NMC
Committed to Nuclear Excellence

Kewaunee Nuclear Power Plant
Operated by Nuclear Management Company, LLC

NRC-03-121 10 CFR 50.90

December 12, 2003

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

KEWAUNEE NUCLEAR POWER PLANT
DOCKET 50-305
LICENSE No. DPR-43

License Amendment Request 198, "ILRT 5-Year Extension," NMC Response to NRC Request for Additional Information"

References:

1. Letter from Thomas Coutu (NMC) to Document Control Desk (NRC), "License Amendment Request 198 To The Kewaunee Nuclear Power Plant Technical Specifications for one-time extension of containment integrated leak rate test interval," dated June 20, 2003
2. Email from John Lamb (NRC) to Gerald Riste (NMC) concerning requests for clarification of information contained in reference letter 1,"Fwd: Kewaunee- Containment ILRT- RAIs (MB9907)," dated August 4, 2003.
3. Email from John Lamb (NRC) to Gerald Riste (NMC) concerning requests for clarification of information contained in reference letter 1,"ILRT RAI," dated September 3, 2003.

The Nuclear Management Company (NMC), in accordance with 10 CFR 50.90, submitted a Licensing Amendment Request (LAR) to the Kewaunee Nuclear Power Plant (KNPP) Technical Specifications (TS) to revise the surveillance requirements for containment integrated leak rate testing in TS 4.4.a, Integrated Leak Rate Tests (Type A). This change allows a one-time extension of the interval between integrated leakage rate tests (ILRTs) from 10 to 15 years.



A001

Following this submittal NMC was contacted concerning clarification of information contained in the reference 1 submittal. Two emails were sent to NMC (reference 2 and 3) requesting additional information. Attachment 1 to this letter contains the questions raised by the NRC staff and attachment 2 contains NMC's response to those questions. The questions are numbered 1-1, 1-2, etc for those sent by the first email and 2-1, 2-2, etc for those sent by the second email.

In preparing NMC's response to these questions NMC determined a revision was necessary to the KNPP report titled "Risk Impact Assessment For Extending Containment Type A Test Internal. The revision to this assessment, revision 1, is enclosed.

As these responses clarify the information contained in the original submittal and the revised assessment still achieves acceptable results, the safety evaluation, significant hazards determination and environmental considerations for the proposed changes contained in reference 1 remain valid. This response contains no new commitments and does not revise any previous commitments.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on December 12, 2003.

KU Hoyer for

Thomas Coutu
Site Vice President Kewaunee Nuclear Power Plant
Nuclear Management Company, LLC

GOR

| | | |
|---|---|---|
| Attachment | 1) | "NRC request for additional information." |
| | 2) | "NMC Response to NRC request for additional information." |
| Enclosure | 1) | "Risk Impact Assessment For Extending Containment Type A Test Internal," analysis file 17547-0001-A3, Rev 1, November 20, 2003. |

cc: Administrator, Region III, USNRC
Senior Resident Inspector, Kewaunee, USNRC
Project Manager, Kewaunee, USNRC
Public Service Commission of Wisconsin

ATTACHMENT 1

NUCLEAR MANAGEMENT COMPANY, LLC
KEWAUNEE NUCLEAR PLANT
DOCKET 50-305

**December 12, 2003**

Letter from Thomas Coutu (NMC)

To

Document Control Desk (NRC)

License Amendment Request 198

NRC Requests for Additional Information (RAI)
Kewaunee Nuclear Power Plant
One Time Deferral of Containment Integrated Leak Rate Test (ILRT)
Docket No. 50-305, (MB9907)

2 Pages to Follow

**August 4, 2003 Questions**

RAI 1-1

On Page 6 of Attachment 1, under Containment In-service Inspection Program, the licensee states that "the first ten-year inspection interval has been established from September 9, 1996, to September 9, 2006. In the NRC response to NEI questions 13, 15, and 16 on containment in-service inspections requirements discussed in NRC letter to NEI entitled "Response to NEI's Topic and Specific Issues related to Containment Inspection Requirements," dated May 30, 1997, the NRC explained that this interpretation of the rule was incorrect. The staff noted that the inspection periods should be determined as required in the ASME Code, Section XI, paragraph IWE-2410. Please provide your actual start dates of the first and subsequent inspection periods for ASME Code Class MC components in the first interval as required by the ASME Code, Section XI.

RAI 1-2

On Page 8, Attachment 1, Under Containment Penetration Bellows: The licensee states that "Kewaunee has nine penetration assemblies that incorporate two-ply mechanical bellows. ... The LLRT administrative acceptance criterion for measured leakage through these penetrations is very low at 100 standard cubic centimeters per minute. These penetrations have been tested each outage per the KNPP Containment Leak Rate Testing program with satisfactory results." If degraded, the bellows could allow more leakage during loss-of-coolant accidents and core damage accidents. Please provide the actual data (satisfactory readings of leakage) recorded earlier during testing.

RAI 1-3

Inspections of some reinforced concrete and steel containments (e.g., North Anna, Brunswick, and D. C. Cook, 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 Kewaunee containment are the part of the steel shell embedded in the basemat and the inaccessible areas on both sides of the cylinder and dome. Please discuss what programs are used to monitor their condition.

**September 3, 2003 Questions**

## RAI 2-1

In the Kewaunee analysis, the frequency of a small leak (Class 3a event) and a large leak (Class 3b event) were estimated using the NEI/EPRI-recommended failure probabilities (derived from available ILRT data), but were further reduced by the probability that a pre-existing leak is not detected by visual examination. In the staff's view, the probability of visually detecting a leak is implicitly reflected in the existing ILRT database, since some level of visual examination has always been part of the containment-testing program. Although the visual examinations conducted under the more recent IWE/IWL containment inspection programs may be more comprehensive than the earlier examinations, the extent to which the frequency of small and large leaks would be reduced by these improved examinations has not been established. Any further explicit credit for detecting a pre-existing leak by visual examination would need to be based on a systematic assessment of the incremental improvement in the ability to visually detect leakage provided by the current inspection program relative to the earlier inspection program. Such an assessment has not been provided.

An additional concern involves the derivation of the 0.28 probability that a pre-existing leak is not detected by visual examination. This derivation appears to be based on an assumption that a corrosion event has an equal chance of occurring at any location on the liner/shell, and therefore the probability of the leak occurring in an inspectable versus uninspectable region is directly proportional to the liner/shell surface area in each of these areas. However, the assumption that the location of the corrosion events will be randomly distributed has not been established, and appears to be at odds with the limited experience with corrosion-related events. In crediting the probability of detecting a pre-existing leak, the likelihood of the leak occurring in an inspectable versus uninspectable region needs to be established based on consideration of inspection experience. This has not been done.

In view of the aforementioned concerns, please provide a reassessment of the risk impacts when no additional credit for visual examinations is taken. Consistent with Regulatory Guide 1.174, if the increase in LERF associated with the requested change exceeds 1E-7 per year, also address the impact of the change on the baseline LERF, including the contribution from internal and external events.

## RAI 2-2

In assessing the potential for age-related degradation in Kewaunee it was assumed that the likelihood of a flaw in regions not contacted by foreign material would be negligible on the basis that none of the flaws found to date occurred in such regions. Although no failures may have been identified to date, there remains some likelihood of an undiscovered flaw in this region. In this regard, the likelihood of a flaw, albeit smaller, should be represented in the assessment, e.g., by assuming 0.5 failures rather than zero failures. Please provide an assessment of the impact if a non-negligible likelihood of a flaw is considered in the evaluation.

RAI 2-2

In assessing the potential for age-related degradation in Kewaunee it was assumed that the likelihood of a flaw in regions not contacted by foreign material would be negligible on the basis that none of the flaws found to date occurred in such regions. Although no failures may have been identified to date, there remains some likelihood of an undiscovered flaw in this region. In this regard, the likelihood of a flaw, albeit smaller, should be represented in the assessment, e.g., by assuming 0.5 failures rather than zero failures. Please provide an assessment of the impact if a non-negligible likelihood of a flaw is considered in the evaluation.

Response to RAI 2-2

The failure of the steel shell designed in accordance with the appropriate codes due to ordinary atmospheric corrosion is expected to be very small and much less than that indicated by an assumed 0.5 failures. However, the attached analysis has been revised to assume 0.5 failures for the region not subject to degradation by foreign material.

RAI 2-3

Although Kewaunee may have less total steel surface area in contact with concrete, those regions where corrosion has historically been a problem may be present in Kewaunee as well, e.g., lower regions of containment where the steel shell contacts the concrete basemat or a sand bed. If (some of) the observed corrosion events occurred in the basemat/shell interface region versus the upper region of the containment, and analogous regions exist in the Kewaunee plant, it is not clear why a reduction factor of 0.2 would be applicable in the assessment of age-related degradation for Kewaunee. Please explain and justify why the types of containment regions and liner/concrete contact modes associated with each of the corrosion events identified to date do not exist in the Kewaunee containment.

**RAI 2-3**

Although Kewaunee may have less total steel surface area in contact with concrete, those regions where corrosion has historically been a problem may be present in Kewaunee as well, e.g., lower regions of containment where the steel shell contacts the concrete basemat or a sand bed. If (some of) the observed corrosion events occurred in the basemat/shell interface region versus the upper region of the containment, and analogous regions exist in the Kewaunee plant, it is not clear why a reduction factor of 0.2 would be applicable in the assessment of age-related degradation for Kewaunee. Please explain and justify why the types of containment regions and liner/concrete contact modes associated with each of the corrosion events identified to date do not exist in the Kewaunee containment.

ATTACHMENT 2

NUCLEAR MANAGEMENT COMPANY, LLC
KEWAUNEE NUCLEAR PLANT
DOCKET 50-305

**December 12, 2003**

Letter from Thomas Coutu (NMC)

To

Document Control Desk (NRC)

License Amendment Request 198

Response To Requests for Additional Information (RAI)
Kewaunee Nuclear Power Plant
One Time Deferral of Containment Integrated Leak Rate Test (ILRT)
Docket No. 50-305, (MB9907)

9 Pages to Follow

RAI 1-1

On Page 6 of Attachment 1, under Containment In-service Inspection Program, the licensee states "the first ten-year inspection interval has been established from September 9, 1996, to September 9, 2006. In the NRC response to NEI questions 13, 15, and 16 on containment in-service inspections requirements discussed in NRC letter to NEI entitled "Response to NEI's Topic and Specific Issues related to Containment Inspection Requirements," dated May 30, 1997, the NRC explained that this interpretation of the rule was incorrect. The staff noted that the inspection periods should be determined as required in the ASME Code, Section XI, paragraph IWE-2410. Please provide your actual start dates of the first and subsequent inspection periods for ASME Code Class MC components in the first interval as required by the ASME Code, Section XI.

Response to RAI 1-1

The actual start date of the first ten-year inspection period for ASME Code Class MC components in the first interval as required by the ASME Code, Section XI, is the Federal Register publishing date of September 9, 1996. Kewaunee Nuclear Power Plant did not adjust the inspection period start date. Therefore, in the first inspection interval the three forty-month inspection periods cover the following dates.

Period 1: September 9, 1996 to January 9, 2000
Period 2: January 9, 2000 to May 9, 2003
Period 3: May 9, 2003 to September 9, 2006

RAI 1-2

On Page 8, Attachment 1, Under Containment Penetration Bellows: The licensee states that "Kewaunee has nine penetration assemblies that incorporate two-ply mechanical bellows. ... The LLRT administrative acceptance criterion for measured leakage through these penetrations is very low at 100 standard cubic centimeters per minute. These penetrations have been tested each outage per the KNPP Containment Leak Rate Testing program with satisfactory results." If degraded, the bellows could allow more leakage during loss-of-coolant accidents and core damage accidents. Please provide the actual data (satisfactory readings of leakage) recorded earlier during testing.

**Response to RAI 1-2**

Table 1 provides the historical as-found LLRT results for each of the two bellows included in the nine penetrations discussed on Page 8, Attachment 1, under Containment Penetration Bellows. While preparing this response it was realized that, while Attachment 1 addresses the nine hot penetrations, one cold penetration, penetration 18 - fuel transfer tube, contains three bellows with mesh inserts and should be included in consideration of this issue. Table 1 also provides the historical results for penetration 18.

All results are below established administrative leakage limits (100 SCCM per bellows).

