ATTACHMENT 4 TO BVY 04-77

TECHNICAL SPECIFICATION PROPOSED CHANGE NO. 268
ONE-TIME INTEGRATED LEAK RATE TEST (ILRT) INTERVAL EXTENSION

RISK IMPACT ASSESSMENT OF EXTENDING CONTAINMENT TYPE A TEST INTERVAL

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VERMONT YANKEE NUCLEAR POWER STATION
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Page 1 Of 70

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Engineering Report Cover Sheet

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Risk Impact Assessment of Extending Containment Type A Test Interval

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Revisions to 10CFR 50, Appendix J allow individual plants to extend Type A surveillance testing requirements from three-in-ten years to at least once per 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 was less than normal containment leakage or $1.0L_a$. Vermont Yankee (VY) selected the revised requirements as its testing program [21]. VY's current ten-year Type A test frequency is due to be performed during the upcoming refueling outage 25 (RFO-25), scheduled for October 2005. Prior to the performance of that test, however, VY is seeking an extension of the test interval to fifteen years. A substantial cost savings will be realized and unnecessary personnel radiation exposure will be avoided by deferring the Type A test for an additional five years. Cost savings have been estimated for this outage at approximately $300,000, which includes labor and equipment, but does not include critical path outage time needed to perform the test. In addition, this initiative directly supports site goals related to capacity factor and World Association of Nuclear Operators (WANO) performance by shortening the planned outage duration for RFO-25.

An evaluation was performed to assess the risk impact of extending the current containment Type A Integrated Leak Rate Test (ILRT) interval. In performing the risk assessment evaluation, the guidelines of NEI 94-01, "Industry Guideline for Implementing Performance-Based Option of 10 CFR Part 50, Appendix J", the methodology used in EPRI TR-104285, ""Risk Assessment of Revised Containment Leak Rate Testing Intervals," and the NRC Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis", were used. The assessment also followed the guidance and additional information distributed by NEI in November 2001 to their Administrative Points of Contact regarding risk assessment evaluation of one-time extensions of containment ILRT intervals and the approach outlined in the Indian Point Unit Three Nuclear Power Plant ILRT extension submittal.

The risk assessment evaluation uses the current VY PRA internal events model that includes a Level 2[1] analysis of core damage scenarios and subsequent containment response resulting in various fission product release categories (including no release). The release category end states from the VY Level 2 model are used together with the population dose information to provide an estimate of the person-rem dose per reactor year associated with various scenarios. The change in plant risk is then evaluated based on the potential change in population dose rate (person-rem/ry), change in Large Early Release Frequency (LERF), and the change in conditional containment failure probability (CCFP).

The risk assessment evaluation examined VY's PRA plant specific accident sequences in which the containment integrity remains intact or the containment is impaired. Specifically, the following were considered:

- 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 a pre-existing isolation failure of plant components associated with Type A integrated leak rate testing. For example, containment liner breach. (EPRI Class 3 sequences).

[1] Level 2 - the evaluation of containment response to severe accident challenges and quantification of the mechanisms, amounts, and probabilities of subsequent radioactive material releases from the containment.

- *Core damage sequences in which containment integrity is impaired due to pre-existing 'failure-to-seal'* failure of plant components associated with either a Type B or Type C local leak rate testing (EPRI Classes 4 and 5 sequences).

- *Core damage sequences involving containment isolation failures due to failures-to-close of large* containment isolation valves initiated by support system failures, or random or common cause valve failures (EPRI Class 2 sequences) and containment isolation failures of pathways left 'opened' following a plant post-maintenance test, or valve failing to close following a valve stroke test (EPRI Class 6 sequences).

- Core damage sequences involving containment failure induced by severe accident phenomena (EPRI Class 7 sequences) or containment bypassed (EPRI Class 8 sequences).

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

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

2) Determine the containment leakage rates for applicable cases, 3a and 3b.

3) Develop the baseline population dose (person-rem) for the applicable EPRI classes.

4) Determine the population dose rate; also know as population dose risk (person-rem/Ry) by multiplying the dose calculated in step (3) by the associated frequency calculated in step (1).

5) Determine the change in probability of leakage detectable only by ILRT, and associated frequency for the new surveillance intervals of interest (Classes 3a and 3b).

6) Determine the population dose rate for the new surveillance intervals of interest.

7) Evaluate the risk impact (in terms of population dose rate and percentile change in population dose rate) for the interval extension cases.

8) Evaluate the risk impact in terms of LERF.

9) Evaluate the change in conditional containment failure probability.

The risk assessment evaluation of the one time ILRT extension is characterized by the following risk metrics: (as used in previously approved ILRT test interval extensions:

- The potential change in population dose rate (person-rem/ry)
- The change in Large Early Release Frequency (LERF)
- The change in conditional containment failure probability (CCFP).

The impact of these risk metrics associated with extending the Type A ILRT interval, are presented in Table ES-1.

The conclusion of the plant internal events risk associated with extending the Type A ILRT interval from ten to fifteen years is as follows.

1) The increase in risk on the total integrated plant risk as measured by person-rem/ry increases for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004% (0.0005 person-rem/ry). This value can be considered to be a negligible increase in risk.

2) Regulatory Guide 1.174 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 core damage frequency (CDF) below 10^{-6}/ry and increases in LERF below 10^{-7}/ry. Since the ILRT does not impact CDF, the relevant criterion is LERF. The increase in LERF resulting from a change in the Type A ILRT test interval from 1-in-10 years to 1-in-15 years is 2.87×10^{-9}/ry. Since Regulatory Guide 1.174 defines very small changes in LERF as below 10^{-7}/ry, increasing the ILRT interval at VY from the currently allowed one-in-ten years to one-in-fifteen years is non-risk significant from a risk perspective.

3) The change in conditional containment failure probability (CCFP) is calculated to demonstrate the impact on 'defense-in-depth'. For the current ten-year ILRT interval, sequences involving no containment failure or small releases contribute 12.01% to the overall plant risk. Alternatively stated, the contribution of sequences involving containment failure for the ten-year interval is 87.99%. These numbers are consisted with those documented in the VY PRA. For the proposed fifteen-year interval, the contribution of sequences involving containment failure increased to 88.05%. Therefore, $\Delta CCFP_{10\text{-}15}$ is found to be 0.06%. This signifies a very small increase and represents a negligible change in the Vermont Yankee containment defense-in-depth.

In addition to the internal events risk assessment evaluation, the impact associated with extending the Type A test frequency interval is further examined by considering external event hazard or potential containment liner corrosion. The purpose for these additional evaluations is to assess whether there are any unique insights or important quantitative information associated with the explicit consideration of external event hazard or containment liner corrosion in the risk assessment results.

The external event hazards or potential containment liner corrosion evaluation was found not to impact any of the above conclusions. The results from these cases are presented in Tables ES-2 and ES-3 respectively and summarized below.

Considerations of the combined internal events and external event hazards assessment during an extension of the ILRT Interval yielded the following conclusions:

1) Based on conservative methodologies in estimating the combined core damage frequency for internal events, seismic events, and fires events, the increase in LERF from extending the VY ILRT frequency from 1-in-10 years to 1-in-15 years is 3.71×10^{-8}/ry. This value falls within the 10^{-7}/ry criterion of Region III, Very Small Change in Risk (Figure 2-1), of the acceptance guidelines in NRC Regulatory Guide 1.174 [5]. Therefore, increasing the ILRT interval at VY from the currently allowed 1-in-10 years to 1-in-15 years is non-risk significant from a risk perspective.

2) The combined internal and external events increase in risk on the total integrated plant risk as measured by person-rem/ry increases for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004% (0.007 person-rem/ry). This value can be considered to be a negligible increase in risk.

3) The change in the combined internal and external events conditional containment failure probability from 1-in-10 years to 1-in-15 years is 0.05%. A change in ΔCCFP of less than 1% is insignificant from a risk perspective.

4) Other salient results are summarized in Table ES-2. The key results to this risk assessment are those for the 10-year interval (current VY ILRT interval) and the 15-year interval (proposed change).

Recently, the NRC issued a series of Requests for Additional Information (RAIs) in response to the one-time relief requests for the ILRT surveillance interval submitted by various licensees. The RAIs requested a risk analysis on the potential increase in risk due to drywell/torus liner leakage, caused by age-related degradation mechanisms.

The risk analysis utilizes the referenced Calvert Cliffs Nuclear Power Plant assessment [20] to estimate the risk impact from containment liner corrosion during an extension of the ILRT interval. Consistent with the Calvert Cliffs analysis, the following issues were addressed:

- Differences between the containment basemat and the drywell and torus liner
- The historical drywell/torus steel shell 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

Considerations of risk impact of containment liner corrosion during an extension of the ILRT Interval yielded the following conclusions:

1) The impact of including age-adjusted corrosion effects in the ILRT assessment has minimal impact on plant risk and is therefore acceptable.

2) The change in LERF, taking into consideration the likelihood of a containment liner flaw due to age-adjusted corrosion is non-risk significant from a risk perspective. Specifically, extending the interval to 15 years from the current 10 years requirement is estimated to be about 3.19×10^{-9}/ry. This is below the Regulatory Guide 1.174 [5] acceptance criteria threshold of 10^{-7}/ry.

3) The age-adjusted corrosion impact in dose increase is estimated to be 5.0×10^{-4} person-rem/ry or 0.0042% from the baseline ILRT 10 year's interval.

4) The age-adjusted corrosion impact on the conditional containment failure probability increase is estimated to be 0.06%.

5) A series of parametric sensitivity studies regarding potential age related corrosion effects on the containment steel liner also demonstrated minimal impact on plant risk.

6) Other salient results are summarized in Table ES-3.

Table ES-1

Internal Events Quantitative Results as a Function of ILRT Interval

EPRI Class	Category Description	Dose (Person-Rem Within 50 miles)[1]	Quantitative Results as a Function of ILRT Interval			
			Current (1-per-10 year ILRT)		Proposed (1-per-15 year ILRT)	
			Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)	Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)
1	No Containment Failure [2]	1.30×10^{3}	5.43×10^{-7}	7.06×10^{-4}	5.12×10^{-7}	6.65×10^{-4}
2	Containment Isolation System Failure	2.73×10^{6}	2.14×10^{-9}	5.85×10^{-3}	2.14×10^{-9}	5.85×10^{-3}
3a	Small Pre-Existing Failures [2], [3]	1.30×10^{4}	5.73×10^{-8}	7.46×10^{-4}	8.60×10^{-8}	1.12×10^{-3}
3b	Large Pre-Existing Failures [2], [3]	4.55×10^{4}	5.73×10^{-9}	2.61×10^{-4}	8.60×10^{-9}	3.91×10^{-5}
4	Type B Failures (LLRT)	--	---	---	---	---
5	Type C Failures (LLRT)	--	---	---	---	---
6	Other Containment Isolation System Failure	--	---	---	---	---
7a	Containment Failure Due to Severe Accident (a)[4]	2.73×10^{6}	3.22×10^{-7}	8.79×10^{-1}	3.22×10^{-7}	8.79×10^{-1}
7b	Containment Failure Due to Severe Accident (b) [4]	2.73×10^{6}	3.85×10^{-6}	$1.05 \times 10^{+1}$	3.85×10^{-6}	$1.05 \times 10^{+1}$
7c	Containment Failure Due to Severe Accident (c) [4]	3.53×10^{6}	9.71×10^{-9}	3.43×10^{-2}	9.71×10^{-9}	3.43×10^{-2}
7d	Containment Failure Due to Severe Accident (d) [4]	2.73×10^{6}	1.63×10^{-7}	4.46×10^{-1}	1.63×10^{-7}	4.46×10^{-1}
8	Containment Bypass Accidents	2.96×10^{6}	5.32×10^{-8}	1.57×10^{-1}	5.32×10^{-8}	1.57×10^{-1}
TOTALS:			5.00×10^{-6}	12.0211	5.00×10^{-6}	12.0215
Increase in Dose Rate						0.0004
Increase in LERF					2.87×10^{-9}	
Increase in CCFP (%)					0.06%	

Table ES-2

Internal and External Events Quantitative Results as a Function of ILRT Interval

EPRI Class	Category Description	Dose (Person-Rem Within 50 miles)[1]	Quantitative Results as a Function of ILRT Interval			
			Current (1-per-10 year ILRT)		Proposed (1-per-15 year ILRT)	
			Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)	Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)
1	No Containment Failure [2]	1.30×10^{3}	7.40×10^{-6}	9.62×10^{-3}	6.99×10^{-6}	9.08×10^{-3}
2	Containment Isolation System Failure	2.73×10^{6}	2.90×10^{-8}	7.93×10^{-2}	2.90×10^{-8}	7.93×10^{-2}
3a	Small Pre-Existing Failures [2], [3]	1.30×10^{4}	7.42×10^{-7}	9.64×10^{-3}	1.11×10^{-6}	1.45×10^{-2}
3b	Large Pre-Existing Failures [2], [3]	4.55×10^{4}	7.42×10^{-8}	3.38×10^{-3}	1.11×10^{-7}	5.06×10^{-3}
4	Type B Failures (LLRT)	--	--	--	--	--
5	Type C Failures (LLRT)	--	--	--	--	--
6	Other Containment Isolation System Failure	--	--	--	--	--
7a	Containment Failure Due to Severe Accident (a)[4]	2.73×10^{6}	4.36×10^{-6}	1.19×10^{1}	4.36×10^{-6}	1.19×10^{1}
7b	Containment Failure Due to Severe Accident (b) [4]	2.73×10^{6}	5.21×10^{-5}	1.42×10^{2}	5.21×10^{-5}	1.42×10^{2}
7c	Containment Failure Due to Severe Accident (c) [4]	3.53×10^{6}	1.31×10^{-7}	4.64×10^{-1}	1.31×10^{-7}	4.64×10^{-1}
7d	Containment Failure Due to Severe Accident (d) [4]	2.73×10^{6}	2.21×10^{-6}	6.06×10^{0}	2.21×10^{-6}	6.06×10^{0}
8	Containment Bypass Accidents	2.96×10^{6}	7.20×10^{-7}	2.13×10^{0}	7.20×10^{-7}	2.13×10^{0}
TOTALS:			6.77×10^{-5}	162.7811	6.77×10^{-5}	162.7871
Increase in Dose Rate						0.0065
Increase in LERF					3.71×10^{-8}	
Increase in CCFP (%)					0.05%	

Table ES-3

Liner Corrosion Impact Quantitative Results as a Function of ILRT Interval

EPRI Class	Category Description	Dose (Person-Rem Within 50 miles)[1]	Quantitative Results as a Function of ILRT Interval			
			Current (1-per-10 year ILRT)		Proposed (1-per-15 year ILRT)	
			Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)	Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)
1	No Containment Failure [2]	1.30×10^{3}	5.43×10^{-7}	7.06×10^{-4}	5.11×10^{-7}	6.65×10^{-4}
	Containment Isolation System Failure	2.73×10^{6}	2.14×10^{-9}	5.85×10^{-3}	2.14×10^{-9}	5.85×10^{-3}
3a	Small Pre-Existing Failures [2], [3]	1.30×10^{4}	5.73×10^{-8}	7.46×10^{-4}	8.60×10^{-8}	1.12×10^{-3}
3b	Large Pre-Existing Failures [2], [3]	4.55×10^{4}	5.97×10^{-9}	2.72×10^{-4}	9.16×10^{-9}	4.17×10^{-4}
4	Type B Failures (LLRT)	--	0.0	0.0	0.0	0.0
5	Type C Failures (LLRT)	--	0.0	0.0	0.0	0.0
6	Other Containment Isolation System Failure	--	0.0	0.0	0.0	0.0
7a	Containment Failure Due to Severe Accident (a)[4]	2.73×10^{6}	3.22×10^{-7}	8.79×10^{-1}	3.22×10^{-7}	8.79×10^{-1}
7b	Containment Failure Due to Severe Accident (b) [4]	2.73×10^{6}	3.85×10^{-6}	1.05×10^{1}	3.85×10^{-6}	1.05×10^{1}
7c	Containment Failure Due to Severe Accident (c) [4]	3.53×10^{6}	9.71×10^{-9}	3.43×10^{-2}	9.71×10^{-9}	3.43×10^{-2}
8a	Containment Failure Due to Severe Accident (d) [4]	2.73×10^{6}	1.63×10^{-7}	4.46×10^{-1}	1.63×10^{-7}	4.46×10^{-1}
8b	Containment Bypass Accidents	2.96×10^{6}	5.32×10^{-8}	1.57×10^{-1}	5.32×10^{-8}	1.57×10^{-1}
TOTALS:			5.00×10^{-6}	12.0211	5.00×10^{-6}	12.0216
Increase in Dose Rate						0.0005
Increase in LERF					3.19×10^{-9}	
Increase in CCFP (%)					0.06%	

Notes to Tables ES-1, Es-2, and ES-3:

1) The population dose associated with the Technical Specification Leakage is based on the analysis provided in Reference [24].

2) Only EPRI classes 1, 3a, and 3b are affected by ILRT (Type A) interval changes.

3) Dose estimates for EPRI Class 3a and 3b, per the NEI Interim Guidance, are calculated as 10 times EPRI Class 1 dose and 35 times EPRI Class 1 dose, respectively.

4) EPRI Class 7, containment failure due to severe accident, was subdivided into three subgroups based on VY Level 2 containment failure modes for dose allocation purposes. Note that this EPRI class is not affected by ILRT interval changes.

Nomenclature

APB	Accident Progression Bin
ATWS	Anticipated Transient Without Scram
CAPB	Collapsed Accident Progression Bin
CCIs	Core-Concrete Interactions
CCFP	Conditional Containment Failure Probability
CD	Core Damage
CDF	Core Damage Frequency
CDFM	Conservative Deterministic Failure Margin
CET	Containment Event Tree
CF	Containment Failure
DCH	Direct Containment Heating
DW	Drywell
EPRI	Electrical Power Research Institute
EVNTRE	Event Progress Analysis Code
PGA	Peak Ground Acceleration
HCLPF	High Confidence Low Probability of Failure
ILRT	Integrated Leak Rate Testing
IPE	Individual Plant Examination
IPEEE	Individual Plant Examination for External Events
ISLOCA	Interface System Loss of Coolant Accident
IP3	Indian Point Unit Three Nuclear Power Plant
LERF	Large Early Release Frequency
LLRT	Local Leak Rate Testing
LOCA	Loss of Coolant Accident
NEI	Nuclear Energy Institute

Nomenclature (continued)

NRC	United States Nuclear Regulatory Commission
MFCR	Mean Factional Contribution to Risk
PDS	Plant Damage State
PRA	Probabilistic Risk Analysis
PSA	Probabilistic Safety Assessment
RAI	Request for Additional Information
RCS	Reactor Coolant System
RPV	Reactor Pressure Vessel
RF	Refueling Outage
SCDF	Seismic Core Damage Frequency
SMA	Seismic Margin Assessment
TS	Technical Specifications
VY	Vermont Yankee Nuclear Power Plant
WANO	World Association of Nuclear Operations
WW	Wetwell

Definitions

Accident sequence - a representation in terms of an initiating event followed by a combination of system, function and operator failures or successes, of an accident that can lead to undesired consequences, with a specified end state (e.g., core damage or large early release). An accident sequence may contain many unique variations of events that are similar.

Core damage - uncovery and heatup of the reactor core to the point at which prolonged oxidation and severe fuel damage is anticipated and involving enough of the core to cause a significant release.

Core damage frequency - expected number of core damage events per unit of time.

End State - is the set of conditions at the end of an event sequence that characterizes the impact of the sequence on the plant or the environment. End states typically include: success states, core damage sequences, plant damage states for Level 1 sequences, and release categories for Level 2 sequences.

Event tree - a quantifiable, logical network that begins with an initiating event or condition and progresses through a series of branches that represent expected system or operator performance that either succeeds or fails and arrives at either a successful or failed end state.

Initiating Event - An initiating event is any event that perturbs the steady state operation of the plant, if operating, or the steady state operation of the decay heat removal systems during shutdown operations such that a transient is initiated in the plant. Initiating events trigger sequences of events that challenge the plant control and safety systems.

ISLOCA - a LOCA when a breach occurs in a system that interfaces with the RCS, where isolation between the breached system and the RCS fails. An ISLOCA is usually characterized by the over-pressurization of a low-pressure system when subjected to RCS pressure and can result in containment bypass

Large early release - the rapid, unmitigated release of airborne fission products from the containment to the environment occurring before the effective implementation of off-site emergency response and protective actions.

Large early release frequency - expected number of large early releases per unit of time.

Level 1 - identification and quantification of the sequences of events leading to the onset of core damage.

Level 2 - evaluation of containment response to severe accident challenges and quantification of the mechanisms, amounts, and probabilities of subsequent radioactive material releases from the containment.

LOCAOC - a LOCA Outside of Containment (LOCAOC) is a breach occurs in a system that interfaces with the RCS and bypasses containment, with the potential to impact systems needed for mitigation of such events. LOCAOC includes breaks in high pressure piping, without the high-to-low pressure interface characteristic of ISLOCA.

Plant damage state - Plant damage states are collections of accident sequence end states according to plant conditions at the onset of severe core damage. The plant conditions considered are those that determine the capability of the containment to cope with a severe core damage accident. The plant damage states represent the interface between the Level 1 and Level 2 analyses.

Probability - is a numerical measure of a state of knowledge, a degree of belief, or a state of confidence about the outcome of an event.

Probabilistic risk assessment - a qualitative and quantitative assessment of the risk associated with plant operation and maintenance that is measured in terms of frequency of occurrence of risk metrics, such as core damage or a radioactive material release and its effects on the health of the public (also referred to as a probabilistic safety assessment, PSA).

Release category - radiological source term for a given accident sequence that consists of the release fractions for various radionuclide groups (presented as fractions of initial core inventory), and the timing, elevation, and energy of release. The factors addressed in the definition of the release categories include the response of the containment structure, timing, and mode of containment failure; timing, magnitude, and mix of any releases of radioactive material; thermal energy of release; and key factors affecting deposition and filtration of radionuclides. Release categories can be considered the end states of the Level 2 portion of a PSA.

Risk - encompasses what can happen (scenario), its likelihood (probability), and its level of damage (consequences).

Risk metrics - the quantitative value, obtained from a PRA analysis, used to evaluate the results of an application (e.g., CDF or LERF).

Severe accident - an accident that involves extensive core damage and fission product release into the reactor vessel and containment, with potential release to the environment.

Split Fraction - a unitless parameter (i.e., probability) used in quantifying an event tree. It represents the fraction of the time that each possible outcome, or branch, of a particular top event may be expected to occur. Split fractions are, in general, conditional on precursor events. At any branch point, the sum of all the split fractions representing possible outcomes should be unity. (Popular usage equates "split fraction" with the failure probability at any branch [a node] in the event tree.)

Vessel Breach - a failure of the reactor vessel occurring during core melt (e.g., at a penetration or due to thermal attack of the vessel bottom head or wall by molten core debris).

SECTION 1

INTRODUCTION

1.1 Purpose

The purpose of this report is to provide supplemental information to support the proposed Vermont Yankee (VY) Technical Specification change of implementing a one-time extension of the containment Type A integrated leak rate test (ILRT) interval from ten years to fifteen years.

The risk assessment follows the guidelines from NEI 94-01 "Industry Guideline for Implementing Performance-Based Option of 10 CFR Part 50, Appendix J" [1], the methodology used in EPRI TR-104285 "Risk Assessment of Revised Containment Leak Rate Testing Intervals" [2], NEI's "Interim Guidance for Performing Risk Impact Assessments In Support of One-Time Extensions for Containment Integrated Leakage Rate Test Surveillance Intervals" [3], NEI 's "Additional Information for ILRT Extensions" [4], and the NRC regulatory guidance on the use of Probabilistic Risk Assessment (PRA) findings and risk insights in support of a request for a change in a plant's licensing basis as outlined in Regulatory Guide 1.174, "An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis" [5].

In addition, the results and findings from the VY Probabilistic Safety Analysis update [6] are used for this risk assessment report.

1.2 Background

In October 26, 1995, the Nuclear Regulatory Commission (NRC) revised 10 CFR 50, Appendix J. The revision to Appendix J provided a performance based option, Option B "Performance-Based Requirements", for leakage-rate testing of light-water-cooled containments.

Under Option B, the Integrated Leak Rate Testing (ILRT) Type A surveillance testing requirements was extended from three-in-ten years to at least once per 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 is less than the maximum allowable containment leakage limit of $1.0L_a$.

In accordance with the revised containment leakage-rate testing for Appendix J, VY selected the requirements under Option B as its testing program. VY's current ten-year Type A test is due to be performed during refueling outage twenty-five (RFO-25, scheduled for October 2005). However, VY seeks a one-time exemption based on the substantial cost savings of $300,000.00 from extending the test from the RFO25 schedule to RFO27. In addition, this initiative directly supports site goals related to capacity factor and World Association of Nuclear Operators (WANO) performance by shortening planned outage duration for RFO25.

The basis for the current 10-year test interval is provided in Section 11.0 of NEI 94-01, Revision 0, which was established in 1995 during development of the performance-based Option B to Appendix J [1]. Section 11.0 of NEI 94-01 states that NUREG-1493, "Performance-Based Containment Leak-Test Program," [7] dated September 1995, provides the technical basis to support rulemaking to revise leakage rate testing requirements contained in Option B to Appendix J.

The NUREG-1493 [7] report examined the impact of containment leakage on public health and safety associated with a range of extended leakage rate test intervals. The NUREG analyzed both Boiling Water Reactors (Peach Bottom and Grand Gulf) and Pressurized Water Reactors (Surry, Sequoyah, and Zion). For Peach Bottom, (a comparable Boiling Water Reactor plant to VY's), it was found that increasing the containment leak rates several orders of magnitude over the design basis (0.5 percent per day to 50 percent per day), results in a negligible increase in total population exposure. Therefore, extending the ILRT interval does not result in any significant increase in risk.

To supplement the NRC's rulemaking basis, NEI undertook another similar study. The results of that study are documented in EPRI research project report TR-104285 [2]. The EPRI Methodology [2] used a simplified risk model--PRA containment event trees (CETs). These CETs provide a risk framework for evaluating the effect of containment isolation failures affected by leakage testing requirements. The complexity of the CET models however is not necessary to evaluate the impact of containment isolation system failures. Therefore, a simplified risk model was developed to distinguish between those accident sequences that are affected by the status of the containment isolation system versus those that are a direct function of severe accident phenomena. The simplified risk model allowed for a smaller number of CET scenarios to be evaluated to determine the baseline risk as well as subsequent analysis to quantify risk effects of extending test intervals. The methodology regrouped core damage accident sequences reported in PRAs reviewed in the study into eight classifications to permit the appropriate delineation among containment isolation failure and containment failure due severe accident phenomena. The eight EPRI accident classes in the simplified model are:

1) Containment remains intact initially and in the long term. The release of fission products (and accident consequences) is determined by the maximum allowable containment leakage.

2) Core damage accident sequences in which containment integrity is impaired due independent (or random) containment isolation failures that include those accident s sequences in which the containment isolation system function fails during the accident progression (i.e., failures-to-close of large containment isolation valves initiated by support system failures, or random or common cause valve failures).

3) Core damage sequences in which containment integrity is impaired due to a pre-existing isolation failure of plant components associated with Type A integrated leak rate testing. For example, containment liner breach.

4) Core damage sequences in which containment integrity is impaired due to an independent (or random) pre-existing isolation failure-to-seal of plant components associated with Type B integrated leak rate testing. These are the Type B-tested components that have isolated but exhibit excessive leakage.

5) Core damage sequences in which containment integrity is impaired due to an independent (or random) pre-existing isolation failure-to-seal of plant components associated with Type C integrated leak rate testing.

6) Core damage sequences in which containment integrity is impaired due to containment isolation failures that include those leak paths not identified by containment leak rate tests. The type of failures considered under this Class includes those valves left open or valves that did not properly seal following test or maintenance activities.

7) Core damage sequences involving containment failure induced by severe accident phenomena. Changes in ILRTs or LLRTs requirements do not impact these accidents.

8) Core damage sequences in which the containment is bypassed (either as an initial condition or induced by accident phenomena). Changes in ILRTs or LLRTs requirements do not impact these accidents.

Based on the improved methodology, NEI issued in November 2001enhanced guidance "Interim Guidance for Performing Risk Impact Assessments In Support of One-Time Extensions for Containment Integrated Leakage Rate Test Surveillance Intervals" [3], and "Additional Information for ILRT Extensions," [4] that builds on the EPRI TR-104285 [2], IP3 [8] and Crystal River submittal [9] methodology and is intended to provide for more consistent submittals to the NRC.

The VY evaluation assesses the change in the predicted population dose rate associated with the interval extension. The assessment also evaluated the risk increase resulting from extending the ILRT interval in terms of Large Early Release Frequency (LERF), and the impact on Conditional Containment Failure Probability (CCFP). Regulatory Guide 1.174 [5] provides guidance for using PRA in risk-informed decisions for determining the risk impact of plant-specific changes to the licensing basis. Regulatory Guide 1.174 [5] defines very small changes in the risk acceptance guidelines as increases in Core Damage Frequency (CDF) of less than 10^{-6} per reactor year and increases in LERF of less than 10^{-7} per reactor year. Since the Type A test does not impact CDF, the only relevant criterion is the change in LERF. Regulatory Guide 1.174 [5] also encourages the use of risk analysis techniques to help ensure and demonstrate that key risk metrics such as defense-in-depth philosophy, are satisfied. Based on that, the increase in the CCFP, which helps to ensure that the defense-in-depth philosophy is maintained, was evaluated.

SECTION 2

EVALUATION

2.1 Method of Analysis

The VY risk assessment analysis uses the approach outlined in EPRI's TR-104285 [2], NEI's Interim Guidance [3], NEI 's "Additional Information for ILRT Extensions" [4], and the NRC regulatory guidance on the use of PRA findings and risk insights in support of a request for a change in a plant's licensing basis as outlined in Regulatory Guide 1.174 [5].

The EPRI TR-104285 methodology [2] involves a quantitative evaluation on the change in public risk of the affect of extending the ILRT and Local Leak Rate Test (LLRT) intervals. The EPRI TR-104285 study combined IPE Level 2[2] models with NUREG-1150 "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants" [10] Level 3[3] population dose models to perform the analysis. This study also used the approach of NUREG-1493 [7] in calculating the increase in pre-existing leakage probability due to extending the ILRT and LLRT test intervals.

EPRI TR-104285 used a simplified containment event tree (CET) to provide a risk-based framework for evaluating the effects of containment isolation failures impacted by Appendix J penetrations testing requirements. The CET regrouped core damage accident sequences into eight accident classes of containment response. These eight accident classes are:

1) Containment intact and isolated
2) Containment isolation failures due to support system or active failures
3) Type A (ILRT) related containment isolation failures
4) Type B (LLRT) related containment isolation failures
5) Type C (LLRT) related containment isolation failures
6) Other penetration related containment isolation failures
7) Containment failure due to core damage accident phenomena
8) Containment bypass

These eight accident classes allow the isolation failures modes and type of penetration analyzed to be correlated directly with Types A, B, and C test relaxation benefits. Each of the eight classes was categorized according to certain release characterization to determine the baseline incremental risk.

Vermont Yankee's risk assessment analysis uses the approach outlined in the NEI's Interim Guidance [3] and NEI 's "Additional Information for ILRT Extensions" [4]. The nine steps of the methodology are:

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

2) Determine the containment leakage rates for applicable cases, 3a and 3b.

3) Develop the baseline population dose (person-rem) for the applicable EPRI classes.

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[2] Level 2 - the evaluation of containment response to severe accident challenges and quantification of the mechanisms, amounts, and probabilities of subsequent radioactive material releases from the containment.

[3] Level 3 - A measure of containment failure sequences leading to public health effects and their frequencies.

4) Determine the population dose rate; also know as population dose risk (person-rem/ry) by multiplying the dose calculated in step (3) by the associated frequency calculated in step (1).

5) Determine the change in probability of leakage detectable only by ILRT, and associated frequency for the new surveillance intervals of interest (Classes 3a and 3b). Note that with increases in the ILRT surveillance interval, the size of the postulated leak path and the associated leakage rate are assumed not to change, however the probability of leakage detectable only by ILRT does increase.

6) Determine the population dose rate for the new surveillance intervals of interest.

7) Evaluate the risk impact (in terms of population dose rate and percentile change in population dose rate) for the interval extension cases.

8) Evaluate the risk impact in terms of LERF.

9) Evaluate the change in conditional containment failure probability.

The latest VY PSA Level 1[4] and Level 2 [6] were used to evaluate the change in population dose rate (person-rem/ry), change in Large Early Release Frequency (LERF), and the change in conditional containment failure probability. In order to assess the impact on offsite dose, a radiological analysis was performed to estimate the VY offsite dose.

The first seven steps of the methodology calculate the change in dose. The eighth step in the interim methodology calculates the change in LERF and compares it to the guidelines in Regulatory Guide 1.174 [5]. Because the change in ILRT test interval does not impact the CDF, the relevant criterion is LERF. The final step of NEI's interim methodology calculates the change in containment failure probability given the change of ILRT test interval from once-per-10 years to once-per-15 years.

2.2 Assumptions

1) The surveillance frequency for Type A testing in NEI 94-01 [1] is at least once per ten years based on an acceptable performance history. Based on the consecutive successful ILRTs performed in the early 1990's, the current ILRT interval for VY is once per ten years [17].

2) The VY Level 1 and Level 2 internal events PSA models provide representative results for the analysis [6].

3) Radionuclide release categories defined in this report are consistent with the EPRI TR-104285 methodology. [2]

4) The EPRI methodology concluded that Severe Accident Phenomena and Bypass Classes accident sequences (e.g., drywell liner melt-through, ATWS, ISLOCA, and LOCAOC) contribution to population dose is unchanged by the proposed ILRT extension. These Classes are included for comparison purposes. As such, no changes introduced by this analysis will alter this conclusion.

5) The reliability of containment isolation valves to close in response to a containment isolation signal is not impacted by the change in ILRT frequency.

[4] Level 1 - identification and quantification of the sequences of events leading to the onset of core damage.

6) The maximum containment leakage for Class 1 sequences is 1La [2]. (La is the Technical Specification maximum allowable containment leakage rate).

7) The maximum containment leakage for Class 3a sequences per the NEI Interim Guidance [3] and previously approved methodology [8, 9] is 10La.

8) The maximum containment leakage for Class 3b sequences per the NEI Interim Guidance [3] and previously approved methodology [8, 9] is 35La.

9) Class 3b release is categorized as LERF, based on the previously approved methodology [8, 9] and NEI's interim methodology [3].

10) Containment leak rates greater than 2La but less than 35La indicate an impaired containment. The leak rate is considered 'small' per the NEI Interim Guidance [3] and previously approved methodology [2, 8, and 9]. Furthermore, these releases have a break opening of greater than 0.5-inch but less than 2-inch diameter [8, 9].

11) Containment leak rates greater than 35La indicates a containment breach. This leak rate is considered 'large' per the NEI Interim Guidance [3] and previously approved methodology [8, 9].

