensitivities

6.1 Sensitivity of Corrosion Impact Assumptions

The results in Tables 12, 13 and 14 show that including corrosion effects calculated using the assumptions described in Section 4.4 does not significantly affect the results of the Type A test interval extension risk assessment.

Sensitivity cases were developed to gain an understanding of the sensitivity of the results to the key parameters in the corrosion risk analysis. The time for the flaw likelihood to double was adjusted from every five years to every two and every ten years. The failure probabilities for the cylinder and dome and the basemat were increased and decreased by an order of magnitude. The total detection failure likelihood was adjusted from 10% to 15% and 5%. The results are presented in Table 16. In every case the impact from including the corrosion effects is very minimal. Even the upper bound estimates with very conservative assumptions for all of the key parameters yield increases in LERF due to corrosion of only 2.8E-8/yr. The results indicate that even with very conservative assumptions, the conclusions from the base analysis would not change.

Table 16: Steel Liner Corrosion Sensitivity Cases

Age (Step 3 in the corrosion analysis)	Containment Breach (Step 4 in the corrosion analysis)	Visual Inspection & Non-Visual Flaws (Step 5 in the corrosion analysis)	Increase in Class 3b Frequency (LERF) for Type A Test Extension 3 to 15 years (per Rx-yr)	
			Total Increase	Increase Due to Corrosion
Base Case Doubles every 5 yrs	Base Case (1% Cylinder 0.1% Basemat)	Base Case (10% Cylinder 100% Basemat)	7.38E-8	8.81E-10
Doubles every 2 yrs	Base	Base	7.49E-8	1.97E-9
Doubles every 10 yrs	Base	Base	7.37E-8	7.25E-10
Base	Base	*15%*	7.42E-8	1.24E-9
Base	Base	*5%*	7.35E-8	5.32E-10
Base	10% Cylinder 1% Basemat	Base	8.18E-8	8.87E-9
Base	0.1% Cylinder 0.01% Basemat	Base	7.30E-8	8.87E-11
Lower Bound				
Doubles every 10 yrs	0.1% Cylinder 0.01% Basemat	5% 1%	7.30E-8	2.91E-11
Upper Bound				
Doubles every 2 yrs	10% Cylinder 1% Basemat	15% 100%	1.00E-7	2.75E-8

6.2 Sensitivity to Class 3B Contribution to LERF

The Class 3b frequency for the base case of a three in ten-year Type A test interval is 1.82E-8/yr [Table 12]. Extending the interval to one in ten years results in a frequency of 6.07E-8/yr [Table 13]. Extending it to one in fifteen years results in a frequency of 9.12E-8/yr [Table 14], which is an increase of 7.3E-8/yr. If 100% of the Class 3b sequences are assumed to have potential releases large enough for LERF, then the increase in LERF due to extending the interval from three in ten to one in fifteen years is below the RG 1.174 threshold for very small changes in LERF of 1E-7/yr.

6.3 Potential Impact from External Events

In the NMP2 IPEEE, the dominant risk contributor from external events was found to be from fire and seismic events. Other potential contributors such as transportation and high winds were found to be within acceptable limits. The fire and seismic IPEEE analyses were subsequently incorporated into the NMP2 PRA model; their CDF and LERF contributions in the NMP2 PRA are provided below:

Hazard	CDF	LERF
Fire	3.0E-6	5.1E-7
Seismic	1.8E-7	1.4E-7
Total	3.1E-6	6.6E-7

Although the fire and seismic IPEEE analyses were incorporated into the NMP2 PRA model, these hazard analyses and models have not been updated since the original IPEEE although the PRA model itself is maintained current with plant design and operation. Thus, the change in LERF from extending the Type A test interval is conservatively estimated using the total external event CDF for fires and seismic. Table 17 shows the results of these calculations.

Table 17: NMP2 Estimated Total LERF Including External Events Impact

Case	3b Frequency (3-per-10 year test)	3b Frequency (1-per-10 year test)	3b Frequency (1-per-15 year test)	LERF Increase (3-per-10 to 1-per-10)	LERF Increase (3-per-10 to 1-per-15)	LERF Increase (1-per-10 to 1-per-15)
External Event Contribution	7.13E-9	2.35E-8	3.57E-8	1.64E-8	2.85E-8	1.21E-8
Internal Event Contribution	1.82E-8	6.07E-8	9.12E-8	4.25E-8	7.29E-8	3.05E-8
Combined (Internal+External)	2.54E-8	8.43E-8	1.27E-7	5.89E-8	1.01E-7	4.26E-8

An increase in LERF of 1.01E-7 is within the range of 1E-07/yr to 1E-06/yr (Region II of the RG 1.174 LERF acceptability curve). This is considered an acceptable small increase if total LERF is less than 1E-5/yr.

7 Conclusion

Based on the results from Section 5 and the sensitivity calculations presented in Section 6, the following conclusions regarding the assessment of the plant risk are associated with extending the Type A test interval to fifteen years:

- Regulatory Guide 1.174 [4] provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Regulatory Guide 1.174 defines very small changes in risk as resulting in increases of CDF below 10^{-6}/yr and increases in LERF below 10^{-7}/yr. Since the Type A test does not impact CDF, the relevant criterion is LERF. The increase in LERF resulting from a change in the Type A test frequency from three in ten years to one in fifteen years is conservatively estimated as 7.3E-8/yr using the EPRI guidance as written. As such, the estimated change in LERF is determined to be "very small" using the acceptance guidelines of Regulatory Guide 1.174.

- Regulatory Guide 1.174 [4] also states that when the calculated increase in LERF is in the range of 1.0E-06 per reactor year to 1.0E-07 per reactor year, applications will be considered only if it can be reasonably shown that the total LERF is less than 1.0E-05 per reactor year. An additional assessment of the impact from external events was also made indicating a combined LERF increase of 1.01E-7. In this case, the total LERF (combined internal and external events) for NMP2 is well below the RG 1.174 acceptance criteria for total LERF of 1.0E-05.

- For the change in Type A test frequency to once-per-fifteen-years, the calculated increase to the total 50-mile population dose for those accident sequences influenced by Type A testing is 3.7E-2 person-rem/yr. EPRI 1009325 Revision 2-A [27] states that a very small population dose increase is defined as ≤ 1.0 person-rem per year or ≤1 % of the total population dose, whichever is less restrictive for the risk impact assessment of the extended Type A test interval. Moreover, the risk impact when compared to other severe accident risks is negligible.

- The increase in the conditional containment failure frequency from the three in ten year interval to one in fifteen year interval is 0.87%. EPRI 1009325 Revision 2-A [27] states that increases in CCFP of ≤ 1.5 percentage points is very small. Therefore this increase is judged to be very small.

The above findings of the NMP2-specific risk assessment confirm the general findings of previous studies (NUREG-1493 and EPRI) that increasing the Type A test interval to 15 years results in a very small change to the NMP2 risk profile.

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