TABLE 1

| PENETRATION BELLOWS LLRT RESULTS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | PENETRATION NUMBER | | | | | | | | | |
| YEAR TESTED | 6W | | 6E | | 7W | | 7E | | 8S | |
| | B1 | B2 | B1 | B2 | B1 | B2 | B1 | B2 | B1 | B2 |
| 1973* | 0.0105 | 0.00477 | 0.00666 | 0.00741 | 0.00867 | 0.0145 | 0.00154 | 0.00576 | 0.000708 | 0.0003 |
| 1976 | 0.012 | 0.005 | 0.004 | 0.006 | 0.01 | 0.013 | 0.041 | 0.027 | 0 | 0.001 |
| 1977 | 0.016 | 0 | 0.078 | 0.048 | 0 | 0.007 | 0.024 | 0.058 | 0.007 | 0.019 |
| 1978* | 0.083 | 0.023 | 0.058 | 0.066 | 0.125 | 0 | 0.056 | 0.055 | 0.049 | 0.057 |
| 1979 | 0.041 | 0.02 | 0.009 | 0.008 | 0.048 | 0.025 | 0.001 | 0 | 0.026 | 0.029 |
| 1980 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1981 | 0.027 | 0.019 | 0.019 | 0.013 | 0.01 | 0.026 | 0.015 | 0.013 | 0.014 | 0.011 |
| 1982 | 0.039 | 0.04 | 0 | 0 | 0.038 | 0.041 | 0 | 0 | 0.01 | 0.014 |
| 1983 | 0.105 | 0.105 | 0 | 0 | 0.105 | 0.105 | 0 | 0 | 0.023 | 0.035 |
| 1984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1985* | 0 | 0 | 0 | 0 | 0 | 0 | 1.5 | 0 | 1 | 0 |
| 1986 | 0 | 0 | 0 | 0 | 6 | 4 | 0 | 10 | 7 | 9 |
| 1987 | 5 | 5 | 0 | 7 | 7 | 4 | 3 | 0 | 5 | 12 |
| 1988 | 4 | 7 | 7 | 3 | 2 | 5 | 2 | 3 | 0 | 1 |
| 1989 | 3.3 | 2.1 | 2.4 | 1.3 | 0.9 | 2.2 | 2.8 | 3.6 | 2.7 | 2.2 |
| 1990 | 2 | 8 | 0 | 5 | 3 | 0 | 0 | 3 | 2 | 4 |
| 1991 | 3 | 0 | 0 | 0 | 0 | 4 | 0 | 3 | 0 | 0 |
| 1992 | 4.7 | 8.6 | 6.1 | 2.6 | 4.1 | 3.4 | 7.6 | 12.8 | 3.9 | 2 |
| 1993 | 5.1 | 9.5 | 43.6 | 48.3 | 3.2 | 3.9 | 42.6 | 51.8 | 46.6 | 52.4 |
| 1994 | 60.2 | 63.1 | 17.5 | 27.9 | 58.4 | 57.4 | 20 | 28.2 | 20.7 | 18.1 |
| 1995 | 7 | 1.3 | 7.9 | 11.3 | 11.9 | 2 | 9.7 | 38.3 | 6.9 | 7.2 |
| 1996& | <20 | <20 | <20 | <20 | <20 | <20 | <20 | 20 | <20 | <20 |
| 1998 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 |
| 2000 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | 30 | <20 | <20 |
| 2001$ | | | <20 | <20 | | | <20 | 36.6 | | |
| 2003 | <20 | <20 | | | <20 | <20 | | | <20 | <20 |

* Results in SCFH from 1973 through 1984
# Results in SCCM from 1985 forward
& Started using test instrument minimum calibration value if measured value was smaller
$ Began extended LLRT test intervals per Option B

TABLE 1 (cont)

| PENETRATION BELLOWS LLRT RESULTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| YEAR TESTED | PENETRATION NUMBER | | | | | | | |
| | 8N | | 9 | | 10 | | 11 | |
| | B1 | B2 | B1 | B2 | B1 | B2 | B1 | B2 |
| 1973* | 0.00135 | 0.000794 | 0.00372 | 0.00522 | 0.0106 | 0.046 | 0.00447 | 0.00072 |
| 1976 | 0.001 | 0 | 0.004 | 0.006 | 0.009 | 0.051 | 0.004 | 0.001 |
| 1977 | 0.021 | 0.032 | 0.011 | 0.08 | 0.173 | 0.058 | 0.022 | 0.055 |
| 1978 | 0.042 | 0.044 | 0.063 | 0.044 | 0.059 | 0.055 | 0.043 | 0.039 |
| 1979 | 0.02 | 0.021 | 0.011 | 0 | 0.023 | 0.019 | 0 | 0.004 |
| 1980 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1981 | 0.017 | 0.015 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1982 | 0.008 | 0.011 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1983 | 0.081 | 0.05 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1984 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1985# | 0 | 0 | 0 | 1 | 1.5 | 0.5 | 0 | 0 |
| 1986 | 10 | 3 | 5 | 4 | 10 | 3 | 0 | 4 |
| 1987 | 0 | 9 | 4 | 0 | 9 | 8 | 7 | 10 |
| 1988 | 16 | 0 | 2 | 3 | 3 | 1 | 3 | 2 |
| 1989 | 1.5 | 0.6 | 3.4 | 3.3 | 3.1 | 3 | 3.1 | 2.5 |
| 1990 | 6 | 5 | 4 | 3 | 0 | 0 | 8 | 3 |
| 1991 | 1 | 0 | 5 | 1 | 4 | 0 | 2 | 3 |
| 1992 | 2.7 | 2.8 | 2.6 | 3 | 2.9 | 7.3 | 10.3 | 8.6 |
| 1993 | 37.5 | 32.9 | 4 | 3.9 | 1.2 | 3.9 | 3.5 | 3.6 |
| 1994 | 17.9 | 18.6 | 53.4 | 17 | 24.8 | 26.4 | 18.1 | 27 |
| 1995 | 90 | 6.3 | 11.6 | 7.5 | 7 | 6.3 | 7.6 | 10.4 |
| 1996& | 20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 |
| 1998 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 |
| 2000 | 57 | <20 | <20 | <20 | <20 | <20 | <20 | <20 |
| 2001$ | <20 | <20 | <20 | <20 | <20 | <20 | | |
| 2003 | | | | | | | <20 | <20 |

* Results in SCFH from 1973 through 1984

# Results in SCCM from 1985 forward & Started using test instrument minimum calibration value if measured value was smaller

$ Began extended LLRT test intervals per Option B

TABLE 1 (cont)

| PENETRATION BELLOWS LLRT RESULTS | | | |
|---|---|---|---|
| YEAR TESTED | PENETRATION NUMBER 18 | | |
| | B1 | B2 | B3 |
| 1973* | 0.00612 | 0.0104 | 0.00723 |
| 1976 | 0 | 0 | 0 |
| 1977 | 0 | 0 | 0 |
| 1978 | 0 | 0 | 0 |
| 1979 | 0.001 | 0.023 | 0.018 |
| 1980 | 0 | 0 | 0 |
| 1981 | 0.059 | 0.023 | 0 |
| 1982 | 0.041 | 0.037 | 0 |
| 1983 | 0.105 | 0.105 | 0 |
| 1984 | 0 | 0 | 0 |
| 1985# | 0 | 0 | 4.2 |
| 1986 | 5 | 3 | 0 |
| 1987 | 0 | 3 | 11 |
| 1988 | 0 | 0 | 9 |
| 1989 | 5.1 | 2.9 | 6.6 |
| 1990 | 4 | 2 | 4 |
| 1991 | 5.3 | 2.1 | 6.4 |
| 1992 | 5.6 | 2.9 | 12.2 |
| 1993 | 5.2 | 4.7 | 5.5 |
| 1994 | 13.6 | 8.8 | 23.4 |
| 1995 | 11.4 | 5.4 | 14.5 |
| 1996& | <20 | <20 | <20 |
| 1998 | <20 | <20 | <20 |
| 2000 | <20 | <20 | <20 |
| 2001$ | <20 | <20 | <20 |
| 2003 | <20 | <20 | <20 |

* Results in SCFH from 1973 through 1984
# Results in SCCM from 1985 forward
& Started using test instrument minimum calibration value if measured value was smaller
$ Began extended LLRT test intervals per Option B

**RAI 1-3**

Inspections of some reinforced concrete and steel containments (e.g., North Anna, Brunswick, and D. C. Cook, 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 Kewaunee containment are the part of the steel shell embedded in the basemat and the inaccessible areas on both sides of the cylinder and dome. Please discuss what programs are used to monitor their condition.

**Response to RAI 1-3**

As part of the scheduled containment ISI inspections, the moisture barrier areas on the periphery of the inaccessible portions of the containment vessel are inspected. Appropriate action would be taken for any indications of degradation in these areas. There is no other established program for monitoring the condition of inaccessible portions of the steel containment vessel.

As discussed on Page 3 of Attachment 1 of reference 1 under Risk Assessment Methodology, the potential impact of age-related corrosion of the steel containment vessel on risk associated with extending the ILRT interval was determined. The details are provided in Attachment 4 of reference 1. The affect of age-related corrosion is included in the risk assessment results presented on pages 4 and 5 of Attachment 1 of reference 1. Because the KNPP containment vessel is freestanding, the fraction of the surface area that is inaccessible for inspection is significantly smaller than at plants with steel-lined concrete containments. As a result, the affect on risk for an extended ILRT interval is substantially less.

**RAI 2-1**

In the Kewaunee analysis, the frequency of a small leak (Class 3a event) and a large leak (Class 3b event) were estimated using the NEI/EPRI-recommended failure probabilities (derived from available ILRT data), but were further reduced by the probability that a pre-existing leak is not detected by visual examination. In the staff's view, the probability of visually detecting a leak is implicitly reflected in the existing ILRT database, since some level of visual examination has always been part of the containment-testing program. Although the visual examinations conducted under the more recent IWE/IWL containment inspection programs may be more comprehensive than the earlier examinations, the extent to which the frequency of small and large leaks would be reduced by these improved examinations has not been established. Any further explicit credit for detecting a pre-existing leak by visual examination would need to be based on a systematic assessment of the incremental improvement in the ability to visually detect leakage provided by the current inspection program relative to the earlier inspection program. Such an assessment has not been provided.

An additional concern involves the derivation of the 0.28 probability that a pre-existing leak is not detected by visual examination. This derivation appears to be based on an assumption that a corrosion event has an equal chance of occurring at any location on the liner/shell, and therefore the probability of the leak occurring in an inspectable versus uninspectable region is directly proportional to the liner/shell surface area in each of these areas. However, the assumption that the location of the corrosion events will be randomly distributed has not been established, and appears to be at odds with the limited experience with corrosion-related events. In crediting the probability of detecting a pre-existing leak, the likelihood of the leak occurring in an inspectable versus uninspectable region needs to be established based on consideration of inspection experience. This has not been done.

In view of the aforementioned concerns, please provide a reassessment of the risk impacts when no additional credit for visual examinations is taken. Consistent with Regulatory Guide 1.174, if the increase in LERF associated with the requested change exceeds 1E-7 per year, also address the impact of the change on the baseline LERF, including the contribution from internal and external events.

## Response to RAI 2-1

A revised analysis is attached which takes no credit for visual inspection in determining Class 3 frequency. This analysis is based on a more recent update of the KNPP PRA including internal and external initiated events. The results of the revised analysis are summarized below.

The increase in ILRT test interval from 10 years to 15 years results in an increase in population dose of 0.0108 person-rem per year, or 0.12% of the total population dose, without considering corrosion and 0.0113 person-rem per year, or 0.13%, if corrosion is considered. The cumulative changes for the ILRT interval increase from that corresponding to 3 tests in 10 years to the requested 15 years are 0.0260 person-rem per year or 0.30%, without corrosion, and 0.0269 person-rem per year or 0.31%, with corrosion. These increases in risk are all small and essentially negligible considering other risk contributions.

The overall baseline LERF for the Kewaunee Nuclear Power Plant including external events is 7.45E-6 per year. The increase in ILRT test interval from 10 years to 15 years results in an increase in LERF (ΔLERF) of 3.2E-07 per year, without considering corrosion and 3.3E-07 per year, with corrosion. The resulting total LERF for the requested change is 7.8E-6 per year including internal and external initiators. The cumulative changes for the ILRT interval increase from that corresponding to 3 tests in 10 years to the requested 15 years are 7.6E-07 per year, without corrosion, and 7.9E-07 per year, with corrosion. The resulting total LERF is 8.2E-6 per year including internal and external initiators. These increases in Δ LERF and LERF are within the RG 1.174 guidelines which states that applications will be considered only if it can be reasonable shown that when the Δ LERF is greater than 1E-7 and less than 1E-6 the total LERF must be less than 1E-5. This application meets these guidelines.