12) Containment leak rates less than 2La indicates an intact containment. This leak rate is considered as 'negligible' per the NEI Interim Guidance [3] and previously approved methodology [8, 9].

13) EPRI accident Class 2 (Large Containment Isolation Failures) potential releases can be consider similar to a release associated with early drywell failure at high reactor pressure vessel (RPV) pressure.

14) Because EPRI Class 8 sequences are containment bypass sequences, potential releases are directly to the environment. Therefore, the containment structure will not impact the release magnitude.

15) An evaluation of the risk impact of the ILRT on shutdown risk is addressed using the generic results from EPRI TR-104285 [2] as augmented by NEI Interim Guidance [3, 4].

2.3 Data and Design Criteria

1) The VY Level 1 and 2 PSA updated model used as input to this analysis reflects the as built, as-operated plant. [6]

2) The CDF value, as reported in the VY PSA update is 5.03×10^{-6}/ry. [6]

3) The VY Level 2 PSA model is used to calculate the release frequencies for the accidents evaluated in this assessment. Table 2-1 summarizes the VY Level 1 PSA internal point-estimate frequency results by core damage plant damage states (PDS). (See Attachment A)

4) Table 2-2 summarizes the pertinent VY Level 2 PSA results in terms of release modes. The total release frequency is 4.42×10^{-6}/ry. Table 2-3 summarizes the correlation of the VY Level 2 PSA results for containment failure accident progression bins in terms of release magnitudes.

5) The random large containment isolation failure probability, from the VY PSA [6] is $4.26\ 10^{-4}$. This value was estimated using Top Event fault tree IS, split fraction ISILRT. Failure-to-close of large (>2-inch diameter) containment isolation valves as well as failure of the containment isolation signal are included in this model. No credit is given for operator action to manually initiate containment isolation.

6) The conditional failure probability of having a small pre-existing containment leak is 0.027. This value is based on work performed in the IP3 ILRT submittal [8] and the NEI Interim Guidance [3]. From the IP3 submittal, the probability that a liner leak will be small made use of the data presented in NUREG-1493 [7]. The data reported in NUREG-1493 found that 23 of 144 tests had allowable leak rates in excess of 1.0La. However, of these 23 'failures' only 4 were found by an Type A ILRT, the others were found by Type B and C testing or errors in test alignments. Therefore, the number of failures considered for 'small releases' are 4-of-144. Recent data collected by NEI and documented in the NEI Interim Guidance [3] found that an additional 38 ILRT have been performed since 1/1/95, with only one failure occurring. This indicates a failure probability of 5/182 (0.027) for a type A ILRT.

7) The conditional failure probability of having a large pre-existing containment leak is 0.0027. This value is derived from the NEI Interim Guidance [3]. It's based on the Jeffreys non-informative prior distribution[5] for zero failures. The formula is as follows:

$$\text{Failure Probability} = \frac{\text{Number of Failures} + 1/2}{\text{Number of Tests} + 1}$$

The number of large failures is zero, so the probability is 0.5/183=0.0027.

8) The Vermont Yankee reactor power level used in this report is the power uprated adjusted value of 1912 MWth [13] (i.e., 120% of 1593 MWth).

9) The VY technical specification maximum allowed containment leakage is 1.5 volume%/day [14].

10) The VY containment free volume used in this report is 264,000 ft^3 (drywell free volume of approximately 134,200 ft^3 and wetwell free volume of approximately 173,900 ft^3) [15].

[5] Application of the Jeffreys non-informative prior is one of a number of statistical analysis approaches to estimating probabilities when no failures have been experienced. The approach was used in NUREG-1150 and more recently in NUREG/CR-5750. NUREG/CR-5750 is now the preferred source of initiating event data, which also involves rare event approximations. The selected approach is more conservative than many other statistical approaches.

2.4 Internal Events Impact

This section provides a step-by-step summary of the NEI guidance [3] as applied to the VY ILRT interval extension risk assessment. Each subsection addresses a step in the NEI guideline [3].

2.4.1 Quantify Baseline Accident Classes Frequencies (Step 1)

This step involves the quantification of the baseline frequencies for each of the EPRI TR-104285 accident classes [2].

Frequency of EPRI Class 1 Sequences. This group consists of all core damage accident progression sequences in which the containment remains isolated and intact (or containment leakage at or below maximum allowable Technical Specification leakage).

Consistent with NEI Interim Guidance [3], the frequency per reactor year for these sequences is calculated by subtracting the frequencies of EPRI Classes 3a and 3b from the sum of all severe accident progression sequence frequencies in which the containment is isolated and intact:

CLASS_1_FREQUENCY = NCF - CLASS_3a_FREQUENCY - CLASS_3b_FREQUENCY

Where:

CLASS_1_FREQUENCY = frequency of EPRI Class 1 given a 3-in-10 years ILRT interval

NCF = frequency in which containment leakage is at or below maximum allowable Technical Specification leakage
= 6.06×10^{-7} /ry [Table 2-2]

CLASS_3a_FREQUENCY = frequency of small pre-existing containment liner leakage
= 1.72×10^{-8}/ry [See write-up below]

CLASS_3b_FREQUENCY = frequency of large pre-existing containment liner leakage
= 1.72×10^{-9}/ry [See write-up below]

Therefore:

$$\text{CLASS\_1\_FREQUENCY} = 6.06 \times 10^{-7} - 1.72 \times 10^{-8} - 1.72 \times 10^{-9}$$

$$\text{CLASS\_1\_FREQUENCY} = 5.88 \times 10^{-7}/\text{ry}$$

Frequency of EPRI Class 2 Sequences. This group consists of all core damage accident progression bins in which the containment isolation system function fails during the accident progression. These sequences are dominated by failure-to-close of large (>2-inch diameter) containment isolation valves [6]. The frequency per reactor year for these sequences is determined as follows:

$$\text{CLASS\_2\_FREQUENCY} = \text{PROB}_{\text{large CI}} * \text{CDF}$$

Where:

CLASS_2_FREQUENCY = frequency of EPRI Class 2 given a 3-in-10 years ILRT interval

$\text{PROB}_{\text{large CI}}$ = random large containment isolation failure probability (i.e. large valves)

$= 4.26 \times 10^{-4}$ [Section 2.3, input#5]

CDF = VY PSA L1 core damage frequency $= 5.03 \times 10^{-6}$/ry [Section 2.3, input #2]

Therefore:

$$CLASS\_2\_FREQUENCY = [4.26 \times 10^{-4}] * [5.03 \times 10^{-6}/ry]$$

$$CLASS\_2\_FREQUENCY = 2.14 \times 10^{-9}/ry$$

Frequency of EPRI Class 3a Sequences. This group consists of all core damage accident progression bins for which a small pre-existing leakage in the containment structure (i.e. containment liner) exists. This type of failure is identifiable only from an ILRT and therefore, affected by a change in ILRT testing frequency.

Consistent with NEI Interim Guidance [4], the frequency per reactor year for this category is calculated as the pre-existing leakage probability multiplied by the residual CDF determined as the total CDF minus the CDF for those individual sequences that either may already (independently) cause a LERF:

$$CLASS\_3a\_FREQUENCY = PROB_{class\_3a} * [CDF_{BASE} - CDF_{INDEP}]$$

Where:

CLASS_3a_FREQUENCY = frequency of EPRI Class 3a given a 3-in-10 years ILRT interval

$PROB_{class\_3a}$ = probability of small pre-existing containment liner leakage

$= 0.027$ [Section 2.3, input#6]

CDF_{BASE} = VY PSA L1 core damage frequency $= 5.03 \times 10^{-6}$/ry [Section 2.3, input #2]

CDF_{INDEP} = CDF for those individual sequences that may independently cause a LERF, identified as EPRI Class 2, Class 7, and Class 8 sequences:

- EPRI Class 2 = 2.14×10^{-9}/ry
- EPRI Class 7a = 3.22×10^{-7}/ry
- EPRI Class 7b = 3.85×10^{-6}/ry
- EPRI Class 7c = 9.71×10^{-9}/ry
- EPRI Class 8a = 1.63×10^{-7}/ry
- EPRI Class 8b = 5.32×10^{-8}/ry

$= 4.40 \times 10^{-6}$/ry

Therefore,

$$CLASS\_3a\_FREQUENCY = 0.027 * [5.03 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry]$$

$$CLASS\_3a\_FREQUENCY = 1.72 \times 10^{-8}/ry$$

Frequency of EPRI Class 3b Sequences. This group consists of all core damage accident progression bins for which a large pre-existing leakage in the containment structure (i.e. containment liner) exists. This type of failure is identifiable only from an ILRT and therefore, affected by a change in ILRT testing frequency.

Consistent with NEI Interim Guidance [3], the frequency per reactor year for this category is calculated as:

$$CLASS\_3b\_FREQUENCY = PROB_{class\_3b} * [CDF_{BASE} - CDF_{INDEP}]$$

Where:

CLASS_3b_FREQUENCY = frequency of EPRI Class 3b given a 3-in-10 years ILRT interval

$PROB_{class\_3b}$ = probability of large pre-existing containment liner leakage
= 0.0027 [Section 2.3, input #7]

CDF_{BASE} = VY PSA L1 core damage frequency = 5.03×10^{-6}/ry [Section 2.3, input #2]

CDF_{INDEP} = CDF for those individual sequences that may independently cause a LERF, identified as EPRI Class 2, Class 7, and Class 8 sequences:

- EPRI Class 2 = 2.14×10^{-9}/ry
- EPRI Class 7a = 3.22×10^{-7}/ry
- EPRI Class 7b = 3.85×10^{-6}/ry
- EPRI Class 7c = 9.71×10^{-9}/ry
- EPRI Class 8a = 1.63×10^{-7}/ry
- EPRI Class 8b = 5.32×10^{-8}/ry

= 4.40×10^{-6}/ry

Therefore,

$$CLASS\_3b\_FREQUENCY = 0.0027 * [5.03 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry]$$

$$CLASS\_3b\_FREQUENCY = 1.72 \times 10^{-9}/ry$$

Frequency of EPRI Class 4 Sequences. This group consists of all core damage accident progression sequences in which the containment isolation system function fails due to a pre-existing failure-to-seal of Type B test component(s). Consistent with NEI Interim Guidance [3], because these failures are detected by Type B tests and not by the Type A ILRT, this group is not evaluated further in this analysis.

Frequency of EPRI Class 5 Sequences. This group consists of all core damage accident progression sequences in which the containment isolation system function fails due to a pre-existing failure-to-seal of Type C test component(s). Consistent with NEI Interim Guidance [3], because these failures are detected by Type C tests, this group is not evaluated any further.

Frequency of EPRI Class 6 Sequences. This group consists of all core damage accident sequences in which the containment isolation function is failed due to "other" pre-existing failure modes (e.g., pathways left open or misalignment of containment isolation vales following a test/maintenance evolution). Consistent with NEI Interim Guidance [3], because these failures are detected by Type B or C tests, this group is not evaluated any further.

Frequency of EPRI Class 7 Sequences. This group consists of all core damage accident progression bins in which containment failure induced by severe accident phenomena occurs (i.e. liner melt-through). Consistent with NEI Interim Guidance [3], the frequency per reactor year for this class is based on the plant Level 2 PSA results [6].

The EPRI Class 7 is sub-divided in this report to reflect the sub-division of the VY Level 2 severe accident phenomena results into those threats posed by energetic phenomena and those related to direct contact of core material with the steel drywell shell. The following sub-classes are defined:

- Class 7a: failure of overall integrity of the containment as a result of postulated energetic phenomena [25], including:
    1. Direct containment heating. This phenomena is caused by dispersal of core debris in the containment atmosphere during RPV failures from high pressure.
    2. Missiles generated from structural debris.
    3. In-vessel or ex-vessel steam explosions.
    4. Vapor suppression failure. This could result from high pressure RPV failures (e.g., due to stuck-open drywell-to-wetwell vacuum breakers, or due to containment flooding which covers the vacuum breakers with water). Vapor suppression failure could also result from SRV discharge to the suppression pool while at elevated pool water temperature or low pool water level.
    5. Recriticality following melt/relocation of core material.

  Containment failures resulting from these phenomena are assumed to be large, and to be located at the drywell head. Choice of this location is conservative, since the release from containment will be directly to the refueling floor, bypassing the lower areas of the reactor building.

- Class 7b: failure of the containment shell as a result of direct contact with core material [25].

  The Mark I drywell steel shell provides the primary containment boundary. The drywell steel shell interfaces directly with the concrete floor of the drywell. The drywell floor is also the location where a substantial fraction of the core debris may be deposited if core damage cannot be arrested in-vessel and the RPV is subsequently breached. Without substantial water injection to the containment during the core melt progression, the steel shell may fail from extremely high local temperature due to the direct contact/proximity of core material. Top Event SI failure implies that a large hole (assumed to be about 2 ft^2) is opened in the drywell shell at the elevation where it contact the pedestal floor.

  The probability of shell meltthrough by molten core material depends on the following factors:

    1. The mode and timing of RPV breach.
    2. The temperature and quantity of debris released from the RPV.
    3. Whether water is present in the pedestal region of the drywell at the time of RPV failure (and afterwards), and how effective this water is in cooling the debris and the drywell shell.

- Class 7c: failure of the containment resulting from loss of containment heat removal capability [25].

  Some form of containment heat removal is assumed to be required in order to achieve a safe, stable state. The Vermont Yankee Mark I containment system is provided with significant heat removal capacity and heat management capabilities. The management of heat in the containment prior to, during, and following a severe core damage event directly affects containment response. The Vermont Yankee containment heat capacity can be classified as both active and passive. The passive capacities include the suppression pool and the containment structure. The active heat management capabilities include the RHR system and venting.

Based on the VY Level 2 PSA results summarized in Reference [6], the frequency of Category 7a is 3.22 x 10^{-7}/ry.

Based on the VY Level 2 PSA results summarized in Reference [6], the frequency of Category 7b is 3.85 x 10^{-6}/ry.

Based on the VY Level 2 PSA results summarized in Reference [6], the frequency of Category 7c is 9.71 x 10^{-9}/ry.

Frequency of EPRI Class 8 Sequences. This group consists of all core damage accident progression bins in which the accident is initiated by a containment bypass scenario. Consistent with NEI Interim Guidance [3], the frequency per reactor year for this class is based on the plant Level 2 PSA results [6].

The EPRI Class 8 is sub-divided in this report to reflect the sub-division into those created by ATWS with high power oscillations, and those due to Interfacing Systems LOCAs. The following sub-classes are defined:

- Class 8a: Containment bypass due to ATWS with high power oscillations (i.e., Accident Class IVA and IVL events). It is assumed that containment failure will be induced by hydrodynamic loads, and that the failure location will be located in the wetwell.
- Class 8b: Containment bypass due to Interfacing Systems LOCAs (i.e., Accident Class V events). Class V sequences where containment bypass and core melt occur are assumed to result in a High-RB release. Note that no credit for Reactor Building retention is taken for these sequences.

Based on the VY Level 2 PSA results summarized in Reference [6], the frequency of Category 8a is 1.63 x 10^{-7}/ry.

Based on the VY Level 2 PSA results summarized in Reference [6], the frequency of Category 8b is 5.32 x 10^{-8}/ry.

Note: for this class the maximum release is not based on the maximum allowable containment leakage, because the releases are released directly to the environment. Therefore, the containment structure will not impact the release magnitude.

The EPRI TR-104285 Class frequencies that result in radionuclide releases to the public are derived in accordance with NEI Interim Guidance [3]. The EPRI TR-104285 class accident sequence frequency results are summarized in Table 2-5.

2.4.2 Containment Leakage Rates (Step 2)

This step defines the containment leakage rates for EPRI accident Classes 3a and 3b. As defined in Step 1, accident Class 3a and 3b are plant accidents with pre-existing containment leakage pathways (designated as "small" and "large") that are identifiable only when performing a Type A ILRT.

The NEI Interim Guidance [3] recommends containment leakage rates of 10La and 35La for accident Classes 3a and 3b, respectively. These values are consistent with previous ILRT frequency extension submittal applications [8]. La is the plant Technical Specification maximum allowable containment leak rate; for VY La is 0.8% of containment air weight per day (per VY Technical Specification).

By definition, and per the NEI Interim Guidance [3] and previously approved methodology [8] the containment leakage rate for Class 1 (i.e., accidents with containment leakage at or below maximum allowable Technical Specification leakage) is 1 La.

2.4.3 Baseline Population Dose Estimate (Step 3)

This step estimates the baseline population dose (person-rem) for each of the EPRI TR-104285 accident classes [3]. The NEI Interim Guidance [4] recommends two options for calculating population dose for the EPRI accident classes:

- Use of NUREG-1150 dose calculations [10]
- Use of plant-specific dose calculations

Because the Vermont Yankee has a Level 3 PSA [24] and associated plant-specific dose, this risk assessment uses plant specific dose results.

The Vermont Yankee PSA offsite consequences are calculated by the MACCS2 consequence model [24]. The principal phenomena analyzed are atmospheric transport of radionuclides, mitigative actions (i.e., evacuation, condemnation of contaminated crops and milk) based on dose projection, dose accumulation by a number of pathways, including food and water ingestion and economic costs. Input for the Level 3 analysis includes Vermont Yankee core radionuclide inventory, source terms from the Level 2 (containment performance analysis) model, site metrological data, projected population distribution (within 50-mile radius) for the year 2025, emergency response evacuation modeling and economic data.

The Vermont Yankee consequence analysis looks at the source term for fourteen collapsed release categories (Table 2-4). These categories represent the source term for each of the one-hundred-seventy-three different containment release modes associated with endstates of the Vermont Yankee containment event tree (Section 4.5 of Reference 6).

The MACCS2 code was used to estimate the consequences in terms of population dose within 50-miles and offsite economic cost. The Vermont Yankee Level 3 PSA MACCS2 population dose results are presented in Table 2-6. (Use of dose results for the 50-mile radius around the plant, as a figure of merit in this risk evaluation is consistent with NUREG-1150 [10], past ILRT [8 &14] frequency extension submittals, and the NEI Interim Guidance. [4 & 5]) .

The Vermont Yankee populations dose information presented in Table 2-6 when combined with the preceding information on the EPRI TR-104285 class accident sequence frequency results (Table 2-5), provides the basis for the assignment of population dose for each EPRI accident category.

Population Dose for EPRI Class 1.

The dose for the "no containment failure" EPRI class 1 sequences is based on PSA Level 2 Release Category "No Containment Failure (NCF)" (Table 2-4). Therefore,

$$\text{CLASS\_1\_DOSE} = 1.30 \times 10^{1} \text{ person-sv} * \frac{100 \text{ person-rem}}{1 \text{person-sv}} \quad \text{[Table 2-6]}$$

$$= 1.30 \times 10^{3} \text{ person-rem}$$

Population Dose for EPRI Class 2.

The 50-miles population dose for the EPRI accident Class 2 (Large Containment Isolation Failures, failure-to-close) is based on the Vermont Yankee PSA Level 2 Release Category "EARLY HIGH" (Table 2-4), which represents the bounding release category for this class. Therefore,

$$\text{CLASS\_2\_DOSE} = 2.73 \times 10^{4} \text{ person-sv} * \frac{100 \text{ person-rem}}{1 \text{person-sv}} \quad \text{[Table 2-6]}$$

$$= 2.73 \times 10^{6} \text{ person-rem}$$

Population Dose for EPRI Class 3.

The 50-miles population dose for the EPRI accident Class 3a (Small Isolation Failures-Liner breach) and accident Class 3b (Large Isolation Failures-Liner breach), per the NEI Interim Guidance [4], are taken as factors of 10La and 35La [4, 8], respectively, times the population dose of EPRI accident Class 1. Therefore,

$$\text{CLASS\_3a\_DOSE} = 10 * \text{CLASS\_1\_DOSE}$$
$$\text{CLASS\_3b\_DOSE} = 35 * \text{CLASS\_1\_DOSE}$$

$$\text{CLASS\_3a\_DOSE} = 10 * 1.30 \times 10^{3} \text{ person-rem}$$
$$\text{CLASS\_3b\_DOSE} = 35 * 1.30 \times 10^{3} \text{ person-rem}$$

$$\text{CLASS\_3a\_DOSE} = 1.30 \times 10^{4} \text{ person-rem}$$
$$\text{CLASS\_3b\_DOSE} = 4.55 \times 10^{4} \text{ person-rem}$$

Population Dose for EPRI Classes 4, 5 &6.

Per the NEI Interim Guidance [4], EPRI accident Classes 4 (Small Isolation Failure - failure-to-seal, Type B test), 5 (Small Isolation Failure - failure-to-seal, Type C test), and 6 (Containment Isolation Failures, dependent failures, personnel errors) are not affected by ILRT frequency and are not analyzed as part of this risk assessment. Therefore no selections of population does estimates are made for these accident classes.

Population Dose for EPRI Class 7a.

The 50-miles population dose for the EPRI accident Class 7a (failure of the containment as a result of postulated energetic phenomena) is based on the Vermont Yankee collapsed PSA Level 2 Release Category "EARLY HIGH" (Table 2-4) , which represents the bounding release category for this class. Therefore,

CLASS_7a_DOSE = 2.73×10^4 person-sv * $\frac{100 \text{ person-rem}}{1 \text{person-sv}}$ [Table 2-6]

= 2.73×10^6 person-rem

Population Dose for EPRI Class 7b.

The 50-miles population dose for the EPRI accident Class 7b (failure of the containment as a result of the threat posed by direct contact with core material) is based on the Vermont Yankee PSA Level 2 Release Category "EARLY HIGH" (Table 2-4) as the bounding release category for this class. Therefore,

CLASS_7b_DOSE = 2.73×10^4 person-sv * $\frac{100 \text{ person-rem}}{1 \text{person-sv}}$ [Table 2-6]

= 2.73×10^6 person-rem

Population Dose for EPRI Class 7c.

The 50-miles population dose for the EPRI accident Class 7c (failure of the containment as a result of the loss of containment heat removal capability) is based on the Vermont Yankee PSA Level 2 Release Category "INTERMEDIATE HIGH" (Table 2-4) , which represents the bounding release category for this class. Therefore,

CLASS_7c_DOSE = 3.53×10^4 person-sv * $\frac{100 \text{ person-rem}}{1 \text{person-sv}}$ [Table 2-6]

= 3.53×10^6 person-rem

Population Dose for EPRI Class 8a.

The 50-miles population dose for the EPRI accident Class 8a (containment bypass due to ATWS with high power oscillations) is based on the Vermont Yankee PSA Level 2 Release Category "EARLY HIGH" (Table 2-4) , which represents the bounding release category for this class. Therefore,

CLASS_8a_DOSE = 2.73×10^4 person-sv * $\frac{100 \text{ person-rem}}{1 \text{person-sv}}$ [Table 2-6]

= 2.73×10^6 person-rem

Population Dose for EPRI Class 8b.

The 50-miles population dose for the EPRI accident Class 8b (containment bypass due to Interfacing Systems LOCAs) is based on the Vermont Yankee PSA Level 2 Release Category "Containment Bypass (V-Seq)" (Table 2-4) , which represents the bounding release category for this class. Therefore,

CLASS_8b_DOSE = 2.96×10^4 person-sv * $\frac{100 \text{ person-rem}}{1 \text{person-sv}}$ [Table 2-6]

= 2.96×10^6 person-rem

Using the preceding information, the population dose for the 50-mile radius surrounding the Vermont Yankee is summarized in Table 2-6. (Note: the use of dose results for the 50-mile radius around the plant as a 'figure of merit' in the risk evaluation is consistent with past ILRT frequency extension submittals, and the NEI Interim Guidance [4]).

2.4.4 Baseline Population Dose Rate Estimate (Step 4)

This step calculates the baseline does rates for each of the eight EPRI's accident classes. The calculation is performed by multiplying the dose calculated in Step 3 (Table 2-6) by the associated frequency calculated in Step 1 (Table 2-5). Since the conditional containment pre-existing leakage probabilities for EPRI accident classes' 3a and 3b are based on a 3-per-10 year ILRT frequency, the calculated baseline results reflect a 3-per-10 year ILRT surveillance frequency.

$CLASS\_1\_DOSE_{RATE}$ = CLASS_1_DOSE * CLASS_1_FREQUENCY
$CLASS\_2\_DOSE_{RATE}$ = CLASS_2_DOSE * CLASS_2_FREQUENCY
$CLASS\_3a\_DOSE_{RATE}$ = CLASS_3a_DOSE * CLASS_3a_FREQUENCY
$CLASS\_3b\_DOSE_{RATE}$ = CLASS_3b_DOSE * CLASS_3b_FREQUENCY
$CLASS\_7a\_DOSE_{RATE}$ = CLASS_7a_DOSE * CLASS_7a_FREQUENCY
$CLASS\_7b\_DOSE_{RATE}$ = CLASS_7b_DOSE * CLASS_7b_FREQUENCY
$CLASS\_7c\_DOSE_{RATE}$ = CLASS_7c_DOSE * CLASS_7c_FREQUENCY
$CLASS\_8a\_DOSE_{RATE}$ = CLASS_8a_DOSE * CLASS_8a_FREQUENCY
$CLASS\_8b\_DOSE_{RATE}$ = CLASS_8b_DOSE * CLASS_8b_FREQUENCY

Where:

$CLASS\_1\_DOSE_{RATE}$ = EPRI accident Class 1 dose rate given a 3-in-10 years ILRT interval
$CLASS\_2\_DOSE_{RATE}$ = EPRI accident Class 2 dose rate given a 3-in-10 years ILRT interval
$CLASS\_3a\_DOSE_{RATE}$ = EPRI accident Class 3a dose rate given a 3-in-10 years ILRT interval
$CLASS\_3b\_DOSE_{RATE}$ = EPRI accident Class 3b dose rate given a 3-in-10 years ILRT interval
$CLASS\_7a\_DOSE_{RATE}$ = EPRI accident Class 7a dose rate given a 3-in-10 years ILRT interval
$CLASS\_7b\_DOSE_{RATE}$ = EPRI accident Class 7b dose rate given a 3-in-10 years ILRT interval
$CLASS\_7c\_DOSE_{RATE}$ = EPRI accident Class 7c dose rate given a 3-in-10 years ILRT interval
$CLASS\_8a\_DOSE_{RATE}$ = EPRI accident Class 8a dose rate given a 3-in-10 years ILRT interval
$CLASS\_8b\_DOSE_{RATE}$ = EPRI accident Class 8b dose rate given a 3-in-10 years ILRT interval

CLASS_1_DOSE = EPRI accident Class 1 dose = 1.30×10^3 (person-rem) [Table 2-6]
CLASS_2_DOSE = EPRI accident Class 2 dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_3a_DOSE = EPRI accident Class 3a dose = 1.30×10^4 (person-rem) [Table 2-6]
CLASS_3b_DOSE = EPRI accident Class 3b dose = 4.55×10^4 (person-rem) [Table 2-6]
CLASS_7a_DOSE = EPRI accident Class 7a dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_7b_DOSE = EPRI accident Class 7b dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_7c_DOSE = EPRI accident Class 7c dose = 3.53×10^6 (person-rem) [Table 2-6]
CLASS_8a_DOSE = EPRI accident Class 8a dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_8b_DOSE = EPRI accident Class 8b dose = 2.96×10^6 (person-rem) [Table 2-6]

CLASS_1_FREQUENCY = frequency of EPRI accident Class 1 given a 3-in-10 years ILRT interval
= 5.88×10^{-7}/ry [Table 2-5]

CLASS_2_FREQUENCY = frequency of EPRI accident Class 2 given a 3-in-10 years ILRT interval
= 2.14×10^{-9}/ry [Table 2-5]

CLASS_3a_FREQUENCY = frequency of EPRI accident Class 3a given a 3-in-10 years ILRT interval
= 1.72×10^{-8}/ry [Table 2-5]

CLASS_3b_FREQUENCY = frequency of EPRI accident Class 3b given a 3-in-10 years ILRT interval
= 1.72×10^{-9}/ry [Table 2-5]

CLASS_7a_FREQUENCY = frequency of EPRI accident Class 7a given a 3-in-10 years ILRT interval
= 3.22×10^{-7}/ry [Table 2-5]

CLASS_7b_FREQUENCY = frequency of EPRI accident Class 7b given a 3-in-10 years ILRT interval
= 3.85×10^{-6}/ry [Table 2-5]

CLASS_7c_FREQUENCY = frequency of EPRI accident Class 7c given a 3-in-10 years ILRT interval
= 9.71×10^{-9}/ry [Table 2-5]

CLASS_8a_FREQUENCY = frequency of EPRI accident Class 8a given a 3-in-10 years ILRT interval
= 1.63×10^{-7}/ry [Table 2-5]

CLASS_8b_FREQUENCY = frequency of EPRI accident Class 8b given a 3-in-10 years ILRT interval
= 5.32×10^{-8}/ry [Table 2-5]

Therefore,

$CLASS\_1\_DOSE_{RATE}$	=	1.30×10^{3}	*	5.88×10^{-7}	=	7.64×10^{-4}	(person-rem/ry)
$CLASS\_2\_DOSE_{RATE}$	=	2.73×10^{6}	*	2.14×10^{-9}	=	5.85×10^{-3}	(person-rem/ry)
$CLASS\_3a\_DOSE_{RATE}$	=	1.30×10^{4}	*	1.72×10^{-8}	=	2.24×10^{-4}	(person-rem/ry)
$CLASS\_3b\_DOSE_{RATE}$	=	4.55×10^{4}	*	1.72×10^{-9}	=	7.83×10^{-5}	(person-rem/ry)
$CLASS\_7a\_DOSE_{RATE}$	=	2.73×10^{6}	*	3.22×10^{-7}	=	8.79×10^{-1}	(person-rem/ry)
$CLASS\_7b\_DOSE_{RATE}$	=	2.73×10^{6}	*	3.85×10^{-6}	=	$1.05 \times 10^{+1}$	(person-rem/ry)
$CLASS\_7c\_DOSE_{RATE}$	=	3.53×10^{6}	*	9.71×10^{-9}	=	3.43×10^{-2}	(person-rem/ry)
$CLASS\_8a\_DOSE_{RATE}$	=	2.73×10^{6}	*	1.63×10^{-7}	=	4.46×10^{-1}	(person-rem/ry)
$CLASS\_8b\_DOSE_{RATE}$	=	2.96×10^{6}	*	5.32×10^{-8}	=	1.57×10^{-1}	(person-rem/ry)

Table 2-7 summarizes the resulting baseline population dose rates by EPRI accident class.

2.4.5 Change in Probability of Detectable Leakage (Step 5)

This step calculates the change in probability of leakage detectable only by ILRT, and associated frequency for the new surveillance intervals of interest. Note that with increases in the ILRT surveillance interval, the size of the postulated leak path and the associated leakage rate are assumed not to change, however the probability of leakage detectable only by ILRT does increase.

According to NUREG-1493 [2] and per the NEI Interim Guidance [4], the calculation of the change in the probability of a pre-existing ILRT-detectable containment leakage is based on the relationship that relaxation of the ILRT interval results in increasing the average time that a pre-existing leak would exist undetected. Specifically, the relaxation of the Type A ILRT interval from 3-in-10 years to 1-in-10 years will increase the average time that a leak detectable only by an ILRT goes undetected from 18 to 60 months[6], a factor of 3.333 increase (60/18). Therefore, the change in probability of leakage due to the ILRT

interval extension is calculated by applying a multiplier factor determined by the ratio of the average times of undetection for the two ILRT interval cases.

From Section 2.3 "Input and Design Criteria", the calculated pre-existing ILRT detectable leakage probabilities based on 3 in-10 years ILRT frequency is 0.027 for small pre-existing leakage (EPRI accident class 3a) and 0.0027 for large pre-existing leakage (EPRI accident class 3b).

Since February 1998, the Vermont Yankee plant has been operating under a 1-in-10 years ILRT testing frequency consistent with the performance-based Option B of 10 CFR Part 50, Appendix J [14]. As a result, the baseline leakage probabilities, (which are based on a 3-in-10 years ILRT frequency) must be revised to reflect the current 1-in-10 years VY ILRT testing frequency. This is performed as follows:

$$PROB_{class\_3a\_10} = PROB_{class\_3a} * \left[\frac{SURTEST_{10}}{18}\right]$$

$$PROB_{class\_3b\_10} = PROB_{class\_3b} * \left[\frac{SURTEST_{10}}{18}\right]$$

Where:

$PROB_{class\_3a\_10}$ = probability of small pre-existing containment liner leakage given a 1-in-10 years ILRT frequency.

$PROB_{class\_3a}$ = probability of small pre-existing containment liner leakage given a 3-in-10 years ILRT frequency = 0.027 [Section 2.3, input#8]

$PROB_{class\_3b}$ = probability of large pre-existing containment liner leakage given a 3-in-10 years ILRT frequency = 0.0027 [Section 2.3, input #9]

$SURTEST_{10}$ = surveillance interval of interest, months/2 = 10 years*12 $\frac{months}{year}$/2 = 60 months

Therefore,

$$PROB_{class\_3a\_10} = 0.027 * \left[\frac{60}{18}\right] = 0.09$$

$$PROB_{class\_3b\_10} = 0.0027 * \left[\frac{60}{18}\right] = 0.009$$

Similarly, the pre-existing ILRT detectable leakage probabilities for the 1-in-15 years ILRT frequency being analyzed by VY are calculated as follows:

$$PROB_{class\_3a\_15} = PROB_{class\_3a} * \frac{SURTEST_{15}}{18}$$

$$PROB_{class\_3b\_15} = PROB_{class\_3b} * \left[\frac{SURTEST_{15}}{18}\right]$$

Where:

$PROB_{class\_3a\_15}$ = probability of small pre-existing containment liner leakage given a 1-in-15 years ILRT frequency.

$PROB_{class\_3a}$ = probability of small pre-existing containment liner leakage given a 3-in-10 years ILRT frequency = 0.027 [Section 2.3, input#6]

$PROB_{class\_3b}$ = probability of large pre-existing containment liner leakage given a 3-in-10 years ILRT frequency = 0.0027 [Section 2.3, input #7]

$SURTEST_{15}$ = surveillance interval of interest, months/2 = 15 years*12$\frac{\text{months}}{\text{year}}$/2 = 90 months

Therefore,

$$PROB_{class\_3a\_15} = 0.027 * \left[\frac{90}{18}\right] = 0.135$$

$$PROB_{class\_3b\_15} = 0.0027 * \left[\frac{90}{18}\right] = 0.0135$$

Given the above revised leakage probabilities, the frequencies of the EPRI accident classes calculated in Step 1, also needs to be revised to reflect the increase change in leakage probabilities.

As previously stated, Type A tests impact only Class 1 and Class 3 sequences. Therefore, EPRI accident Class 1 frequency changes are calculated similar to Step 1, and the rest of EPRI's Classes; 2, 7 and 8 remain the same.