The increase in ILRT test interval from 10 years to 15 years results in an increase in conditional containment failure probability (CCFP) of 0.0019, without considering corrosion and 0.0021, with corrosion. The cumulative changes for the ILRT interval increase from that corresponding to 3 tests in 10 years to the requested 15 years are 0.0044, without corrosion, and 0.0047, with corrosion. These increases in CCFP are very small changes and are essentially negligible considering other risk contributions.

These results are summarized in the following table.

| | Test Interval Extended | |
|---|---|---|
| | From 3 in 10 years to 1 in 15 years | From 1 in 10 years to 1 in 15 years |
| Total person-rem/year increase | | |
| Without Corrosion | 0.0260 | 0.0108 |
| Including Corrosion | 0.0269 | 0.0113 |
| | | |
| The percentage increase in person-rem/year risk | | |
| Without Corrosion | 0.30% | 0.12% |
| Including Corrosion | 0.31% | 0.13% |
| | | |
| Change in LERF (per year) | | |
| Without Corrosion | 7.6E-07 | 3.2E-07 |
| Including Corrosion | 7.9E-07 | 3.3E-07 |
| | | |
| Total LERF after above Change (per year) | | |
| Without Corrosion | 8.2E-06 | 7.8E-06 |
| Including Corrosion | 8.2E-06 | 7.8E-06 |
| | | |
| Change in the Conditional Containment Failure Probability | | |
| Without Corrosion | 0.0044 | 0.0019 |
| Including Corrosion | 0.0047 | 0.0021 |

The above results demonstrate that the increases in risk and LERF resulting from the proposed amendment are within established guidelines and defense-in-depth principles would be maintained.

**Response to RAI 2-3**

It is expected that the likelihood of accelerated corrosion due to foreign material in contact with the steel liner or shell of containment will be proportional to the surface area where this potential exists. This is the area at risk. The frequency of accelerated corrosion will therefore be given by

$$= \left[\frac{\text{(Number of oberved failures)}}{\text{(Years of data)}}\right]\left[\frac{\text{(Area at risk for KNPP)}}{\text{(Area at risk for the industry)}}\right]$$

$$\left[\frac{\text{(Number of oberved failures)}}{\text{(Years of data)}}\right]\left[\frac{\text{(Area at risk for KNPP)}}{\text{(Unit average area at risk) (Number of units in the industry)}}\right]$$

$$= \left[\frac{\text{(Number of oberved failures)}}{\text{(Years of data)(Number of units in the industry)}}\right]\left[\frac{\text{(Area at risk for KNPP)}}{\text{(Unit average area at risk)}}\right]$$

The last term in brackets was originally taken to be the fraction of the KNPP area at risk based on the reasoning that the majority of containments in the industry are large dry containments of steel lined concrete where essentially the entire area is at risk and the total areas are generally larger than at KNPP.

The average area at risk for the industry has been estimated by dividing the 104 operating plants into 11 categories of similar arrangements and constructon features and estimating the area for a representative plant in each catgegory. The result is an average area at risk of 61,900 $ft^2$. The ratio of the KNPP area at risk of 13,800 ft to this average is 0.223, compared to the 0.20 originally used. This updated value was used in the attached revised anlaysis.

Enclosure 1

NUCLEAR MANAGEMENT COMPANY, LLC
KEWAUNEE NUCLEAR PLANT
DOCKET 50-305

**December 12, 2003**

Letter from Thomas Coutu (NMC)

To

Document Control Desk (NRC)

License Amendment Request 198

"Risk Impact Assessment For Extending Containment Type A Test Internal,"

17547-0001-A3,

Rev 1, November 20, 2003.

37 Pages to Follow

**Nuclear Management Company**
**Kewaunee Nuclear Power Plant**

# RISK IMPACT ASSESSMENT FOR EXTENDING CONTAINMENT TYPE A TEST INTERVAL

Analysis File 17547-0001-A3, Rev. 1

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## 1.0 CLIENT

Nuclear Management Company – Kewaunee Nuclear Power Plant

## 2.0 TITLE

Risk Informed/Risk Impact Assessment for Extending Containment Type A Test Interval

## 3.0 AUTHOR

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## 4.0 PURPOSE

The purpose of this calculation is to assess the risk impact for extending the Integrated Leak Rate Test (ILRT) interval for the Kewaunee Nuclear Power Plant (KNPP) from ten to fifteen years. In October 26, 1995, the Nuclear Regulatory Commission (NRC) revised 10 CFR 50, Appendix J. The revision to Appendix J allowed individual plants to select containment leakage testing frequency under Option A "Prescriptive Requirements" or Option B "Performance-Based Requirements". KNPP selected the requirements under Option B as its testing program.

The surveillance testing requirements (for Option B of Appendix J) as proposed in NEI 94-01 [Reference 1] for Type A testing is at least once per 10 years 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 1.00La. KNPP will use this analysis to seek a one-time exemption from a 10 year test interval to a 15 year test interval.

## 5.0 INTENDED USE OF ANALYSIS RESULTS

The results of this calculation will be used to obtain NRC approval to extend the Integrated Leak Rate Test interval from one in ten years to one in fifteen years.

## 6.0 TECHNICAL APPROACH

The methodology used for this analysis is similar to the assessments originally performed for Crystal River 3 (CR3) [Reference 2] and Indian Point 3 (IP3) [Reference 3] with enhancements outlined in the EPRI Interim Guidance [Reference 4] and incorporated in numerous subsequent submittals, such as Salem [Reference 5] and D. C. Cook [Reference 6]. The ILRT interval extensions requested by these submittals have been approved by the NRC. The impact of age-related degradation of the containment is also evaluated in a sensitivity study (see Appendix A) using methodology similar to that first employed in the Calvert Cliffs Nuclear Plant (CCNPP) response to an NRC Request for Additional Information (RAI) [Reference 7] and subsequently used in numerous other submittals including those for Comanche Peak and D. C. Cook [References 8 and 6].

This calculation was performed in accordance with NEI 94-01 [Reference 1] guidelines, and the NRC regulatory guidance on the use of Probabilistic Risk Assessment (PRA) findings and risk insights in support of a licensee request for changes to a plant's licensing basis, Regulatory Guide RG 1.174 [Reference 9]. This methodology is similar to that presented in EPRI TR-104285 [Reference 10] and NUREG-1493 [Reference 11] and incorporates the revised guidance and additional information of References 4 and 12. It uses a simplified bounding analysis approach to evaluate the risk impact of increasing the ILRT Type A interval from 10 to 15 years by using core damage and containment failure

frequency information from the most recent update of the KNPP PRA including both internal and external initiating events [Reference 13]. Specifically, the following were considered:

- Core damage sequences in which the containment remains intact initially and in the long term (EPRI TR-104285 Class 1 sequences).

- Core damage sequences in which containment integrity is impaired due to pre-existing isolation failures of plant components other than those subjected to Type B or Type C tests. For example, this includes sequences with pre-existing liner breach or steam generator manway leakage (EPRI TR-104285 Class 3 sequences). Type B tests measure component leakage across pressure retaining boundaries (e.g., gaskets, expansion bellows and air locks). Type C tests measure component leakage rates across containment isolation valves.

- Core damage sequences in which containment integrity is impaired due to containment isolation failures of pathways left 'open' following a plant post-maintenance test. For example, this includes situations in which a valve fails to close following a valve stroke test (EPRI TR-104285 Class 6 sequences).

- Accident sequences involving containment failure induced by severe accident phenomena (EPRI TR-104285 Class 7 sequences), containment bypassed (EPRI TR-104285 Class 8 sequences), large containment isolation failures (EPRI TR-104285 Class 2 sequences) and small containment isolation 'failure-to-seal' events (EPRI TR-104285 Class 4 and 5 sequences). The sequences of these classes are impacted by changes in Type B and C test intervals, not changes in the Type A test interval (Type A test measures the containment air mass and calculates the leakage from the change in mass over time).

Detailed descriptions of Classes 1 through 8 are excerpted from Reference 10 and provided in Table 1 of this analysis.

This calculation uses the following steps.

***Step 1 – Quantify the baseline frequency per reactor year for each of the eight accident classes (See Table 2).***

The KNPP Level 1 and 2 PRA analyses [Reference 13], and NUREG-1493 [Reference 11] were used to provide data to evaluate the annual frequencies for Classes 1,2,3,6,7 and 8. These frequencies are evaluated in detail in Section 11.1 of this analysis. Table 2 summarizes the results of this step. Class 4 and 5 sequences were not quantified because they are not impacted by the Type A test interval and are small contributors to the total. The containment failure modes modeled in the KNPP Level 2 analysis were based on important phenomena and system related events identified in NUREG-1335 [Reference 14].

***Step 2 – Develop plant specific person-rem dose (population dose) per reactor year for each of the eight accident classes (See Table 4).***

Reference 16 was used to develop person-rem for each of the classes described in Table 1 excluding Classes 4 and 5. Reference 15 is a calculation of the conditional person-rem dose to the population, within a 50-mile radius from the KNPP. The total population dose frequency in person-rem per year for each class is evaluated in detail in Section 11.2 of this analysis. Table 4 summarizes the results of this step.

***Step 3 – Evaluate risk impact of extending Type A test interval.***

This step evaluates potential increase in the population dose due to extending the ILRT test interval from that for 3 tests in 10 year (a 3 year interval) to a 10 year interval and to a 15 year interval. Section 11.3 of this calculation contains the detailed evaluation of this step. Section 13.0 and Tables 4, 5 and 6 summarize the results of this step.

***Step 4 – Determine the change in risk in terms of Large Early Release Frequency (LERF) in Accordance with R.G. 1.174 [Reference 9].***

This step evaluates the increase in the Large Early Release Frequency (LERF) due to extending the ILRT test interval from a 3 year test interval to a 15 year test interval and from a 10 year to a 15 year test interval. Section 11.4 of this calculation contains the detailed evaluation of this step while Section 13.0 summarizes the result of this step.

***Step 5 – Determine the change in the Conditional Containment Failure Probability for the proposed and cumulative changes of Type A test interval.***

This step evaluates the increase in the Conditional Containment Failure Probability (CCFP) due to extending the ILRT test interval from one test interval to another. The changes in CCFP are evaluated in detail in Section 11.5 while Section 13.0 summarizes the results of this step.

The technical approach for the sensitivity study evaluating the potential impact of age-related corrosion of the steel containment is provided in Appendix A along with the detailed calculations and results.

## 7.0 INPUT INFORMATION

1. Updated PRA total Core Damage Frequency (CDF) and the frequency of various release categories from KNPP updated Level 2 PRA as calculated in Reference 13. These results include sequences initiated by internal and external initiating events.

2. Population Doses for containment failure modes. Provided by "KNPP Year 2000 Offsite Dose Assessment", Calculation # 17547-0001-A1", dated 3/21/2003 [Reference 15].

## 8.0 REFERENCES


1. NEI 94-01, "Industry Guideline for Implementing Performance-Based Option of 10CFR Part 50, Appendix J, July 26, 1995, Revision 0.

2. "Crystal River – Unit 3 – License Amendment Request #267, Revision 2, Supplemental Risk-Informed Information in Support of License Amendment Request #267," Florida Power, 3F0601-06, June 20, 2001.

3. "Supplemental Information Regarding Proposed Change to Section 6.14 of the Administrative Section of the Technical Specification", Entergy, IPN-01-007, Indian Point 3 Nuclear Power Plant, January 18, 2001.

4. J. Haugh, J. M. Gisclon, W. Parkinson, K. Canavan, "Interim Guidance for Performing Risk Impact Assessments in Support of One-Time Extensions for Containment Integrated Leakage Rate Test Surveillance Intervals", Rev. 4, EPRI, November, 2001.

5. "Request for Change to Technical Specifications, One-Time Extension to Increase the Interval of the Integrated Leak Rate Test from Ten to Fifteen Years, Salem Generating Station Unit 2," PSEG Nuclear LLC, March 22, 2002.

6. "Donald C. Cook Nuclear Plant Units 1 and 2, Response to Nuclear Regulatory Commission Request for Additional Information Regarding the License Amendment Request for a One-time Extension of Integrated Leakage Rate Test Interval," Indiana Michigan Power Company, November 11, 2002.