Revised Frequency of EPRI Class 3a Sequences. Consistent with NEI Interim Guidance [4], the frequency per reactor year for this category is calculated as:

$$CLASS\_3a\_FREQUENCY_{10} = PROB_{class\_3a\_10} * [CDF_{BASE} - CDF_{INDEP}]$$

$$CLASS\_3a\_FREQUENCY_{15} = PROB_{class\_3a\_15} * [CDF_{BASE} - CDF_{INDEP}]$$

Where:

$CLASS\_3a\_FREQUENCY_{10}$ = frequency of small pre-existing containment liner leakage given a 1-in-10 years ILRT interval

$CLASS\_3a\_FREQUENCY_{15}$ = frequency of small pre-existing containment liner leakage given a 1-in-15 years ILRT interval

$PROB_{class\_3a\_10}$ = probability of small pre-existing containment liner leakage given a 1-in-10 years ILRT frequency = 0.09 [See above write-up]

$PROB_{class\_3a\_15}$ = probability of small pre-existing containment liner leakage given a 1-in-15 years ILRT frequency = 0.135 [See above write-up]

CDF_{BASE} = VY PSA L1 core damage frequency = 5.03×10^{-6}/ry [See step 1 write-up]

CDF_{INDEP} = CDF for those individual sequences that may independently cause a LERF, identified as EPRI Class 2, Class 7, and Class 8 sequences
= 4.40×10^{-6}/ry [See step 1 write-up]

Therefore,

$$CLASS\_3a\_FREQUENCY_{10} = 0.09 * [5.03 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry] = 5.73 \times 10^{-8}/ry$$

$$CLASS\_3a\_FREQUENCY_{15} = 0.135 * [5.03 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry] = 8.60 \times 10^{-8}/ry$$

Frequency of EPRI Class 3b Sequences. Consistent with NEI Interim Guidance [4], the frequency per reactor year for this category is calculated as:

$$CLASS\_3b\_FREQUENCY_{10} = PROB_{class\_3b\_10} * [CDF_{BASE} - CDF_{INDEP}]$$

$$CLASS\_3b\_FREQUENCY_{15} = PROB_{class\_3b\_15} * [CDF_{BASE} - CDF_{INDEP}]$$

Where:

$CLASS\_3b\_FREQUENCY_{\_10}$ = frequency of small pre-existing containment liner leakage given a 1-in-10 years ILRT interval

$CLASS\_3b\_FREQUENCY_{\_15}$ = frequency of small pre-existing containment liner leakage given a 1-in-15 years ILRT interval

$PROB_{class\_3b\_10}$ = probability of small pre-existing containment liner leakage given a 1-in-10 years ILRT frequency = 0.009 [See above write-up]

$PROB_{class\_3b\_15}$ = probability of small pre-existing containment liner leakage given a 1-in-15 years ILRT frequency = 0.0135 [See above write-up]

CDF_{BASE} = VY PSA L1 core damage frequency = 5.03×10^{-6}/ry [See step 1 write-up]

CDF_{INDEP} = CDF for those individual sequences that may independently cause a LERF, identified as EPRI Class 2, Class 7, and Class 8 sequences
= 4.40×10^{-6}/ry [See step 1 write-up]

Therefore,

$$CLASS\_3b\_FREQUENCY_{10} = 0.009 * [5.03 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry] = 5.73 \times 10^{-9}/ry$$

$$CLASS\_3b\_FREQUENCY_{15} = 0.0135 * [5.03 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry] = 8.60 \times 10^{-9}/ry$$

2.4.6 Population Dose Rate for New ILRT Interval (Step 6)

This step, per the NEI Interim Guidance [3], calculates the population dose rate for the new surveillance intervals of interest by multiplying the population dose (Table 2-6) by the frequency for each of the eight EPRI's accident classes (Tables 2-5 & 2-8). In addition, sum the accident class dose rates to obtain the total dose rate.

Per the NEI Interim Guidance [4], EPRI accident Classes 4 (Small Isolation Failure - failure-to-seal, Type B test), 5 (Small Isolation Failure - failure-to-seal, Type C test), and 6 (Containment Isolation Failures, dependent failures, personnel errors) are not affected by ILRT frequency and are not analyzed as part of this risk assessment. Therefore no selections of population dose estimates are made for these accident classes.

The calculation for a 1-in-10 years ILRT interval is as follows:

$$CLASS\_1\_DOSE_{RATE\text{-}10} = CLASS\_1\_DOSE * CLASS\_1\_FREQUENCY_{10}$$
$$CLASS\_2\_DOSE_{RATE\text{-}10} = CLASS\_2\_DOSE * CLASS\_2\_FREQUENCY_{10}$$
$$CLASS\_3a\_DOSE_{RATE\text{-}10} = CLASS\_3a\_DOSE * CLASS\_3a\_FREQUENCY_{10}$$
$$CLASS\_3b\_DOSE_{RATE\text{-}10} = CLASS\_3b\_DOSE * CLASS\_3b\_FREQUENCY_{10}$$
$$CLASS\_7a\_DOSE_{RATE\text{-}10} = CLASS\_7a\_DOSE * CLASS\_7a\_FREQUENCY_{10}$$
$$CLASS\_7b\_DOSE_{RATE\text{-}10} = CLASS\_7b\_DOSE * CLASS\_7b\_FREQUENCY_{10}$$
$$CLASS\_7c\_DOSE_{RATE\text{-}10} = CLASS\_7c\_DOSE * CLASS\_7c\_FREQUENCY_{10}$$
$$CLASS\_8a\_DOSE_{RATE\text{-}10} = CLASS\_8a\_DOSE * CLASS\_8a\_FREQUENCY_{10}$$
$$CLASS\_8b\_DOSE_{RATE\text{-}10} = CLASS\_8b\_DOSE * CLASS\_8b\_FREQUENCY_{10}$$

Where:

$CLASS\_1\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 1 dose rate given a 1-in-10 years ILRT interval
$CLASS\_2\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 2 dose rate given a 1-in-10 years ILRT interval
$CLASS\_3a\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 3a dose rate given a 1-in-10 years ILRT interval
$CLASS\_3b\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 3b dose rate given a 1-in-10 years ILRT interval
$CLASS\_7a\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 7a dose rate given a 1-in-10 years ILRT interval
$CLASS\_7b\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 7b dose rate given a 1-in-10 years ILRT interval
$CLASS\_7c\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 7c dose rate given a 1-in-10 years ILRT interval
$CLASS\_8a\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 8a dose rate given a 1-in-10 years ILRT interval
$CLASS\_8b\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 8b dose rate given a 1-in-10 years ILRT interval

CLASS_1_DOSE = EPRI accident Class 1 dose = 1.30×10^3 (person-rem) [Table 2-6]
CLASS_2_DOSE = EPRI accident Class 2 dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_3a_DOSE = EPRI accident Class 3a dose = 1.30×10^4 (person-rem) [Table 2-6]
CLASS_3b_DOSE = EPRI accident Class 3b dose = 4.55×10^4 (person-rem) [Table 2-6]
CLASS_7a_DOSE = EPRI accident Class 7a dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_7b_DOSE = EPRI accident Class 7b dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_7c_DOSE = EPRI accident Class 7c dose = 3.53×10^6 (person-rem) [Table 2-6]
CLASS_8a_DOSE = EPRI accident Class 8a dose = 2.73×10^6 (person-rem) [Table 2-6]
CLASS_8b_DOSE = EPRI accident Class 8b dose = 2.96×10^6 (person-rem) [Table 2-6]

$CLASS\_1\_FREQUENC\ Y_{10}$ = frequency of EPRI accident Class 1 given a 1-in-10 years ILRT Interval = 5.43×10^{-7}/ry [Table 2-8]

CLASS_2_FREQUENC Y_{10} = frequency of EPRI accident Class 2 given a 3-in-10 years ILRT Interval = 2.14×10^{-9}/ry [Table 2-5]

CLASS_3a_FREQUENC Y_{10} = frequency of EPRI accident Class 3a given a 1-in-10 years ILRT Interval = 5.73×10^{-8}/ry [Table 2-8]

CLASS_3b_FREQUENC Y_{10} = frequency of EPRI accident Class 3b given a 1-in-10 years ILRT Interval = 5.73×10^{-9}/ry [Table 2-8]

CLASS_7a_FREQUENC Y_{10} = frequency of EPRI accident Class 7a given a 3-in-10 years ILRT Interval = 3.22×10^{-7}/ry [Table 2-5]

CLASS_7b_FREQUENC Y_{10} = frequency of EPRI accident Class 7b given a 3-in-10 years ILRT Interval = 3.85×10^{-6}/ry [Table 2-5]

CLASS_7c_FREQUENC Y_{10} = frequency of EPRI accident Class 7c given a 3-in-10 years ILRT Interval = 9.71×10^{-9}/ry [Table 2-5]

CLASS_8a_FREQUENC Y_{10} = frequency of EPRI accident Class 8a given a 3-in-10 years ILRT Interval = 1.63×10^{-7}/ry [Table 2-5]

CLASS_8b_FREQUENC Y_{10} = frequency of EPRI accident Class 8b given a 3-in-10 years ILRT Interval = 5.32×10^{-8}/ry [Table 2-5]

Therefore,

CLASS_1_DOSE$_{RATE\text{-}10}$	=	1.30×10^{3}	*	5.43×10^{-7}	=	7.06×10^{-4}	(person-rem/ry)
CLASS_2_DOSE$_{RATE\text{-}10}$	=	2.73×10^{6}	*	2.14×10^{-9}	=	5.85×10^{-3}	(person-rem/ry)
CLASS_3a_DOSE$_{RATE\text{-}10}$	=	1.30×10^{4}	*	5.73×10^{-8}	=	7.46×10^{-4}	(person-rem/ry)
CLASS_3b_DOSE$_{RATE\text{-}10}$	=	4.55×10^{4}	*	5.73×10^{-9}	=	2.61×10^{-4}	(person-rem/ry)
CLASS_7a_DOSE$_{RATE\text{-}10}$	=	2.73×10^{6}	*	3.22×10^{-7}	=	8.79×10^{-1}	(person-rem/ry)
CLASS_7b_DOSE$_{RATE\text{-}10}$	=	2.73×10^{6}	*	3.85×10^{-6}	=	$1.05 \times 10^{+1}$	(person-rem/ry)
CLASS_7c_DOSE$_{RATE\text{-}10}$	=	3.53×10^{6}	*	9.71×10^{-9}	=	3.43×10^{-2}	(person-rem/ry)
CLASS_8a_DOSE$_{RATE\text{-}10}$	=	2.73×10^{6}	*	1.63×10^{-7}	=	4.46×10^{-1}	(person-rem/ry)
CLASS_8b_DOSE$_{RATE\text{-}10}$	=	2.96×10^{6}	*	5.32×10^{-8}	=	1.57×10^{-1}	(person-rem/ry)

The calculation for a 1-in-15 years ILRT interval is as follows for the:

CLASS_1_DOSE$_{RATE\text{-}15}$	=	CLASS_1_DOSE	*	CLASS_1_FREQUENCY$_{15}$
CLASS_2_DOSE$_{RATE\text{-}15}$	=	CLASS_2_DOSE	*	CLASS_2_FREQUENCY$_{15}$
CLASS_3a_DOSE$_{RATE\text{-}15}$	=	CLASS_3a_DOSE	*	CLASS_3a_FREQUENCY$_{15}$
CLASS_3b_DOSE$_{RATE\text{-}15}$	=	CLASS_3b_DOSE	*	CLASS_3b_FREQUENCY$_{15}$
CLASS_7a_DOSE$_{RATE\text{-}15}$	=	CLASS_7a_DOSE	*	CLASS_7a_FREQUENCY$_{15}$
CLASS_7b_DOSE$_{RATE\text{-}15}$	=	CLASS_7b_DOSE	*	CLASS_7b_FREQUENCY$_{15}$
CLASS_7c_DOSE$_{RATE\text{-}15}$	=	CLASS_7c_DOSE	*	CLASS_7c_FREQUENCY$_{15}$
CLASS_8a_DOSE$_{RATE\text{-}15}$	=	CLASS_8a_DOSE	*	CLASS_8a_FREQUENCY$_{15}$
CLASS_8b_DOSE$_{RATE\text{-}15}$	=	CLASS_8b_DOSE	*	CLASS_8b_FREQUENCY$_{15}$

Where:

CLASS_1_DOSE$_{RATE\text{-}15}$ = EPRI accident Class 1 dose rate given a 1-in-15 years ILRT interval
CLASS_2_DOSE$_{RATE\text{-}15}$ = EPRI accident Class 2 dose rate given a 1-in-15 years ILRT interval

$CLASS\_3a\_DOSE_{RATE\text{-}15}$ = EPRI accident Class 3a dose rate given a 1-in-15 years ILRT interval
$CLASS\_3b\_DOSE_{RATE\text{-}15}$ = EPRI accident Class 3b dose rate given a 1-in-15 years ILRT interval
$CLASS\_7a\_DOSE_{RATE\text{-}15}$ = EPRI accident Class 7a dose rate given a 1-in-15 years ILRT interval
$CLASS\_7b\_DOSE_{RATE\text{-}15}$ = EPRI accident Class 7b dose rate given a 1-in-15 years ILRT interval
$CLASS\_7c\_DOSE_{RATE\text{-}15}$ = EPRI accident Class 7c dose rate given a 1-in-15 years ILRT interval
$CLASS\_8a\_DOSE_{RATE\text{-}15}$ = EPRI accident Class 8a dose rate given a 1-in-15 years ILRT interval
$CLASS\_8b\_DOSE_{RATE\text{-}15}$ = EPRI accident Class 8b dose rate given a 1-in-15 years ILRT interval

CLASS_1_DOSE = EPRI accident Class 1 dose = 1.30×10^{3} (person-rem) [Table 2-6]
CLASS_2_DOSE = EPRI accident Class 2 dose = 2.73×10^{6} (person-rem) [Table 2-6]
CLASS_3a_DOSE = EPRI accident Class 3a dose = 1.30×10^{4} (person-rem) [Table 2-6]
CLASS_3b_DOSE = EPRI accident Class 3b dose = 4.55×10^{4} (person-rem) [Table 2-6]
CLASS_7a_DOSE = EPRI accident Class 7a dose = 2.73×10^{6} (person-rem) [Table 2-6]
CLASS_7b_DOSE = EPRI accident Class 7b dose = 2.73×10^{6} (person-rem) [Table 2-6]
CLASS_7c_DOSE = EPRI accident Class 7c dose = 3.53×10^{6} (person-rem) [Table 2-6]
CLASS_8a_DOSE = EPRI accident Class 8a dose = 2.73×10^{6} (person-rem) [Table 2-6]
CLASS_8b_DOSE = EPRI accident Class 8b dose = 2.96×10^{6} (person-rem) [Table 2-6]

$CLASS\_1\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 1 given a 1-in-15 years ILRT Interval = 5.12×10^{-7}/ry [Table 2-8]

$CLASS\_2\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 2 given a 3-in-10 years ILRT Interval = 2.14×10^{-9}/ry [Table 2-5]

$CLASS\_3a\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 3a given a 1-in-15 years ILRT Interval = 8.60×10^{-8}/ry [Table 2-8]

$CLASS\_3b\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 3b given a 1-in-15 years ILRT Interval = 8.60×10^{-9}/ry [Table 2-8]

$CLASS\_7a\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 7a given a 3-in-10 years ILRT Interval = 3.22×10^{-7}/ry [Table 2-5]

$CLASS\_7b\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 7b given a 3-in-10 years ILRT Interval = 3.85×10^{-6}/ry [Table 2-5]

$CLASS\_7c\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 7c given a 3-in-10 years ILRT Interval = 9.71×10^{-9}/ry [Table 2-5]

$CLASS\_8a\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 8a given a 3-in-10 years ILRT Interval = 1.63×10^{-7}/ry [Table 2-5]

$CLASS\_8b\_FREQUENC\ Y_{15}$ = frequency of EPRI accident Class 8b given a 3-in-10 years ILRT Interval = 5.32×10^{-8}/ry [Table 2-5]

Therefore,

$CLASS\_1\_DOSE_{RATE\text{-}15} = 1.30 \times 10^{3} * 5.12 \times 10^{-7} = 6.65 \times 10^{-4}$ (person-rem/ry)
$CLASS\_2\_DOSE_{RATE\text{-}15} = 2.73 \times 10^{6} * 2.14 \times 10^{-9} = 5.85 \times 10^{-3}$ (person-rem/ry)
$CLASS\_3a\_DOSE_{RATE\text{-}15} = 1.30 \times 10^{4} * 5.73 \times 10^{-8} = 1.12 \times 10^{-3}$ (person-rem/ry)
$CLASS\_3b\_DOSE_{RATE\text{-}15} = 4.55 \times 10^{4} * 5.73 \times 10^{-9} = 3.91 \times 10^{-4}$ (person-rem/ry)
$CLASS\_7a\_DOSE_{RATE\text{-}15} = 2.73 \times 10^{6} * 3.22 \times 10^{-7} = 8.79 \times 10^{-1}$ (person-rem/ry)
$CLASS\_7b\_DOSE_{RATE\text{-}15} = 2.73 \times 10^{6} * 3.85 \times 10^{-6} = 1.05 \times 10^{+1}$ (person-rem/ry)

$CLASS\_7c\_DOSE_{RATE\text{-}15}$	=	3.53×10^{6}	*	9.71×10^{-9}	=	3.43×10^{-2}	(person-rem/ry)
$CLASS\_8a\_DOSE_{RATE\text{-}15}$	=	2.73×10^{6}	*	1.63×10^{-7}	=	4.46×10^{-1}	(person-rem/ry)
$CLASS\_8b\_DOSE_{RATE\text{-}15}$	=	2.96×10^{6}	*	5.32×10^{-8}	=	1.57×10^{-1}	(person-rem/ry)

The dose rates per EPRI accident class as a function of ILRT interval are summarized in Table 2-9.

2.4.7 Change in Population Dose Rate Due to New ILRT Interval (Step 7)

This step, per the NEI Interim Guidance [4] calculates the percentage of the total dose rate attributable to EPRI accident Classes 3a and 3b (those accident classes affected by change in ILRT surveillance interval) and the change in this result dose rate from the base dose rate attributable to changes in ILRT surveillance interval.

Based on the results summarized in Table 2-10, for the current VY Station 1-in10 years ILRT interval, the percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b is calculated as follows:

PER_CTD_{10} = percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b given a 1-in-10 years ILRT interval, which is calculated using the following equation:

$$PER\_CTD_{10} = \left[\frac{CLASS\_3a\_DOSE_{RATE-10} + CLASS\_3b\_DOSE_{RATE-10}}{TOTAL\_DOSE_{RATE-10}}\right] * 100\%$$

$CLASS\_3a\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 3a dose rate given a 1-in-10 years ILRT interval
= 7.46×10^{-4} [Table 2-9]

$CLASS\_3b\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 3b dose rate given a 1-in-10 years ILRT interval
= 2.61×10^{-4} [Table 2-9]

$TOTAL\_DOSE_{RATE\text{-}10}$ = Total dose rate for all EPRI's classes given a 1-in-10 years ILRT interval
= 12.0211 [Table 2-9]

Therefore,

$$PER\_CTD_{10} = \left[\frac{7.46\times10^{-4} + 2.61\times10^{-4}}{12.0211}\right] * 100\% = 0.0084\%$$

The percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b based on the propose 1-in-15 years ILRT interval is calculated as follows:

PER_CTD_{15} = percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b given a 1-in-15 years ILRT interval, which is calculated using the following equation:

$$PER\_CTD_{15} = \left[\frac{CLASS\_3a\_DOSE_{RATE-15} + CLASS\_3b\_DOSE_{RATE-15}}{TOTAL\_DOSE_{RATE-15}}\right] * 100\%$$

$CLASS\_3a\_DOSE_{RATE\text{-}10}$ = EPRI accident Class 3a dose rate given a 1-in-10 years ILRT interval

= 1.12×10^{-3} [Table 2-9]

$CLASS\_3b\_DOSE_{RATE-10}$ = EPRI accident Class 3b dose rate given a 1-in-10 years ILRT interval
= 3.91×10^{-4} [Table 2-9]

$TOTAL\_DOSE_{RATE-10}$ = Total dose rate for all EPRI's classes given a 1-in-10 years ILRT interval
= 12.0215 [Table 2-9]

Therefore,

$$PER\_CTD_{15} = \left[\frac{1.12\times10^{-3} + 3.91\times10^{-4}}{12.0215}\right] * 100\% = 0.0126\%$$

Based on the above results, the changes from the 1-in-10 years to 1-in-15 years dose rate is as follows:

$$INCREASE_{10-15} = \left[\frac{TOTAL\_DOSE_{RATE-15} - TOTAL\_DOSE_{RATE-10}}{TOTAL\_DOSE_{RATE-10}}\right] * 100\%$$

Where:

$INCREASE_{10-15}$ = percent change from 1-in-10 years ILRT interval to 1-in-15 years ILRT interval

$TOTAL\_DOSE_{RATE-15}$= Total dose rate for all EPRI's classes given a 1-in-15 years ILRT interval
= 12.0215 (person-rem/ry) [Table 2-9]

$TOTAL\_DOSE_{RATE-10}$= Total dose rate for all EPRI's classes given a 1-in-10 years ILRT interval
= 12.0211 (person-rem/ry) [Table 2-9]

Therefore,

$$INCREASE_{10-15} = \left[\frac{12.0215 - 12.0211}{12.0211}\right] * 100\% = 0.0038\%$$

2.4.8 Change in LERF Due to New ILRT Interval (Step 8)

This step, per the NEI Interim Guidance [4] calculates the change in the large early release frequency with extending the ILRT interval from 1-in-10 years to 1-in15-years.

The risk impact associated with extending the ILRT interval involves the potential that a core damage event that normally would result in only a small radioactive release from containment could in fact result in a large release due to failure to detect a pre-existing leak during the relaxation period. For this evaluation only accident Class 3 sequences have the potential to result in large releases if a pre-existing leak were present. Class 1 sequences are not considered as potential large release pathways because for these sequences the containment remains intact. Therefore, the containment leak rate is expected to be small (less than 2La). A larger leak rate would imply an impaired containment, such as classes 2, 3, 6 and 7.

Late releases are excluded regardless of the size of the leak because late releases are, by definition, not a LERF event. At the same time, sequences in the Vermont Yankee PSA [6], which result in large releases (e.g., large isolation valve failures), are not impacted because a LERF will occur regardless of

the presence of a pre-existing leak. Therefore, the frequency of accident Class 3b sequences (Table 2-8) is used as the LERF for Vermont Yankee.

The affect on the LERF risk measure due to the proposed ILRT interval extension is calculated as follows:

$$\Delta LERF_{10\text{-}15} = CLASS\_3b\_FREQUENCY_{15} - CLASS\_3b\_FREQUENCY_{10}$$

Where:

$\Delta LERF_{10\text{-}15}$ = the change in LERF from 1-in-10 years ILRT interval to 1-in-15 years ILRT interval

CLASS_3b_FREQUENC Y_{15} = frequency of EPRI accident Class 3b given a 1-in-15 years ILRT Interval = 8.60×10^{-9}/ry [Table 2-8]

CLASS_3b_FREQUENC Y_{10} = frequency of EPRI accident Class 3b given a 1-in-10 years ILRT Interval = 5.73×10^{-9}/ry [Table 2-8]

Therefore,

$$\Delta LERF_{10\text{-}15} = 8.60 \times 10^{-9}/ry - 5.73 \times 10^{-9}/ry$$

$$\Delta LERF_{10\text{-}15} = 2.87 \times 10^{-9}/ry$$

Regulatory Guide 1.174 [5] provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Regulatory Guide 1.174 [5] defines very small changes in risk as resulting in increases of core damage frequency (CDF) below 10^{-6}/ry and increases in LERF below 10^{-7}/ry. Since the ILRT does not impact CDF, the relevant risk metric is LERF.

This ΔLERF of 2.87×10^{-9}/ry falls into Region III, Very Small Change in Risk (Figure 2-1), of the acceptance guidelines in NRC Regulatory Guide 1.174 [5]. Therefore, because Regulatory Guide 1.174 [5] defines very small changes in LERF as below 10^{-7}/ry, increasing the ILRT interval at Vermont Yankee from the currently allowed 1-in-10 years to 1-in-15 years is non-risk significant from a risk perspective.

It should be noted that if the risk increase is measured from the original 3-in-10-year interval, the increase in LERF is as follows:

$$\Delta LERF_{3\text{-}15} = CLASS\_3b\_FREQUENCY_{15} - CLASS\_3b\_FREQUENCY_{3}$$

Where:

$\Delta LERF_{3\text{-}15}$ = the change in LERF from 3-in-10 years ILRT interval to 1-in-15 years ILRT interval

CLASS_3b_FREQUENC Y_{15} = frequency of EPRI accident Class 3b given a 1-in-15 years ILRT Interval = 8.60×10^{-9}/ry [Table 2-8]

CLASS_3b_FREQUENC Y_{3} = frequency of EPRI accident Class 3b given a 3-in-10 years ILRT Interval = 1.72×10^{-9}/ry [Table 2-8]

Therefore,

$$\Delta LERF_{3\text{-}15} = 8.60 \times 10^{-9}/ry - 1.72 \times 10^{-9}/ry$$

$$\Delta LERF_{3\text{-}15} = 6.88 \times 10^{-9}/ry$$

Similar to the $\Delta LERF_{10\text{-}15}$ result, the $\Delta LERF_{3\text{-}15}$ is also non-risk significant from a risk perspective.

2.4.9 Impact on Conditional Containment Failure Probability (Step 9)

This step, per the NEI Interim Guidance [4] calculates the change in conditional containment failure probability (CCFP). The CCFP risk metric ensures and shows that the proposed change in ILRT interval is consistent with the defense-in-depth philosophy describe in Regulatory Guide 1.174 [5][7].

In this calculation, the change in CCFP tracts the impact of the ILRT on both early (LERF) and late radionuclide releases. Based on the NEI Interim Guidance [4], CCFP consists of all those accident sequences resulting in a radionuclide release other than the intact containment state for EPRI accident Class 1, and small failures state for EPRI accident Class 3a. In addition, the CCFP is conditional given a severe core damage accident. The change in CCFP is calculated by the following equation:

$$CCFP = 1 - \left[\frac{Intact\_Containment\_Frequency}{Total\_CDF} \right]$$

OR

$$CCFP = \left\{ 1 - \left[\frac{CLASS\_1\_FREQ + CLASS\_3a\_FREQ}{CDF_{BASE}} \right] \right\} * 100\%$$

For the 1-in-10 years ILRT interval:

$$CCFP_{10} = \left\{ 1 - \left[\frac{CLASS\_1\_FREQ_{10} + CLASS\_3a\_FREQ_{10}}{CDF_{BASE}} \right] \right\} * 100\%$$

Where:

$CCFP_{10}$ = conditional containment failure probability given 1-in-10 years ILRT interval

CDF_{BASE} = VY PSA L1 core damage frequency = 5.03×10^{-6}/ry [Section 2.3, input #2]

$CLASS\_1\_FREQ_{10}$ = frequency of EPRI accident Class 1 given a 1-in-10 years ILRT Interval
= 5.43×10^{-7}/ry [Table 2-8]

$CLASS\_3a\_FREQ_{10}$ = frequency of EPRI accident Class 3a given a 1-in-10 years ILRT Interval
= 5.73×10^{-8}/ry [Table 2-8]

Therefore,

$$CCFP_{10} = \left\{ 1 - \left[\frac{5.43 \times 10^{-7} + 5.73 \times 10^{-8}}{5.03 \times 10^{-6}} \right] \right\} * 100\% = 87.99\%$$

[7] The defense-in-depth philosophy is maintained as a reasonable balance among prevention of core damage, containment failure and consequence mitigation.

For the 1-in-15 years ILRT interval:

$$CCFP_{15} = \left\{1 - \left[\frac{CLASS\_1\_FREQ_{15} + CLASS\_3a\_FREQ_{15}}{CDF_{BASE}}\right]\right\} * 100\%$$

Where:

$CCFP_{15}$ = conditional containment failure probability given 1-in-15 years ILRT interval

CDF_{BASE} = VY PSA L1 core damage frequency = 5.03×10^{-6}/ry [Section 2.3, input #2]

$CLASS\_1\_FREQ_{15}$ = frequency of EPRI accident Class 1 given a 1-in-15 years ILRT Interval
= 5.12×10^{-7}/ry [Table 2-8]

$CLASS\_3a\_FREQ_{15}$ = frequency of EPRI accident Class 3a given a 1-in-15 years ILRT Interval
= 8.60×10^{-8}/ry [Table 2-8]

Therefore,

$$CCFP_{15} = \left\{1 - \left[\frac{5.12\times10^{-7} + 8.60\times10^{-8}}{5.03\times10^{-6}}\right]\right\} * 100\% = 88.05\%$$

The change in the conditional containment failure probability from 1-in-10 years to 1-in-15 years is calculated as follows:

$\Delta CCFP_{10\text{-}15}$ = $CCFP_{15}$ - $CCFP_{10}$

$\Delta CCFP_{10\text{-}15}$ = 88.05% - 87.99%

$\Delta CCFP_{10\text{-}15}$ = 0.06%

This change in CCFP of less than 1% is insignificant from a risk perspective.

2.5 External Events Impact

In response to Generic Letter 88-20, Supplement 4 [16], VY submitted an Individual Plant Examination of External Events (IPEEE) in June 1996 [17]. The IPEEE was a review of external hazard risk (i.e., seismic, fires, high winds, external flooding, etc) to identify potential plant vulnerabilities and to understand severe accident risks. The results of the VY IPEEE are therefore used in this risk assessment to provide a comparison of the effect of external hazards when extending the current 1-in-10 years to 1-in-15 years Type A ILRT interval.

The VY IPEEE submittal [17] examined a spectrum of external events hazards based on acceptable screening methods (NRC seismic margin [19], the EPRI Fire Induced Vulnerability Evaluation Methodology (FIVE) [26], etc.). These screening methods use varying levels of conservatism; therefore, it is not practical to incorporate realistic quantitative risk assessments of all external event hazards into the ILRT extension assessment at this time. As a result, external events hazards are evaluated as a sensitivity case to demonstrate that the conclusions of the internal events analysis would not be changed if external events hazards were considered.

The impact of external events on this ILRT risk assessment is summarized in this section (refer to Appendix A for further details).

The purpose of the external events evaluation is to determine whether there are any unique insights or important quantitative information that explicitly impact the risk assessment results when considering only internal events.

The quantitative consideration of external hazards is discussed in more detail in Appendix A of this report. As can be seen from Appendix A, if the external hazard risk results of the VY IPEEE are included in this assessment (i.e., in addition to internal events), the change in LERF associated with the increase in ILRT interval from 10 years to 15 years is estimated to be 3.71×10^{-8}/ry. This delta-LERF falls within the Region III, Very Small Change in Risk (Figure 2-1), of NRC Regulatory Guide 1.174 [5].

Other salient results from Appendix A, found the combined internal and external events increase in risk for those accident sequences influenced by Type A testing, compared with the total integrated plant risk, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, to be 0.004% or 0.007 person-rem/ry. In addition, the change in the combined internal and external events conditional containment failure probability from 1-in-10 years to 1-in-15 years is 0.05%. A change in CCFP of less than 1% is insignificant from a risk perspective.

Therefore, incorporating external event accident sequence results into this analysis does not change the conclusion of internal events only risk assessment (i.e., increasing the VY ILRT interval from 10 to 15 years is an acceptable plant change from a risk perspective). This result is expected, because the proposed ILRT interval extension impacts plant risk in a very specific and limited way.

2.6 Containment Liner Corrosion Risk Impact

Recently, the NRC issued a series of Requests for Additional Information (RAIs) in response to the one-time relief requests for the ILRT surveillance interval submitted by various licensees. One of the RAIs related to the risk assessment performed in this report is provided below.

Request for Additional Information:

Inspections of reinforced and steel containments at some facilities (e.g., North Anna, Brunswick D.C. Cook, and Oyster Creek) have indicated degradation from the uninspectable (embedded) side of the steel shell and liner of primary containments. The major uninspectable areas of the Mark I containment are the vertical portion of the drywell shell and part of the shell sandwiched between the drywell floor and the basemat. Please discuss what programs are used to monitor their conditions. Also, address how potential leakage due to age-related degradation from these uninspectable areas are factored into the risk assessment in support of the requested interval extension.

The impact of the risk assessment portion of the above RAIs is summarized in this section (refer to Appendix B for further details).

The containment liner corrosion analysis utilizes the referenced Calvert Cliffs Nuclear Power Plant assessment [20] to estimate the likelihood and risk-implication of degradation-induced leakage occurring and going undetected in visual examinations during the extended test interval. It should be noted that the Calvert Cliffs analysis was performed for a concrete cylinder and dome containment with a steel liner whereas VY has a free standing steel containment building. Both sites do, however, have a concrete basemat with a steel liner.

Consistent with the Calvert Cliffs analysis, the following issues are addressed:

- Differences between the containment basemat and the drywell and torus liner
- The historical drywell/torus steel shell 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

Consistent with Calvert Cliffs analysis [20], the following six steps are performed:

1) Determine the historical liner flaw likelihood.

2) Determine aged adjusted liner flaw likelihood.

3) Determine the increase in flaw likelihood between 3, 10 and 15 years.

4) Determine the likelihood of containment breach given liner flaw.

5) Determine the visual inspection detection failure.

6) Determine the likelihood of non-detected containment leakage.

In additions to these steps, the following three additional steps are added to evaluate risk-implication of containment liner corrosion:

7) Evaluate the risk impact in terms of population dose rate and percentile change for the interval cases.

8) Evaluate the risk impact in terms of LERF.

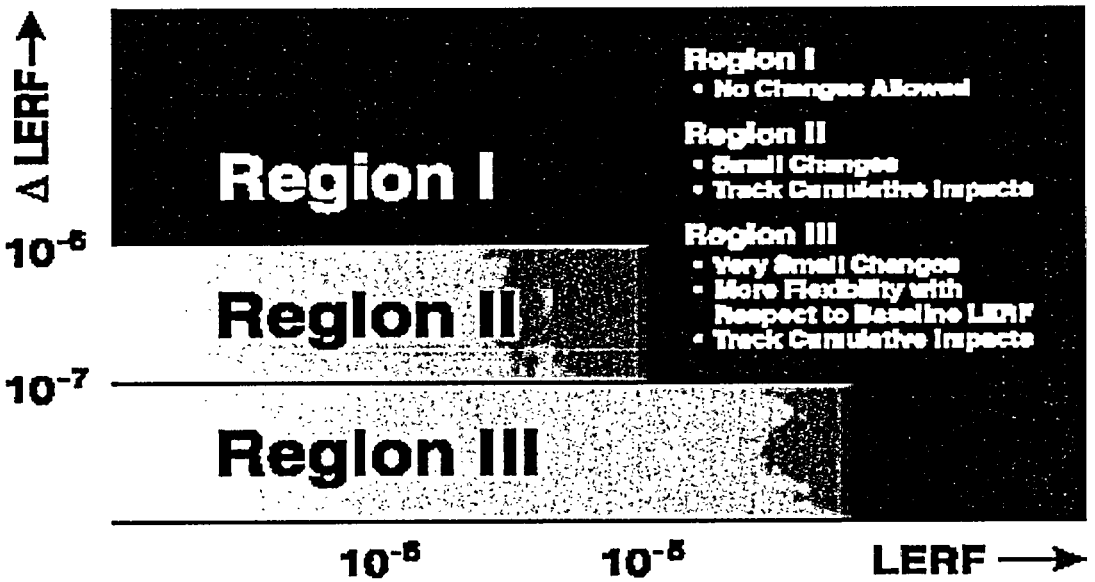
9) Evaluate the change in conditional containment failure probability.