7. "Calvert Cliffs Nuclear Power Plant Unit No. 1; Docket No. 50-317, ," Constellation Nuclear letter to USNRC, March 27, 2002.

8. "Comanche Peak Steam Electric Station (CPSES), Docket Nos. 50-445 and 50-446, Response to Request for Additional Information Regarding License Amendment Request (LAR) 01-14 Revision to Technical Specification (TS) 5.5.16 Containment Leakage Rate Testing Program," TXU Energy letter to USNRC, June 12, 2002.

9. Regulatory Guide 1.174, " An Approach for using Probabilistic Risk Assessment in Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis" July 1998.

10. EPRI TR-104285, "Risk Assessment of Revised Containment Leak Rate Testing Intervals" August 1994.

11. NUREG-1493, "Performance-Based Containment Leak-Test Program, July 1995".

12. NEI Memo, "One-Time Extension of Containment Integrated Leak Rate Test Interval – Additional Information", Nuclear Energy Institute, November 30, 2001.

13. Edward Coen, "Calculations for ILRT Extension," KNPP, transmitted via E-mail, 10/21/03.

14. United States Nuclear Regulatory Commission, "Individual Plant Examination: Submittal Guidance," NUREG-1335, August 1989.

15. P.J. Fulford, "Risk Impact Assessment For Extending Containment Type A Test Interval," SCIENTECH, INC. Analysis File 17547-0001-A1, Rev. 0, March 21, 2003

16. S. E. Phillippi, "Calculation of Inspectable And Uninspectable Containment Vessel Surface Areas," SCIENTECH, INC. Analysis File 17547-0001-A2, Rev. 0 March 24, 2003


## 9.0 MAJOR ASSUMPTIONS:

1. The containment leakage for Class 1 sequences is assumed to be 1 La. [Reference 4]

2. The containment leakage for Class 3a sequences is assumed to be 10 La. [Reference 4]

3. The containment leakage for Class 3b sequences is assumed to be 35 La. [Reference 4]

4. Because Class 8 sequences are containment bypass sequences (e.g., Steam Generator Tube Rupture - SGTR, Isolation Loss of Coolant Accidents - ISLOCA), potential releases are primarily directly to the environment. Therefore, the integrity of the containment structure will not significantly impact the release magnitude.

## 10.0 IDENTIFICATION OF COMPUTER CODES

None used.

## 11.0 DETAILED ANALYSIS:

### 11.1 Step 1 – Quantify the baseline frequency per reactor year for each of the eight accident classes presented in Table 1.

As mentioned in the methods section above, step 1 quantifies the annual frequencies for the eight accident classes defined in Reference 11. Except for Class 1 and Class 7, the equations used in this quantification are very similar to those used in the Indian Point Unit 3 (IP3) Calculation [Reference 3]. Class 1 and Class 7 were evaluated based on the Crystal River Unit 3 (CR3) Calculation [Reference 2] where the term CI (CI is the sum of the frequencies for Classes 3a, 3b, and 6) is deducted from Class 1 as shown below. In the IP3 Calculation [Reference 3], the term CI was deducted from Class 7. Class 3 was evaluated based on Interim Guidance and Additional Information from EPRI and NEI [References 4 and 12].

Reference 13 provides the following results of the latest KNPP PRA update. Also included are the accident classes corresponding to the KNPP Release Categories (RCs).

| KNPP Release Category | Description | Accident Class | Frequency (per year) | | | |
|---|---|---|---|---|---|---|
| | | | Internal Initiators | Fire Initiators | Seismic Initiators | Total |
| 1 | No Cont. Failure | 1 | 5.652E-07 | 3.795E-06 | | 4.36E-06 |
| 2 | Isol. Failure | 2 | 1.074E-08 | 6.054E-07 | | 6.16E-07 |
| 3 | LER - Isol. Failure | 2 | 1.088E-09 | 3.176E-08 | | 3.28E-08 |
| 4 | Basemat Melt-through | 7 | 1.933E-05 | 1.373E-04 | 4.31E-06* | 1.61E-04 |
| 5 | Press. Failure | 7 | 2.023E-06 | 3.797E-07 | | 2.40E-06 |
| 6 | LER - Press. Failure | 7 | 3.927E-10 | 0.00 | | 3.93E-10 |
| 7 | LER - ISLOCA | 8 | 2.690E-07 | 0.00 | 5.08E-06* | 5.35E-06 |
| 8 | LER - SGTR | 8 | 2.070E-06 | 0.00 | | 2.07E-06 |
| | | | | | | |
| | TOTAL CDF | | 2.427E-05 | 1.421E-04 | 9.39E-06 | 1.76E-04 |
| | TOTAL LERF | | 2.340E-06 | 3.176E-08 | 5.08E-06 | 7.45E-06 |

* For seismic initiators, a detailed Level 2 analysis was not performed; hence only CDF and LERF are calculated. Values in release categories are chosen to represent the most likely release category. They have no effect on the risk impact of the change in ILRT test interval.

The annual frequencies for each accident class are assessed as follows:

<u>**Class 1 Sequences.**</u> This group consists of all core damage accident progression bins for which the containment remains intact. For this analysis the associated maximum containment leakage for this group is 1 La. The frequency for these sequences is determined as follows:

Class_1_Frequency = No_Cont_Failure_Freq – CI

Where:

No-Cont_Failure_Freq = 4.36E-06/yr [From table above for RC 1]

CI = Class_3a_Frequency + Class_3b_Frequency + Class_6_Frequency

= 4.75E-06/yr + 1.91E-07/yr + 1.76E-07 /yr = 5.12E-06/yr
[These values are obtained from the Class 3 and 6 sequences sections below.]

or

Class_1_Frequency = 4.36E-06/yr – 5.12E-06/yr = - 7.60E-07/yr (taken to be 0.0)

The value above is negative because the Class 3a frequency exceeds the no containment failure frequency from the PRA. This is due to the relatively high assessed containment failure frequency for basemat melt-through. Since the Class 1 cannot be negative its frequency will be set to zero and total CDF will be maintained by subtracting the remaining 7.60E-07 from the basemat failure frequency (RC 4), which is the principal contributor to Class 7. This release category will be assigned to a new subclass 7a. This is discussed further below.

**Class 2 Sequences.** This group consists of all core damage accident progression bins for which pre-existing leakage due to failure to isolate the containment occurs. These sequences are dominated by failures to close of greater than 2-inch diameter but less than 5-inch diameter containment isolation valves (RC 2). Failure to close of very large isolation valves (greater than 5 inches) that could lead to a large early release (LER) (RC 3) have a much lower frequency.

The frequency for these sequences is determined as follows:

Class_2_Frequency = The sum of RC 2 and 3 frequencies [From table above]
Class_2_Frequency = 6.16E-07/yr + 3.28E-08/yr
Class_2_Frequency = 6.49E-07/yr

**Class 3 Sequences.** This group consists of all core damage accident progression bins for which pre-existing leakage in the containment structure (i.e., containment liner) exists. The containment leakage for these sequences can be either small (10 La for Class 3a) or large (35 La for Class 3b).

For this analysis, the question on containment analysis was modified to include the probability of a liner breach (due to excessive leakage) at the time of core damage. This class is divided into two classes (Class 3a and Class 3b). Class 3a is defined as small liner breach and Class 3b represents a large containment breach. Evaluation of these two classes is based on EPRI TR-104285 [Reference 10], the EPRI Interim Guidance [Reference 4] and the NEI Additional Information [Reference 12].

The frequency for this Class event is determined as follows:

Class_3a_Frequency = Prob(Class 3a)*CDF
Class_3b_Frequency = Prob(Class 3b)* (portion of CDF that may be impacted by Type A leakage and contribute to Class 3b)

*Frequency of Class 3a Event (Small Containment Breach) –Class_3a_Frequency*

To calculate the probability that a liner leak will be small (Class 3a), use was made of the data presented in NUREG-1493 [Reference 12] and the EPRI Interim Guidance [Reference 4]. NUREG-1493 states that 144 ILRTs have been conducted. The data reported that 23 of 144 tests had allowable leak rates in excess of 1 La. However, of these 23 'failures,' only 4 were found by an ILRT.

The others were found by Type B and C testing or were errors in test alignments. Therefore, the number of failures considered for 'small releases' are 4 of 144. The EPRI Interim Guidance stated that one failure found by an ILRT was found in 38 ILRTs performed after NUREG-1493. Thus, the best estimate of the probability of a small leak, Prob(Class 3a), is calculated as 5/182 = 0.027 [Reference 4].

The total updated CDF is 1.76E-04 / yr from Reference 13.
Therefore the frequency of release due to Class 3a failures is calculated as:

Class_3a_Frequency = Prob(Class 3a) * CDF
= 0.027 * 1.76E-04/yr = 4.75E-06/yr

*Frequency of Class 3b Event (Large Containment Breach) –Class_3b_Frequency*

To calculate the probability that a liner leak will be large (Class 3b), use was made of the data presented in NUREG-1493 [Reference 11] and new data presented by the EPRI Interim Guidance [Reference 4]. One data set found in NUREG-1493 reviewed 144 ILRTs and the EPRI Interim Guidance reviewed additional 38 ILRTs. The largest reported leak rate from those 144 tests was 21 times the allowable leakage rate (La). Since 21 La does not constitute a large release, no large releases have occurred based on the 144 ILRTs reported in NUREG-1493. One failure was found in the 38 ILRTs discussed in the EPRI Interim Guidance and this failure was not considered large.

Because no Class 3b failures have occurred in 182 ILRT tests, the EPRI Interim Guidance suggested that the Jeffery's non-informative prior distribution would be appropriate for the Class 3b distribution. (The rationale for using the Jeffery's non-informative prior distribution was discussed in Reference 4.)

Prob(Class 3b) = Failure probability = (# of failures (0) + ½)/(Number of tests (182) + 1)

The number of large failures is zero and the probability is

Prob(Class 3b) = 0.5/183 = 0.0027

The use of this probability and the total core damage frequency (CDF) as the Class 3b frequency is very conservative since not all core damage sequences will contribute to releases equivalent to a Class 3b failure. A number of sequences (containment bypass sequences and those resulting in a early containment failure due to severe accident phenomena –hydrogen explosion, etc.) will lead to large risk-significant releases regardless if there is a preexisting leak or not and including them in Class 3b is not appropriate. Further, there are a number of sequences that would not lead to large risk-significant releases due to the presence of release mitigation or significant warning time before release. Therefore:

PCDF_TypeA = Portion of CDF that may be impacted by Type A leakage and contribute to Class 3b = Total CDF – (CDF of sequences that have a large release irrespective of Type A Leakage) - (CDF of sequences that cannot cause a large risk significant release)

Where:

CDF = 1.76E-04/yr [From Reference 13]

CDF of sequences that have a large release irrespective of Type A Leakage
= Sum of RC 3, RC 6, RC 7 and RC 8 = Total LERF

= 7.45E-06/yr [From table above]

CDF of sequences that cannot cause a large risk significant release (principally late core damage basemat melt-through sequences after station blackout)

= 3.73E-06 + 9.415E-05 [From Reference 13]
= 9.788E-05/yr

Therefore:

PCDF_TypeA = 1.76E-04 – 7.45E-06 – 9.788E-05 = 7.07E-05/yr

Therefore the frequency of release due to Class 3b failures is calculated as:

Class_3b_Frequency = Prob(Class 3b) * PCDF_TypeA

= 0.0027 * 7.07E-05 = 1.91E-07 / yr

It should be noted that in the above, no credit is taken for detecting the leak by visual examination. For Kewaunee all but approximately 20% of the containment surface area is accessible for inspection (Reference 16). One hundred percent of these surfaces are inspected in accordance with Appendix J of ASME Section XI at a frequency of 3 in 10 years. It is expected that these inspections will detect liner leaks particularly of the size to cause a large release. Since the visual examination frequency remains the same as the original or base case of 3 in 10 years and the data on which the probability of Class 3b failures is based did not take credit for failures detected by visual examination, visual inspection would directly reduce the increase in these failures due to extending the ILRT interval. No credit is however taken for this reduction.

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

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

**Class 6 Sequences.** This group is similar to Class 2 and addresses additional failure modes not typically modeled in PRAs due to the low probability of occurrence. These are sequences that involve core damage accident progression bins for which a failure-to-seal containment leakage due to failure to isolate the containment occurs. These sequences are dominated by misalignment of containment isolation valves following a test/maintenance evolution.

The low failure probabilities are based on the need for multiple failures, the presence of automatic closure signals, and control room indication. Based on the purpose of this calculation, and the fact that this failure class is not impacted by Type A testing, no further evaluation is needed. This is consistent with the EPRI guidance. However, in order to maintain consistency with the previously approved methodology, i.e., PROB(Class6) > 0, a conservative screening value of 1.0E-03 will be used to evaluate this class.

The annual frequency for these sequences is determined as follows:

Class_6_Frequency = (Screening Value) *CDF

Where:

Screening Value = $1.0 \times 10^{-3}$ [Assumed Conservative Value]

CDF = 1.76-04/yr

Class_6_Frequency = 1.0E-03 * 1.76E-04/yr = 1.76E-07 /yr

**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., H2 combustion). As can be seen from the results of the KNPP PRA this class includes a relatively high frequency for basemat melt-through. This would occur very late after core damage. If a preexisting leak were to occur then, while basemat melt-through would not be prevented, most of the activity would have been released, This effectively reduces the risk for this containment failure mode.

As indicated for Class 1, the frequencies of Classes 3a, 3b and 6 must be subtracted from the no containment failure frequency in order to maintain the CDF. Because of a low no containment failure frequency (due to the high basemat melt-through frequency) this adjustment would result in a negative Class 1 frequency. Since this is impossible, the remainder of the adjustment, after Class 1 is reduced to zero is subtracted from the basemat melt-through frequency. This release category is assigned to a separate subclass (7a) inorder to simplify the risk calculations in Steps 2 and 3. The other sequences are assigned to Class 7b. The annual frequency for these classes is determined as follows:

Class_7b_Frequency = Sum of RC 5 and RC 6 Frequencies
= 2.40E-06 + 3.93E-10 [From above table]
= 2.40E-06/yr

Class_7a_Frequency = RC 4 frequency – ( CI - RC 1 frequency)
= 1.61E-04 - ( 5.12E-06 - 4.36E-06 )
= 1.61E-04 - 0.76E-06
= 1.60E-04/yr

**Class 8 Sequences.** This group consists of all core damage accident progression bins in which containment bypass occurs. The failure frequency for this class is:

Class_8_Frequency = Sum of RC 7 and RC 8 Frequencies
= 5.35E-06 + 2.07E-06 [From above table]
= 7.42E-06/yr

Note for this class the maximum release is not based on normal containment leakage, because most of the releases are directly to the environment. Therefore, the integrity of the containment structure will not significantly impact the release magnitude.

The annual frequencies for the eight classes are summarized in Table 2.

## 11.2 Step 2 – Develop plant specific person-rem dose (population dose) per reactor year for each of the eight accident classes and quantify baseline risk

In accordance with guidance given by Reference 10, this step develops the KNPP population dose and evaluates the baseline risk impact for the eight accident classes defined in the previous sections of this calculation.

## 2a) Characterize accident scenarios into major groups (eight classes).

(See Class 1 through 8 sequences above)

## 2b) Develop plant specific person-rem dose (population dose) per reactor year.

Reference 15 documents an assessment of the KNPP site population dose consequences due to the accidental release of radiological materials resulting from several severe accident scenarios. This assessment utilizes the meteorology, year 2000 population distribution, geographic data, evacuation time estimates and other offsite data from a recent Level 3 analysis for the Point Beach Nuclear Plant (PBNP) which is located approximately 4 miles from KNPP. A comparison of the features and surrounding conditions for the two site locations indicates that use of the PBNP inputs for KNPP will result in population doses appropriate, or slightly conservative for KNPP.

The source terms used for the KNPP consequence analysis are for a planned KNPP uprated power level of 1772 MWth and KNPP specific severe accident analysis for sequences representative of the 8 Release Categories. The 50-mile population dose (person-rem) for each RC is given below along with the RC frequency, the risk in person-rem/year (the product of the frequency and the population dose) and the EPRI accident class.

| KNPP Release Category | Description | Frequency (per year) | Population Dose (person-rem) | Risk (person-rem/year) | Accident Class |
|---|---|---|---|---|---|
| 1 | No Cont. Failure | 4.36E-06 | 1.20E+02 | 5.23E-04 | 1 |
| 2 | Isol. Failure | 6.16E-07 | 2.01E+05 | 1.24E-01 | 2 |
| 3 | LER - Isol. Failure | 3.28E-08 | 2.97E+05 | 9.74E-03 | 2 |
| 4 | Basemat Melt-through | 1.61E-04 | 7.51E+01 | 1.21E-02 | 7a |
| 5 | Press. Failure | 2.40E-06 | 4.04E+05 | 9.70E-01 | 7b |
| 6 | LER - Press. Failure | 3.93E-10 | 2.60E+05 | 1.02E-04 | 7b |
| 7 | LER - ISLOCA | 5.35E-06 | 1.17E+06 | 6.26E+00 | 8 |
| 8 | LER - SGTR | 2.07E-06 | 6.35E+05 | 1.31E+00 | 8 |
| | | | | | |
| | TOTAL | 1.76E-04 | | 8.69E+00 | |

The population dose for each accident class in the table is determined from the total risk for the class divided by the total frequency for the class, or

Class 2 = (1.24E-01 + 9.74E-03)/(6.16E-07 + 3.28e-08) = 2.059E+05 person-rem
Class 7a = 7.510E+01 person-rem
Class 7b = (9.70E-01 + 1.02E-04)/( 2.40E-06 + 3.93E-10)
= 4.040E+05 person-rem
Class 8 = (6.26E+00 + 1.31E+00)/(5.35E-06 + 2.07E-06) = 1.021E+06 person-rem

The population dose for Classes 3a and 3b are taken to be 10 and 35, respectively, times that for Class 1 based on the assumed leakage rates of 10 La and 35 La.

Class 1 = (1.20E+02) * 1 La = 1.20E+02 person-rem
Class 3a = (1.20E+02) * 10 La = 1.20E+03 person- rem
Class 3b = (1.20E+02) * 35 La = 4.20E+03 person-rem

The population dose for Class 6 is assumed to be the same as that for Class 2.

The above values of conditional population dose are summarized in Table 3.

### 2c) Calculate and Review Baseline Risk for Each Accident Class

The baseline risk for each accident class is presented in Table 4. The baseline risk is defined as the product of the containment failure mode frequency and the conditional population dose. Table 4 is the product of Tables 2 and 3. The ILRT baseline risk is based on the test interval corresponding to 3 tests in 10 years or about a 3 year interval.

As mentioned in the method section of this calculation, only Classes 3a and 3b are impacted by the Type A ILRT test. Therefore, the percent risk contribution (%Base_Risk) for these classes is:

%Base_Risk = [( Class3a_Base + Class3b_Base) / Total_base)] * 100

Where:

Class3a_Base = 5.70E-03 person-rem/year

Class3b_Base = 8.02E-04 person-rem/year

Class_3_Base_Total = = 5.70E-03 + 8.02E-04 = 6.50E-03 person-rem/yr

Total_base = 8.73 person-rem/year

%Base_Risk = (6.50E-03 / 8.73) * 100
%Base_Risk = 0.074%

***Therefore, the total baseline risk contribution of leakage, potentially impacted by the ILRT test interval, represented by Class 3 accident scenarios is 0.0065 person-rem/year or 0.074% of the total population exposure risk.***

## 11.3 <u>Step 3 – Evaluate risk impact of extending Type A test interval.</u>

### Risk impact due to 10-year test interval

According to NUREG-1493 [Reference 11], extending the Type A ILRT interval from that corresponding to 3 tests in 10 years to that for 1 test in 10 years will increase the average time that a leak, detectable only by an ILRT, goes undetected from 18 to 60 months. The average time that a pre-existing leak may go undetected is calculated by multiplying the test interval by 0.5 and multiplying by 12 to convert from "years" to "months." The recent EPRI Guidance suggested use the factor of 3.33 (60/18) to estimate the increase of Class 3 since Type A tests impact only Class 3 sequences. Also, as with the baseline case, the frequency of Classes 1 and 7a have been reduced by the frequencies of Classes 3a, 3b, and Class 6 in order to preserve total CDF.

The results of this calculation are presented in Table 5.

Based on the above values, the Type A 10-year test frequency percent risk contribution (%Risk_10) for Class 3 is as follows:

%Risk_10 = [(Class3a_10 +Class3b_10) / Total_10] * 100

Where:

Class3a_10 = 1.90E-02 person-rem/year

Class3b_10 = 2.67E-03 person-rem/year

Class3_10_total = 1.90E-02 + 2.67E-03 = 2.17E-02 person-rem/year

Total_10 = 8.75+00 person-rem/year

%Risk_10 = (2.17E-02 / 8.75E+00) * 100

%Risk_10 = 0.25%

***Therefore, the total risk contribution of leakage for Type A 10-Year ILRT interval represented by Class 3 accident scenarios is 0.0217 person-rem/year or 0.25% of the total population risk.***

Since the only change in risk is due to the change in Class 3 (conservatively neglecting the reduction in risk for Class 7a), the percent risk increase due to extending the ILRT interval from that corresponding to 3 tests in 10 years (baseline case) to that corresponding to 1 test in 10 years is evaluated as follows:

[(Total_10 – Total_base) / Total_base] * 100 =
[(Class3_10_total - Class_3_Base_Total) / Total_base] * 100

Where:

| | |
|---|---|
| Class_3_Base_Total = 6.50E-03 person-rem/yr | [From above] |
| Class3_10_total = 2.17E-02 person-rem/year | [From above] |
| Total_base = 8.73 person-rem/year | [From Table 4] |

[( Class3_10_total - Class3_Base_total) / Total_base] * 100
= [(2.17E-02 - 6.50E-03) / 8.73 ] * 100 = (1.52E-02/8.73) * 100 = 0.17 %

***Therefore, The total risk increase due to extending the ILRT interval from that corresponding to 3 tests in 10 years (baseline case) to that corresponding to 1 test in 10 years is 0.0152 person-rem/year or 0.17% of the total population risk.***

## Risk Impact due to 15-year test interval

The risk contribution for a 15-year interval is similar to the 10-year interval. The difference is in the increase in probability of leakage value. If the test interval is extended to 15 years, the mean time that a leak detectable only by an ILRT test goes undetected increases to 90 months (0.5 * 15 * 12). Reference 12 suggested to use a factor of 5 (90/18) to account for the increased likelihood of fail to detect, which will be implemented here. As with the baseline case, the PRA frequency of Classes 1 and 7a have been reduced by the frequency of Class 3a, 3b, and Class 6 in order to preserve total CDF. The results for this calculation are presented in Table 5.

Based on the above values, the Type A 15-year test interval percent risk contribution (%Risk _15) for Class 3 is as follows:

%Risk_15 = [(Class3a_15 +Class3b_15) / Total_15] * 100

Where:

Class3a_15 = 2.85E-02 person-rem/year

Class3b_15 = 4.01E-03 person-rem/year

Class3_15_total = 2.85E-02 + 4.01E-03 = 3.25E-02 person-rem/year

Total_15 = 8.76 person-rem/year [From Table 5]

%Risk_15 = (3.25E-02 / 8.76) * 100
%Risk_15 =0.37%

***Therefore, the total risk contribution of leakage for Type A 15-year ILRT interval represented by Class 3 accident scenarios is 0.0325 person-rem/year or 0.37% of the total population risk.***

The percent risk increase due to extending the ILRT interval from that corresponding to 3 tests in 10 years (baseline case) to that corresponding to 1 test in 15 years is evaluated as follows:

[(Total_15 – Total_base) / Total_base] * 100 =
[(Class3_15_total - Class_3_Base_Total) / Total_base] * 100

Where:

Class3_15_total = 3.25E-02 person-rem/year [From above]
Class_3_Base_Total = 6.50E-03 person-rem/yr [From above]
Total_base = 8.73 person-rem/year [From Table 4]

[(Class3_15_total - Class_3_Base_Total) / Total_base] * 100
= [(3.25E-02 – 6.50E-03 )/ 8.73 ] * 100 = (2.60E-02/8.73) * 100 = 0.30%

***Therefore, the total risk increase due to extending the ILRT interval from that corresponding to 3 tests in 10 years (baseline case) to that corresponding to 1 test in 15 years is 0.0260 person-rem/year or 0.30% of the total baseline population risk.***

The percent risk increase in terms of person-rem/year from a 10 year to a 15 year test interval for Classes 3a and 3b is:

% Risk (10-15PR) =[(Class3_15_total) – (Class3_10_Total) / (Class3_10_Total)]*100

Where:

Class3_15_total = 3.25E-02 person-rem/year [From above]
Class3_10_Total = 2.17E-02 person-rem/year [From above]

% Risk (10-15PR) = [(3.25E-02 – 2.17E-02) /2.17E-02 ] * 100 = 50%

The increase in person-rem/year for all accident classes (conservatively neglecting the reduction in Class 7a risk) from 1 in 10 years to 1 in 15 years test interval is:

(Class3_15_total - Class3_10_Total) = 3.25E-02 – 2.17E-02 = 1.08E-02 person-rem/year

The percent risk increase due to extending the ILRT interval from 1 in 10 years to 1 in 15 years is evaluated as follows:

[(Class3_15_total - Class3_10_Total) / Total_10] * 100

Where:

Class3_15_total = 3.25E-02 person-rem/year [From above]
Class3_10_Total = 2.17E-02 person-rem/year [From above]
Total_10 = 8.75 person-rem/year [From Table 5]

[(Class3_15_total - Class3_10_Total) / Total_10] * 100 = [(3.25E-02 – 2.17E-02 )/ 8.75 ] * 100
= (1.08E-02 /8.75) * 100 = 0.12%

***Therefore, the total risk increase due to extending the ILRT interval from 10 years to 15 years is 0.0108 person-rem/year or 0.12% of the total baseline population risk.***

### 11.4 Step 4 – Determine the change in risk in terms of Large Early Release Frequency (LERF)

This step evaluates the increase in the Large Early Release Frequency (LERF) due to extending the ILRT test interval from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years and from a 10 year interval to a 15 year interval.