The quantitative consideration of the containment liner corrosion analysis is discussed in more detail in Appendix B of this report. As can be seen from Appendix B, including corrosion effects in the ILRT assessment would not alter the conclusions from the original internal events analysis. That is, the change in LERF from extending the interval to 15 years from the current 10-year requirement is estimated to be 3.19×10^{-9}/ry. This value is below the NRC Regulatory Guide 1.174 [5] of 10^{-7}/ry. Therefore, because Regulatory Guide 1.174 [5] defines very small changes in LERF as below 10^{-7}/ry, increasing the ILRT interval at VY from the currently allowed 1-in-10 years to 1-in-15 years and taking into consideration the likelihood of a containment liner flaw due to corrosion is non-risk significant from a risk perspective. Additionally, the dose increase is estimated to be 5.00×10^{-4} person-rem/ry or 0.0042%, and the conditional containment failure probability increase is estimated to be 0.06%. Both of these increases are also considered to be small. As a result, the ILRT interval extension is considered to have a minimal impact on plant risk (including age-adjusted corrosion impacts), and is therefore acceptable.

In addition, a series of parametric sensitivity studies (discussed in more detail in Appendix B of this report) regarding the potential age related corrosion effects on the containment steel liner also predict that even with conservative assumptions, the conclusions from the original internal events analysis would not change.

Figure 2-1

Acceptance Guidelines[8] for Large Early Release Frequency [5]



[8] The analysis will be subject to increased technical review and management attention as indicated by the darkness of the shading of the figure. In the context of the integrated decisionmaking, the boundaries between regions should not be interpreted as being definitive; the numerical values associated with defining the regions in the figure are to be interpreted as indicative values only.

Table 2-1

Internal Core Damage Frequency Contributions by Plant Damage States

Bin	Bin Description	Frequency	Percent Total CDF
ID	Transient sequences with loss of all injection. Core damage occurs with the reactor at low pressure.	1.4219×10^{-6}	28.25%
IA	Transient sequences with loss of all high pressure injection and failure to depressurize. Core damage occurs with the reactor at high pressure.	1.1321×10^{-6}	22.50%
IBL	'Late' SBO. Core cooling is maintained by HPCI/RCIC until batteries deplete.	8.3971×10^{-7}	16.69%
IIA	Transient sequence with loss of all containment heat removal. Core damage is caused by containment failure.	4.3501×10^{-7}	8.64%
IBE	'Early' SBO sequences. Core damage occurs due to early failure of HPCI and RCIC.	3.1907×10^{-7}	6.34%
IIIB	Small or Medium LOCA sequences for which the reactor cannot be depressurized prior to core damage occurring.	2.0785×10^{-7}	4.13%
IIV	Transient sequences where the main condenser and RHR fail, and the torus vent opens for containment pressure relief. Core damage occurs when ECCS systems fail NPSH, due to failure to reclose the vent.	1.8050×10^{-7}	3.59%
IIIC	LOCA sequences with loss of injection. Core damage occurs with the reactor at low pressure.	1.3739×10^{-7}	2.73%
IVA	ATWS sequences where core damage is caused by containment failure.	1.1218×10^{-7}	2.23%
IED	'Early' SBO sequences caused by failure of DC-1 and DC-2.	5.6127×10^{-8}	1.12%
V	Containment Bypass sequences. (Interfacing systems LOCA and LOCA outside of containment.)	5.3176×10^{-8}	1.06%
IVL	ATWS sequences where core damage occurs due to overpressure failure of the Reactor Coolant System.	5.2938×10^{-8}	1.05%
IIL	Loss of containment heat removal with RPV breach but no initial core damage; core damage after containment failure.	4.7995×10^{-8}	0.95%
IC	ATWS sequences where core damage is caused by loss of injection during level/power control.	1.6074×10^{-8}	0.32%
IEC	Transient sequences with delayed loss of dc power due to failure of battery chargers.	9.8624×10^{-9}	0.20%
IIID	LOCA sequences where core damage is caused by containment failure. Containment fails due to failure of vapor suppression (stuck-open vacuum breaker.)	6.3348×10^{-9}	0.13%
IIIA	RPV ruptures due to failure of all over-pressure protection systems (SO=F).	4.3631×10^{-9}	0.09%
	TOTAL	5.0326×10^{-6}	100%

Table 2-2

Summary of Vermont Yankee PSA LEVEL 2 Release Categories [6]

Release Category	Frequency (/ry)	% of Total CDF
Early High	1.51×10^{-6}	31.01
Intermediate High	4.37×10^{-9}	0.09
Late High	6.53×10^{-7}	12.99
Early Medium	2.09×10^{-6}	41.57
Intermediate Medium	2.43×10^{-9}	0.05
Late Medium	1.83×10^{-8}	0.36
Early Low	7.81×10^{-8}	1.55
Intermediate Low	0.00×10^{0}	< 0.01
Late Low	0.00×10^{0}	< 0.01
Early Low-Low	4.04×10^{-9}	0.08
Intermediate Low-Low	1.07×10^{-8}	0.21
Late Low-Low	0.00×10^{0}	< 0.01
Containment Bypass (V-Seq)	5.32×10^{-8}	1.08
No Containment Failure (NCF)	6.06×10^{-7}	12.07
TOTAL	5.03×10^{-6}	100.00

Nomenclature:

Timing:

Late : greater than 24 hours.
Intermediate : 6 to 24 hours.
Early : Less than 6 hours.

Magnitude:

NCF : Little to no release.
Low-Low : Less than 0.1% Iodine.
Low : 0.1 to 1% Cs Iodine.
Medium : 1 to 10% Cs Iodine.
High : Greater than 10% Cs Iodide

Containment Bypass:

V-Seq : ISLOCA & LOCAOC accident sequences; these are treated as Early High releases.

Table 2-3

Summary of VY PSA LEVEL 2 Containment Failures [6]

Containment End State	Frequency (/ry)	% Of Total CDF
No Containment Failure	6.06×10^{-7}	12.1
Containment Isolation Failure[9]	2.55×10^{-8}	0.5
Containment Failure – Energetic Phenomena	3.22×10^{-7}	6.4
Containment Failure – Contact w/core material	3.85×10^{-6}	76.5
Containment Failure – Loss of Heat Removal Capability	9.71×10^{-9}	0.2
Bypass (ATWS/ISLOCA/LOCAOC)	2.16×10^{-7}	4.3

[9] VY containment isolation failures include large containment isolation failures (failure-to-close), small isolation failures (liner breach), and large isolation failures (liner breach).

Total	5.03×10^{-6}	100.0

Table 2-4

VY Population Doses for Each PSA LEVEL 2 Release Category

Release Category	Population Dose (person-sv)
No Containment Failure (NCF)	$1.30 \times 10^{+1}$
Early High	$2.73 \times 10^{+4}$
Intermediate High	$3.53 \times 10^{+4}$
Late High	$2.69 \times 10^{+4}$
Early Medium	$1.47 \times 10^{+4}$
Intermediate Medium	$1.02 \times 10^{+4}$
Late Medium	$1.13 \times 10^{+4}$
Early Low	$2.11 \times 10^{+3}$
Intermediate Low	$2.71 \times 10^{+3}$
Late Low	–
Early Low-Low	$6.18 \times 10^{+2}$
Intermediate Low-Low	$2.80 \times 10^{+2}$
Late Low-Low	–
Containment Bypass (V-Seq)	$2.96 \times 10^{+4}$

Table 2-5

VY PSA Level 2 Release Frequencies As A Function of EPRI Accident Class

EPRI Class	Accident Class Description	Frequency (/ry)	% Of Total CDF
1	No Containment Failure	5.88×10^{-7}	11.75%
2	Large Containment Isolation Failures (Failure-to-close)	2.14×10^{-9}	0.04%
3a	Small Isolation Failures (Liner breach)	1.72×10^{-8}	0.34%
3b	Large Isolation Failures (Liner Breach)	1.72×10^{-9}	0.03%
4	Small isolation failure - failure-to-seal (Type B test)	---	---
5	Small isolation failure - failure-to-seal (Type C test)	---	---
6	Containment Isolation Failures (dependent failures, personnel errors)	---	---
7a	Severe Accident Phenomena Induced Containment Failure - energetic phenomena	3.22×10^{-7}	6.44%
7b	Severe Accident Phenomena Induced Containment Failure - direct contact with core material	3.85×10^{-6}	76.87%
7c	Severe Accident Phenomena Induced Containment Failure - containment failures due to loss of heat removal	9.71×10^{-9}	0.19%
8a	Containment Bypassed (ATWS)	1.63×10^{-7}	3.26%
8b	Containment Bypassed (ISLOCA, LOCAOC)	5.32×10^{-8}	1.06%
	TOTAL	5.00×10^{-6}	100.00%

Table 2-6

VY Population Dose Estimates As A
Function of EPRI Accident Class within 50-Mile Radius

EPRI Class	Accident Class Description	Person-Rem within 50 miles
1	No Containment Failure	1.30×10^3
2	Large Containment Isolation Failures (Failure-to-close)	2.73×10^6
3a	Small Isolation Failures (Liner breach)	1.30×10^4
3b	Large Isolation Failures (Liner Breach)	4.55×10^4
4	Small isolation failure - failure-to-seal (Type B test)	--
5	Small isolation failure - failure-to-seal (Type C test)	--
6	Containment Isolation Failures (dependent failures, personnel errors)	--
7a	Severe Accident Phenomena Induced Containment Failure - energetic phenomena	2.73×10^6
7b	Severe Accident Phenomena Induced Containment Failure - direct contact with core material	2.73×10^6
7c	Severe Accident Phenomena Induced Containment Failure - containment failures due to loss of heat removal	3.53×10^6
8a	Containment Bypassed (ATWS)	2.73×10^6
8b	Containment Bypassed (ISLOCA, LOCAOC)	2.96×10^6

Table 2-7

VY Dose Rate Estimates as a Function of EPRI Accident Class For Population within 50-Miles (Base Line 3 per 10 year ILRT)

EPRI Class	Accident Class Description	Person-Rem within 50 miles	Frequency (/ry)	Dose Rate (Person-Rem/ry)
1	No Containment Failure	1.30×10^{3}	5.88×10^{-7}	7.64×10^{-4}
2	Large Containment Isolation Failures (Failure-to-close)	2.73×10^{6}	2.14×10^{-9}	5.85×10^{-3}
3a	Small Isolation Failures (Liner breach)	1.30×10^{4}	1.72×10^{-8}	2.24×10^{-4}
3b	Large Isolation Failures (Liner Breach)	4.55×10^{4}	1.72×10^{-9}	7.83×10^{-5}
4	Small isolation failure - failure-to-seal (Type B test)	--	---	---
5	Small isolation failure - failure-to-seal (Type C test)	--	---	---
6	Containment Isolation Failures (dependent failures, personnel errors)	--	---	---
7a	Severe Accident Phenomena Induced Containment Failure - energetic phenomena	2.73×10^{6}	3.22×10^{-7}	8.79×10^{-1}
7b	Severe Accident Phenomena Induced Containment Failure - direct contact with core material	2.73×10^{6}	3.85×10^{-6}	$1.05 \times 10^{+1}$
7c	Severe Accident Phenomena Induced Containment Failure - containment failures due to loss of heat removal	3.53×10^{6}	9.71×10^{-9}	3.43×10^{-2}
8a	Containment Bypassed (ATWS)	2.73×10^{6}	1.63×10^{-7}	4.46×10^{-1}
8b	Containment Bypassed (ISLOCA, LOCAOC)	2.96×10^{6}	5.32×10^{-8}	1.57×10^{-1}
		TOTALS	5.00×10^{-6}	$1.20 \times 10^{+1}$

Table 2-8
EPRI Accident Class Frequency as a Function of ILRT Interval

EPRI Class	Baseline (3-per-10 year ILRT) /ry	Current (1-in-10 years ILRT) /ry	Proposed (1-per-15 year ILRT) /ry
1	5.88×10^{-7}	5.43×10^{-7}	5.12×10^{-7}
3a	1.72×10^{-8}	5.73×10^{-8}	8.60×10^{-8}
3b	1.72×10^{-9}	5.73×10^{-9}	8.60×10^{-9}

Table 2-9
Baseline Dose Rate Estimates By EPRI Accident Class for Population Within 50-Mile

EPRI Class	Accident Class Description	Dose Rate as a Function of ILRT Interval (Person-Rem / ry)		
		Baseline	Current	Proposed
		3-per-10 years ILRT	1-per-10 years ILRT	1-per-15 years ILRT
1	No Containment Failure	7.64×10^{-4}	7.06×10^{-4}	6.65×10^{-4}
2	Large Containment Isolation Failures (Failure-to-close)	5.85×10^{-3}	5.85×10^{-3}	5.85×10^{-3}
3a	Small Isolation Failures (Liner breach)	2.24×10^{-4}	7.46×10^{-4}	1.12×10^{-3}
3b	Large Isolation Failures (Liner Breach)	7.83×10^{-5}	2.61×10^{-4}	3.91×10^{-5}
4	Small isolation failure - failure-to-seal (Type B test)	---	---	---
5	Small isolation failure - failure-to-seal (Type C test)	---	---	---
6	Containment Isolation Failures (dependent failures, personnel errors)	---	---	---
7a	Severe Accident Phenomena Induced Containment Failure - energetic phenomena	8.79×10^{-1}	8.79×10^{-1}	8.79×10^{-1}
7b	Severe Accident Phenomena Induced Containment Failure - direct contact with core material	$1.05 \times 10^{+1}$	$1.05 \times 10^{+1}$	$1.05 \times 10^{+1}$
7c	Severe Accident Phenomena Induced Containment Failure - containment failures due to loss of heat removal	3.43×10^{-2}	3.43×10^{-2}	3.43×10^{-2}
8a	Containment Bypassed (ATWS)	4.46×10^{-1}	4.46×10^{-1}	4.46×10^{-1}
8b	Containment Bypassed (ISLOCA, LOCAOC)	1.57×10^{-1}	1.57×10^{-1}	1.57×10^{-1}
	TOTALS	12.0204	12.0211	12.0215

SECTION 3

SUMMARY OF RESULTS

3.1 Internal Events Impact

An evaluation was performed to assess the risk impact of extending the current containment Type A Integrated Leak Rate Test (ILRT) interval. In performing the risk assessment evaluation, the guidance and additional information distributed by NEI in November 2001 to their Administrative Points of Contact [3,4] regarding risk assessment evaluation of one-time extensions of containment ILRT intervals and the approach outlined in the Indian Point Unit Three Nuclear Power Plant ILRT [8, 9] extension submittal were used. The assessment also followed previous work as outline in NEI 94-01 [1], the methodology used in EPRI TR-104285 [2], and the NRC Regulatory Guide 1.174 [5].

These results demonstrate a very small impact on risk associated with the one time extension of the ILRT test interval to 15 years. The following is a brief summary of some of the key aspects of the ILRT test interval extension risk analysis:

1) The baseline (3-in-10 years) risk contribution (person-rem) associated with containment leakage affected by the ILRT and represented by Classes 3a and 3b accident scenarios is 0.003% of the total risk.

2) When the ILRT interval is 1-in-10 years, the risk contribution of leakage (person-rem) represented by Classes 3a and 3b accident scenarios increases to 0.008% of the total risk.

3) When the ILRT interval is 1-in-15 years, the risk contribution of leakage represented by Classes 3a and 3b accident scenarios increases to 0.013% of the total risk.

4) The increase in risk on the total integrated plant risk as measured by person-rem/reactor year increases for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004% (0.0005 person-rem/ry). This value can be considered to be a negligible increase in risk.

5) The risk increase in LERF from reducing the ILRT test frequency from the current once-per-l 0 years to once-per-15 years is 2.87 x 10^{-9}/ry. This is determined to be very small using the acceptance guidelines of Regulatory Guide 1.174.

6) The risk increase in LERF from the original 3-in-10 years test frequency; to once-per-15 years is 6.88 x 10^{-9}/ry. This is also found to be "very small" using the acceptance guidelines in Regulatory Guide 1.174.

7) The change in CCFP of 0.06% is deemed to be insignificant and reflects sufficient defense-in-depth.

8) Other salient results are summarized in Table 3-1. The key results to this risk assessment are those for the 10-year interval (current VY ILRT interval) and the 15-year interval (proposed change). The 3-in-10 year ILRT is a baseline starting point for this risk assessment given that the pre-existing containment leakage probabilities (estimated based on industry experience – refer to Section 1.2) are reflective of the 3-per-10 year ILRT testing.

3.2 External Events Impact

This analysis provides an evaluation of external events hazards (seismic, fires, high winds, external flooding, etc) impacts within the framework of the ILRT interval extension risk assessment. Similar to the internal events analysis, the combined impact of internal and external events confirms that the impact (due to the proposed ILRT extension) on the external hazard portion of the VY plant risk profile is comparable to that shown for internal events. It is deemed that the calculated risk increase for both internal and external hazards would remain "small".

These results demonstrate a small impact on risk associated with the one time extension of the ILRT test interval to 15 years. The following is a brief summary of some of the key aspects of the ILRT test interval extension risk analysis for the combined internal and external events analysis:

1) The baseline (3-in-10 years) risk contribution (person-rem) associated with containment leakage affected by the ILRT and represented by Classes 3a and 3b accident scenarios is 0.003% of the total risk.

2) When the ILRT interval is 1-in-10 years, the risk contribution of leakage (person-rem) represented by Classes 3a and 3b accident scenarios increases to 0.008% of the total risk.

3) When the ILRT interval is 1-in-15 years, the risk contribution of leakage represented by Classes 3a and 3b accident scenarios increases to 0.012% of the total risk.

4) The combined internal and external events increase in risk on the total integrated plant risk for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004% (0.007 person-rem/ry). This value can be considered to be a negligible increase in risk.

5) The combined internal and external events risk increase in LERF from reducing the ILRT test frequency from the current once-per-10 years to once-per-15 years is 3.71×10^{-8}/ry. This is less than 10^{-7}/ry, which is within the bounds of Region III, Very Small Change in Risk (Figure 2-1), of the acceptance guidelines of Regulatory Guide 1.174.

6) The combined internal and external events change in CCFP of 0.06% is deemed to be insignificant and reflects sufficient defense-in-depth.

7) Other salient results are summarized in Table 3-2.

3.3 Containment Liner Corrosion Risk Impact

This analysis provides a sensitivity evaluation of considering potential corrosion impacts within the framework of the ILRT interval extension risk assessment. The analysis confirms that the ILRT interval extension has a minimal impact on plant risk. Additionally, a series of parametric sensitivity studies regarding the potential age related corrosion effects on the steel shell also indicate that even with very conservative assumptions, the conclusions from the original analysis would not change. That is, the ILRT interval extension is judged to have a minimal impact on plant risk and is therefore acceptable.

1) The baseline (3-in-10 years) risk contribution (person-rem) associated with containment leakage affected by the ILRT and represented by Classes 3a and 3b accident scenarios is 0.0027% of the total risk.

2) When the ILRT interval is 1-in-10 years, the risk contribution of leakage (person-rem) represented by Classes 3a and 3b accident scenarios increases to 0.0085% of the total risk.

3) When the ILRT interval is 1-in-15 years, the risk contribution of leakage represented by Classes 3a and 3b accident scenarios increases to 0.0128% of the total risk.

4) The age-adjusted corrosion impact on the total integrated plant risk for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.0042% (0.0005 person-rem/ry). This value can be considered to be a negligible increase in risk.

5) The age-adjusted corrosion impact risk increase in LERF from reducing the ILRT test frequency from the current once-per-10 years to once-per-15 years is 3.19×10^{-9}/ry. This is determined to be below the 10^{-7}/ry criterion of Region III, Very Small Change in Risk (Figure 2-1), of the acceptance guidelines of Regulatory Guide 1.174.

6) This age-adjusted corrosion impact change in CCFP of 0.06% is deemed to be insignificant and reflects sufficient defense-in-depth.

7) Other results (taken from Appendix B) of the updated ILRT assessment including the potential impact from non-detected containment leakage scenarios assuming that 100% of the leakages result in EPRI Class 3b are show in Table 3-3.

Additional sensitivity cases were also developed to gain an understanding of the containment liner corrosion sensitivity to various key parameters. The sensitivity cases are as follows:

- Sensitivity Case 1 - Flaw rate doubles every 2 years
- Sensitivity Case 2 - Flaw rate doubles every 10 years
- Sensitivity Case 3 - 5% Visual inspection failures
- Sensitivity Case 4 - 15% Visual inspection failures
- Sensitivity Case 5 - Containment breach base point 10 times lower
- Sensitivity Case 6 - Containment breach base point 10 times higher
- Sensitivity Case 7 - Flaw rate doubles every 10 years, containment breach base point 10 times lower, 5% visual inspection failures and 10% EPRI accident Class 3b are LERF (Lower bound)
- Sensitivity Case 8 - Flaw rate doubles every 2 years, containment breach base point 10 times higher, 15% visual inspection failures and 100% EPRI accident Class 3b are LERF (upper bound)

The results of the containment liner corrosion sensitivities cases, taken from Appendix B are summarized in Table 3-4.

Table 3-1

Summary of Risk Impact on Extending Type A ILRT Test Frequency – Internal Events

	Base Case 3 Years			Extend to 10 Years			Extend to 15 Years		
EPRI Class	CDF (Per ry)	Per-Rem	Per-Rem (Per ry)	CDF (Per ry)	Per-Rem	Per-Rem (Per ry)	CDF (Per ry)	Per-Rem	Per-Rem (Per ry)
1	5.88×10^{-7}	1.30×10^{3}	7.64×10^{-4}	5.43×10^{-7}	1.30×10^{3}	7.06×10^{-4}	5.12×10^{-7}	1.30×10^{3}	6.65×10^{-4}
2	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}
3a	1.72×10^{-8}	1.30×10^{4}	2.24×10^{-4}	5.73×10^{-8}	1.30×10^{4}	7.46×10^{-4}	8.60×10^{-8}	1.30×10^{4}	1.12×10^{-3}
3b	1.72×10^{-9}	4.55×10^{4}	7.83×10^{-5}	5.73×10^{-9}	4.55×10^{4}	2.61×10^{-4}	8.60×10^{-9}	4.55×10^{4}	3.91×10^{-5}
4	--	--	0.00	--	--	0.00	--	--	0.00
5	--	--	0.00	--	--	0.00	--	--	0.00
6	--	--	0.00	--	--	0.00	--	--	0.00
7a	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}
7b	3.85×10^{-6}	2.73×10^{6}	$1.05 \times 10^{+1}$	3.85×10^{-6}	2.73×10^{6}	$1.05 \times 10^{+1}$	3.85×10^{-6}	2.73×10^{6}	$1.05 \times 10^{+1}$
7c	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}
7d	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}
8	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}
Total	5.00×10^{-6}	--	12.0204	5.00×10^{-6}	--	12.0211	5.00×10^{-6}	--	12.0215
ILRT Dose Rate from 3a and 3b			3.02×10^{-4}			1.01×10^{-3}			1.51×10^{-3}
% Of Total			0.0025%			0.0084%			0.0126%
Delta Dose Rate from 3a and 3b (10 to 15 yr)									5.03×10^{-4}
LERF from 3b			1.72×10^{-9}			5.73×10^{-9}			8.60×10^{-9}
Delta LERF (10 to 15 yr)									2.87×10^{-9}
CCFP %			87.91%			87.99%			88.05%
Delta CCFP % (10 to 15 yr)									0.06%

Table 3-2

Summary of Risk Impact on Extending Type A ILRT Test Frequency – Effect of Internal and External Events Risk on VY ILRT Risk Assessment

	Base Case 3 Years			Extend to 10 Years			Extend to 15 Years		
EPRI Class	CDF (Per ry)	Per-Rem	Per-Rem (Per ry)	CDF (Per ry)	Per-Rem	Per-Rem (Per ry)	CDF (Per ry)	Per-Rem	Per-Rem (Per ry)
1	7.96×10^{-6}	1.30×10^{3}	1.03×10^{-2}	7.40×10^{-6}	1.30×10^{3}	9.62×10^{-3}	6.99×10^{-6}	1.30×10^{3}	9.08×10^{-3}
2	2.90×10^{-8}	2.73×10^{6}	7.93×10^{-2}	2.90×10^{-8}	2.73×10^{6}	7.93×10^{-2}	2.90×10^{-8}	2.73×10^{6}	7.93×10^{-2}
3a	2.33×10^{-7}	1.30×10^{4}	3.03×10^{-3}	7.42×10^{-7}	1.30×10^{4}	9.64×10^{-3}	1.11×10^{-6}	1.30×10^{4}	1.45×10^{-2}
3b	2.33×10^{-8}	4.55×10^{4}	1.06×10^{-3}	7.42×10^{-8}	4.55×10^{4}	3.38×10^{-3}	1.11×10^{-7}	4.55×10^{4}	5.06×10^{-3}
4	--	--	0.00	--	--	0.00	--	--	0.00
5	--	--	0.00	--	--	0.00	--	--	0.00
6	--	--	0.00	--	--	0.00	--	--	0.00
7a	4.36×10^{-6}	2.73×10^{6}	1.19×10^{1}	4.36×10^{-6}	2.73×10^{6}	1.19×10^{1}	4.36×10^{-6}	2.73×10^{6}	1.19×10^{1}
7b	5.21×10^{-5}	2.73×10^{6}	1.42×10^{2}	5.21×10^{-5}	2.73×10^{6}	1.42×10^{2}	5.21×10^{-5}	2.73×10^{6}	1.42×10^{2}
7c	1.31×10^{-7}	3.53×10^{6}	4.64×10^{-1}	1.31×10^{-7}	3.53×10^{6}	4.64×10^{-1}	1.31×10^{-7}	3.53×10^{6}	4.64×10^{-1}
7d	2.21×10^{-6}	2.73×10^{6}	6.06×10^{0}	2.21×10^{-6}	2.73×10^{6}	6.06×10^{0}	2.21×10^{-6}	2.73×10^{6}	6.06×10^{0}
8	7.20×10^{-7}	2.96×10^{6}	2.13×10^{0}	7.20×10^{-7}	2.96×10^{6}	2.13×10^{0}	7.20×10^{-7}	2.96×10^{6}	2.13×10^{0}
Total	6.77×10^{-5}	--	162.7729	6.77×10^{-5}	--	162.7811	6.77×10^{-5}	--	162.7871
ILRT Dose Rate from 3a and 3b		4.09×10^{-3}			1.30×10^{-2}			1.95×10^{-2}	
% Of Total		0.0025%			0.0080%			0.0120%	
Delta Dose Rate from 3a and 3b (10 to 15 yr)								6.51×10^{-3}	
LERF from 3b		2.33×10^{-8}			7.42×10^{-8}			1.11×10^{-7}	
Delta LERF (10 to 15 yr)								3.71×10^{-8}	
CCFP %		87.91%			87.99%			88.04%	
Delta CCFP % (10 to 15 yr)								0.05%	

Table 3-3

Summary of Risk Impact on Extending Type A ILRT Test Frequency – Impact of Containment Steel Liner Corrosion on VY ILRT Intervals

	Base Case 3 Years			Extend to 10 Years			Extend to 15 Years		
EPRI Class	CDF (Per Ry)	Per-Rem	Per-Rem (Per Ry)	CDF (Per Ry)	Per-Rem	Per-Rem (Per Ry)	CDF (Per Ry)	Per-Rem	Per-Rem (Per Ry)
1	5.88×10^{-7}	1.30×10^{3}	7.64×10^{-4}	5.43×10^{-7}	1.30×10^{3}	7.06×10^{-4}	5.11×10^{-7}	1.30×10^{3}	6.65×10^{-4}
2	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}
3a	1.72×10^{-8}	1.30×10^{4}	2.24×10^{-4}	5.73×10^{-8}	1.30×10^{4}	7.46×10^{-4}	8.60×10^{-8}	1.30×10^{4}	1.12×10^{-3}
3b	1.76×10^{-9}	4.55×10^{4}	8.01×10^{-5}	5.97×10^{-9}	4.55×10^{4}	2.72×10^{-4}	9.16×10^{-9}	4.55×10^{4}	4.17×10^{-4}
4	0.0	N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0
5	0.0	N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0
6	0.0	N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0
7a	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}
7b	3.85×10^{-6}	2.73×10^{6}	1.05×10^{1}	3.85×10^{-6}	2.73×10^{6}	1.05×10^{1}	3.85×10^{-6}	2.73×10^{6}	1.05×10^{1}
7c	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}
8a	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}
8b	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}
Total	5.00×10^{-6}		12.0204	5.00×10^{-6}		12.0211	5.00×10^{-6}		12.0216
ILRT Dose Rate from 3a and 3b			3.04×10^{-4} ($+1.86 \times 10^{-6}$)*			1.02×10^{-3} ($+1.08 \times 10^{-5}$)*			1.54×10^{-3} ($+2.53 \times 10^{-5}$)*
% Of Total			0.0025% (+0.00002%)*			0.0085% (+0.0001%)*			0.0128% (+0.0002%)*
Delta Dose Rate from 3a and 3b (10 to 15 yr)									5.00×10^{-4} (+0.0014%)*
LERF from 3b			1.76×10^{-9} ($+4.09 \times 10^{-11}$)*			5.97×10^{-9} ($+2.38 \times 10^{-10}$)*			9.16×10^{-9} ($+5.56 \times 10^{-10}$)*
Delta LERF (10 to 15 yr)									3.19×10^{-9} ($+3.18 \times 10^{-10}$)*
CCFP %			87.98% (+0.0008%)*			88.07% (+0.0167%)*			88.13% (+0.0111%)*
Delta CCFP % (10 to 15 yr)									0.06% (+0.0063%)*

* Denotes increase from original values presented in Section 2.4, Steps 7, 8, and 9 of this report.

Table 3-4

Containment Steel Liner Corrosion Sensitivity Cases

Age (Step 2)	Drywell/ Torus Breach (Step 4)	Visual Inspection & Non-Visual Flaws (Step 5)	Likelihood Flaw is LERF (EPRI Class 3b)	LERF Increase From Corrosion (3-in-10 years)	LERF Increase From Corrosion (1-in-10 years)	LERF Increase From Corrosion (1 to 15 years)	Total LERF Increase From ILRT Extension (10 to 15 years)
Base Case Doubles every 5 yrs	Base Case 0.8017%liner 0.0802%floor	Base Case 10%	Base Case 100%	Base Case 4.09×10^{-11}	Base Case 2.38×10^{-10}	Base Case 5.56×10^{-10}	Base Case 3.19×10^{-9}
Doubles every 2 yrs	Base	Base	Base	1.17×10^{-11}	1.99×10^{-10}	1.15×10^{-9}	3.82×10^{-9}
Doubles every 10 yrs	Base	Base	Base	6.08×10^{-11}	8.33×10^{-11}	1.08×10^{-10}	2.89×10^{-9}
Base	Base	5%	Base	3.91×10^{-11}	2.28×10^{-10}	5.32×10^{-10}	3179×10^{-9}
Base	Base	15%	Base	4.27×10^{-11}	2.49×10^{-10}	5.81×10^{-10}	3.20×10^{-9}
Base	0.16033%liner[10] 0.01603%floor[14]	Base	Base	8.18×10^{-12}	4.76×10^{-11}	1.11×10^{-10}	2.93×10^{-9}
Base	4.0042% liner[11] 0.4004%floor[15]	Base	Base	2.04×10^{-10}	1.19×10^{-9}	2.78×10^{-9}	4.46×10^{-9}
Lower Bound							
Doubles every 10 yrs	0.16033%liner[14] 0.01603%floor[14]	5%	10%	1.16×10^{-12}	5.03×10^{-12}	9.21×10^{-12}	2.87×10^{-9}
Upper Bound							
Doubles every 2 yrs	4.0042% liner[15] 0.4004%floor[15]	15%	100%	6.11×10^{-11}	1.04×10^{-9}	6.02×10^{-9}	7.85×10^{-9}

[10] Base point 10 times lower than base case of 0.0001 at 20 psia.
[11] Base point 10 times higher than base case of 0.01 at 20 psia.

SECTION 4

CONCLUSIONS

4.1 Internal Events Impact

A risk assessment of the impact of changing VY Integrated Leak Rate Test (ILRT) interval from the currently approved 1-in-10 year interval to a one-time extension to 1-in-15 years has been performed.

Based on the above results, the following are main conclusions regarding the assessment of the plant risk associated with extending the Type A ILRT test frequency from ten-years to fifteen years:

1. Regulatory Guide 1.174 [5] provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Regulatory Guide 1.174 [5] defines very small changes in risk as resulting in increases of CDF below 10^{-6}/ry and increases in LERF below 10^{-7}/ry. Since the ILRT does not impact CDF, the relevant criterion is LERF. The increase in LERF resulting from a change in the Type A ILRT test interval from 1-in-10 years to 1-in-15 years is 2.87×10^{-9}/ry. Since Regulatory Guide 1.174 [5] defines very small changes in LERF as below 10^{-7}/ry, increasing the ILRT interval at VY from the currently allowed one-in-ten years to one-in-fifteen years is non-risk significant from a risk perspective.

2. The increase in risk on the total integrated plant risk as measured by person-rem/reactor year increases for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004% (0.0005 person-rem/ry). This value can be considered to be a negligible increase in risk.

3. The change in conditional containment failure probability (CCFP) is calculated to demonstrate the impact on 'defense-in-depth'. The $\Delta CCFP_{10\text{-}15}$ is found to be 0.06%. This signifies a very small increase and represents a negligible change in the VY containment defense-in-depth.

Table 4-1 summarizes the above conclusions.

4.2 External Events Impact

Based on the results from Appendix A, "External Event Assessment During an Extension of the ILRT Interval," the following are main conclusions regarding the assessment of the plant risk associated with extending the Type A ILRT test frequency from ten-years to fifteen years:

1. Based on conservative methodologies in estimating the core damage frequency for internal events, seismic events, and fires events, the $\Delta LERF_{COMBINED10\text{-}15}$ of 3.71×10^{-8}/ry from extending the VY ILRT frequency from 1-in-10 years to 1-in-15 years is slightly above the 10^{-7}/ry criterion of Region III, Very Small Change in Risk (Figure 2-1), of the acceptance guidelines in NRC Regulatory Guide 1.174 [5]. Therefore, increasing the ILRT interval at VY from the currently allowed 1-in-10 years to 1-in-15 years is non-risk significant from a risk perspective.

2. The combined internal and external events increase in risk on the total integrated plant risk as measured by person-rem/reactor year increases for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004% (0.007 person-rem/ry). This value can be considered to be a negligible increase in risk.