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 large release due to failure to detect a pre-existing leak during the relaxation period. For this evaluation only Class 3b sequences, which have the potential to result in large releases if pre-existing leak were present, are impacted by the ILRT Type A test.

The previous methodology [References 2 and 3] employed for determining LERF (Class 3b frequency) involved multiplying the total CDF by the failure probability for this class (3b) of accident. This was done for simplicity and is conservative. However, some plant-specific accident classes leading to core damage are likely to include individual sequences that either may already (independently) cause a LERF or could never cause a LERF. For instance, the CR3 [Reference 2] evaluation assumption number 7 states that "The containment releases for Classes 2, 6, 7, and 8 are not impacted by the ILRT Type A test frequency. These classes already include containment failure with release consequences equal or greater than those impacted by Type A."

These corrections have been accounted for in determining the Class 3b frequency in Section 11.1 above. Consequently the LERF values affected by the ILRT are equal to the Class 3b frequencies given above, or

The Baseline LERF affected by ILRT =1.91E-07 per year [Table 4]

The 1 in 10 years LERF affected by ILRT = 1.91E-07* 3.33 = 6.36E-07 per year [Table 5]

The 1 in 15 years LERF affected by ILRT = 1.91E-07* 5 = 9.55E-07 per year [Table 6]

***Change in LERF due to test interval going from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years =***

***9.55E-07 – 1.91E-07 = 7.64E-07/year***

***Change in LERF due to test interval going from 1 in 10 years to 1 in 15 years =***

***9.55E-07 – 6.36E-07 = 3.19E-07/year***

The total LERF for KNPP including external events is 7.45E-06 per year (Reference 13). Therefore, the LERF with the above changes due to ILRT extensions are

***The LERF after including the change due to test interval going from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years =***

***7.45E-06 + 7.64E-07 = 8.21E-06/year***

***The LERF after including the change due to test interval going from 1 in 10 years to 1 in 15 years =***

***7.45E-06 + 3.19E-07 = 7.77E-06/year***

## 11.5 Step 5 – Determine the change in the Conditional Containment Failure Probability (CCFP) for the proposed and cumulative changes of Type A test interval

The change in Conditional Containment Failure Probability (CCFP) for the proposed and cumulative changes are estimated as follows:

1. Estimate the CCFP for each test interval (i.e., 3 years, 10 years, and 15 years)
2. Calculate the change in CCFP between the test intervals.

The Conditional Containment Failure Probability (CCFP) can be defined as:

[1 – (Class_1_ Frequency + Class_3a_ Frequency)/CDF ]

Where

Class_1_ Frequency = Frequency per year of No Containment Failure.

Class_3a_ Frequency = Frequency per year of Small Isolation Failure.

As indicated above, to maintain a fixed CDF the Class 1 frequency is reduced to zero due to the impact of the Class 3a, 3b and 6 frequencies. If the relationship above for CCFP is used, the increase in Class 3a frequency with increased ILRT interval will result in a decrease in the CCFP rather than the expected increase. Combining the general relationship for Class 1 given in Section 11.1,

Class_1_Frequency = No_Cont_Failure_Freq – CI

Where:

No-Cont_Failure_Freq = Release Category 1 Freguency

CI = Class_3a_Frequency + Class_3b_Frequency + Class_6_Frequency

with the above relationship for CCFP gives

CCFP = [1 - (Release Category 1 Frequency - Class_3b_Frequency - Class_6_Frequency)/CDF]

This result gives the expected result that the only impact on CCFP due to ILRT interval changes is due to Class 3b.

Using this equation and the data from the KNPP PRA summarized in Step 1 for release category 1 (4.36E-06 per year) and Table 4 (i.e., Class 3b frequency of 1.91E-07 per year, the Class 6 frequency of 1.76E-07 year and a CDF is 1.76E-04 per year), the CCFP for 3 tests in 10 years is

$$1-[(4.36E\text{-}06 - 1.91E\text{-}07 - 1.76E\text{-}07)/ 1.76E\text{-}04] = 0.9773$$

For 1 test in 10 years the only value that changes is the Class 3b frequency (6.36E-07), therefore the CCFP for 1 test in 10 years is

$$1-[(4.36E\text{-}06 - 6.36E\text{-}07 - 1.76E\text{-}07)/ 1.76E\text{-}04] = 0.9798$$

For 1 test in 15 years the only value that changes is the Class 3b frequency (9.55E-07), therefore the CCFP for 1 test in fifteen years is

$$1-[(4.36E\text{-}06 - 9.55E\text{-}07 - 1.76E\text{-}07)/ 1.76E\text{-}04] = 0.9817$$

***The change in CCFP due to the ILRT interval going from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years***

***= 0.9817 – 0.9773 = 0.0044***

***The change in CCFP due to the ILRT interval going from that corresponding to 1 test in 10 years to that corresponding to 1 test in 15 years***

***= 0.9817 – 0.9798 = 0.0019***

## 12.0 COMPUTER INPUT AND OUTPUT

NONE

## 13.0 SUMMARY OF RESULTS

The table below summarizes the major results.

| | Test Interval Extended | |
|---|---|---|
| | From 3 in 10 years to 1 in 15 years | From 1 in 10 years to 1 in 15 years |
| Total person-rem/year increase (See Section 11.3) | 0.026 | 0.011 |
| The percentage increase person-rem/year risk (See Section 11.3) | 0.30% | 0.12% |
| Change in LERF – per year (See Section 11.4) | 7.6E-07 | 3.2E-07 |
| Total LERF including above change – per year | 8.2E-06 | 7.8E-06 |
| Change in the Conditional Containment Failure Probability (See Section 11.5) | 0.0044 | 0.0019 |

Other results are shown in the following table.

| Class | Risk Impact | | |
|---|---|---|---|
| | Baseline 3 in 10 years | 1 in 10 years | 1 in 15 years |
| 3a and 3b. These classes are impacted by Type A test | 0.074% of integrated value based on 10 La for Class 3a and 35 La for Class 3b, which is equivalent to: 0.0065 person-rem/year | 0.25 % of integrated value based on 10 La for Class 3a and 35 La for Class 3b, which is equivalent to: 0.022 person-rem/year | 0.37% of integrated value based on 10 La for Class 3a and 35 La for Class 3b, which is equivalent to: 0.033 person-rem/year |
| Total Integrated Risk | 8.73 person-rem/year | 8.75 person-rem/year | 8.76 person-rem/year |

Appendix A provides an assessment of the sensitivity of the above results to age-related corrosion of the containment shell. The above major results are repeated below along with the results if the impact of age-related corrosion is included.

| | Test Interval Extended | |
|---|---|---|
| | From 3 in 10 years to 1 in 15 years | From 1 in 10 years to 1 in 15 years |
| **Total person-rem/year increase** | | |
| Without Corrosion | 0.0260 | 0.0108 |
| Including Corrosion | 0.0269 | 0.0113 |
| | | |
| **The percentage increase in person-rem/year risk** | | |
| Without Corrosion | 0.30% | 0.12% |
| Including Corrosion | 0.31% | 0.13% |
| | | |
| **Change in LERF (per year)** | | |
| Without Corrosion | 7.6E-07 | 3.2E-07 |
| Including Corrosion | 7.9E-07 | 3.3E-07 |
| | | |
| **Total LERF after above Change (per year)** | | |
| Without Corrosion | 8.2E-06 | 7.8E-06* |
| Including Corrosion | 8.2E-06 | 7.8E-06* |
| | | |
| **Change in the Conditional Containment Failure Probability** | | |
| Without Corrosion | 0.0044 | 0.0019 |
| Including Corrosion | 0.0047 | 0.0021 |

* This value assumes LERF before change is that for a one test in ten-year interval.

## 14.0 CONCLUSIONS:

The conclusions regarding the change in plant risk associated with extension of the Type A ILRT test frequency from one test in ten-years to one test in fifteen-years, based on the results in Section 13, are as follows:

The change in Type A test frequency from once per 10 years to once per 15 years increases the total integrated plant risk for those accident sequences influenced by Type A testing by only 0.011 person-rem/year. This increase in person-rem/year is negligible when compared to other accident risks.

Reg.Guide 1.174 provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Small changes in risk are defined in Reg. Guide 1.174 as increases of CDF in the range of 1E-06/yr to 1E-05/yr or increases in LERF in the range of 1E-07/yr to 1E-06/yr. 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 frequency from once per 10 years to once per 15 years is 3.2E-07/yr. The acceptance guidelines for this change are that it can be reasonably shown that the total LERF is less than 1E-05/yr and that the cumulative changes be tracked. The total LERF for the requested change is 7.8E-06/yr including internal and external initiators and meets the total LERF criterion.

The cumulative change in LERF due to the change in ILRT frequency from 3 tests in 10 years to 1 test in 15 years is 7.6E-07/yr. The resulting total LERF is 8.2E-06/yr. These values also meet the Reg. Guide 1.174 acceptance guidelines.

The change in conditional containment failure probability due to the requested change in ILRT frequency is 0.0019 (or 0.19%) and is small compared to the total containment failure probability.

The cumulative impact of the change in ILRT frequency from 3 tests in 10 years to 1 test in 15 years is an increase in integrated risk of 0.026 person-rem/year or 0.30% of the baseline risk and an increase of 0.0044 in conditional containment failure probability. All of these cumulative changes are small and considered acceptable.