3. The change in the combined internal and external events conditional containment failure probability from 1-in-10 years to 1-in-15 years is 0.05%. A change in ΔCCFP of less than 1% is insignificant from a risk perspective.

Table 4-2 summarizes the above conclusions.

4.3 Containment Liner Corrosion Risk Impact

Based on the results from Appendix B, "Risk Impact of Containment Liner Corrosion During an Extension of the ILRT Interval," the following are main conclusions regarding the assessment of the plant risk associated with extending the Type A ILRT test frequency from ten-years to fifteen years:

1. The impact of including age-adjusted corrosion effects in the ILRT assessment has minimal impact on plant risk and is therefore acceptable.

2. The change in LERF, taking into consideration the likelihood of a containment liner flaw due to age-adjusted corrosion is non-risk significant from a risk perspective. Specifically, extending the interval to 15 years from the current 10 years requirement is estimated to be about 3.19×10^{-9}/ry. This is below the Regulatory Guide 1.174 [5] acceptance criteria threshold of 10^{-7}/ry.

3. The age-adjusted corrosion impact in dose increase is estimated to be 5.0×10^{-4} person-rem/ry or 0.0042% from the baseline ILRT 10 year's interval.

4. The age-adjusted corrosion impact on the conditional containment failure probability increase is estimated to be 0.6%.

5. A series of parametric sensitivity studies regarding potential age related corrosion effects on the containment steel liner also demonstrated minimal impact on plant risk.

Table 4-3 summarizes the above conclusions.

Table 4-1
Quantitative Results as a Function of ILRT Interval - Internal Events

EPRI Class	Category Description	Dose (Person-Rem Within 50 miles)[1]	Quantitative Results as a Function of ILRT Interval			
			Current (1-per-10 year ILRT)		Proposed (1-per-15 year ILRT)	
			Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)	Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)
1	No Containment Failure [2]	1.30×10^{3}	5.43×10^{-7}	7.06×10^{-4}	5.12×10^{-7}	6.65×10^{-4}
2	Containment Isolation System Failure	2.73×10^{6}	2.14×10^{-9}	5.85×10^{-3}	2.14×10^{-9}	5.85×10^{-3}
3a	Small Pre-Existing Failures [2], [3]	1.30×10^{4}	5.73×10^{-8}	7.46×10^{-4}	8.60×10^{-8}	1.12×10^{-3}
3b	Large Pre-Existing Failures [2], [3]	4.55×10^{4}	5.73×10^{-9}	2.61×10^{-4}	8.60×10^{-9}	3.91×10^{-5}
4	Type B Failures (LLRT)	--	0.00	0.00	0.00	0.00
5	Type C Failures (LLRT)	--	0.00	0.00	0.00	0.00
6	Other Containment Isolation System Failure	--	0.00	0.00	0.00	0.00
7a	Containment Failure Due to Severe Accident (a)[4]	2.73×10^{6}	3.22×10^{-7}	8.79×10^{-1}	3.22×10^{-7}	8.79×10^{-1}
7b	Containment Failure Due to Severe Accident (b)[4]	2.73×10^{6}	3.85×10^{-6}	$1.05 \times 10^{+1}$	3.85×10^{-6}	$1.05 \times 10^{+1}$
7c	Containment Failure Due to Severe Accident (c)[4]	3.53×10^{6}	9.71×10^{-9}	3.43×10^{-2}	9.71×10^{-9}	3.43×10^{-2}
7d	Containment Failure Due to Severe Accident (d)[4]	2.73×10^{6}	1.63×10^{-7}	4.46×10^{-1}	1.63×10^{-7}	4.46×10^{-1}
8	Containment Bypass Accidents	2.96×10^{6}	5.32×10^{-8}	1.57×10^{-1}	5.32×10^{-8}	1.57×10^{-1}
TOTALS:			5.00×10^{-6}	12.0211	5.00×10^{-6}	12.0215
Increase in Dose Rate						0.0004
Increase in LERF					2.87×10^{-9}	
Increase in CCFP (%)					0.06%	

Table 4-2

Quantitative Results as a Function of ILRT Interval - Internal and External Events

EPRI Class	Category Description	Dose (Person-Rem Within 50 miles)[1]	Quantitative Results as a Function of ILRT Interval			
			Current (1-per-10 year ILRT)		Proposed (1-per-15 year ILRT)	
			Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)	Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)
1	No Containment Failure [2]	1.30×10^{3}	7.40×10^{-6}	9.62×10^{-3}	6.99×10^{-6}	9.08×10^{-3}
2	Containment Isolation System Failure	2.73×10^{6}	2.90×10^{-8}	7.93×10^{-2}	2.90×10^{-8}	7.93×10^{-2}
3a	Small Pre-Existing Failures [2], [3]	1.30×10^{4}	7.42×10^{-7}	9.64×10^{-3}	1.11×10^{-6}	1.45×10^{-2}
3b	Large Pre-Existing Failures [2], [3]	4.55×10^{4}	7.42×10^{-8}	3.38×10^{-3}	1.11×10^{-7}	5.06×10^{-3}
4	Type B Failures (LLRT)	--	0.00	0.00	0.00	0.00
5	Type C Failures (LLRT)	--	0.00	0.00	0.00	0.00
6	Other Containment Isolation System Failure	--	0.00	0.00	0.00	0.00
7a	Containment Failure Due to Severe Accident (a)[4]	2.73×10^{6}	4.36×10^{-6}	1.19×10^{1}	4.36×10^{-6}	1.19×10^{1}
7b	Containment Failure Due to Severe Accident (b) [4]	2.73×10^{6}	5.21×10^{-5}	1.42×10^{2}	5.21×10^{-5}	1.42×10^{2}
7c	Containment Failure Due to Severe Accident (c) [4]	3.53×10^{6}	1.31×10^{-7}	4.64×10^{-1}	1.31×10^{-7}	4.64×10^{-1}
7d	Containment Failure Due to Severe Accident (d) [4]	2.73×10^{6}	2.21×10^{-6}	6.06×10^{0}	2.21×10^{-6}	6.06×10^{0}
8	Containment Bypass Accidents	2.96×10^{6}	7.20×10^{-7}	2.13×10^{0}	7.20×10^{-7}	2.13×10^{0}
TOTALS:			6.77×10^{-5}	162.7811	6.77×10^{-5}	162.7871
Increase in Dose Rate						0.0065
Increase in LERF					3.71×10^{-8}	
Increase in CCFP (%)					0.05%	

Table 4-3
Quantitative Results as a Function of ILRT Interval - Liner Corrosion Impact

EPRI Class	Category Description	Dose (Person-Rem Within 50 miles)[1]	Quantitative Results as a Function of ILRT Interval			
			Current (1-per-10 year ILRT)		Proposed (1-per-15 year ILRT)	
			Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)	Accident Frequency (per ry)	Population Dose Rate (Person-Rem / Ry Within 50 miles)
1	No Containment Failure [2]	1.30×10^{3}	5.43×10^{-7}	7.40×10^{-4}	5.11×10^{-7}	6.65×10^{-4}
	Containment Isolation System Failure	2.73×10^{6}	2.14×10^{-9}	5.65×10^{-3}	2.14×10^{-9}	5.85×10^{-3}
3a	Small Pre-Existing Failures [2], [3]	1.30×10^{4}	5.73×10^{-8}	7.73×10^{-4}	8.60×10^{-8}	1.12×10^{-3}
3b	Large Pre-Existing Failures [2], [3]	4.55×10^{4}	5.97×10^{-9}	2.82×10^{-4}	9.16×10^{-9}	4.17×10^{-4}
4	Type B Failures (LLRT)	--	0.0	0.00	0.0	0.0
5	Type C Failures (LLRT)	--	0.0	0.00	0.0	0.0
6	Other Containment Isolation System Failure	--	0.0	0.00	0.0	0.0
7a	Containment Failure Due to Severe Accident (a)[4]	2.73×10^{6}	3.22×10^{-7}	8.91×10^{-1}	3.22×10^{-7}	8.79×10^{-1}
7b	Containment Failure Due to Severe Accident (b) [4]	2.73×10^{6}	3.85×10^{-6}	9.99	3.85×10^{-6}	1.05×10^{1}
7c	Containment Failure Due to Severe Accident (c) [4]	3.53×10^{6}	9.71×10^{-9}	3.48×10^{-2}	9.71×10^{-9}	3.43×10^{-2}
8a	Containment Failure Due to Severe Accident (d) [4]	2.73×10^{6}	1.63×10^{-7}	4.16×10^{-1}	1.63×10^{-7}	4.46×10^{-1}
8b	Containment Bypass Accidents	2.96×10^{6}	5.32×10^{-8}	1.57×10^{-1}	5.32×10^{-8}	1.57×10^{-1}
TOTALS:			5.00×10^{-6}	12.0211	5.00×10^{-6}	12.0216
Increase in Dose Rate						0.0042%
Increase in LERF					3.19×10^{-9}	
Increase in CCFP (%)					0.06%	

Notes to Tables 15, 16, and 17:

1) The population dose associated with the Technical Specification Leakage is based on the analysis provided in Reference [24].

2) Only EPRI accident classes 1, 3a, and 3b are affected by ILRT (Type A) interval changes.

3) Dose estimates for EPRI Class 3a and 3b, per the NEI Interim Guidance, are calculated as 10 times EPRI Class 1 dose and 35 times EPRI Class 1 dose, respectively.

4) EPRI Class 7, containment failure due to severe accident, was subdivided into four subgroups based on VY Level 2 containment failure modes for dose allocation purposes. Note that this EPRI class is not affected by ILRT interval changes.

SECTION 5

REFERENCES

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Appendix A

External Event Assessment During an Extension of the ILRT Interval

Table of Contents

Tables

A1.0 Introduction

This appendix discusses the risk-implication associated with external hazards in support of the VY Integrated Leak Rate Testing (ILRT) interval extension risk assessment.

In response to Generic Letter 88-20, Supplement 4 [16], VY submitted an Individual Plant Examination of External Events (IPEEE) in June 1998 [17]. The IPEEE was a review of external hazard risk (i.e., seismic, fires, high winds, external flooding, etc) to identify potential plant vulnerabilities and to understand severe accident risks. The results of the VY IPEEE are therefore used in this risk assessment to provide a comparison of the effect of external hazards when extending the current 1-in-10 years to 1-in-15 years Type A ILRT interval.

A2.0 VY IPEEE Seismic Analysis

A2.1 Seismic Analysis Methodology Selection

The VY plant has been designed to accommodate a safe-shutdown earthquake (SSE) with 0.14g peak ground acceleration (PGA). The seismic analysis performed in the IPEEE study is intended to act as a performance check on the design, estimating seismic capacity beyond the SSE.

The seismic analysis methodology implemented for VY satisfied the NRC requirements for performing a seismic IPEEE as presented in Generic Letter 88-20, Supplement 4 [19]. The methodology comprises an NRC seismic margin assessment (SMA) following the guidance of NUREG-1407 "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," [18] and EPRI NP-6041 "A Methodology for Assessment of Nuclear Power Plant Seismic Margin," [19] and a containment performance analysis. A seismic margin can be expressed in terms of the earthquake motion level that compromises plant safety--the seismic margin assessment determines whether there is high confidence that the plant can survive a given earthquake. No core damage frequency sequences were quantified as part of the IPEEE seismic risk analysis.

Seismic events were evaluated using the Seismic Margins Analysis (SMA) method. The SMA methodology uses a deterministic approach to identify the weakest components in terms of a High Confidence Low Probability of Failure (HCLPF) peak ground acceleration.

The conclusions of the VY IPEEE seismic risk analysis are as follows:

- For Vermont Yankee, the SMA identified that the lowest HCLPF components in the selected primary and alternate safe shutdown paths are the Condensate Storage Tank (CST) with a HCLPF of .25g and the Diesel Fuel Oil Storage Tank (FOST) with a HCLPF of .29g. These values, although below the 0.3g review level earthquake, represent significant margin to the design basis 0.14g earthquake.

- The HCLPF for all other components in the safe shutdown paths meet or exceed the 0.3g review level earthquake upon resolution of A-46 outliers.

A2.2 Seismic Analysis Assumptions

1) The Simplified Hybrid Method as presented in OECD-NEA Workshop on Seismic Risk, "Overview of Methods for Seismic PRA and Margin Analysis Including Recent Innovations" [22] is used to approximate the VY seismic-induced core damage frequency based on the seismic margin analysis results found in the VY IPEEE submittal [17].

A2.3 Seismic Analysis Input

1) Based upon the results from the SMA performed for the Vermont Yankee IPEEE, the individual HCLPF values for the following components will be used to determine the risk impact of seismic events [17]:

Component Description	Component HCLPF
Fuel Oil Storage Tank (FOST)	0.29g PGA
Condensate Storage Tank (CST)	0.25g PGA

2) The 10% NEP standard normal variable is -1.282. This value is derived from the OECD-NEA Workshop on Seismic Risk [22].

3) The 1% NEP standardized normal variable is -2.326. This value is derived from the OECD-NEA Workshop on Seismic Risk [22].

4) The Simplified Hybrid method presented in OECD-NEA Workshop on Seismic Risk [22] recommends a variable factor $\exists$ equal to 0.3 to estimate the plant damage seismic risk.

5) The seismic hazard curve for the VY site, based upon EPRI NP-6395-D, "Probabilistic Seismic Hazard Evaluation at Nuclear Plant Sites in the Central and Eastern United States: Resolution of the Charleston Issue" [23], is summarized in tabular form in Table A-1.

Table A-1
Vermont Yankee's EPRI Site Seismic Hazard Curve

Acceleration	Frequency of Exceedance (/yr)			
(g)	15%	50%	85%	Mean
0.05	2.04E-04	7.06E-04	2.04E-03	1.29E-03
0.08	9.15E-05	3.31E-04	1.04E-03	6.74E-04
0.15	1.99E-05	7.68E-05	2.92E-04	1.96E-04
0.26	4.87E-06	2.32E-05	1.01E-04	6.91E-05
0.31	2.71E-06	1.40E-05	6.62E-05	4.58E-05
0.41	9.84E-07	6.06E-06	3.22E-05	2.29E-05
0.51	3.99E-07	3.01E-06	1.72E-05	1.28E-05
0.66	1.20E-07	1.19E-06	7.57E-06	6.15E-06
0.82	4.27E-08	5.30E-07	3.88E-06	3.32E-06
1.02	1.14E-08	2.01E-07	1.78E-06	1.64E-06

A2.4 Seismic Analysis Method of Analysis

Although quantitative risk information is not directly available from the VY SMA IPEEE analysis, a paper presented by Robert P. Kennedy [22] provides a method called the Simplified Hybrid Method for obtaining a seismic-induced CDF estimate based on results of an SMA analysis. This methodology requires only the plant HCLPF to estimate the seismic CDF. The approach entails the following steps:

Step 1A - Determine the HCLPF seismic capacity C_{HCLPF} from the SMA analysis.

Step 2A - Estimate the 10% conditional probability of failure capacity $C_{10\%}$.

Step 3A - Determine hazard exceedance frequency $H_{10\%}$ that corresponds to $C_{10\%}$ from the hazard curve.

Step 4A - Determine seismic accident type risk P_F.

Step 5A - Determine the seismic core damage frequency (SCDF).

Step 1A - Determine the HCLPF seismic capacity C_{HCLPF} from the SMA analysis

The VY seismic analysis found two components with values above the review level earthquake of 0.3g; fuel oil storage tank and condensate storage tank. The respective HCLPF values are:

$$C_{HCLPF\text{-}FOST} = 0.29g$$
$$C_{HCLPF\text{-}CST} = 0.25g$$

However, the above values do not directly consider the effect of random failures on seismic risk because it uses the HCLPF Maximum/Minimum method to approximate the seismic accident type fragility. Per the OECD-NEA Workshop on Seismic Risk [22] methodology a HCLPF reduction factor is applied to each of the above seismic component to account for non-seismic failures and human errors.

Based on an examination of the seismic IPEEE results a HCLPF reduction factor of 0.7 was selected. As a result, the revised seismic accident type HCLPF values are:

$$C_{HCLPF\text{-}FOST} = 0.29g \;/\; 0.7 = 0.41g$$
$$C_{HCLPF\text{-}CST} = 0.25g \;/\; 0.7 = 0.36g$$

Step 2A - Estimate the 10% conditional probability of failure capacity $C_{10\%}$

Per the work presented in OECD-NEA Workshop on Seismic Risk [???], the 10% conditional probability of failure capacity is calculated as follows:

$$C_{10\%} = F_3 * C_{HCLPF}$$

Where:

$C_{10\%}$ = 10% conditional probability of failure capacity

C_{HCLPF} = seismic component type HCLPF capacity by the CDFM (Conservative Deterministic Failure Margin) method

$$F_3 = e^{(NEP10\%-NEP1\%)3}$$

Where:

NEP10% = 10% NEP standard normal variable is = -1.282 [Input #2]

NEP1% = 1% NEP standard normal variable is = -2.326 [Input #3]

F_3 = variable factor = 0.3 [Input #4]

Therefore, $F_3 = e^{[(-1.282)-(-2.326)]*0.3} = 1.37$

and

$C_{10\%FOST}$ = 1.37 * $C_{HCLPF\text{-}FOST}$ = 1.37 * 0.41 = 0.56g PGA
$C_{10\%CST}$ = 1.37 * $C_{HCLPF\text{-}CST}$ = 1.37 * 0.36 = 0.49g PGA

Step 3A - Determine hazard exceedance frequency $H_{10\%}$ that corresponds to $C_{10\%}$ from the hazard curve

The seismic hazard curve for the VY site, as presented in Table A-1 is used to determine the hazard exceedance frequency $H_{10\%}$ that corresponds to $C_{10\%}$. These are as follows:

Seismic Accident Type	Acceleration (g)	Mean Frequency of Exceedance (/ry)
$H_{10\%FOST}$	0.56	1.06E-6
$H_{10\%CST}$	0.49	1.28E-5

Step 4A - Determine seismic accident type risk PF

Per the OECD-NEA Workshop on Seismic Risk [22], the seismic accident type risk is calculated as follows:

$P_{F\text{-}FOST}$ = 0.5 * $H_{10\%FOST}$ = 0.5 * 1.06E-6 = 5.3E-7/ry
$P_{F\text{-}CST}$ = 0.5 * $H_{10\%CST}$ = 0.5 * 1.28E-5 = 6.4E-6/ry

Because any seismic event results in a loss-of-offsite power, a subsequent failure of the fuel oil storage tank results in a seismic-induced station blackout. Therefore, $P_{F\text{-}FOST}$ represents the seismic-induced station blackout frequency of 5.3E-7/ry and is assigned a core damage accident bin of S-IBL ('Late' SBO. Core cooling is maintained by HPCI/RCIC until batteries deplete).

Similarly; the seismic failure of the condensate storage tank ($P_{F\text{-}CST}$) implies successful emergency diesel generators operation following the occurrence of the seismic-induced loss-of-offsite power. Therefore, this implies a seismic-induced core damage progression resulting in the loss of reactor pressure vessel injection, and is assigned into the core damage accident class 'Transient sequences with loss of all high-pressure injection and failure to depressurize. Core damage occurs with the reactor at high-pressure' (S-IA).

Step 5A - Determine the seismic core damage frequency (SCDF)

The step involves the summation of the individual seismic accident types frequencies.

SCDF = $P_{F\text{-}FOST}$ + $P_{F\text{-}CST}$

SCDF = 5.3E-7/ry + 6.4E-6/ry

SCDF = 6.93E-6/ry

This information is used in Section A5.0 of this appendix to provide insight into the impact of external hazard risk on the conclusions of this ILRT risk assessment.

A3.0 VY IPEEE Fire Analysis

A3.1 Fire Analysis Methodology Selection

The Fire analysis performed for the VY IPEEE submittal [17] used the EPRI Fire Induced Vulnerability Evaluation Methodology (FIVE) [26]. The fire PRA analysis entailed the identification of critical areas of vulnerability, the calculation of fire initiation frequencies, the identification of fire-induced initiating events and their impact on systems, the disabling of critical safety functions, and potential fire-induced containment failure. Based on this examination, the Core Damage Frequency from internal fires is estimated to be 5.58 x 10^{-5}/ry [27].

The VY IPEEE concluded that fire-induced CDF sequences are dominated by the following fire events.

- Cable Vault fire involving redundant divisions of equipment, which require Control Room evacuation and implementation of Alternate Shutdown methods. Automatic or manual suppression is not credited for these fire events based on fire damage calculations using the FIVE method.
- Control Room fire with failure of manual suppression, where Control Room evacuation and implementation of Alternate Shutdown methods are required.
- Switchgear Room fire with failure of automatic suppression. Based on fire damage calculations using the FIVE method, an unsuppressed Switchgear Room fire could result in a loss of normal power, failure of an emergency bus, and degradation of the Vernon Tie. Station power relies on one Emergency Diesel Generator (EDG) and its associated emergency bus.

A3.2 Fire Analysis Method of Analysis

The VY IPEEE submittal [17,27] for the fire induced core damage scenarios and the associated frequency results were reviewed in support of this assessment. The result is judged to be conservative because of limited data and conservative fire propagation and mitigate assumptions. The CDF results for all the compartments, which were quantitatively evaluated, are provided in Table A-2.

This information is used in Section A5.0 of this appendix to provide insight into the impact of external hazard risk on the conclusions of this ILRT risk assessment.

Table A-2
Vermont Yankee's IPEEE Fire Events – Core Damage Frequency Results

Building/ Area	Fire Compartment	Description of Fire Event(s)	Fire Compartment CDF (/ry)
Reactor Building	RBNEC	Northeast ECCS Corner Room, El. 213' and 232'	3.80E-09
	RBHP	HPCI Room, El. 213'	9.00E-09
	RBRCL	Lower RCIC Corner Room, El. 213' at NW Corner	6.70E-08
	RBRCU	Upper RCIC Corner Room, El. 232' at NW Corner	4.50E-08
	RBSEC	Southeast ECCS Corner Room, El. 213' and 232'	1.00E-08
	RBSWC	Southwest CRD Corner Room, El. 213' and 232' (treated as part of RB4)	See RB4
	RB1	Torus Room, El. 213', Zone RB1 (north)	1.30E-07
	RB2	Torus Room, El. 213', Zone RB2 (south)	7.40E-07
	RB3	Reactor Building, El. 252', Zone RB3 (north), Self-ignited Cable Fire	5.10E-06
		Reactor Building, El. 252', Zone RB3 (north), In-situ MCC Fire	

		Reactor Building, El. 252', Zone RB3 (north), transient lube oil spill	
		Reactor Building, El. 252', Zone RB3 (north), transient/in-situ Class A trash fire	
	RB4	Reactor Building, El. 252', Zone RB4 (south), Self-Ignited Cable Fire	3.30E-06
		Reactor Building, El. 252', Zone RB4 (south), CRD Repair Room Fire	
		Reactor Building, El. 252', Zone RB4 (south), In-situ MCC Fire	
		Reactor Building, El. 252', Zone RB4 (south), transient lube oil spill	
		Reactor Building, El. 252', Zone RB4 (south), transient/in-situ Class A trash fire	
	RBMG	Reactor Building, El. 280', Recirc. MG Set Fire	3.40E-07
	RB5	Reactor Building, El. 280', Zone RB5 (north)	7.30E-07
	RB6	Reactor Building, El. 280', Zone RB6 (south)	3.50E-07
	RB303	Reactor Building, El. 303'	4.90E-07
	RB318	Reactor Building, El. 318'	1.90E-08
	RB345	Reactor Building, El. 345'	1.50E-09
	RBSZ-S1	Reactor Building, El. 252', Separation Zone Div. S1 Trays	6.50E-07
	RBSZ-S2	Reactor Building, El. 252', Separation Zone Div. S2 Trays	6.50E-07
Control Building	SGW	West Switchgear Room at El. 248', Bus 1/8 Fire	9.00E-06
		West Switchgear Room at El. 248', Bus 3 Fire	
		West Switchgear Room at El. 248', T-8 Transformer Fire	
	SGE	East Switchgear Room at El. 248', Bus 2/9 Fire	7.00E-06
		East Switchgear Room at El. 248', Bus 4 Fire	
		West Switchgear Room at El. 248', T-9 Transformer Fire	
	CV	Cable Vault, El. 262', Division S1 Panel Fire Affecting Division S2 Cable Trays	1.50E-05
		Cable Vault, El. 262', Division S2 Panel Fire Affecting Division S1 Cable Trays	
		Cable Vault, El. 262', Self-Ignited Cable Fire	
	CVBT	Cable Vault Battery Room, El. 262'	3.20E-06
	CR	Control Room, El. 272'	5.70E-06
Turbine Building	DGA	Emergency Diesel Generator Room A	4.50E-07
	DGB	Emergency Diesel Generator Room B	4.60E-07
	TURB	Turbine Building, All General Areas	1.10E-06
	WMACH	Machine Shop and Stores Warehouse - South Turbine Building	
Intake & Discharge Structure	INTCW	Circulating Water Pump Room Fire - Intake Structure	1.60E-09
	INTSW	Service Water Pump Room Fire - Intake Structure	3.10E-07
	DISCH	Discharge Structure Fire	9.40E-10
Radwaste	RADW	FRADW Radwaste Building Fire	5.20E-08
	RWC	FRWC Radwaste Corridor Fire	
Misc. Structures	AOG	Advanced Off Gas Building Fire	1.40E-07
	DGOP	EDG Fuel Oil Storage Tank and Transfer Pump House Fire	1.20E-08
	FOB	Office Building - North End of Turbine Building	
	RHOUSE	Relay and Metering House - 345 kV Switchyard	4.00E-07
	MTFRM	Main/Aux. Transformer Fire W/Propagation to Turbine Building	6.80E-08
	STFRM	Startup Transformer Fire W/Propagation to Turbine Building	2.80E-07
TOTAL			5.58E-05

A4.0 Other External Hazards

The VY IPEEE submittal [17], in addition to the internal fires and seismic events, examined a number of other external hazards:

- High Winds and Tornadoes
- External Flooding
- Transportation and Nearby Facility Accidents
- Aircraft Hazard
- Severe Weather & Lightning

No risks to the plant occasioned by high winds and tornadoes, external floods, ice, and hazardous chemical, transportation and nearby facility incidents were identified that might lead to core damage with a predicted frequency in excess of 10^{-6}/year. Therefore, these other external event hazards are not included in this appendix and are expected not to impact the conclusions of this ILRT risk assessment.

A5.0 Effect of External Events Hazard Risk on ILRT Risk Assessment

A5.1 Effect of External Hazard Risk on ILRT Risk Assessment Assumptions

Because both the seismic margin analysis and fire PRA did not report any seismic-induced accident progression releases, for the purpose of this report the EPRI accident classes for External Events will be based on percent contribution for the accident class frequencies for Internal Events as presented in Table 2-3.

Both the seismic margin analysis and the fire PRA are dominated by non-recoverable accident sequences that would be expected to result in large early release. Specifically, non-recoverable station blackout accident sequences, and loss of high-pressure injection systems with failure to depressurize. From the VY PSA Level 2 analysis for internal events, these class of accidents (i.e.: ID, IA, IED, IBE and IBL) dominate the occurrence of a large early release.

Per the NEI Guidance Document [4], Enclosure 1, Discussion of Conservatisms in Quantitative Guidance for Delta LERF Impact," specific accident sequences that independently cause a LERF or could never cause a LERF, are to be removed from Class 3b LERF evaluation. Therefore, for the external events impact on the ILRT risk assessment, the evaluation of LERF is performed by multiplying the Class 3b probability by only that portion of core damage frequency that is impacted by Type A ILRT.

A5.2 Effect of External Events Hazard Risk on ILRT Risk Assessment Input

1) Based on the examination in Sections A2.0 through A4.0, the VY external event initiated CDF is approximately 5.58×10^{-5}/ry (internal fires) + 6.93×10^{-6}/ry (seismic) = 6.27×10^{-5}/ry.

2) Based on Section A5.1, the following Level 2 release frequencies for external events is based upon the distribution determined for the EPRI Class frequencies of internal events as shown in Table 2-3.

Table A-3
Vermont Yankee's IPEEE
Estimated Level 2 Release Frequencies As A Function of EPRI Accident Class

EPRI Class	Accident Class Description	Extenal Events Frequency (/ry)
1	No Containment Failure	7.37×10^{-06}
2	Large Containment Isolation Failures (Failure-to-close)	2.69×10^{-08}
3a	Small Isolation Failures (Liner breach)	2.16×10^{-07}
3b	Large Isolation Failures (Liner Breach)	2.16×10^{-08}
4	Small isolation failure - failure-to-seal (Type B test)	--
5	Small isolation failure - failure-to-seal (Type C test)	--
6	Containment Isolation Failures (dependent failures, personnel errors)	--
7a	Severe Accident Phenomena Induced Containment Failure - energetic phenomena	4.04×10^{-06}
7b	Severe Accident Phenomena Induced Containment Failure - direct contact with core material	4.82×10^{-05}
7c	Severe Accident Phenomena Induced Containment Failure - containment failures due to loss of heat removal	1.22×10^{-07}
8a	Containment Bypassed (ATWS)	2.05×10^{-06}
8b	Containment Bypassed (ISLOCA, LOCAOC)	6.67×10^{-07}
	TOTAL	6.27×10^{-05}

A5.3 Effect of External Events Hazard Risk on ILRT Risk Assessment Method of Analysis

The VY IPEEE external events risk information presented in Sections A2, A3 and A4 is used to calculate the following, in accordance with the NEI Interim Guidance [3] :

1) Evaluate the risk impact for the New Surveillance Intervals of Interest

2) Evaluate the external hazard risk impact in terms of LERF

3) Evaluate the external hazard change in conditional containment failure probability

1) **Evaluate the risk impact for the New Surveillance Intervals of Interest.**

This step calculates the percentage of the total dose rate attributable to EPRI accident Classes 3a and 3b (those accident classes affected by change in ILRT surveillance interval) and the change in this result dose rate from the base dose rate attributable to changes in ILRT surveillance interval.