The impact of age-related corrosion of the steel containment has a negligible or very small impact on each of the risk measures associated with the extension of the Type A ILRT test frequency. The above conclusions remain valid

## Table 1- Detailed Description for the Eight Accident Classes as defined by EPRI TR-104285

| Class | Detailed Description |
|---|---|
| 1 | Containment remains intact including accident sequences that do not lead to containment failure in the long term. The release of fission products (and attendant consequences) is determined by the maximum allowable leakage rate values $L_a$, under Appendix J for that plant. The allowable leakage rates ($L_a$), are typically 0.1 weight percent of containment volume per day for PWRs .(all measured at $P_a$, calculated peak containment pressure related to the design basis accident). Changes to leak rate testing frequencies do not affect this classification. |
| 2 | Containment isolation failures (as reported in the IPEs) include those accidents in which the pre-existing leakage is due to failure to isolate the containment. These include those that are dependent on the core damage accident in progress (e. g., initiated by common cause failure or support system failure of power) and random failures to close a containment path. Changes in Appendix J testing requirements do not impact these accidents. |
| 3 | Independent (or random) isolation failures include those accidents in which the pre-existing isolation failure to seal (i. e., provide a leak-tight containment) is not dependent on the sequence in progress. This accident class is applicable to sequences involving ILRTs (Type A tests) and potential failures not detectable by LLRTs. |
| 4 | Independent (or random) isolation failures include those accidents in which the pre-existing isolation failure to seal is not dependent on the sequence in progress. This class is similar to Class 3 isolation failures, but is applicable to sequences involving Type B tests and their potential failures. These are the Type B- tested components that have isolated but exhibit excessive leakage. |
| 5 | Independent (or random) isolation failures include those accidents in which the pre-existing isolation failure to seal is not dependent on the sequence in progress. This class is similar to Class 4 isolation failures, but is applicable to sequences involving Type C tests and their potential failures. |
| 6 | Containment isolation failures include those leak paths not identified by the LLRTs. The type of penetration failures considered under this class includes those covered in the plant test and maintenance requirement or verified by in service inspection and testing (ISI/IST) program. This failure to isolate is not typically identified in LLRT. Changes in Appendix J LLRT test intervals do not impact this class of accidents. |
| 7 | Accidents involving containment failure induced by severe accident phenomena. Changes in Appendix J testing requirements do not impact these accidents. |
| 8 | Accidents in which the containment is bypassed (either as an initial condition or induced by phenomena) are included in Class 8. Changes in Appendix J testing requirements do not typically impact these accidents, particularly for PWRs. |

### TABLE 2 - Containment Frequency Measures for a Given Accident Class

| Class | Description | Frequency - per yr. |
|---|---|---|
| 1 | No Containment Failure | 0.00E+00 |
| 2 | Large Containment Isolation Failure (Failure-To-Close) | 6.49E-07 |
| 3a | Small Isolation Failures (Liner Breach) | 4.75E-06 |
| 3b | Large Isolation Failures (Liner Breach) | 1.91E-07 |
| 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) | 1.76E-07 |
| 7a | Severe Accident Phenomena Induced Failure (Basemat Melt-through) | 1.60E-04 |
| 7b | Other Severe Accident Phenomena Induced Failure (Early and Late Failures) | 2.40E-06 |
| 8 | Containment Bypassed (SGTR) | 7.42E-06 |
| Core Damage | All Containment Event Tree (CET) Endstates | 1.76E-04 |

### TABLE 3 – Conditional Person-Rem Measures for a Given Accident Class

| Class | Description | Person-Rem (50-miles) |
|---|---|---|
| 1 | No Containment Failure | 1.200E+02 |
| 2 | Large Containment Isolation Failure (Failure-To-Close) | 2.059E+05 |
| 3a | Small Isolation Failures (Liner Breach) | 1.200E+03 |
| 3b | Large Isolation Failures (Liner Breach) | 4.200E+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) | 2.059E+05 |
| 7a | Severe Accident Phenomena Induced Failure (Basemat Melt-through) | 7.510E+01 |
| 7b | Other Severe Accident Phenomena Induced Failure (Early and Late Failures) | 4.040E+05 |
| 8 | Containment Bypassed (SGTR) | 1.021E+06 |
| | | |

## TABLE 4 – Baseline Mean Consequence Measures for a Given Accident Class

| Class | Description | Frequency - per yr | Person-Rem (50-miles) | Person-Rem/yr (50-miles) |
|---|---|---|---|---|
| 1 | No Containment Failure | 0.00E+00 | 1.200E+02 | 0.00E+00 |
| 2 | Large Containment Isolation Failure (Failure-To-Close) | 6.49E-07 | 2.059E+05 | 1.34E-01 |
| 3a | Small Isolation Failures (Liner Breach) | 4.75E-06 | 1.200E+03 | 5.70E-03 |
| 3b | Large Isolation Failures (Liner Breach) | 1.91E-07 | 4.200E+03 | 8.02E-04 |
| 4 | Small Isolation Failure – Failure-To-Seal (Type B test) | | | 0.00E+00 |
| 5 | Small Isolation Failure – Failure-To-Seal (Type C Test) | | | 0.00E+00 |
| 6 | Containment Isolation Failures (Dependent failures, Personnel Errors) | 1.76E-07 | 2.059E+05 | 3.62E-02 |
| 7a | Severe Accident Phenomena Induced Failure (Basemat Melt-through) | 1.60E-04 | 7.510E+01 | 1.20E-02 |
| 7b | Other Severe Accident Phenomena Induced Failure (Early and Late Failures) | 2.40E-06 | 4.040E+05 | 9.70E-01 |
| 8 | Containment Bypassed (SGTR) | 7.42E-06 | 1.021E+06 | 7.57E+00 |
| | All CET End states | 1.76E-04 | | 8.73E+00 |

## TABLE 5 Mean Consequence Measures for 10 – Year Test Interval for a Given Accident Class

| Class | Description | Frequency -per yr | Person-Rem (50-miles) | Person-Rem/yr (50-miles) |
|---|---|---|---|---|
| 1 | No Containment Failure | 0.00E+00 | 1.200E+02 | 0.00E+00 |
| 2 | Large Containment Isolation Failure (Failure-To-Close) | 6.49E-07 | 2.059E+05 | 1.34E-01 |
| 3a | Small Isolation Failures (Liner Breach) | 1.58E-05 | 1.200E+03 | 1.90E-02 |
| 3b | Large Isolation Failures (Liner Breach) | 6.36E-07 | 4.200E+03 | 2.67E-03 |
| 4 | Small Isolation Failure – Failure-To-Seal (Type B test) | | | 0.00E+00 |
| 5 | Small Isolation Failure – Failure-To-Seal (Type C Test) | | | 0.00E+00 |
| 6 | Containment Isolation Failures (Dependent failures, Personnel Errors) | 1.76E-07 | 2.059E+05 | 3.62E-02 |
| 7a | Severe Accident Phenomena Induced Failure (Basemat Melt-through) | 1.49E-04 | 7.510E+01 | 1.12E-02 |
| 7b | Other Severe Accident Phenomena Induced Failure (Early and Late Failures) | 2.40E-06 | 4.040E+05 | 9.70E-01 |
| 8 | Containment Bypassed (SGTR) | 7.42E-06 | 1.021E+06 | 7.57E+00 |
| | All CET Endstates | 1.76E-04 | | 8.75E+00 |

**TABLE 6 - Mean Consequence Measures for 15 – Year Test Interval for a Given Accident Class**

| Class | Description | Frequency - per yr | Person-Rem (50-miles) | Person-Rem/yr (50-miles) |
|---|---|---|---|---|
| 1 | No Containment Failure | 0.00E+00 | 1.200E+02 | 0.00E+00 |
| 2 | Large Containment Isolation Failure (Failure-To-Close) | 6.49E-07 | 2.059E+05 | 1.34E-01 |
| 3a | Small Isolation Failures (Liner Breach) | 2.37E-05 | 1.200E+03 | 2.85E-02 |
| 3b | Large Isolation Failures (Liner Breach) | 9.55E-07 | 4.200E+03 | 4.01E-03 |
| 4 | Small Isolation Failure – Failure-To-Seal (Type B test) | | | 0.00E+00 |
| 5 | Small Isolation Failure – Failure-To-Seal (Type C Test) | | | 0.00E+00 |
| 6 | Containment isolation Failures (Dependent failures, Personnel Errors) | 1.76E-07 | 2.059E+05 | 3.62E-02 |
| 7a | Severe Accident Phenomena Induced Failure (Basemat Melt-through) | 1.40E-04 | 7.510E+01 | 1.06E-02 |
| 7b | Other Severe Accident Phenomena Induced Failure (Early and Late Failures) | 2.40E-06 | 4.040E+05 | 9.70E-01 |
| 8 | Containment Bypassed (SGTR) | 7.42E-06 | 1.021E+06 | 7.57E+00 |
| | All CET End States | 1.76E-04 | | 8.76E+00 |

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ANALYSIS FILE: 17547-0001-A3, Rev. 1, Appendix A

A.1.0 CLIENT Nuclear Management Company – Kewaunee Nuclear Power Plant

A.2.0 TITLE Effect of Age-Related Degradation on Risk Informed/Risk Impact Assessment for Extending Containment Type A Test Interval

A.3.0 AUTHOR E. Robert Schmidt

## A.4.0 PURPOSE

The purpose of this calculation is to assess the effect of age-related degradation of the containment on the risk impact for extending the Kewaunee Nuclear Power Plant (KNPP) Integrated Leak Rate Test (ILRT or Containment Type A test) interval from ten to fifteen years.

## A.5.0 INTENDED USE OF ANALYSIS RESULTS

The results of this calculation will be used to indicate the sensitivity of the risk associated with the extension in the ILRT interval to potential age-related degradation of the containment shell to support obtaining NRC approval to extend the Integrated Leak Rate Test (ILRT) interval at KNPP from 10 years to 15 years.

## A.6.0 TECHNICAL APPROACH

The present analysis shows the sensitivity of the results of the assessment of the risk impact of extending the Type A test interval for the KNPP to age-related liner corrosion.

The prior assessment included the increase in containment leakage for EPRI Containment Failure Class 3 leakage pathways that are not included in the Type B or Type C tests. These classes (3a and 3b) include the potential for leakage due to flaws in the containment shell. The impact of increasing the ILRT interval for these classes included the probability that a flaw would occur and be detected by the Type A test that was based on historical data. Since the historical data includes all known failure events, the resulting risk impact inherently includes that due to age-related degradation.

The present analysis is intended to provide additional assurance that age-related liner corrosion will not change the conclusions of the prior assessment. The methodology used for this analysis is similar to the assessments performed for Calvert Cliffs Nuclear Power Plant (CCNPP - Reference A1), Comanche Peak Steam Electric Station (CPSES - Reference A2), D. C. Cook (CNP - Reference A3) and St. Lucie (SL - Reference A4) in responses to requests for additional information (RAIs) from the NRC staff. The CCNPP, CPSES and CNP extension request submittals have been approved by the NRC.

The significantly lower potential for corrosion of freestanding steel shell containments, such as that at KNPP, is considered. This is due to the significantly smaller surface area susceptible to corrosion resulting from foreign material imbedded in concrete contacting the steel containment. Because of this, the analysis is carried out separately for those portions of the containment not in potential contact with

foreign material and those portions in potential contact with the foreign material. (This is considered more appropriate than the cylinder and dome portions and the basemat portions utilized in prior analyses.)

As in Reference A1, this calculation uses the following steps with KNPP values utilized where appropriate:

*Step 1 – Determine a corrosion-related flaw likelihood*

Historical data will be used to determine the annual rate of corrosion flaws for the containment. The significantly lower potential for corrosion in the freestanding KNPP containment will be included.

*Step 2 – Determine an age-adjusted flaw likelihood*

The historical flaw likelihood will be assumed to double every 5 years. The cumulative likelihood of a flaw is then determined as a function of ILRT interval.

*Step 3 – Determine the change in flaw likelihood for an increase in inspection interval*

The increase in the likelihood of a flaw due to age-related corrosion over the increase in time interval between tests is then determined from the results of Step 2.

*Step 4 – Determine the likelihood of a breach in containment given a flaw*

For there to be a significant leak from the containment, the flaw must lead to a gross breach of the containment. The likelihood of this occurring is determined as a function of pressure and evaluated at the KNPP ILRT pressure.

*Step 5 – Determine the likelihood of failure to detect a flaw by visual inspection*

The likelihood that the visual inspection will fail to detect a flaw will be determined considering the portion of the containment that is uninspectable at KNPP as well as an inspection failure probability.

*Step 6 – Determine the likelihood of non-detected containment leakage due to the increase in test interval*

The likelihood that the increase in test interval will lead to a containment leak not detected by visual examination is then determined as the product of the increase in flaw likelihood due to the increased test interval (Step 3), the likelihood of a breach in containment (Step 4) and the visual inspection non-detection likelihood (Step 5). The results of the above for the two regions of the containment are then added to get the total increased likelihood of non-detected containment leakage due to age-related corrosion resulting from the increase in ILRT interval.

The result of Step 6 is then used, along with the results of the prior risk analysis in the body of this analysis to determine the increase in LERF as well as the increase in person-rem/year and conditional containment failure probability due to age-related liner corrosion.

## A.7.0 INPUT INFORMATION

1. General methodology and generic results from the Calvert Cliffs assessment of age-related liner degradation (Reference A1).

2. The KNPP ILRT test pressure of 45.4 to 46.0 psig (Reference A5).

3. KNPP containment failure pressure of 137 psia (Reference A6). This is a conservatively low value corresponding to a high confidence of a low probability of failure.

4. Fraction of containment shell that cannot be inspected for Appendix J, ASME Section XI of 0.20 (Reference A7).

5. The surface area of the containment potentially in contact with foreign material either imbedded in the adjacent concrete or trapped in the areas of limited access is 13,800 $ft^2$ (Reference A7).