The change in population dose rate is calculated as outline in Step 7 (section 2.4.7, page 46 of 80) of this report. The results of this calculations is presented below as follows:

For 3-in-10 years (internal fires and seismic event),

EPRI Class	Person-Rem within 50 miles	Frequency (/ry)	Dose Rate (Person-Rem/ry)
1	1.30×10^{3}	7.37×10^{-06}	9.58×10^{-3}
2	2.73×10^{6}	2.69×10^{-08}	7.34×10^{-2}
3a	1.30×10^{4}	2.16×10^{-07}	2.81×10^{-3}
3b	4.55×10^{4}	2.16×10^{-08}	9.82×10^{-4}
4	---	--	---
5	---	--	---
6	---	--	---
7a	2.73×10^{6}	4.04×10^{-06}	1.10×10^{1}
7b	2.73×10^{6}	4.82×10^{-05}	1.32×10^{2}
7c	3.53×10^{6}	1.22×10^{-07}	4.30×10^{-1}
8a	2.73×10^{6}	2.05×10^{-06}	5.59×10^{0}
8b	2.96×10^{6}	6.67×10^{-07}	1.97×10^{0}
	TOTALS	6.27×10^{-05}	1.507525×10^{2}

For 1-in-10 years (internal fires and seismic event),

EPRI Class	Person-Rem within 50 miles	Frequency (/ry)	Dose Rate (Person-Rem/ry)
1	1.30×10^{3}	6.85×10^{-06}	8.91×10^{-3}
2	2.73×10^{6}	2.69×10^{-08}	7.34×10^{-2}
3a	1.30×10^{4}	6.85×10^{-07}	8.90×10^{-3}
3b	4.55×10^{4}	6.85×10^{-08}	3.11×10^{-3}
4	---	--	---
5	---	--	---

6	---	--	---
7a	2.73×10^{6}	4.04×10^{-06}	1.10×10^{1}
7b	2.73×10^{6}	4.82×10^{-05}	1.32×10^{2}
7c	3.53×10^{6}	1.22×10^{-07}	4.30×10^{-1}
8a	2.73×10^{6}	2.05×10^{-06}	5.59×10^{0}
8b	2.96×10^{6}	6.67×10^{-07}	1.97×10^{0}
	TOTALS	6.27×10^{-05}	1.507600×10^{2}

For 1-in-15 years (internal fires and seismic event),

EPRI Class	Person-Rem within 50 miles	Frequency (/ry)	Dose Rate (Person-Rem/ry)
1	1.30×10^{3}	6.48×10^{-06}	8.42×10^{-3}
2	2.73×10^{6}	2.69×10^{-08}	7.34×10^{-2}
3a	1.30×10^{4}	1.03×10^{-06}	1.33×10^{-2}
3b	4.55×10^{4}	1.03×10^{-07}	4.67×10^{-3}
4	---	--	---
5	---	--	---
6	---	--	---
7a	2.73×10^{6}	4.04×10^{-06}	1.10×10^{1}
7b	2.73×10^{6}	4.82×10^{-05}	1.32×10^{2}
7c	3.53×10^{6}	1.22×10^{-07}	4.30×10^{-1}
8a	2.73×10^{6}	2.05×10^{-06}	5.59×10^{0}
8b	2.96×10^{6}	6.67×10^{-07}	1.97×10^{0}
	TOTALS	6.27×10^{-05}	1.507655×10^{2}

Based on the results summarized above and those presented in Table 2-9 (see page 57 of 80), for the current VY 1-in10 years ILRT interval, the percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b is calculated as follows:

$$PER\_CTD_{COMB\text{-}10} = \left[\frac{CLASS\_3a\_DOSE_{COMB\text{-}10} + CLASS\_3b\_DOSE_{COMB\text{-}10}}{TOTAL\_DOSE_{COMB\text{-}10}} \right] * 100\%$$

Where:

$PER\_CTD_{COMB-10}$ = combined internal and external events percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b given an 1-in-10 years ILRT interval

$CLASS\_3a\_DOSE_{COMB-10}$ = combined internal and external events EPRI accident Class 3a dose rate given a 1-in-10 years ILRT interval

= $CLASS\_3a\_DOSE_{INTERNAL-10}$ + $CLASS\_3a\_DOSE_{EXTERNAL-10}$

$CLASS\_3b\_DOSE_{COMB-10}$ = combined internal and external events EPRI accident Class 3b dose rate given a 1-in-10 years ILRT interval

= $CLASS\_3b\_DOSE_{INTERNAL-10}$ + $CLASS\_3b\_DOSE_{EXTERNAL-10}$

$CLASS\_3a\_DOSE_{INTERNAL-10}$ = internal events EPRI accident Class 3a dose rate given a 1-in-10 years ILRT interval = 7.46×10^{-4} /ry [Table 2-9]

$CLASS\_3b\_DOSE_{INTERNAL-10}$ = internal events EPRI accident Class 3b dose rate given a 1-in-10 years ILRT interval = 2.61×10^{-4} /ry [Table 2-9]

$CLASS\_3a\_DOSE_{EXTERNAL-10}$ = external events EPRI accident Class 3a dose rate given a 1-in-10 years ILRT interval = 8.90×10^{-3} person-rem/ry [See 1-in-10 years table above]

$CLASS\_3b\_DOSE_{EXTERNAL\ 10}$ = external events EPRI accident Class 3b dose rate given a 1-in-10 years ILRT interval = 3.11×10^{-3} person-rem/ry [See 1-in-10 years table above]

$TOTAL\_DOSE_{COMB-10}$ = Total combined internal and external events dose rate for all EPRI's Classes given a 1-in-10 years ILRT interval

= $TOTAL\_DOSE_{INTERNAL-10}$ + $TOTAL\_DOSE_{EXTERNAL-10}$

$TOTAL\_DOSE_{INTERNAL-10}$ = Total internal events dose rate for all EPRI's Classes given a 1-in-10 years ILRT interval = 12.0211 (person-rem/ry) [Table 2-9]

$TOTAL\_DOSE_{EXTERNAL-10}$ = Total external events dose rate for all EPRI's Classes given a 1-in-10 years ILRT interval = 150.7600 (person-rem/ry) [See 1-in-10 years table above]

Therefore,

$$PER\_CTD_{COMB-10} = \left[\frac{(7.46\times10^{-4} + 8.90\times10^{-3}) + (2.61\times10^{-4} + 3.11\times10^{-3})}{(12.0211 + 150.7600)}\right] * 100\%$$

$PER\_CTD_{COMB-10}$ = 0.0080%

The percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b based on the proposed 1-in-15 years ILRT interval is calculated as follows:

$$PER\_CTD_{COMB-15} = \left[\frac{CLASS\_3a\_DOSE_{COMB-15} + CLASS\_3b\_DOSE_{COMB-15}}{TOTAL\_DOSE_{COMB-15}} \right] * 100\%$$

Where:

$PER\_CTD_{COMB-15}$ = combined internal and external events percentage contribution to total dose rate from EPRI's accident Classes 3a and 3b given an 1-in-15 years ILRT interval

$CLASS\_3a\_DOSE_{COMB-15}$ = combined internal and external events EPRI accident Class 3a dose rate given a 1-in-15 years ILRT interval

= $CLASS\_3a\_DOSE_{INTERNAL-15}$ + $CLASS\_3a\_DOSE_{EXTERNAL-15}$

$CLASS\_3b\_DOSE_{COMB-15}$ = combined internal and external events EPRI accident Class 3b dose rate given a 1-in-15 years ILRT interval

= $CLASS\_3b\_DOSE_{INTERNAL-15}$ + $CLASS\_3b\_DOSE_{EXTERNAL-15}$

$CLASS\_3a\_DOSE_{INTERNAL-15}$ = internal events EPRI accident Class 3a dose rate given a 1-in-15 years ILRT interval = 1.12×10^{-3} person-rem/ry [Table 2-9]

$CLASS\_3b\_DOSE_{INTERNAL-15}$ = internal events EPRI accident Class 3b dose rate given a 1-in-15 years ILRT interval = 3.91×10^{-4} person-rem/ry [Table 2-9]

$CLASS\_3a\_DOSE_{EXTERNAL-15}$ = external events EPRI accident Class 3a dose rate given a 1-in-15 years ILRT interval = 1.33×10^{-2} person-rem/ry [See 1-in-15 years table above]

$CLASS\_3b\_DOSE_{EXTERNAL\ 15}$ = external events EPRI accident Class 3b dose rate given a 1-in-15 years ILRT interval = 4.67×10^{-3} person-rem/ry [See 1-in-15 years table above]

$TOTAL\_DOSE_{COMB-15}$ = Total combined internal and external events dose rate for all EPRI's Classes given a 1-in-15 years ILRT interval

= $TOTAL\_DOSE_{INTERNAL-15}$ + $TOTAL\_DOSE_{EXTERNAL-15}$

$TOTAL\_DOSE_{INTERNAL-15}$ = Total internal events dose rate for all EPRI's Classes given a 1-in-15 years ILRT interval = 12.0215 (person-rem/ry) [Table 2-9]

$TOTAL\_DOSE_{EXTERNAL-15}$ = Total external events dose rate for all EPRI's Classes given a 1-in-15 years ILRT interval = 150.7655 (person-rem/ry) [See 1-in-10 years table above]

Therefore,

$$PER\_CTD_{COMB-15} = \left[\frac{(1.12\times10^{-3} + 1.33\times10^{-2}) + (3.91\times10^{-4} + 4.67\times10^{-3})}{(12.0215 + 150.7655)}\right] * 100\%$$

$PER\_CTD_{COMB-15}$ = 0.0120%

Based on the above results, the combined internal and external events changes from the 1-in-10 years to 1-in-15 years dose rate is as follows:

$$INCR\_CTD_{COMB\_10-15} = \left[\frac{TOTAL\_DOSE_{COMB-15} + TOTAL\_DOSE_{COMB-10}}{TOTAL\_DOSE_{COMB-10}}\right] * 100\%$$

Where:

$INCR\_CTD_{COMB\_10-15}$ = combined internal and external events percent change from 1-in-10 years ILRT interval to 1-in-15 years ILRT interval

$TOTAL\_DOSE_{COMB-15}$ = Total combined internal and external events dose rate for all EPRI's Classes given a 1-in-15 years ILRT interval

= $TOTAL\_DOSE_{INTERNAL-15}$ + $TOTAL\_DOSE_{EXTERNAL-15}$

$TOTAL\_DOSE_{COMB-10}$ = Total combined internal and external events dose rate for all EPRI's Classes given a 1-in-10 years ILRT interval

= $TOTAL\_DOSE_{INTERNAL-10}$ + $TOTAL\_DOSE_{EXTERNAL-10}$

$TOTAL\_DOSE_{INTERNAL-15}$ = Total internal events dose rate for all EPRI's Classes given a 1-in-15 years ILRT interval = 12.0215 (person-rem/ry) [Table 2-9]

$TOTAL\_DOSE_{EXTERNAL-15}$ = Total external events dose rate for all EPRI's Classes given a 1-in-10 years ILRT interval = 150.7655 (person-rem/ry) [See 1-in-10 years table above]

$TOTAL\_DOSE_{INTERNAL-10}$ = Total internal events dose rate for all EPRI's Classes given a 1-in-15 years ILRT interval = 12.0211 (person-rem/ry) [Table 2-9]

$TOTAL\_DOSE_{EXTERNAL-10}$ = Total external events dose rate for all EPRI's Classes given a 1-in-10 years ILRT interval = 150.7600 (person-rem/ry) [See 1-in-10 years table above]

Therefore,

$$INCR\_CTD_{COMB\_10-15} = \left[\frac{(12.0215 + 150.7655) - (12.0211 + 150.7600)}{(12.0211 + 150.7600)}\right] * 100\%$$

$INCR\_CTD_{COMB\_10-15}$ = 0.004%

The above increase in risk on the total integrated plant risk for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004%. This value can be considered to be a negligible increase in risk.

Evaluate the External Events Hazard Risk Impact in Terms of LERF

This step, per the NEI Interim Guidance [3] calculates the change in the large early release frequency with extending the ILRT interval from 1-in-10 years to 1-in15-years.

The combined internal and external events affect on the LERF risk measure due to the proposed ILRT interval extension is calculated as follows:

$$\Delta LERF_{COMBINED10\text{-}15} = CLASS\_3b_{COMBINED15} - CLASS\_3b_{COMBINED10}$$

Where:

$\Delta LERF_{COMBINED10\text{-}15}$ = the combined internal and external events change in LERF from 1-in-10 years ILRT interval to 1-in-15 years ILRT interval

$CLASS\_3b_{COMBINED15}$ = the combined internal and external frequency of EPRI accident Class 3b given a 1-in-15 years ILRT Interval

= $CLASS\_3b_{INTERNAL\text{-}15} + CLASS\_3b_{EXTERNAL\text{-}15}$

$CLASS\_3b_{INTERNAL\text{-}15}$ = internal events frequency of EPRI accident Class 3b given a 1-in-15 years ILRT Interval = 8.60×10^{-9}/ry [Table 2-8]

$CLASS\_3b_{EXTERNAL\text{-}15}$ = external events frequency of EPRI accident Class 3b given a 1-in-15 years ILRT Interval = 1.03×10^{-7}/ry [See 1-in-15 years table above]

$CLASS\_3b_{COMBINED10}$ = the combined internal and external frequency of EPRI accident Class 3b given a 1-in-10 years ILRT Interval

= $CLASS\_3b_{INTERNAL\text{-}10} + CLASS\_3b_{EXTERNAL\text{-}10}$

$CLASS\_3b_{INTERNAL\text{-}10}$ = internal events frequency of EPRI accident Class 3b given a 1-in-10 years ILRT Interval = 5.73×10^{-9}/ry [Table 2-8]

$CLASS\_3b_{EXTERNAL\text{-}10}$ = external events frequency of EPRI accident Class 3b given a 1-in-10 years ILRT Interval = 6.85×10^{-8}/ry [See 1-in-10 years table above]

Therefore,

$$\Delta LERF_{COMBINED10\text{-}15} = (8.60 \times 10^{-9} + 1.03 \times 10^{-7}) - (5.73 \times 10^{-9} + 6.85 \times 10^{-8}/ry)$$

$$\Delta LERF_{COMBINED10\text{-}15} = 3.71 \times 10^{-8}/ry$$

The risk acceptance criteria of Regulatory Guide 1.174 as previously discussed in Section 2.4.8, Step 8 of this report, is used here to assess the ILRT interval extension. Regulatory Guide 1.174, "An Approach for Using PRA in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis" [5], provides NRC recommendations for using risk information in support of applications requesting changes to the license basis of the plant.

The $\Delta LERF_{COMBINED10\text{-}15}$ of 3.71×10^{-8}/ry from extending the VY LRT frequency from 1-in-10 years to 1-in-15 years falls into Region III, Very Small Change in Risk (Figure 2-1), of the acceptance guidelines in NRC Regulatory Guide 1.174 [5]. Therefore, because Regulatory Guide 1.174 [5] defines very small

changes in LERF as below 10^{-7}/ry, increasing the ILRT interval at VY from the currently allowed 1-in-10 years to 1-in-15 years is non-risk significant from a risk perspective.

Evaluate the External Events Hazard Change in Conditional Containment Failure Probability

This step calculates the change in conditional containment failure probability (CCFP).

Similar to Step 9 (Section 2.4.9) of this report, the change in CCFP tracts the impact of the ILRT on both early (LERF) and late radionuclide releases. Therefore, CCFP consists of all those accident sequences resulting in a radionuclide release other that the intact containment state for EPRI accident Class 1, and small failure states for EPRI accident Class 3a. In additional, the CCFP is conditional given a severe core damage accident. The change in CCFP is calculated by the following equation:

$$CCFP = \left\{1 - \left[\frac{CLASS\_1\_FREQ + CLASS\_3a\_FREQ}{CDF_{BASE}}\right]\right\} * 100\%$$

For the combined internal and external events 1-in-10 years ILRT interval:

$$CCFP_{COMB-10} = \left\{1 - \left[\frac{CLASS\_1_{COMB-10} + CLASS\_3a_{COMB-10}}{CDF_{BASE-COMB}}\right]\right\} * 100\%$$

Where:

$CCFP_{COMB-10}$ = combined internal and external events conditional containment failure probability given 1-in-10 years ILRT interval

$CLASS\_1_{COMB-10}$ = combined internal and external events frequency of EPRI accident Class 1 given a 1-in-10 years ILRT interval

= $CLASS\_1_{INTERNAL-10}$ + $CLASS\_1_{EXTERNAL-10}$

$CLASS\_1_{INTERNAL-10}$ = internal events frequency of EPRI accident Class 1given a 1-in-10 years ILRT interval = 5.43×10^{-7}/ry [Table 2-8]

$CLASS\_1_{EXTERNAL-10}$ = external events frequency of EPRI accident Class 1given a 1-in-10 years ILRT interval = 6.85×10^{-6}/ry [See 1-in-10 years table above]

$CLASS\_3a_{COMB-10}$ = combined internal and external events frequency of EPRI accident Class 1 given a 1-in-10 years ILRT interval

= $CLASS\_3a_{INTERNAL-10}$ + $CLASS\_3a_{EXTERNAL-10}$

$CLASS\_3a_{INTERNAL-10}$ = internal events frequency of EPRI accident Class 3a given a 1-in-10 years ILRT interval = 5.73×10^{-8}/ry [Table 2-8]

$CLASS\_3a_{EXTERNAL-10}$ = external events frequency of EPRI accident Class 3a given a 1-in-10 years ILRT interval = 6.85×10^{-7}/ry [See 1-in-10 years table above]

$CDF_{BASE-COMB}$ = VY combined internal events and external events CDF

= 5.03×10^{-6}/ry [Section 5, input#2] + 6.27×10^{-5}/ry [Section A5.3, input#1]
= 6.78×10^{-5}/ry

Therefore,

$$CCFP_{COMB-10} = \left\{1 - \left[\frac{(5.43\times10^{-7} + 6.85\times10^{-6}) + (5.73\times10^{-8} + 6.85\times10^{-7})}{6.78\times10^{-5}}\right]\right\} * 100\%$$

$CCFP_{COMBINED-10}$ = 87.99%

For the combined internal and external events 1-in-15 years ILRT interval:

$$CCFP_{COMB-15} = \left\{1 - \left[\frac{CLASS\_1_{COMB-15} + CLASS\_3a_{COMB-15}}{CDF_{BASE-COMB}}\right]\right\} * 100\%$$

Where:

$CCFP_{COMB-15}$ = combined internal and external events conditional containment failure probability given 1-in-15 years ILRT interval

$CLASS\_1_{COMB-15}$ = combined internal and external events frequency of EPRI accident Class 1 given a 1-in-15 years ILRT interval

= $CLASS\_1_{INTERNAL-15}$ + $CLASS\_1_{EXTERNAL-15}$

$CLASS\_1_{INTERNAL-15}$ = internal events frequency of EPRI accident Class 1given a 1-in-10 years ILRT interval = 5.12×10^{-7}/ry [Table 2-8]

$CLASS\_1_{EXTERNAL-15}$ = external events frequency of EPRI accident Class 1given a 1-in-10 years ILRT interval = 6.48×10^{-6}/ry [See 1-in-10 years table above]

$CLASS\_3a_{COMB-15}$ = combined internal and external events frequency of EPRI accident Class 1 given a 1-in-10 years ILRT interval

= $CLASS\_3a_{INTERNAL-15}$ + $CLASS\_3a_{EXTERNAL-15}$

$CLASS\_3a_{INTERNAL-15}$ = internal events frequency of EPRI accident Class 3a given a 1-in-10 years ILRT interval = 8.60×10^{-8}/ry [Table 2-8]

$CLASS\_3a_{EXTERNAL-15}$ = external events frequency of EPRI accident Class 3a given a 1-in-10 years ILRT interval = 1.03×10^{-6}/ry [See 1-in-10 years table above]

$CDF_{BASE-COMB}$ = VY combined internal events and external events CDF
= 5.03×10^{-6}/ry [Section 5, input#2] + 6.27×10^{-5}/ry [Section A5.3, input#1]
= 6.78×10^{-5}/ry

Therefore,

$$CCFP_{COMB-10} = \left\{1 - \left[\frac{(5.12\times10^{-7} + 6.48\times10^{-6}+) + (8.60\times10^{-8} + 1.03\times10^{-6}+)}{6.78\times10^{-5}}\right]\right\} * 100\%$$

$CCFP_{COMBINED-15}$ = 88.04%

Therefore, the change in the combined internal and external events conditional containment failure probability from 1-in-10 years to 1-in-15 years is:

$\Delta CCFP_{COMBINED10-15}$ = $CCFP_{COMBINED15}$ - $CCFP_{COMBINED10}$

$\Delta CCFP_{COMBINED10-15}$ = 88.04% - 87.99%

$\Delta CCFP_{COMBINED10-15}$ = 0.05%

This change in CCFP of less than 1% is insignificant from a risk perspective.

The effects of external hazard risk on ILRT risk are shown in Table A-4. The combined internal and external events effect on the ILRT risk is shown in Table A-5. This Table combines the results of Table 2-9 with the results depicted in Table A-4.

A6.0 Conclusions

This appendix discusses the risk-implication associated with external hazards in support of the VY Integrated Leak Rate Testing (ILRT) interval extension risk assessment. The following conclusions are derived from this evaluation

1. The $\Delta LERF_{COMBINED10-15}$ of 3.71 x 10^{-8}/ry from extending the VY ILRT frequency from 1-in-10 years to 1-in-15 years falls within Region III, Very Small Change in Risk (Figure 2-1), of the acceptance guidelines in NRC Regulatory Guide 1.174 [5]. Therefore, increasing the ILRT interval at VY from the currently allowed 1-in-10 years to 1-in-15 years is non-risk significant from a risk perspective.

2. The combined internal and external events increase in risk for those accident sequences influenced by Type A testing, compared with the total integrated plant risk, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.004% (0.007 person-rem/ry). This value can be considered to be a negligible increase in risk.

3. The change in the combined internal and external events conditional containment failure probability from 1-in-10 years to 1-in-15 years is 0.05%. A change in CCFP of less than 1% is insignificant from a risk perspective.

Table A-4

Effect of External Events Hazard Risk on VY ILRT Risk Assessment

EPRI Class	Accident Class Description	Dose Rate as a Function of ILRT Interval (Person-Rem / ry)		
		Baseline	Current	Proposed
		3-per-10 years ILRT	1-per-10 years ILRT	1-per-15 years ILRT
1	No Containment Failure	9.58×10^{-3}	8.91×10^{-3}	8.42×10^{-3}
2	Large Containment Isolation Failures (Failure-to-close)	7.34×10^{-2}	7.34×10^{-2}	7.34×10^{-2}
3a	Small Isolation Failures (Liner breach)	2.81×10^{-3}	8.90×10^{-3}	1.33×10^{-2}
3b	Large Isolation Failures (Liner Breach)	9.82×10^{-4}	3.11×10^{-3}	4.67×10^{-3}
4	Small isolation failure - failure-to-seal (Type B test)	---	---	---
5	Small isolation failure - failure-to-seal (Type C test)	---	---	---
6	Containment Isolation Failures (dependent failures, personnel errors)	---	---	---
7a	Severe Accident Phenomena Induced Containment Failure - energetic phenomena	1.10×10^{1}	1.10×10^{1}	1.10×10^{1}
7b	Severe Accident Phenomena Induced Containment Failure - direct contact with core material	1.32×10^{2}	1.32×10^{2}	1.32×10^{2}
7c	Severe Accident Phenomena Induced Containment Failure - containment failures due to loss of heat removal	4.30×10^{-1}	4.30×10^{-1}	4.30×10^{-1}
8a	Containment Bypassed (ATWS)	5.59×10^{0}	5.59×10^{0}	5.59×10^{0}
8b	Containment Bypassed (ISLOCA, LOCAOC)	1.97×10^{0}	1.97×10^{0}	1.97×10^{0}
	TOTALS	150.7525	150.7600	150.7655

Table A-5

Effect of Internal and External Events Risk on VY ILRT Risk Assessment

EPRI Class	Accident Class Description	Dose Rate as a Function of ILRT Interval (Person-Rem / ry)		
		Baseline	Current	Proposed
		3-per-10 years ILRT	1-per-10 years ILRT	1-per-15 years ILRT
1	No Containment Failure	1.03×10^{-2}	9.62×10^{-3}	9.08×10^{-3}
2	Large Containment Isolation Failures (Failure-to-close)	7.93×10^{-2}	7.93×10^{-2}	7.93×10^{-2}
3a	Small Isolation Failures (Liner breach)	3.03×10^{-3}	9.64×10^{-3}	1.45×10^{-2}
3b	Large Isolation Failures (Liner Breach)	1.06×10^{-3}	3.38×10^{-3}	5.06×10^{-3}
4	Small isolation failure - failure-to-seal (Type B test)	--	--	--
5	Small isolation failure - failure-to-seal (Type C test)	--	--	--
6	Containment Isolation Failures (dependent failures, personnel errors)	--	--	--
7a	Severe Accident Phenomena Induced Containment Failure - energetic phenomena	1.19×10^{1}	1.19×10^{1}	1.19×10^{1}
7b	Severe Accident Phenomena Induced Containment Failure - direct contact with core material	1.42×10^{2}	1.42×10^{2}	1.42×10^{2}
7c	Severe Accident Phenomena Induced Containment Failure - containment failures due to loss of heat removal	4.64×10^{-1}	4.64×10^{-1}	4.64×10^{-1}
8a	Containment Bypassed (ATWS)	6.06×10^{0}	6.06×10^{0}	6.06×10^{0}
8b	Containment Bypassed (ISLOCA, LOCAOC)	2.13×10^{0}	2.13×10^{0}	2.13×10^{0}
	TOTALS	162.7729	162.7811	162.7871

Appendix B

Risk Impact of Containment Liner Corrosion During an Extension of the ILRT Interval

Table of Contents

Tables

Figures

B1.0 Introduction

Inspections of reinforced and steel containments at some facilities (e.g., North Anna, Brunswick D.C. Cook, and Oyster Creek) have indicated degradation from the inaccessible side of the steel shell and liner of primary containments. The major inaccessible areas of the Mark I containment are the vertical portion of the drywell shell and part of the shell located between the drywell floor and the basemat. As a result of these inaccessible areas, a potential increase in risk due to liner leakage, caused by age-related degradation mechanisms may occur when extending the current 1-in-10 years to 1-in-15 years Type A Integrated Leak Rate Testing (ILRT) interval.

Therefore, this appendix evaluates the likelihood and risk-implication associated with containment liner corrosion going undetected in visual examinations during the proposed extension of the ILRT interval.

B2.0 Method of Analysis

The analysis utilizes the referenced Calvert Cliffs Nuclear Power Plant assessment [20] to estimate the risk impact from containment liner corrosion during an extension of the ILRT interval.

Consistent with the Calvert Cliffs analysis, the following issues are addressed:

- Differences between the containment basemat and the drywell and torus liner
- The historical drywell/torus steel shell 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

The method of analysis determines the total likelihood of non-detected containment leakage given a change in the likelihood that a flaw exists (i.e., increase in flaw likelihood due to the ILRT extension), that the flaw is not detected and that flaw results in a breach.

Consistent with Calvert Cliffs analysis [20], the following six steps are performed:

1) Determine the historical liner flaw likelihood.
2) Determine aged adjusted liner flaw likelihood.
3) Determine the increase in flaw likelihood between 3, 10 and 15 years.
4) Determine the likelihood of containment breach given liner flaw.
5) Determine the visual inspection detection failure.
6) Determine the likelihood of non-detected containment leakage.

In additions to these steps, the following three additional steps are added to evaluate the risk-implication of containment liner corrosion:

7) Evaluate the risk impact in terms of population dose rate and percentile change for the interval cases.

8) Evaluate the risk impact in terms of LERF.

9) Evaluate the change in conditional containment failure probability.

B3.0 Assumptions

1) Consistent with the Calvert Cliffs methodology [20], a half failure is assumed for basemat concealed liner corrosion due to the lack of identified failures.

2) Consistent with the Calvert Cliffs methodology [20], the leakage potential via the drywell floor (due to crack formation) is considered less likely than other sections of the containment structure.

3) Consistent with the Calvert Cliffs methodology [20], the likelihood of the containment atmosphere reaching the outside atmosphere given a liner flaw exists was estimated as a function of the pressure inside the containment.

4) Consistent with the Calvert Cliffs methodology [20], the containment liner flaw likelihood doubles every five years. This is based solely on judgment and is included in this analysis to address the increase likelihood of corrosion as the containment liner ages.

5) Consistent with the Calvert Cliffs methodology [20], the probability of a concurrent containment breach given a flaw in the containment liner is depicted as an exponential function.

6) Consistent with the Calvert Cliffs methodology [20], a 0.05 (5%) visual inspection detection failure likelihood given the flaw is visible and a total detection failure likelihood of 0.10 (10%) is used[12].

7) Consistent with the Calvert Cliffs methodology [20], 1.0 (100%) visual inspection detection failure likelihood given the flaw is located in an inaccessible area of either the drywell or torus.

8) Consistent with the Calvert Cliffs methodology [20], all non-detectable containment failures are considered to result in large early releases.

B4.0 Input

1) The containment liner failure rate is based on two industry events:

    1. On September 22, 1999, North Anna Unit 2 experienced through-wall corrosion of the metal liner. The corrosion appeared to have been initiated from a piece of lumber imbedded in the concrete behind the liner plate.

    2. On April 27, 1999, inspection at Brunswick 2 discovered two through-wall holes and pitting in the drywell shell. The through-wall condition was believed to have originated from the coated (visible) side.

2) The number of steel-lined containments is 70 [20].

[12] Note: to date, all liner corrosion events have been detected through visual inspection.

3) The exposure time in detecting a containment flaw is 5.5 years. This is consistent with the Calvert Cliffs methodology [20] and reflects the time period since 10CFR 50.55a starting requiring visual inspection. This is deemed conservative, since the exposure time period is bounding as no additional failures have been identified in the nuclear industry since March 2002 and no failures were identified prior to September 1996 (the date when 10CFR 50.55a was implemented).

4) Consistent with the Calvert Cliffs methodology [20], leakage through the drywell floor is 10 times less likely than through other sections of the containment structure.

5) The probability of a concurrent containment breach given a flaw in the containment liner is depicted as an exponential function. This curve is used to interpolate the containment failure probability at the pressure at which the ILRT is to be performed for the accessible and inaccessible areas of containment. Consistent with the Calvert Cliffs methodology, the lower bound limit was assigned a failure probability of 0.1% at a pressure of 20 psia and the upper bound was assigned a failure probability of 100% at the ultimate containment failure pressure of 154.7 psia [29].

B5.0 Steel Shell Corrosion Analysis

Step 1B - Determine the Historical Liner Flaw Likelihood.

This step calculates historical liner flaw likelihood consistent wit the Calvert Cliffs methodology [20]. This value, for Vermont Yankee consists of the accessible potion of the drywell and torus, the inaccessible portion of the drywell and submergence area of the torus, and the inaccessible area of the drywell floor.

The accessible portion of the drywell and torus liner flaw likelihood is determined as follows:

$$AHLF_{DT} = NFAIL_a \quad / \quad (NPLANTS * TEXPO)$$

The inaccessible portion of the drywell and submergence area of the torus liner flaw likelihood is determined as follows:

$$IAHLF_{DT} = NFAIL_a \quad / \quad (NPLANTS * TEXPO)$$

The inaccessible area of the drywell floor

$$IAHLF_{DF} = NFAIL_{ia} \quad / \quad (NPLANTS * TEXPO)$$

Where:

$AHLF_{DT}$ = accessible portion of the drywell and torus liner flaw
$IAHLF_{DT}$ = inaccessible portion of the drywell and submergence area of the torus liner flaw likelihood
$IAHLF_{DF}$ = inaccessible area of the drywell floor liner flaw
$NFAIL_a$ = number of industry events due to liner corrosion = 2 [Section B4.0, Input #1]
$NFAIL_{ia}$ = number of industry events due basemat corrosion = 0.5 [Section B3.0, Input #1]
NPLANTS = number of steel-lined containments = 70 [Section B4.0, Input #2]
TEXPO = time exposure since issuing of 10CFR50.55a = 5.5 years[Section B4.0, Input #3]

Therefore,

$AHLF_{DT}$ = 2 / (70 * 5.5) = 5.19×10^{-3}/yr

$IAHLF_{DT}$ = 2 / (70 * 5.5) = 5.19×10^{-3}/yr

$IAHLF_{DF}$ = 0.5 / (70 * 5.5) = 1.30×10^{-3}/yr

The above results are documented in Table B-4.

Step 2B - Determine Aged Adjusted Liner Flaw Likelihood.

Per the Calvert Cliffs methodology [20], the aged adjustment liner flaw likelihood is calculated for a 15-year interval given that the failure rate doubles every 5 years (Section B3.0, assumption #4) or increases 14.9 % per year. In addition, the average for the 5th to 10th year was set to the historical failure calculated in Step 1B.

The results, based on an iterative process that satisfies the above conditions are presented in Table B-1.

Step 3B - Determine the increase in flaw likelihood between 3, 10 and 15 years[13].

This step calculates the increase in flaw likelihood at 3-in-10 years interval (or 1-in-3 years), 1-in-10 years interval, and 1-in-15 years interval, per the Calvert Cliffs methodology [20]. The results of Step 2B are use to generate these values as follows:

Accessible portion of the drywell and torus,

$$ADTFLAW_{3\text{-}10} = \sum_{i=1,3} ADTF_{RATEii}$$

$$ADTFLAW_{1\text{-}10} = \sum_{i=1,10} ADTF_{RATEii}$$

$$ADTFLAW_{1\text{-}15} = \sum_{i=1,15} ADTF_{RATEii}$$

[13] Note: 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-in-10 years, 1-in-10 years, and 1-in-15 years intervals consistent with the evaluation in this calculation, and then the delta-LERF values are determined from there.

Inaccessible portion of the drywell and submergence area of the torus,

$$IDTFLAW_{3\text{-}10} = \sum_{i=1,3} IDTF_{RATEii}$$

$$IDTFLAW_{1\text{-}10} = \sum_{i=1,10} IDTF_{RATEii}$$

$$IDTFLAW_{1\text{-}15} = \sum_{i=1,15} IDTF_{RATEii}$$

Inaccessible area of the drywell floor

$$DFFLAW_{3\text{-}10} = \sum_{i=1,3} DFF_{RATEii}$$

$$DFFLAW_{1\text{-}10} = \sum_{i=1,10} DFF_{RATEii}$$

$$DFFLAW_{1\text{-}15} = \sum_{i=1,15} DFF_{RATEii}$$

Where:

$ADTFLAW_{3\text{-}10}$ = increase in flaw likelihood at 3-in-10 years test interval given accessible portion of the drywell and torus

$ADTFLAW_{1\text{-}10}$ = increase in flaw likelihood at 1-in-10 years test interval given accessible portion of the drywell and torus

$ADTFLAW_{1\text{-}15}$ = increase in flaw likelihood at 1-in-15 years test interval given accessible portion of the drywell and torus

$IDTFLAW_{3\text{-}10}$ = increase in flaw likelihood at 3-in-10 years test interval given inaccessible portion of the drywell and submergence area of the torus

$IDTFLAW_{1\text{-}10}$ = increase in flaw likelihood at 1-in-10 years test interval given inaccessible portion of the drywell and submergence area of the torus

$IDTFLAW_{1\text{-}15}$ = increase in flaw likelihood at 1-in-15 years test interval given inaccessible portion of the drywell and submergence area of the torus

$DFFLAW_{3\text{-}10}$ = increase in flaw likelihood at 3-in-10 years test interval given inaccessible area of the drywell floor

$DFFLAW_{1\text{-}10}$ = increase in flaw likelihood at 1-in-10 years test interval given inaccessible area of the drywell floor

$DFFLAW_{1\text{-}15}$ = increase in flaw likelihood at 1-in-15 years test interval given inaccessible area of the drywell floor

$ADTF_{RATEii}$ = aged adjusted liner flaw likelihood, given accessible portion of the drywell and torus (Table B-1)

$IDTF_{RATEii}$ = aged adjusted liner flaw likelihood, given inaccessible portion of the drywell and submergence area of the torus (Table B-1)

DFF_{RATEii} = aged adjusted liner flaw likelihood, given inaccessible area of the drywell floor (Table B-1)

Therefore,

$ADTFLAW_{3\text{-}10}$	=	0.71%,	$ADTFLAW_{1\text{-}10}$	=	4.14%,	$ADTFLAW_{1\text{-}15}$	=	9.68%
$IDTFLAW_{3\text{-}10}$	=	0.71%,	$IDTFLAW_{1\text{-}10}$	=	4.14%,	$IDTFLAW_{1\text{-}15}$	=	9.68%
$DFFLAW_{3\text{-}10}$	=	0.18%,	$DFFLAW_{1\text{-}10}$	=	1.04%,	$DFFLAW_{1\text{-}15}$	=	2.42%

The above results are documented in Table B-2.

Step 4B - Determine the Likelihood of Containment Breach Given Liner Flaw.

The likelihood of a breach in containment given a liner flaw is based on the Calvert Cliffs methodology [20] with a Vermont Yankee specific value for the upper-end pressure failure (100% likelihood) taken from Section 4.4 of the PSA [29]. A containment pressure of 154.7 psia corresponds with the 100% probability of failure. The lower-end pressure failure (0.1% likelihood) is set at 20 psia, consistent with Calvert Cliffs [20]. Per the Calvert Cliffs methodology [20], the containment failure probability (FP) versus containment pressure (P) is assumed to be an equation of the form:

$$FP(P) = b * e^{m*p}$$

Where:

FP (P) = containment failure probability given containment liner breach

m = slope of the containment failure probability

b = intercept of the containment failure probability

p = containment pressure, psia

The two anchor points of 0.1% at 20 psia and 100% at 154.7 psia provide sufficient information to solve for the slope m, and the intercept b, as follows:

Slope m,

$$m = LN(FP(100\%) - LN(0.1\%) \quad / \quad (\text{Upper Pressure- Lower Pressure})$$

$$m = LN(1.0) - LN(0.001) \quad / \quad (154.7\text{-}20)$$

$$m = 5.13 \times 10^{-2}$$

Intercept b,

$$b = FP(100\%) \quad / \quad e^{m*p}$$

$$b = 1 \quad / \quad e^{5.13 \times 10\text{-}2*154.7}$$

$$b = 3.58 \times 10^{-4}$$

The Vermont Yankee April 26, 1995 ILRT used a test pressure of 45.9 psig (or 60.6 psia) [28]. Based on this pressure the likelihood of containment breach in the liner is:

$$FP(60.6\ \text{psia}) = 3.58 \times 10^{-4} * e^{5.13 \times 10\text{-}2*60.6}$$

$$FP(60.6\ \text{psia}) = 0.00802 \quad \text{or} \quad 0.802\%$$

For the Drywell floor, the failure probability is set to one-tenth of the failure probability for Drywell walls, or 0.0802%. (See Section B3.0, Assumption #4 and Section B4.0, Input #2).

Based on the above equation, containment liner breach and drywell floor intermediate values for FP are calculated and presented in Table B-3 and Figure B-1.

Step 5B - Determine the visual inspection detection failure.

This step examines the visual inspection detection failure likelihood for Vermont Yankee. The three areas of interest are the accessible portion of the drywell and torus, the inaccessible portion of the drywell and submergence area of the torus, and the inaccessible portion of the drywell floor.

The visual inspection detection failure likelihood for the accessible area of the drywell and torus (100% inside and outside of drywell head, 100% drywell liner inside, 100% torus outside area, and 100% torus inside area above waterline is set to 10%, consistent with the Calvert Cliffs analysis [20]. This represents a 5% (0.05) failure to identify a visual flaw and 5% (0.05) likelihood that the flaw is not visible.

The inaccessible portion of the drywell (virtually 0% drywell liner outside because it is encased in concrete), and submergence area of the torus is assigned a 100% (1.0) visual detection failure likelihood. This is bounding, as the submerged area of the Torus may be examined.

Because the liner under the Drywell floor cannot be visually inspected, a visual detection failure likelihood of 100 % (1.0) is assigned, consistent with the Calvert Cliffs method.

The above results are documented in Table B-4.

Step 6B - Determine the likelihood of non-detected containment leakage

Per the Calvert Cliffs methodology [20], the likelihood of a non-detected containment leakage is calculated by multiplying the results of Steps 3B, 4B, and 5B. This yields the following:

Accessible portion of the drywell and torus,

$$ADTLEAK_{3\text{-}10} = ADTFLAW_{3\text{-}10} * ADTFP_{ILRT} * ADTVISUAL$$

$$ADTLEAK_{1\text{-}10} = ADTFLAW_{1\text{-}10} * ADTFP_{ILRT} * ADTVISUAL$$

$$ADTLEAK_{1\text{-}15} = ADTFLAW_{1\text{-}15} * ADTFP_{ILRT} * ADTVISUAL$$

Where:

$ADTLEAK_{3\text{-}10}$ = likelihood of non-detected containment leakage, given 3-in-10 years test interval and accessible portion of the drywell and torus

$ADTLEAK_{1\text{-}10}$ = likelihood of non-detected containment leakage, given 1-in-10 years test interval and accessible portion of the drywell and torus

$ADTLEAK_{1\text{-}15}$ = likelihood of non-detected containment leakage, given 1-in-15 years test interval and accessible portion of the drywell and torus

$ADTFLAW_{3\text{-}10}$ = increase in flaw likelihood at 3-in-10 years test interval given accessible portion of the drywell and torus = 0.71% (0.0071) [Table B-2]

$ADTFLAW_{1\text{-}10}$ = increase in flaw likelihood at 1-in-10 years test interval given accessible portion of the drywell and torus = 4.14% (0.0414) [Table B-2]

$ADTFLAW_{1\text{-}15}$ = increase in flaw likelihood at 1-in-15 years test interval given accessible portion of the drywell and torus = 9.68% (0.0968) [Table B-2]

$ADTFP_{ILRT}$ = likelihood of containment breach at ILRT test pressure (60.6 psia) given liner flaw and accessible portion of the drywell and torus = 0.00802 (0.802%) [Step 4B]

ADTVISUAL = visual inspection detection failure accessible portion of the drywell and torus = 0.1 (10%) [Step 5B]

Therefore,

$$ADTLEAK_{3\text{-}10} = 0.0071 * 0.00802 * 0.1 = 5.694 \times 10^{-6} \ (0.00057\%)$$

$$ADTLEAK_{1\text{-}10} = 0.0414 * 0.00802 * 0.1 = 3.320 \times 10^{-5} \ (0.00332\%)$$

$$ADTLEAK_{1\text{-}15} = 0.0968 * 0.00802 * 0.1 = 7.763 \times 10^{-5} \ (0.00775\%)$$

Inaccessible portion of the drywell and submergence area of the torus,

$$IDTLEAK_{3\text{-}10} = IDTFLAW_{3\text{-}10} * ADTFP_{ILRT} * IDTVISUAL$$

$$IDTLEAK_{1\text{-}10} = IDTFLAW_{1\text{-}10} * ADTFP_{ILRT} * IDTVISUAL$$

$$IDTLEAK_{1\text{-}15} = IDTFLAW_{1\text{-}15} * ADTFP_{ILRT} * IDTVISUAL$$

Where:

$IDTLEAK_{3\text{-}10}$ = likelihood of non-detected containment leakage, given 3-in-10 years test interval and inaccessible portion of the drywell and submergence area of the torus

$IDTLEAK_{1\text{-}10}$ = likelihood of non-detected containment leakage, given 1-in-10 years test interval and inaccessible portion of the drywell and submergence area of the torus

$IDTLEAK_{1\text{-}15}$ = likelihood of non-detected containment leakage, given 1-in-15 years test interval and inaccessible portion of the drywell and submergence area of the torus

$IDTFLAW_{3\text{-}10}$ = increase in flaw likelihood at 3-in-10 years test interval given inaccessible portion of the drywell and submergence area of the torus = 0.71% (0.0071) [Table B-2]

$IDTFLAW_{1\text{-}10}$ = increase in flaw likelihood at 1-in-10 years test interval given inaccessible portion of the drywell and submergence area of the torus = 4.14% (0.0414) [Table B-2]

$IDTFLAW_{1\text{-}15}$ = increase in flaw likelihood at 1-in-15 years test interval given inaccessible portion of the drywell and submergence area of the torus = 9.68% (0.0968) [Table B-2]

$ADTFP_{ILRT}$ = likelihood of containment breach at ILRT test pressure (60.6 psia) given liner flaw and inaccessible portion of the drywell and submergence area of the torus = 0.00802 (0.802%) [Step 4B]

IDTVISUAL = visual inspection detection failure inaccessible portion of the drywell and submergence area of the torus = 1.0 (100%) [Step 5B]

Therefore,

$$IDTLEAK_{3\text{-}10} = 0.0071 * 0.00802 * 1.0 = 5.694 \times 10^{-5} \ (0.0057\%)$$

$$IDTLEAK_{1\text{-}10} = 0.0414 * 0.00802 * 1.0 = 3.320 \times 10^{-4} \ (0.0332\%)$$

$$IDTLEAK_{1\text{-}15} = 0.0968 * 0.00802 * 1.0 = 7.763 \times 10^{-4} \ (0.0776\%)$$

Inaccessible portion of the drywell floor,

$$DFLEAK_{3\text{-}10} = DFTFLAW_{3\text{-}10} * DFTFP_{ILRT} * DFTVISUAL$$

$$DFTLEAK_{1\text{-}10} = DFTFLAW_{1\text{-}10} * DFTFP_{ILRT} * DFTVISUAL$$

$$DFTLEAK_{1\text{-}15} = DFTFLAW_{1\text{-}15} * DFTFP_{ILRT} * DFTVISUAL$$

Where:

$DFLEAK_{3\text{-}10}$ = likelihood of non-detected containment leakage, given 3-in-10 years test interval and inaccessible portion of the drywell floor

$DFLEAK_{1\text{-}10}$ = likelihood of non-detected containment leakage, given 1-in-10 years test interval and inaccessible portion of the drywell floor

$DFLEAK_{1\text{-}15}$ = likelihood of non-detected containment leakage, given 1-in-15 years test interval and inaccessible portion of the drywell floor

$DFFLAW_{3\text{-}10}$ = increase in flaw likelihood at 3-in-10 years test interval given inaccessible portion of the drywell floor = 0.18% (0.0018) [Table B-2]

$DFFLAW_{1\text{-}10}$ = increase in flaw likelihood at 1-in-10 years test interval given inaccessible portion of the drywell floor = 1.04% (0.0104) [Table B-2]

$DFFLAW_{1\text{-}15}$ = increase in flaw likelihood at 1-in-15 years test interval given inaccessible portion of the drywell floor = 2.42% (0.0242) [Table B-2]

$DFTFP_{ILRT}$ = likelihood of containment breach at ILRT test pressure (60.6 psia) given liner flaw and inaccessible portion of the drywell floor = 0.000802 (0.0802%) [Step 4B]

DFVISUAL = visual inspection detection failure inaccessible portion of the drywell floor
= 1.0 (100%) [Step 5B]

Therefore,

$$DFTLEAK_{3\text{-}10} = 0.0018 * 0.000802 * 1.0 = 1.444 \times 10^{-6} \ (0.00014\%)$$

$$DFTLEAK_{1\text{-}10} = 0.0104 * 0.000802 * 1.0 = 8.341 \times 10^{-6} \ (0.00083\%)$$

$$DFTLEAK_{1\text{-}15} = 0.0242 * 0.000802 * 1.0 = 1.941 \times 10^{-5} \ (0.00194\%)$$

Total Likelihood of Non-Detected Containment Leakage due to Corrosion is,

$$TOTAL_{3\text{-}10} = ADTLEAK_{3\text{-}10} + IDTLEAK_{3\text{-}10} + DFTLEAK_{3\text{-}10}$$

$$TOTAL_{1\text{-}10} = ADTLEAK_{1\text{-}10} + IDTLEAK_{1\text{-}10} + DFTLEAK_{1\text{-}10}$$

$$TOTAL_{1\text{-}15} = ADTLEAK_{1\text{-}15} + IDTLEAK_{1\text{-}15} + DFTLEAK_{1\text{-}15}$$

Where:

$TOTAL_{3\text{-}10}$ = total likelihood of non-detected containment leakage due to corrosion, given 3-in-10 years test interval

$TOTAL_{1\text{-}10}$ = total likelihood of non-detected containment leakage due to corrosion, given 1-in-10 years test

$TOTAL_{1\text{-}15}$ = total likelihood of non-detected containment leakage due to corrosion, given 1-in-15 years test interval

$ADTLEAK_{3\text{-}10}$ = likelihood of non-detected containment leakage, given 3-in-10 years test interval and accessible portion of the drywell and torus

$ADTLEAK_{1\text{-}10}$ = likelihood of non-detected containment leakage, given 1-in-10 years test interval and accessible portion of the drywell and torus

$ADTLEAK_{1\text{-}15}$ = likelihood of non-detected containment leakage, given 1-in-15 years test interval and accessible portion of the drywell and torus

$IDTLEAK_{3\text{-}10}$ = likelihood of non-detected containment leakage, given 3-in-10 years test interval and inaccessible portion of the drywell and submergence area of the torus

$IDTLEAK_{1\text{-}10}$ = likelihood of non-detected containment leakage, given 1-in-10 years test interval and inaccessible portion of the drywell and submergence area of the torus

$IDTLEAK_{1\text{-}15}$ = likelihood of non-detected containment leakage, given 1-in-15 years test interval and inaccessible portion of the drywell and submergence area of the torus

$DFLEAK_{3\text{-}10}$ = likelihood of non-detected containment leakage, given 3-in-10 years test interval and inaccessible portion of the drywell floor

$DFLEAK_{1\text{-}10}$ = likelihood of non-detected containment leakage, given 1-in-10 years test interval and inaccessible portion of the drywell floor

$DFLEAK_{1\text{-}15}$ = likelihood of non-detected containment leakage, given 1-in-15 years test interval and inaccessible portion of the drywell floor

Therefore,

$TOTAL_{3\text{-}10}$ = 0.00057% + 0.00570% + 0.00014% = 0.00641%

$TOTAL_{1\text{-}10}$ = 0.00332% + 0.03322% + 0.00083% = 0.03737%

$TOTAL_{1\text{-}15}$ = 0.00776% + 0.07763% + 0.00194% = 0.08733%

The above results are documented in Table B-4.

Step 7B - Evaluate the Risk Impact in Terms of Population Dose Rate and Percentile Change for the Interval Cases.

This step calculates the change in population dose rate for EPRI accident Class 3b (all non-detectable containment failures are considered to result in large early releases), the change in percentage of the total dose rate attributable to liner corrosion and the change in this result dose rate from the base dose rate attributable to changes in ILRT surveillance interval.

The change in population dose rate is calculated as outline in Section 2.4.7 (Step 7), of this risk assessment (see page 43 of 73).

Increase to EPRI class 3b frequencies

$$LINER\_CLASS\_3b\_FREQ_{3\text{-}10} = (PROB_{class\_3b\_3\text{-}10} + LINER\_CLASS\_3B\_INCREASE_{3\text{-}10}) \times (CDF - CDF_{INDEP})$$

$$LINER\_CLASS\_3b\_FREQ_{1\text{-}10} = (PROB_{class\_3b\_1\text{-}10} + LINER\_CLASS\_3B\_INCREASE_{1\text{-}10}) \times (CDF - CDF_{INDEP})$$

$$LINER\_CLASS\_3b\_FREQ_{1\text{-}15} = (PROB_{class\_3b\_3\text{-}10} + LINER\_CLASS\_3B\_INCREASE_{1\text{-}15}) \times (CDF - CDF_{INDEP})$$

Where:

$LINER\_CLASS\_3b\_FREQ_{3\text{-}10}$ = frequency of EPRI Class 3b due to liner corrosion failure given a 3-in-10 years ILRT interval

$LINER\_CLASS\_3b\_FREQ_{1\text{-}10}$ = frequency of EPRI Class 3b due to liner corrosion failure given a 1-in-10 years ILRT interval

$LINER\_CLASS\_3b\_FREQ_{1\text{-}15}$ = frequency of EPRI Class 3b due to liner corrosion failure given a 1-in-15 years ILRT interval

$PROB_{class\_3b\_3\text{-}10}$ = probability of large pre-existing containment liner leakage
= 0.0027 [Section 2.3, input #7]

$PROB_{class\_3b\_1\text{-}10}$ = probability of large pre-existing containment liner leakage
= 0.0090 [Section 2.4.5 Step 5, page 37 of 73]

$PROB_{class\_3b\_1\text{-}15}$ = probability of large pre-existing containment liner leakage
= 0.0135 [Section 2.4.5 Step 5, page 38 of 73]

CDF_{INDEP} = CDF for those individual sequences that independently cause a LERF, (identified as EPRI Class 2, Class 7a and 7b, and Class 8 sequences) and loss of containment heat removal sequences (EPRI Class 7c)
= 4.40×10^{-6}/ry [Section 2.4.1 Step 1, page 28 of 73]

CDF = Vermont Yankee PSA core damage frequency
= 5.00×10^{-6}/ry [Section 2.3, input #2]

$LINER\_CLASS\_3B\_INCREASE_{3\text{-}10} = TOTAL_{3\text{-}10} \times EPRI\_CLASS\_3B\_FRACTION$

$LINER\_CLASS\_3B\_INCREASE_{1\text{-}10} = TOTAL_{1\text{-}10} \times EPRI\_CLASS\_3B\_FRACTION$

$LINER\_CLASS\_3B\_INCREASE_{1\text{-}15} = TOTAL_{1\text{-}15} \times EPRI\_CLASS\_3B\_FRACTION$

Where:

$LINER\_CLASS\_3B\_INCREASE_{3\text{-}10}$ = liner corrosion increase in EPRI class 3b given 3-in-10 years test interval

$LINER\_CLASS\_3B\_INCREASE_{1\text{-}10}$ = liner corrosion increase in EPRI class 3b given 1-in-10 years test interval

$LINER\_CLASS\_3B\_INCREASE_{1\text{-}15}$ = liner corrosion increase in EPRI class 3b given 1-in-15 years test interval

$TOTAL_{3\text{-}10}$ = total likelihood of non-detected containment leakage due to corrosion, given 3-in-10 years test interval
= 0.00641% [see above calculation and Table B-4]

$TOTAL_{1\text{-}10}$ = total likelihood of non-detected containment leakage due to corrosion, given 3-in-10 years test interval
= 0.03737% [see above calculation and Table B-4]

$TOTAL_{1\text{-}15}$ = total likelihood of non-detected containment leakage due to corrosion, given 3-in-10 years test interval
= 0.08733% [see above calculation and Table B-4]

EPRI_CLASS_3B_FRACTION = fraction of containment failures due to liner corrosion and considered to result in large early releases.
= 100% [Assumpiton#8]

Therefore:

$LINER\_CLASS\_3B\_INCREASE_{3\text{-}10} = 0.00642\% \times 1.0 = 0.00642\%$

$LINER\_CLASS\_3B\_INCREASE_{1\text{-}10} = 0.03737\% \times 1.0 = 0.03737\%$

$LINER\_CLASS\_3B\_INCREASE_{1\text{-}15} = 0.08729\% \times 1.0 = 0.08729\%$

Therefore:

$LINER\_CLASS\_3b\_FREQ_{3\text{-}10} = (0.0027 + 0.00642\%) \times (5.00 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry)$
$LINER\_CLASS\_3b\_FREQ_{3\text{-}10} = 1.76 \times 10^{-9}/ry$

$LINER\_CLASS\_3b\_FREQ_{1\text{-}10} = (0.0090 + 0.03737\%) \times (5.00 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry)$
$LINER\_CLASS\_3b\_FREQ_{1\text{-}10} = 5.97 \times 10^{-9}/ry$

$LINER\_CLASS\_3b\_FREQ_{1\text{-}15} = (0.0135 + 0.08729\%) \times (5.00 \times 10^{-6}/ry - 4.40 \times 10^{-6}/ry)$
$LINER\_CLASS\_3b\_FREQ_{1\text{-}15} = 9.16 \times 10^{-9}/ry$

Increase to EPRI class 1 frequencies

$LINER\_CLASS\_1\_FREQ_{3\text{-}10}$ = NCF - CLASS_3a_FREQUENCY - $LINER\_CLASS\_3b\_FREQ_{3\text{-}10}$

$LINER\_CLASS\_1\_FREQ_{1\text{-}10}$ = NCF - $CLASS\_3a\_FREQUENCY_{10}$ - $LINER\_CLASS\_3b\_FREQ_{1\text{-}10}$

$LINER\_CLASS\_1\_FREQ_{1\text{-}15}$ = NCF - $CLASS\_3a\_FREQUENCY_{15}$ - $LINER\_CLASS\_3b\_FREQ_{1\text{-}15}$

Where:

$LINER\_CLASS\_1\_FREQ_{3\text{-}10}$ = frequency of EPRI Class 1 given a 3-in-10 years ILRT interval

$LINER\_CLASS\_1\_FREQ_{1\text{-}10}$ = frequency of EPRI Class 1 given a 1-in-10 years ILRT interval

$LINER\_CLASS\_1\_FREQ_{1\text{-}15}$ = frequency of EPRI Class 1 given a 1-in-15 years ILRT interval

CLASS_3a_ FREQUENCY = frequency of small pre-existing containment liner leakage
= 1.72×10^{-8}/ry [Section 2.4.1 Step 1, page 28 of 70]

$CLASS\_3a\_FREQUENCY_{10}$ = frequency of small pre-existing containment liner leakage given a 1-in-10 years ILRT interval
= 5.73×10^{-8}/ry [Section 2.4.5, Step 5 page 39 of 70]

$CLASS\_3a\_FREQUENCY_{15}$ = frequency of small pre-existing containment liner leakage given a 1-in-15 years ILRT interval
= 8.60×10^{-8}/ry [Section 2.4.5, Step 5 page 39 of 70]

$LINER\_CLASS\_3b\_FREQ_{3\text{-}10}$ = frequency of EPRI Class 3b due to liner corrosion failure given a 3-in-10 years ILRT interval
= 1.76×10^{-9}/ry [Above write-up, page B-14 of B-26]

$LINER\_CLASS\_3b\_FREQ_{1\text{-}10}$ = frequency of EPRI Class 3b due to liner corrosion failure given a 1-in-10 years ILRT interval
= 5.97×10^{-9}/ry [Above write-up, page B-14 of B-26]

$LINER\_CLASS\_3b\_FREQ_{1\text{-}15}$ = frequency of EPRI Class 3b due to liner corrosion failure given a 3-in-15 years ILRT interval
= 9.16×10^{-9}/ry [Above write-up, page B-14 of B-26]

NCF = frequency in which containment leakage is at or below maximum allowable Technical Specification Leakage
= 6.07×10^{-7}/ry [Table 2-2]

Therefore:

$LINER\_CLASS\_1\_FREQ_{3\text{-}10} = 6.07 \times 10^{-7}/ry - 1.72 \times 10^{-8}/ry - 1.76 \times 10^{-9}/ry$
$LINER\_CLASS\_1\_FREQ_{3\text{-}10} = 5.88 \times 10^{-7}/ry$

$LINER\_CLASS\_1\_FREQ_{1\text{-}10} = 6.07 \times 10^{-7}/ry - 5.73 \times 10^{-8}/ry - 5.97 \times 10^{-9}/ry$
$LINER\_CLASS\_1\_FREQ_{1\text{-}10} = 5.43 \times 10^{-7}/ry$

$LINER\_CLASS\_1\_FREQ_{1\text{-}15} = 6.07 \times 10^{-7}/ry - 8.60 \times 10^{-8}/ry - 9.16 \times 10^{-9}/ry$
$LINER\_CLASS\_1\_FREQ_{1\text{-}15} = 5.11 \times 10^{-7}/ry$

The results of other pertinent calculations, are presented below as follows:

For 3-in-10 years,

EPRI Class	Person-rem	Frequency/Ry		Person-rem/Ry
1	1.30×10^{3}	5.88×10^{-7}		7.64×10^{-4}
2	2.73×10^{6}	2.14×10^{-9}	Corrosion Addition	5.85×10^{-3}
3a	1.30×10^{4}	1.72×10^{-8}		2.24×10^{-4}
3b	4.55×10^{4}	1.76×10^{-9}	4.09×10^{-11}	8.01×10^{-5}
4	N/A	0.0		0.0
5	N/A	0.0		0.0
6	N/A	0.0		0.0
7a	2.73×10^{6}	3.22×10^{-7}		8.79×10^{-1}
7b	2.73×10^{6}	3.85×10^{-6}		1.05×10^{1}
7c	3.53×10^{6}	9.71×10^{-9}		3.43×10^{-2}
8a	2.73×10^{6}	1.63×10^{-7}		4.46×10^{-1}
8b	2.96×10^{6}	5.32×10^{-8}		1.57×10^{-1}
Total		**5.00×10^{-6}**		**12.0204**

ILRT Dose Rate from 3a and 3b = 2.24×10^{-4} + 8.01×10^{-5} = 3.04×10^{-4} person-rem/ry
% Of Total = 100 * [2.24×10^{-4} + 8.01×10^{-5}] / 12.0204 = 0.0025%
LERF from 3b = 1.76×10^{-9}
$CCFP\%_{LINER3\text{-}10}$ = 1 - [(5.88×10^{-7} + 1.72×10^{-8}) / 5.03×10^{-6}] = 87.97%

For 1-in-10 years,

EPRI Class	Person-rem	Frequency/Ry		Person-rem/Ry
1	1.30×10^{3}	5.43×10^{-7}		7.06×10^{-4}
2	2.73×10^{6}	2.14×10^{-9}	Corrosion Addition	5.85×10^{-3}
3a	1.30×10^{4}	5.73×10^{-8}		7.46×10^{-4}
3b	4.55×10^{4}	5.97×10^{-9}	2.38×10^{-10}	2.72×10^{-4}
4	N/A	0.0		0.0
5	N/A	0.0		0.0
6	N/A	0.0		0.0
7a	2.73×10^{6}	3.22×10^{-7}		8.79×10^{-1}
7b	2.73×10^{6}	3.85×10^{-6}		1.05×10^{1}
7c	3.53×10^{6}	9.71×10^{-9}		3.43×10^{-2}
8a	2.73×10^{6}	1.63×10^{-7}		4.46×10^{-1}
8b	2.96×10^{6}	5.32×10^{-8}		1.57×10^{-1}
Total		**5.00×10^{-6}**		**12.0211**

ILRT Dose Rate from 3a and 3b = 7.46×10^{-4} + 2.72×10^{-4} = 1.02×10^{-3} person-rem/ry
% Of Total = 100 * [7.46×10^{-4} + 2.72×10^{-4}] / 12.0211 = 0.0085%
LERF from 3b = 5.97×10^{-9}/ry
$CCFP\%_{LINER1\text{-}10}$ = 1 - [(5.43×10^{-7} + 5.73×10^{-8}) / 5.03×10^{-6}] = 88.07%

For 1-in-15 years,

EPRI Class	Person-rem	Frequency/Ry		Person-rem/Ry
1	1.30×10^{3}	5.11×10^{-7}		6.65×10^{-4}
2	2.73×10^{6}	2.14×10^{-9}	Corrosion Addition	5.85×10^{-3}
3a	1.30×10^{4}	8.60×10^{-8}		1.12×10^{-3}
3b	4.55×10^{4}	9.16×10^{-9}	5.77×10^{-10}	4.17×10^{-4}
4	N/A	0.0		0.0
5	N/A	0.0		0.0
6	N/A	0.0		0.0
7a	2.73×10^{6}	3.22×10^{-7}		8.79×10^{-1}
7b	2.73×10^{6}	3.85×10^{-6}		1.05×10^{1}
7c	3.53×10^{6}	9.71×10^{-9}		3.43×10^{-2}
8a	2.73×10^{6}	1.63×10^{-7}		4.46×10^{-1}
8b	2.96×10^{6}	5.32×10^{-8}		1.57×10^{-1}
Total		**5.00×10^{-6}**		**12.0216**

ILRT Dose Rate from 3a and 3b = 1.12×10^{-3} + 4.17×10^{-4} = 1.54×10^{-3} person-rem/ry
% Of Total = 100 * [1.16×10^{-3} + 4.32×10^{-4}] / 12.0216 = 0.0128%
LERF from 3b = 9.16×10^{-9}/ry
$CCFP\%_{LINER1-15}$ = 1 - [(5.11×10^{-7} + 8.60×10^{-8}) / 5.03×10^{-6}] = 88.13%

Based on the above results, the changes from the 1-in-10 years to 1-in-15 years dose rate is as follows:

$$INCREASE_{LINER10-15} = \left[\frac{TOT\text{-}DOSE_{RATE\text{-}LINER15} - TOT\text{-}DOSE_{RATE\text{-}LINER10}}{TOT\text{-}DOSE_{RATE\text{-}LINER10}} \right] * 100$$

Where:

$INCREASE_{LINER10-15}$ = percent change from 1-in-10 years ILRT interval to 1-in-15 years ILRT interval

$TOT\text{-}DOSE_{RATE\text{-}LINER15}$ = Total dose rate for all EPRI's Classes given a 1-in-15 years ILRT interval
= 12.0216 (person-rem/ry) [See for 1-in-15 years table above]

$TOT\text{-}DOSE_{RATE\text{-}LINER10}$ = Total dose rate for all EPRI's Classes given a 1-in-10 years ILRT interval
= 12.0211 (person-rem/ry) [See for 1-in-10 years table above]

Therefore,

$$INCREASE_{LINER10-15} = \left[\frac{12.0216 - 12.0211}{12.0211} \right] * 100 = 0.0042\%$$

The above increase in risk on the total integrated plant risk for those accident sequences influenced by Type A testing, given the change from a 1-in-10 years test interval to a 1-in-15 years test interval, is found to be 0.0042%. This value can be considered to be a negligible increase in risk.

Step 8B - Evaluate the risk impact in terms of LERF

This step calculates the change in the large early release frequency with extending the ILRT intervals from 1-in-10 years to 1-in15-years given the inclusion of a postulated liner corrosion flaw failure.

The affect on the LERF risk measure due to liner corrosion flaw is calculated as follows:

$$\Delta LERF_{LNER10\text{-}15} = LINER\_CLASS\_3b\_FREQ_{1\text{-}15} - LINER\_CLASS\_3b\_FREQ_{1\text{-}10}$$

Where:

$\Delta LERF_{LNER10\text{-}15}$ = the change in LERF from 1-in-10 years ILRT interval to 1-in-15 years ILRT interval

$LINER\_CLASS\_3b\_FREQ_{1\text{-}15}$ = frequency of EPRI accident Class 3b given a 1-in-15 years ILRT interval = 9.16×10^{-9}/ry [Step 7B]

$LINER\_CLASS\_3b\_FREQ_{1\text{-}10}$ = frequency of EPRI accident Class 3b given a 1-in-10 years ILRT interval = 5.97×10^{-9}/ry [Step 7B]

Therefore,

$$\Delta LERF_{LNER10\text{-}15} = 9.16 \times 10^{-9} - 5.97 \times 10^{-9}$$

$$\Delta LERF_{LNER10\text{-}15} = 3.19 \times 10^{-9}/ry$$

Based on this result, the inclusion of corrosion effects in the ILRT assessment would not change the previous conclusions of this calculation (See Sections 3 and 4). That is, the change in LERF from extending the interval to 15 years from the current 10 years requirement is estimated to be about 3.19×10^{-9}/ry. This value is below the NRC Regulatory Guide 1.174 [5] of 10^{-7}/yr. Therefore, because Regulatory Guide 1.174 [5] defines very small changes in LERF as below 10^{-7}/yr, increasing the ILRT interval at Vermont Yankee from the currently allowed 1-in-10 years to 1-in-15 years and taking into consideration the likelihood of a containment liner flaw due to corrosion is non-risk significant from a risk perspective.

Similarly, the change in LERF from the original 3-in-10-year interval is calculated as follows:

$$\Delta LERF_{LNER3\text{-}15} = LINER\_CLASS\_3b\_FREQ_{1\text{-}15} - LINER\_CLASS\_3b\_FREQ_{3\text{-}10}$$

Where:

$\Delta LERF_{LNER3\text{-}15}$ = the change in LERF from 3-in-10 years ILRT interval to 1-in-15 years ILRT interval

$LINER\_CLASS\_3b\_FREQ_{1\text{-}15}$ = frequency of EPRI accident Class 3b given a 1-in-15 years ILRT interval = 9.16×10^{-9}/ry [Step 7B]

$LINER\_CLASS\_3b\_FREQ_{3\text{-}10}$ = frequency of EPRI accident Class 3b given a 1-in-10 years ILRT interval = 1.76×10^{-9}/ry [Step 7B]

Therefore,

$$\Delta LERF_{LNER3\text{-}15} = 9.16 \times 10^{-9} - 1.76 \times 10^{-9}$$

$$\Delta LERF_{LNER3\text{-}15} = 7.40 \times 10^{-9}/ry$$

Similar to the $\Delta LERF_{LNER10\text{-}15}$ result, the $\Delta LERF_{LNER3\text{-}15}$ is also non-risk significant from a risk perspective.

Step 9B - Evaluate the change in conditional containment failure probability

This step calculates the change in conditional containment failure probability (CCFP). Similar to Section 2.4.9 Step 9 of this risk assessment, the change in CCFP tracts the impact of the ILRT on both early (LERF) and late radionuclide releases. Therefore, CCFP consists of all those accident sequences resulting in a radionuclide release other that the intact containment state for EPRI accident Class 1, and small failures state for EPRI accident Class 3a. In additional, the CCFP is conditional given a severe core damage accident. Therefore, the change in the conditional containment failure probability from 1-in-10 years to 1-in-15 years is:

$$\Delta CCFP_{LINER10\text{-}15} = CCFP_{LINER1\text{-}15} - CCFP_{LINER1\text{-}10}$$

Where:

$\Delta CCFP_{LINER10\text{-}15}$ = the change in conditional containment failure probability from 1-in-10 years to 1-in-15 years given non-detected containment leakage

$CCFP_{LINER1\text{-}10}$ = conditional containment failure probability given 1-in-10 years ILRT interval and potential non-detected containment leakage = 88.07% [Step 7B]

$CCFP_{LINER1\text{-}15}$ = conditional containment failure probability given 1-in-15 years ILRT interval and potential non-detected containment leakage = 88.13% [Step 7B]

Therefore,

$$\Delta CCFP_{LINER10\text{-}15} = 88.13\% - 88.07\%$$

$$\Delta CCFP_{LINER10\text{-}15} = 0.06\%$$

This change in $\Delta CCFP_{LINER10\text{-}15}$ of less than 1% is insignificant from a risk perspective.

The results of Steps 7B, 8B, and 9B of the updated ILRT assessment including the potential impact from non-detected containment leakage scenarios assuming that 100% of the leakages result in EPRI Class 3b are show in Table B-5.

B6.0 Steel Shell Corrosion Sensitivity

Additional sensitivity cases were also developed to gain an understanding of the sensitivity of this analysis to the various key parameters. The sensitivity cases are as follows:

- Sensitivity Case 1 - Flaw rate doubles every 2 years
- Sensitivity Case 2 - Flaw rate doubles every 10 years
- Sensitivity Case 3 - 5% Visual inspection failures
- Sensitivity Case 4 - 15% Visual inspection failures
- Sensitivity Case 5 - Containment breach base point 10 times lower
- Sensitivity Case 6 - Containment breach base point 10 times higher
- Sensitivity Case 7 - Flaw rate doubles every 10 years, containment breach base point 10 times lower, 5% visual inspection failures and 10% EPRI accident Class 3b are LERF (Lower bound)
- Sensitivity Case 8 - Flaw rate doubles every 2 years, containment breach base point 10 times higher, 15% visual inspection failures and 100% EPRI accident Class 3b are LERF (upper bound)

The above sensitivities cases used the calculational methodology presented in Steps 2B to 9B. These steps were developed in an EXCEL spreadsheet. They are reproduced in Attachment A.

These results are summarized in Table B-6.

B7.0 Conclusions

This appendix provides a sensitivity evaluation of considering potential containment liner corrosion impacts within the structure of the ILRT interval extension risk assessment. The evaluation yields the following conclusions:

1. The impact of including age-adjusted corrosion effects in the ILRT assessment has minimal impact on plant risk and is therefore acceptable.
2. The change in LERF, taking into consideration the likelihood of a containment liner flaw due to age-adjusted corrosion is non-risk significant from a risk perspective. Specifically, extending the interval to 15 years from the current 10 years requirement is estimated to be about 3.19×10^{-9}/ry. This is below the Regulatory Guide 1.174 [5] acceptance criteria threshold of 10^{-7}/yr.
3. The age-adjusted corrosion impact in dose increase is estimated to be 5.00×10^{-4} person-rem/ry or 0.0042% from the baseline ILRT 10 year's interval.
4. The age-adjusted corrosion impact on the conditional containment failure probability increase is estimated to be 0.06%.
5. A series of parametric sensitivity studies regarding potential age related corrosion effects on the containment steel liner also demonstrated minimal impact on plant risk.

Table B-1

Flaw Failure Rate as a Function of Time

Year	Accessible Area Drywell and Torus		Inaccessible Area Drywell and Torus		Drywell Floor	
	Failure Rate	Success Rate	Failure Rate	Success Rate	Failure Rate	Success Rate
0	1.79×10^{-3}	9.98×10^{-1}	1.79×10^{-3}	9.98×10^{-1}	4.46×10^{-4}	1.00
1	2.05×10^{-3}	9.98×10^{-1}	2.05×10^{-3}	9.98×10^{-1}	5.13×10^{-4}	9.99×10^{-1}
2	2.36×10^{-3}	9.98×10^{-1}	2.36×10^{-3}	9.98×10^{-1}	5.89×10^{-4}	9.99×10^{-1}
3	2.71×10^{-3}	9.97×10^{-1}	2.71×10^{-3}	9.97×10^{-1}	6.77×10^{-4}	9.99×10^{-1}
4	3.11×10^{-3}	9.97×10^{-1}	3.11×10^{-3}	9.97×10^{-1}	7.78×10^{-4}	9.99×10^{-1}
5	3.57×10^{-3}	9.96×10^{-1}	3.57×10^{-3}	9.96×10^{-1}	8.94×10^{-4}	9.99×10^{-1}
6	4.11×10^{-3}	9.96×10^{-1}	4.11×10^{-3}	9.96×10^{-1}	1.03×10^{-3}	9.99×10^{-1}
7	4.72×10^{-3}	9.95×10^{-1}	4.72×10^{-3}	9.95×10^{-1}	1.18×10^{-3}	9.99×10^{-1}
8	5.42×10^{-3}	9.95×10^{-1}	5.42×10^{-3}	9.95×10^{-1}	1.36×10^{-3}	9.99×10^{-1}
9	6.23×10^{-3}	9.94×10^{-1}	6.23×10^{-3}	9.94×10^{-1}	1.56×10^{-3}	9.98×10^{-1}
10	7.16×10^{-3}	9.93×10^{-1}	7.16×10^{-3}	9.93×10^{-1}	1.79×10^{-3}	9.98×10^{-1}
11	8.23×10^{-3}	9.92×10^{-1}	8.23×10^{-3}	9.92×10^{-1}	2.06×10^{-3}	9.98×10^{-1}
12	9.45×10^{-3}	9.91×10^{-1}	9.45×10^{-3}	9.91×10^{-1}	2.36×10^{-3}	9.98×10^{-1}
13	1.09×10^{-2}	9.89×10^{-1}	1.09×10^{-2}	9.89×10^{-1}	2.71×10^{-3}	9.97×10^{-1}
14	1.25×10^{-2}	9.88×10^{-1}	1.25×10^{-2}	9.88×10^{-1}	3.12×10^{-3}	9.97×10^{-1}
15	1.43×10^{-2}	9.86×10^{-1}	1.43×10^{-2}	9.86×10^{-1}	3.58×10^{-3}	9.96×10^{-1}

Table B-2

Flaw Failure Rate as a Function of Test Interval

Years	Accessible Area Drywell and Torus		Inaccessible Area Drywell and Torus		Drywell Floor	
	Failure Rate	Success Rate	Failure Rate	Success Rate	Failure Rate	Success Rate
3-in-10	0.71%	9.93×10^{-1}	0.71%	9.93×10^{-1}	0.18%	9.98×10^{-1}
1-in-10	4.14%	9.59×10^{-1}	4.14%	9.59×10^{-1}	1.04%	9.90×10^{-1}
1-in-15	9.68%	9.03×10^{-1}	9.68%	9.03×10^{-1}	2.42%	9.76×10^{-1}

Table B-3

Vermont Yankee Containment Failure Probability Given Containment Liner Flaw

Pressure (psia)	Containment Liner Failure Probability	Drywell Floor Failure Probability
0	0.0004	0.00004
10	0.0006	0.0001
15	0.0008	0.0001
20	0.0010	0.0001
30	0.0017	0.0002
40	0.0028	0.0003
50	0.0047	0.0005
60	0.0078	0.0008
70	0.0130	0.0013
80	0.0217	0.0022
90	0.0362	0.0036
95	0.0468	0.0047
100	0.0605	0.0061
110	0.1011	0.0101
120	0.1688	0.0169
130	0.2820	0.0282
140	0.4710	0.0471
150	0.7866	0.0787
155	1.0	0.1

Figure B-1

Vermont Yankee Containment Failure Probability Given Containment Liner Flaw

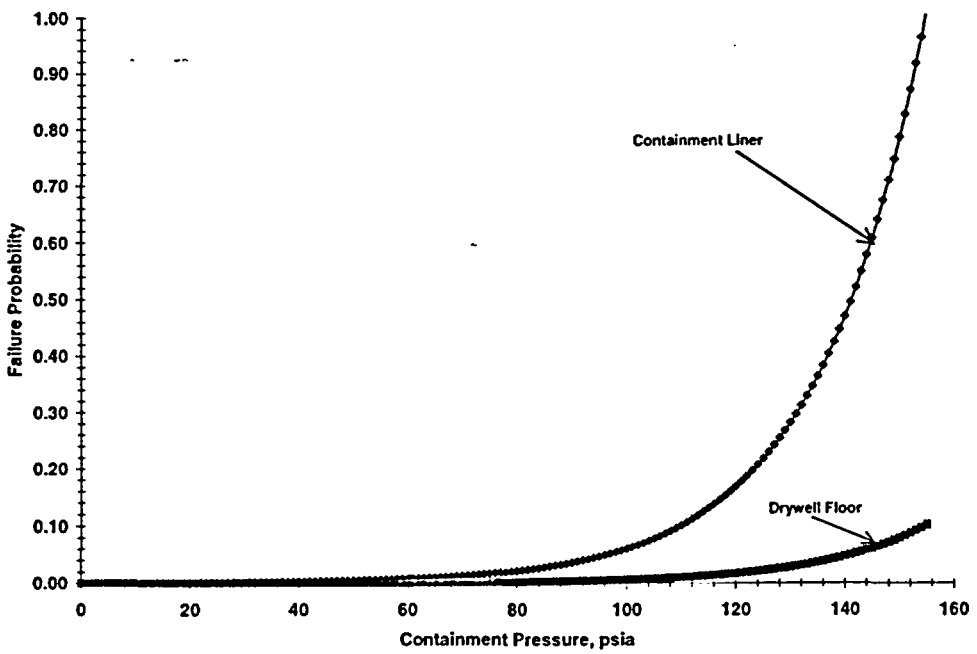

Table B-4

Vermont Yankee Containment Liner Corrosion Base Case

Step	Description	Accessible Area Drywell and Torus		Inaccessible Area Drywell and Torus		Drywell Floor	
1	Historical Steel Shell Flaw Likelihood	5.19×10^{-3}		5.19×10^{-3}		1.30×10^{-3}	
2	Age Adjusted Steel Shell Flaw Likelihood	Year	Failure Rate	Year	Failure Rate	Year	Failure Rate
		1	2.05×10^{-3}	1	2.05×10^{-3}	1	4.46×10^{-4}
		5-15	5.19×10^{-3}	5-15	5.19×10^{-3}	5-15	1.30×10^{-3}
		15	1.43×10^{-2}	15	1.43×10^{-2}	15	3.58×10^{-3}
3	Increase in Flaw Likelihood at 3, 10, and 15 years	0.71% (3-to-10 years) 4.14% (1-to-10 years) 9.68% (1-to-15 years)		0.71% (3-to-10 years) 4.14% (1-to-10 years) 9.68% (1-to-15 years)		0.18% (3-to-10 years) 1.04% (1-to-10 years) 2.42% (1-to-15 years)	
4	Likelihood of Breach in Containment Given Steel Shell Flaw	Pressure (psia)	Likelihood of Breach	Pressure (psia)	Likelihood of Breach	Pressure (psia)	Likelihood of Breach
		20	0.0010	20	0.0010	20	0.0001
		60.6 (ILRT)	0.0080	60.6 (ILRT)	0.0080	60.6 (ILRT)	0.0008
		130	0.2820	130	0.2820	130	0.0282
		140	0.4710	140	0.4710	140	0.0471
		155	0.9658	155	0.9658	155	0.0966
5	Visual Inspection Detection Failure Likelihood	0.1 (10%)		1.0 (100%)		1.0 (100%)	
6	Likelihood of Non-Detected Containment Leakage (Steps 3 * 4* 5)	0.00057% (3-to-10 years) 0.00332% (1-to-10 years) 0.00776% (1-to-15 years)		0.00570% (3-to-10 years) 0.03320% (1-to-10 years) 0.07759% (1-to-15 years)		0.00014% (3-to-10 years) 0.00083% (1-to-10 years) 0.00194% (1-to-15 years)	
Total Likelihood of Non-Detected Containment Leakage		0.00642% (3-to-10 years) 0.03737% (1-to-10 years) 0.08729% (1-to-15 years)					

Table B-5

Impact of Containment Steel Liner Corrosion on Vermont Yankee ILRT Intervals

	Base Case 3 Years			Extend to 10 Years			Extend to 15 Years		
EPRI Class	CDF (Per Ry)	Per-Rem	Per-Rem (Per Ry)	CDF (Per Ry)	Per-Rem	Per-Rem (Per Ry)	CDF (Per Ry)	Per-Rem	Per-Rem (Per Ry)
1	5.88×10^{-7}	1.30×10^{3}	7.64×10^{-4}	5.43×10^{-7}	1.30×10^{3}	7.06×10^{-4}	5.11×10^{-7}	1.30×10^{3}	6.65×10^{-4}
2	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}	2.14×10^{-9}	2.73×10^{6}	5.85×10^{-3}
3a	1.72×10^{-8}	1.30×10^{4}	2.24×10^{-4}	5.73×10^{-8}	1.30×10^{4}	7.46×10^{-4}	8.60×10^{-8}	1.30×10^{4}	1.12×10^{-3}
3b	1.76×10^{-9}	4.55×10^{4}	8.01×10^{-5}	5.97×10^{-9}	4.55×10^{4}	2.72×10^{-4}	9.16×10^{-9}	4.55×10^{4}	4.17×10^{-4}
4	0.0	N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0
5	0.0	N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0
6	0.0	N/A	0.0	0.0	N/A	0.0	0.0	N/A	0.0
7b	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}	3.22×10^{-7}	2.73×10^{6}	8.79×10^{-1}
7b	3.85×10^{-6}	2.73×10^{6}	1.05×10^{1}	3.85×10^{-6}	2.73×10^{6}	1.05×10^{1}	3.85×10^{-6}	2.73×10^{6}	1.05×10^{1}
7c	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}	9.71×10^{-9}	3.53×10^{6}	3.43×10^{-2}
8a	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}	1.63×10^{-7}	2.73×10^{6}	4.46×10^{-1}
8b	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}	5.32×10^{-8}	2.96×10^{6}	1.57×10^{-1}
Total	5.00×10^{-6}		12.0204	5.00×10^{-6}		12.0211	5.00×10^{-6}		12.0216
ILRT Dose Rate from 3a and 3b			3.04×10^{-4} ($+1.86 \times 10^{-6}$)*			1.02×10^{-3} ($+1.08 \times 10^{-5}$)*			1.54×10^{-3} ($+2.53 \times 10^{-5}$)*
% Of Total			0.0025% (+0.00002%)*			0.0085% (+0.0001%)*			0.0128% (+0.0002%)*
Delta Dose Rate from 3a and 3b (10 to 15 yr)									**5.00×10^{-4} (+0.0014%)***
LERF from 3b			1.76×10^{-9} ($+4.09 \times 10^{-11}$)*			5.97×10^{-9} ($+2.38 \times 10^{-10}$)*			9.16×10^{-9} ($+5.56 \times 10^{-10}$)*
Delta LERF (10 to 15 yr)									**3.19×10^{-9} ($+3.18 \times 10^{-10}$)***
CCFP %			87.98% (+0.0008%)*			88.07% (+0.0167%)*			88.13% (+0.0111%)*
Delta CCFP % (10 to 15 yr)									**0.06% (+0.0063%)***

* Denotes increase from original values presented in Section 2 of this report.

Table B-6

Containment Steel Liner Corrosion Sensitivity Cases

Age (Step 2)	Drywell/ Torus Breach (Step 4)	Visual Inspection & Non-Visual Flaws (Step 5)	Likelihood Flaw is LERF (EPRI Class 3b)	LERF Increase From Corrosion (3-in-10 years)	LERF Increase From Corrosion (1-in-10 years)	LERF Increase From Corrosion (1 to 15 years)	Total LERF Increase From ILRT Extension (10 to 15 years)
Base Case Doubles every 5 yrs	Base Case 0.8017%liner 0.0802%floor	Base Case 10%	Base Case 100%	Base Case 4.09×10^{-11}	Base Case 2.38×10^{-10}	Base Case 5.56×10^{-10}	Base Case 3.19×10^{-9}
Doubles every 2 yrs	Base	Base	Base	1.17×10^{-11}	1.99×10^{-10}	1.15×10^{-9}	3.82×10^{-9}
Doubles every 10 yrs	Base	Base	Base	6.08×10^{-11}	8.33×10^{-11}	1.08×10^{-10}	2.89×10^{-9}
Base	Base	5%	Base	3.91×10^{-11}	2.28×10^{-10}	5.32×10^{-10}	3179×10^{-9}
Base	Base	15%	Base	4.27×10^{-11}	2.49×10^{-10}	5.81×10^{-10}	3.20×10^{-9}
Base	0.16033%liner[14] 0.01603%floor[14]	Base	Base	8.18×10^{-12}	4.76×10^{-11}	1.11×10^{-10}	2.93×10^{-9}
Base	4.0042% liner[15] 0.4004%floor[15]	Base	Base	2.04×10^{-10}	1.19×10^{-9}	2.78×10^{-9}	4.46×10^{-9}
Lower Bound							
Doubles every 10 yrs	0.16033%liner[14] 0.01603%floor[14]	5%	10%	1.16×10^{-12}	5.03×10^{-12}	9.21×10^{-12}	2.87×10^{-9}
Upper Bound							
Doubles every 2 yrs	4.0042% liner[15] 0.4004%floor[15]	15%	100%	6.11×10^{-11}	1.04×10^{-9}	6.02×10^{-9}	7.85×10^{-9}

[14] Base point 10 times lower than base case of 0.0001 at 20 psia.
[15] Base point 10 times higher than base case of 0.01 at 20 psia.

Attachment A

VY Risk Impact of Containment Liner Corrosion During an Extension of the ILRT Interval Results

Table of Contents

A1.0 Introduction

This attachment presents the results of the Vermont Yankee risk impact of containment liner corrosion during an extension of the ILRT interval. Seven sensitivity cases were examined. These are:

- Sensitivity Case 1 - Flaw rate doubles every 2 years
- Sensitivity Case 2 - Flaw rate doubles every 10 years
- Sensitivity Case 3 - 5% Visual inspection failures
- Sensitivity Case 4 - 15% Visual inspection failures
- Sensitivity Case 5 - Containment breach base point 10 times lower
- Sensitivity Case 6 - Containment breach base point 10 times higher
- Sensitivity Case 7 - Flaw rate doubles every 10 years, containment breach base point 10 times lower, 5% visual inspection failures and 10% EPRI accident Class 3b are LERF (Lower bound)
- Sensitivity Case 8 - Flaw rate doubles every 2 years, containment breach base point 10 times higher, 15% visual inspection failures and 100% EPRI accident Class 3b are LERF (upper bound)

The EXCEL spreadsheet results are presented in the following sections.

A2.0 Sensitivity Case 1 - Flaw Rate Doubles Every 2 Years

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	0.20%	0.20%	0.05%
1 to 10 years	3.46%	3.46%	0.86%
1 to 15 years	20.07%	20.07%	5.02%
Other Assumptions:			
Containment Breach	0.8017%	0.8017%	0.0802%
Visual Inspection Failures	10.0%	100.0%	100.0%
EPRI Class 3a Fraction	0.0%	0.0%	0.0%
EPRI Class 3b Fraction	100.0%	100.0%	100.0%

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.00016%	0.00163%	0.00004%	0.00184%
				0.00184%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.88E-07		7.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	1.72E-08	0.00E+00	2.24E-04
3b	4.55E+04	1.73E-09	1.17E-11	7.88E-05
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0204**
			Risk Contribution:	0.003%
			From 3a and 3b:	3.02E-04
			3b LERF:	1.73E-09
			CCFP:	87.98%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.00000%
	0.0028%	0.0277%	0.0007%	0.03117%
				0.03117%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.43E-07		7.06E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	5.73E-08	0.00E+00	7.46E-04
3b	4.55E+04	5.93E-09	1.99E-10	2.70E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0211**

Risk Contribution:	0.01%
From 3a and 3b:	1.02E-03
3b LERF:	5.93E-09
CCFP:	88.07%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.00000%
	0.0161%	0.1609%	0.0040%	0.18099%
				0.18099%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	1.30E+03	5.11E-07		6.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	8.60E-08	0.00E+00	1.12E-03
3b	4.55E+04	9.76E-09	1.15E-09	4.44E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0216**

Risk Contribution:	0.01%
From 3a and 3b:	1.56E-03
3b LERF:	9.76E-09
CCFP:	88.14%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	5.04E-04
3 to 15 Increase (Person-rem/ry):	1.16E-03
10 to 15 Delta-LERF:	3.82E-09
3 to 15 Delta-LERF:	8.02E-09
10 to 15 Delta-CCFP:	0.08%
3 to 15 Delta-CCFP:	0.16%

3 to 15 Delta-LERF from Corrosion:	8.02E-09
10 to 15 Delta-LERF from Corrosion:	3.82E-09
Increase in LERF (ILRT 3-to-15 years)	1.08E-08

A3.0 Sensitivity Case 2 - Flaw Rate Doubles Every 10 Years

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	**1.06%**	**1.06%**	**0.26%**
1 to 10 years	**4.58%**	**1.06%**	**1.15%**
1 to 15 years	**8.38%**	**1.06%**	**2.10%**

Other Assumptions:

Containment Breach	0.8017%	0.8017%	0.0802%
Visual Inspection Failures	10.0%	100.0%	100.0%
EPRI Class 3a Fraction	0.0%	0.0%	0.0%
EPRI Class 3b Fraction	100.0%	100.0%	100.0%

Increases to 3a and 3b Frequencies				**Total**
	0.00000%	0.00000%	0.00000%	0.00000%
	0.00085%	0.00848%	0.00021%	0.00955%
				0.00955%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.87E-07		7.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	1.72E-08	0.00E+00	2.24E-04
3b	4.55E+04	1.78E-09	6.08E-11	8.10E-05
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0204**

Risk Contribution:	0.003%
From 3a and 3b:	3.05E-04
3b LERF:	1.78E-09
CCFP:	87.98%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.00000%
	0.0037%	0.0085%	0.0009%	0.01308%
				0.01308%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.43E-07		7.06E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	5.73E-08	0.00E+00	7.46E-04
3b	4.55E+04	5.82E-09	8.33E-11	2.65E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0211**

Risk Contribution:	0.01%
From 3a and 3b:	1.01E-03
3b LERF:	5.82E-09
CCFP:	88.06%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.00000%
	0.0067%	0.0085%	0.0017%	0.01689%
				0.01689%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	1.30E+03	5.12E-07		6.65E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	8.60E-08	0.00E+00	1.12E-03
3b	4.55E+04	8.71E-09	1.08E-10	3.96E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0215**

Risk Contribution:	0.01%
From 3a and 3b:	1.51E-03
3b LERF:	8.71E-09
CCFP:	88.12%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	4.63E-04
3 to 15 Increase (Person-rem/ry):	1.11E-03
10 to 15 Delta-LERF:	2.89E-09
3 to 15 Delta-LERF:	6.93E-09
10 to 15 Delta-CCFP:	0.06%
3 to 15 Delta-CCFP:	0.14%

3 to 15 Delta-LERF from Corrosion:	6.93E-09
10 to 15 Delta-LERF from Corrosion:	2.89E-09
Increase in LERF (ILRT 3-to-15 years)	1.99E-09

A4.0 Sensitivity Case 3 - 5% Visual Inspection Failures

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	0.71%	0.71%	0.18%
1 to 10 years	4.14%	4.14%	1.04%
1 to 15 years	9.68%	9.68%	2.42%
Other Assumptions:			
Containment Breach	0.8017%	0.8017%	0.0802%
Visual Inspection Failures	5.0%	100.0%	100.0%
EPRI Class 3a Fraction	0.0%	0.0%	0.0%
EPRI Class 3b Fraction	100.0%	100.0%	100.0%

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.0000%
	0.0003%	0.0057%	0.0001%	0.0061%
				0.0061%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.88E-07		7.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	1.72E-08	0.00E+00	2.24E-04
3b	4.55E+04	1.76E-09	3.91E-11	8.01E-05
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0204**
			Risk Contribution:	0.003%
			From 3a and 3b:	3.04E-04
			3b LERF:	1.76E-09
			CCFP:	87.98%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.0000%
	0.0017%	0.0332%	0.0008%	0.0357%
				0.0357%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.43E-07		7.06E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	5.73E-08	0.00E+00	7.46E-04
3b	4.55E+04	5.96E-09	2.28E-10	2.71E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0211**
			Risk Contribution:	0.01%
			From 3a and 3b:	1.02E-03
			3b LERF:	5.96E-09
			CCFP:	88.07%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.0000%
	0.0039%	0.0776%	0.0019%	0.0834%
				0.0834%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	1.30E+03	5.11E-07		6.65E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	8.60E-08	0.00E+00	1.12E-03
3b	4.55E+04	9.13E-09	5.32E-10	4.16E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0216**
			Risk Contribution:	0.01%
			From 3a and 3b:	1.53E-03
			3b LERF:	9.13E-09
			CCFP:	88.13%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	4.76E-04
3 to 15 Increase (Person-rem/ry):	1.13E-03
10 to 15 Delta-LERF:	**3.17E-09**
3 to 15 Delta-LERF:	7.37E-09
10 to 15 Delta-CCFP:	0.06%
3 to 15 Delta-CCFP:	0.15%

3 to 15 Delta-LERF from Corrosion:	7.37E-09
10 to 15 Delta-LERF from Corrosion:	3.17E-09
Increase in LERF (ILRT 3-to-15 years)	6.30E-09

A5.0 Sensitivity Case 4 - 15% Visual Inspection Failures

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	0.71%	0.71%	0.18%
1 to 10 years	4.14%	4.14%	1.04%
1 to 15 years	9.68%	9.68%	2.42%
Other Assumptions:			
Containment Breach	0.8017%	0.8017%	0.0802%
Visual Inspection Failures	15.0%	100.0%	100.0%
EPRI Class 3a Fraction	0.0%	0.0%	0.0%
EPRI Class 3b Fraction	100.0%	100.0%	100.0%

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.0000%
	0.0009%	0.0057%	0.0001%	0.0067%
				0.0067%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.88E-07		7.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	1.72E-08	0.00E+00	2.24E-04
3b	4.55E+04	1.76E-09	4.27E-11	8.02E-05
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0204**

Risk Contribution:	0.003%
From 3a and 3b:	3.04E-04
3b LERF:	1.76E-09
CCFP:	87.98%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.0000%
	0.0050%	0.0332%	0.0008%	0.0390%
				0.0390%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.43E-07		7.06E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	5.73E-08	0.00E+00	7.46E-04
3b	4.55E+04	5.98E-09	2.49E-10	2.72E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0211**

Risk Contribution:	0.01%
From 3a and 3b:	1.02E-03
3b LERF:	5.98E-09
CCFP:	88.07%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.0000%	0.0000%	0.0000%	0.0000%
	0.0116%	0.0776%	0.0019%	0.0912%
				0.0912%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	1.30E+03	5.11E-07		6.65E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	8.60E-08	0.00E+00	1.12E-03
3b	4.55E+04	9.18E-09	5.81E-10	4.18E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0216**

Risk Contribution:	0.01%
From 3a and 3b:	1.54E-03
3b LERF:	9.18E-09
CCFP:	88.13%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	4.77E-04
3 to 15 Increase (Person-rem/ry):	1.13E-03
10 to 15 Delta-LERF:	**3.20E-09**
3 to 15 Delta-LERF:	7.42E-09
10 to 15 Delta-CCFP:	0.06%
3 to 15 Delta-CCFP:	0.15%

3 to 15 Delta-LERF from Corrosion:	7.42E-09
10 to 15 Delta-LERF from Corrosion:	3.20E-09
Increase in LERF (ILRT 3-to-15 years)	6.89E-09

A6.0 Sensitivity Case 5 - Containment Breach Base Point 10 Times Lower

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	0.71%	0.71%	0.18%
1 to 10 years	4.14%	4.14%	1.04%
1 to 15 years	9.68%	9.68%	2.42%
Other Assumptions:			
Containment Breach	0.1603%	0.1603%	0.0160%
Visual Inspection Failures	10.0%	100.0%	100.0%
EPRI Class 3a Fraction	0.0%	0.0%	0.0%
EPRI Class 3b Fraction	100.0%	100.0%	100.0%

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.00011%	0.00114%	0.00003%	0.00128%
				0.00128%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	5.88E-07		7.64E-04	5.88E-07
2	2.14E-09	Corrosion Addition	5.85E-03	2.14E-09
3a	1.72E-08	0.00E+00	2.24E-04	1.72E-08
3b	1.73E-09	8.18E-12	7.87E-05	1.73E-09
4	0.00E+00		0.00E+00	0.00E+00
5	0.00E+00		0.00E+00	0.00E+00
6	0.00E+00		0.00E+00	0.00E+00
7a	3.22E-07		8.79E-01	3.22E-07
7b	3.85E-06		1.05E+01	3.85E-06
7c	9.71E-09		3.43E-02	9.71E-09
8a	1.63E-07		4.46E-01	1.63E-07
8b	5.32E-08		1.57E-01	5.32E-08
Total	**5.00E-06**		**12.0204**	**5.00E-06**
			Risk Contribution:	0.0025%
			From 3a and 3b:	3.02E-04
			3b LERF:	1.73E-09
			CCFP:	87.98%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.00066%	0.00664%	0.00017%	0.00747%
				0.00747%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	5.43E-07		7.06E-04	5.43E-07
2	2.14E-09	Corrosion Addition	5.85E-03	2.14E-09
3a	5.73E-08	0.00E+00	7.46E-04	5.73E-08
3b	5.78E-09	4.76E-11	2.63E-04	5.78E-09
4	0.00E+00		0.00E+00	0.00E+00
5	0.00E+00		0.00E+00	0.00E+00
6	0.00E+00		0.00E+00	0.00E+00
7a	3.22E-07		8.79E-01	3.22E-07
7b	3.85E-06		1.05E+01	3.85E-06
7c	9.71E-09		3.43E-02	9.71E-09
8a	1.63E-07		4.46E-01	1.63E-07
8b	5.32E-08		1.57E-01	5.32E-08
Total	**5.00E-06**		**12.0211**	**5.00E-06**
			Risk Contribution:	0.0084%
			From 3a and 3b:	1.01E-03
			3b LERF:	5.78E-09
			CCFP:	88.06%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.00155%	0.01552%	0.00039%	0.01746%
				0.01746%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	5.12E-07		6.65E-04	5.12E-07
2	2.14E-09	Corrosion Addition	5.85E-03	2.14E-09
3a	8.60E-08	0.00E+00	1.12E-03	8.60E-08
3b	8.71E-09	1.11E-10	3.96E-04	8.71E-09
4	0.00E+00		0.00E+00	0.00E+00
5	0.00E+00		0.00E+00	0.00E+00
6	0.00E+00		0.00E+00	0.00E+00
7a	3.22E-07		8.79E-01	3.22E-07
7b	3.85E-06		1.05E+01	3.85E-06
7c	9.71E-09		3.43E-02	9.71E-09
8a	1.63E-07		4.46E-01	1.63E-07
8b	5.32E-08		1.57E-01	5.32E-08
Total	**5.00E-06**		**12.0215**	**5.00E-06**
			Risk Contribution:	0.0126%
			From 3a and 3b:	1.51E-03
			3b LERF:	8.71E-09
			CCFP:	88.12%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	4.65E-04
3 to 15 Increase (Person-rem/ry):	1.11E-03
10 to 15 Delta-LERF:	**2.93E-09**
3 to 15 Delta-LERF:	6.98E-09
10 to 15 Delta-CCFP:	0.058%
3 to 15 Delta-CCFP:	0.14%

3 to 15 Delta-LERF from Corrosion:	6.98E-09
10 to 15 Delta-LERF from Corrosion:	2.93E-09
Increase in LERF (ILRT 3-to-15 years)	1.32E-09

A7.0 Sensitivity Case 6 - Containment Breach Base Point 10 Times Higher

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	0.71%	0.71%	0.18%
1 to 10 years	4.14%	4.14%	1.04%
1 to 15 years	9.68%	9.68%	2.42%
Other Assumptions:			
Containment Breach	4.0042%	4.0042%	0.4004%
Visual Inspection Failures	10.0%	100.0%	100.0%
EPRI Class 3a Fraction	0.0%	0.0%	0.0%
EPRI Class 3b Fraction	100.0%	100.0%	100.0%

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.00285%	0.02849%	0.00071%	0.03205%
				0.03205%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.87E-07		7.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	1.72E-08	0.00E+00	2.24E-04
3b	4.55E+04	1.92E-09	2.04E-10	8.76E-05
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0204**
			Risk Contribution:	0.0028%
			From 3a and 3b:	3.23E-04
			3b LERF:	2.00E-09
			CCFP:	87.12%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.01659%	0.16593%	0.00415%	0.18667%
				0.18667%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.42E-07		7.05E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	5.73E-08	0.00E+00	7.46E-04
3b	4.55E+04	6.92E-09	1.19E-09	3.15E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0211**

Risk Contribution:	0.0088%
From 3a and 3b:	1.06E-03
3b LERF:	6.92E-09
CCFP:	88.09%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.03876%	0.38756%	0.00969%	0.43600%
				0.43600%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	1.30E+03	5.09E-07		6.62E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	8.60E-08	0.00E+00	1.12E-03
3b	4.55E+04	1.14E-08	2.78E-09	5.18E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0217**

Risk Contribution:	0.0136%
From 3a and 3b:	1.64E-03
3b LERF:	1.14E-08
CCFP:	88.18%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	5.32E-04
3 to 15 Increase (Person-rem/ry):	1.22E-03
10 to 15 Delta-LERF:	**4.46E-09**
3 to 15 Delta-LERF:	9.46E-09
10 to 15 Delta-CCFP:	0.089%
3 to 15 Delta-CCFP:	0.19%

3 to 15 Delta-LERF from Corrosion:	9.46E-09
10 to 15 Delta-LERF from Corrosion:	4.46E-09
Increase in LERF (ILRT 3-to-15 years)	3.29E-08

A8.0 Sensitivity Case 7 - Lower bound
(Flaw rate doubles every 10 years, containment breach base point 10 times lower, 5% visual inspection failures and 10% EPRI accident Class 3b are LERF)

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	**1.06%**	**1.06%**	**0.26%**
1 to 10 years	**4.58%**	**4.58%**	**1.15%**
1 to 15 years	**8.38%**	**8.38%**	**2.10%**
Other Assumptions:			
Containment Breach	0.1603%	0.1603%	0.0160%
Visual Inspection Failures	5.0%	100.0%	100.0%
EPRI Class 3a Fraction	90.0%	90.0%	90.0%
EPRI Class 3b Fraction	10.0%	10.0%	10.0%

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00008%	0.00153%	0.00004%	0.00164%
	0.00001%	0.00017%	0.00000%	0.00018%
				0.00182%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.88E-07		7.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	1.72E-08	1.05E-11	2.24E-04
3b	4.55E+04	1.72E-09	1.16E-12	7.83E-05
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0204**

Risk Contribution:	0.0025%
From 3a and 3b:	3.02E-04
3b LERF:	1.72E-09
CCFP:	87.98%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00033%	0.00661%	0.00017%	0.00711%
	0.00004%	0.00073%	0.00002%	0.00079%
				0.00790%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.43E-07		7.06E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	5.74E-08	4.53E-11	7.46E-04
3b	4.55E+04	5.74E-09	5.03E-12	2.61E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0211**
			Risk Contribution:	0.0084%
			From 3a and 3b:	1.01E-03
			3b LERF:	5.74E-09
			CCFP:	88.06%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00060%	0.01210%	0.00030%	0.01301%
	0.00007%	0.00134%	0.00003%	0.00145%
				0.01445%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	1.30E+03	5.12E-07		6.65E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	8.61E-08	8.29E-11	1.12E-03
3b	4.55E+04	8.61E-09	9.21E-12	3.92E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0215**
			Risk Contribution:	0.0126%
			From 3a and 3b:	1.51E-03
			3b LERF:	8.61E-09
			CCFP:	88.12%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	4.63E-04
3 to 15 Increase (Person-rem/ry):	1.11E-03
10 to 15 Delta-LERF:	**2.87E-09**
3 to 15 Delta-LERF:	6.89E-09
10 to 15 Delta-CCFP:	0.057%
3 to 15 Delta-CCFP:	0.14%

3 to 15 Delta-LERF from Corrosion:	6.89E-09
10 to 15 Delta-LERF from Corrosion:	2.87E-09
Increase in LERF (ILRT 3-to-15 years)	1.22E-09

A9.0 Sensitivity Case 8 - Upper Bound
(Flaw rate doubles every 2 years, containment breach base point 10 times higher, 15% visual inspection failures and 100% EPRI accident Class 3b are LERF)

3-in-10 years

From Estimated Change

	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor
1 to 3 years	**0.20%**	**0.20%**	**0.05%**
1 to 10 years	**3.46%**	**3.46%**	**0.86%**
1 to 15 years	**20.07%**	**20.07%**	**5.02%**
Other Assumptions:			
Containment Breach	4.0042%	4.0042%	0.4004%
Visual Inspection Failures	15.0%	100.0%	100.0%
EPRI Class 3a Fraction	0.0%	0.0%	0.0%
EPRI Class 3b Fraction	100.0%	100.0%	100.0%

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.00122%	0.00816%	0.00020%	0.00959%
				0.00959%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 3 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.87E-07		7.64E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	1.72E-08	0.00E+00	2.24E-04
3b	4.55E+04	1.78E-09	6.11E-11	8.11E-05
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0204**

Risk Contribution:	0.0025%
From 3a and 3b:	3.05E-04
3b LERF:	1.78E-09
CCFP:	87.98%

1-in-10 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.02076%	0.13837%	0.00346%	0.16259%
				0.16259%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 10 yrs	Dose Person-rem/ry
1	1.30E+03	5.42E-07		7.05E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	5.73E-08	0.00E+00	7.46E-04
3b	4.55E+04	6.77E-09	1.04E-09	3.08E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
7d	2.73E+06	1.63E-07		4.46E-01
8	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0211**
			Risk Contribution:	0.0088%
			From 3a and 3b:	1.05E-03
			3b LERF:	6.77E-09
			CCFP:	88.08%

1-in-15 years

Increases to 3a and 3b Frequencies	Drywell/Torus	Inaccessible DW/Torus	Drywell Floor	Total
	0.00000%	0.00000%	0.00000%	0.00000%
	0.12053%	0.80354%	0.02009%	0.94416%
				0.94416%

Release type	VY Dose Person-rem	CDF Frequency/ry	Case 1 in 15 yrs	Dose Person-rem/ry
1	1.30E+03	5.06E-07		6.58E-04
2	2.73E+06	2.14E-09	Corrosion Addition	5.85E-03
3a	1.30E+04	8.60E-08	0.00E+00	1.12E-03
3b	4.55E+04	1.46E-08	6.02E-09	6.65E-04
4	N/A	0.00E+00		0.00E+00
5	N/A	0.00E+00		0.00E+00
6	N/A	0.00E+00		0.00E+00
7a	2.73E+06	3.22E-07		8.79E-01
7b	2.73E+06	3.85E-06		1.05E+01
7c	3.53E+06	9.71E-09		3.43E-02
8a	2.73E+06	1.63E-07		4.46E-01
8b	2.96E+06	5.32E-08		1.57E-01
Total		**5.00E-06**		**12.0218**
			Risk Contribution:	0.0148%
			From 3a and 3b:	1.78E-03
			3b LERF:	1.46E-08
			CCFP:	88.24%

Other Pertinent Risk Metrics:

10 to 15 Increase (Person-rem/ry):	6.82E-04
3 to 15 Increase (Person-rem/ry):	1.37E-03
10 to 15 Delta-LERF:	7.85E-09
3 to 15 Delta-LERF:	1.28E-08
10 to 15 Delta-CCFP:	0.156%
3 to 15 Delta-CCFP:	0.26%

3 to 15 Delta-LERF from Corrosion:	1.28E-08
10 to 15 Delta-LERF from Corrosion:	7.85E-09
Increase in LERF (ILRT 3-to-15 years)	5.62E-08