6. The number of containments, either free-standing steel shell or concrete with steel liners is 104 and the average area of steel potentially in contact with foreign material either imbedded in the adjacent concrete or trapped in the areas of limited access is 61,900 ft2 (Reference A11)

## A.8.0 REFERENCES

A1. "Calvert Cliffs Nuclear Power Plant Unit No. 1; Docket No. 50-317, Response to Request for Additional Information Concerning the License Amendment Request for a One-time Integrated Leakage Rate Test Extension," Constellation Nuclear letter to USNRC, March 27, 2002.

A2. "Comanche Peak Steam Electric Station (CPSES), Docket Nos. 50-445 and 50-446, Response to Request for Additional Information Regarding License Amendment Request (LAR) 01-14 Revision to Technical Specification (TS) 5.5.16 Containment Leakage Rate Testing Program," TXU Energy letter to USNRC, June 12, 2002.

A3. "Donald C. Cook Nuclear Plant Units 1 and 2, Response to Nuclear Regulatory Commission Request for Additional Information Regarding the License Amendment Request for a One-time Extension of Integrated Leakage Rate Test Interval," Indiana Michigan Power Company, November 11, 2002.

A4. "St. Lucie Units 1 and 2, Docket Nos. 50-335 and 50-389, Proposed License Amendments, Request for Additional Information Response on Risk-Informed One Time Increase in Integrated Leak Rate Test Surveillance Interval,' Florida Power & Light Company letter to USNRC, December 13, 2003.

A5. "Containment Building Integrated Leak Rate Test", SP 56A-088, Rev. F, KNPP.

A6. Edward Coen, "Section 6.0 Level 2 Source Term And Sensitivity Analysis," KSEC6.doc, KNPP, transmitted by E-mail 2/12/03

A7. S. E. Phillippi, "Calculation of Inspectable And Uninspectable Containment Vessel Surface Areas," SCIENTECH, INC. Analysis File 17547-0001-A2, Rev. 0, March 24, 2003

A8. "Containment Liner Through Wall Defect due to Corrosion," Licensee Event Report, LER-NA2-99-02, North Anna Nuclear Power Station Unit 2.

A9. "Brunswick Steam Electric Plant, Units 1 and 2, Dockets 50-325 and 50-324/License Nos. DPR-71 and DPR-62, Response to Request for Additional Information Regarding Request for License Amendments – Frequency of Performance Based Leakage Rate Testing," CP&L letter to USNRC, February 5, 2002.

A10. "IE Information Notice No. 86-99: Degradation Of Steel Containments," USNRC, December 8, 1986.

A11. E. R. Schmidt, "Calculation of Industry Average Containment Surface Area Subject to Age-Related Corrosion Due to Foreign Material," Analysis File 17547-0001-A4, Rev. 0, November 14, 2003

A12. "PRA Procedures Guide," NUREG/CR-2300, December 1982


## A.9.0 MAJOR ASSUMPTIONS:

1. As indicated in the NRC's RAIs (References A3 and A4, for example) there have been 4 instances of age-related corrosion leading to holes in steel containment liners or shells. Three of these instances (Cook -Reference A3, North Anna – Reference A8 and Brunswick – Reference A9) were in concrete containments with steel liners and due to foreign material imbedded in the concrete in contact with the steel liner. The fourth instance (Oyster Creek – Reference A10) was in a freestanding steel containment and occurred in an area where sand fills the gap between the steel shell and the surrounding concrete and was attributed to water accumulating in this sand. This data is therefore considered to represent a corrosion induced failure rate only for the areas of the KNPP in contact with concrete or other areas where foreign material may be trapped. For the other areas where the containment steel shell is not likely to be in contact with foreign material, the corrosion induced failure rate should be substantially lower and taken to be that based on no observations of corrosion failure in these regions.

2. The historical data of age-related corrosion leading to holes in the steel containment has occurred primarily (3 out of 4 instances) for steel lined concrete containments. For these containments the surface area in contact with the concrete comprises essentially the entire surface area of the containment. As indicated in Reference A7, this is true for only 20% of the KNPP containment surface area. Since the greater the surface area in contact with the concrete, the greater the chance of foreign material being in contact with steel containment and therefore the greater the chance of corrosion induced flaws, the containment failure rate due to corrosion will be taken to be proportional to the surface area in contact with the concrete. The containment failure rate due to corrosion will be taken to be that for the industry times the ratio of the surface area at risk for KNPP to the average area at risk for the industry.

3. The visual inspection data are conservatively limited to 5.5 years reflecting the time from September 1996, when 10 CFR 50.55a started requiring visual inspection, through March 2002, the cutoff date for this analysis. Additional success data were not used to limit the aging impact of this corrosion issue, even though inspections were being performed prior to September 1996 (and after March 2002) and there is no evidence that liner corrosion issues were identified. (Step 1)

4. As in Reference A1, the containment flaw likelihood is assumed to double every 5 years. This is included to address the increased likelihood of corrosion due to aging. (Step 2)

5. The likelihood of a significant breach in the containment due to a corrosion induced localized flaw is a function of containment pressure. At low pressures, a breach is very unlikely. Near the nominal failure point, a breach is expected. As in Reference A1, anchor points of 0.1% chance of cracking near the flaw at 20 psia and 100% chance at the failure pressure (137 psia for KNPP from Reference A6) are assumed with logarithmic interpolation between these two points. (Step 4)

6. In general, the likelihood of a breach in the lower head region of the containment occurring, and this breach leading to a large release to the atmosphere, is less then that for the cylindrical portion of the

containment. The assumption discussed in item 5 above is, however, conservatively applied to the lower head region of the containment, as well as to the cylindrical portions.

7. All non-detected containment overpressure leakage events are assumed to be large early releases.
8. The interval between ILRTs at the original frequency of 3 tests in 10 years is taken to be 3 years.

## A.10.0 IDENTIFICATION OF COMPUTER CODES

None used.

## A.11.0 DETAILED ANALYSIS:

### A.11.1 *Step 1 – Determine a corrosion-related flaw likelihood*

As discussed in Assumptions 1, 2 and 3, the likelihood of through wall defects due to corrosion for the areas of the containment potentially contacted by foreign material is based on 4 data points in 5.5 years.

$$[4 \text{ failures} * (13{,}800 \text{ ft}^2 \ / \ 61{,}900 \text{ ft}^2)\ /\ (104 \text{ plants} * 5.5 \text{ years/plant}) = 1.56\text{E-03 per year}$$

For the areas of the containment where foreign material is not likely to contact the containment the defect likelihood is taken to be that for no observed failures using a non-informative prior distribution (Reference 12.)

Failure Frequency = [# of failures (0) + ½]/[Number of unit years (104 * 5.5)] = 8.74E-04 per year

A similar area-at-risk correction as above for the area in contact with concrete is not appropriate for the area where foreign material is not likely to contact the containment since the majority of the steel liner or shell for all plants has at least one side of the surface subject to this reduced corrosion (and none has been observed).

### A.11.2 *Step 2 – Determine an age-adjusted liner flaw likelihood*

Reference A1 provides the impact of the assumption that the historical flaw likelihood will double every 5 years on the yearly, cumulative and average likelihood that an age-related flaw will occur. For a flaw likelihood of 5.2E-03 per year, the 15 year average flaw likelihood is 6.27E-03 per year for the cylinder/dome region. This result of Reference A1 is generic in nature, as it does not depend on any plant specific inputs except the assumed historical flaw likelihood.

For the present assumption of 4 historical failures in 104 plants, the 15 year average flaw likelihood is 30% (1.56E-03/5.2E-03 = 0.30 or 30%) of the above value (6.27E-03) or 1.88E-03 per year, and in accordance with Assumption 1, is applicable to the region of the containment potentially in contact with foreign material.

Similarly, for the region of the containment not potentially in contact with foreign material, the 15 year average flaw likelihood is 16.5% (8.74E-04/5.2E-03 = 0.165 or 16.5%) of the above value (6.27E-03) or 1.03E-03 per year.

### A.11.3 *Step 3 – Determine the change in flaw likelihood for an increase in inspection interval*

The increase in the likelihood of a flaw due to age-related corrosion over the increase in time interval between tests from 3 to 15 years is determined from the result of Step 2 in Reference A1 to be 8.7% for the cylinder/dome region based on assumed historical flaw likelihood and the resulting 6.27E-03 per year 15 year average flaw likelihood. This result of Reference A1 is generic in nature, as it does not depend on any plant specific inputs except the assumed historical flaw likelihood.

For the present assumption of 4 historical failures in 104 plants, the increase in the likelihood of a flaw due to age-related corrosion over the increase in time interval between tests from 3 to 15 years is 30% (as in Step 2) of that given in Reference A1 (0.3 * 8.7%) or 2.61% and in accordance with Assumption 1 is applicable to only the region of the containment potentially in contact with foreign material.

Similarly, for the region of the containment not potentially in contact with foreign material, the increase in the likelihood of a flaw due to age-related corrosion over the increase in time interval between tests from 3 to 15 years is 16.5% (as in Step 2) of that given in Reference A1 or 1.44%.

### A.11.4 *Step 4 – Determine the likelihood of a breach in containment given a liner flaw*

The likelihood of a breach in containment occurring is determined as a function of pressure as follows.

For a logarithmic interpolation on likelihood of breach

$$\text{Log (likelihood of breach)} = m\,(\text{ pressure }) + a$$

Where: m = slope
a = intercept

The values of m and a are determined from solution of the two equations for the values of 0.1% at 20 psia and 100% at containment failure pressure of 137 psia (Reference A6).

$$\text{Log } 0.1 = m * 20 + a$$

$$\text{Log } 100 = m * 137 + a$$

or

$$m = (\text{Log } 100 - \text{Log } 0.1) / (137 - 20) = 0.02564$$

and

$$a = \text{Log } 0.1 - 0.02564 * 20 = -1.5128$$

The upper end of the range of KNPP ILRT pressures of 46.0 psig (Reference A5) gives the highest likelihood of breach.

At 60.7 psia (46.0 + 14.7), the above equation gives

$$\text{Log (likelihood of breach)} = 0.02564 * 60.7 - 1.5128 = 0.04355$$

$$\text{Likelihood of breach} = 10^{0.04355} = 1.11\%$$

In accordance with Reference A1, the above value is for the cylinder/dome portions of the containment. For this analysis, this value is also assumed to be applicable to the region of the containment potentially in contact with foreign material.

### A.11.5 *Step 5 – Determine the likelihood of failure to detect a flaw by visual inspection*

A review of the geometry of the containment shell and the relative areas that are not inspectable and those in potential contact with foreign material, indicates that these two areas are essentially the same, both comprising approximately 20% of the total surface area of the steel shell (Reference A7). Consequently, the portion of the containment not likely to be in contact with potential foreign material is 100% visually inspectable, while the portion that may be in contact with potential foreign material is not visually inspectable. A 10% failure rate for that portion of the containment that is visually inspectable is assumed.

### A.11.6 *Step 6 – Determine the likelihood of non-detected containment leakage due to the increase in test interval*

The likelihood of non-detected containment leakage in each region due to age-related corrosion of the liner considering the increase in ILRT interval is then given by

| The increased likelihood of an undetected flaw because of the increased ILRT Interval (Step 3) | * | The likelihood of a containment breach given a liner flaw (Step 4) | * | The likelihood that visual inspection will not detect the flaw (Step 5) |
|---|---|---|---|---|

= 1.44% * 0.0111 * 0.10 = 0.00160% for the regions not potentially contacted by foreign material

= 2.61% * 0.0111 * 1.0 = 0.0290% for the regions potentially contacted by foreign material.

The total is then the sum of the values for the two regions or

**Total Likelihood of Non-Detected Containment Leakage = 0.0016% + 0.0290% = 0.0306%**

for the ILRT interval increase from 3 years to 15 years.

### A.11.7 *Impact on Risk*

The above indicates that there is a very small likelihood that corrosion will lead to undetected containment leakage over the increase in ILRT interval from 3 to 15 years. If it is assumed that this leakage is sufficient to lead to a large release and therefore could contribute to the Large Early Release Frequency (LERF), the above percent increase would be applied to the portion of the core damage frequency (CDF) whose release may be impacted by the leakage and could contribute to the LERF. Note that this is identified in the CCNPP submittal of Reference A1 as "The non-large early release frequency (LERF) containment over-pressurization failures...".

From the body of this analysis (PCDF_TypeA in Section 11.1) this value is 7.07E-05 per year. The resulting increase in LERF is

**Delta LERF due to age-related corrosion = 0.000306 * 7.07E-05 = 2.16E-08 per year**

The total increase in LERF due to the increase in ILRT interval from 3 years (or the equivalent 3 in10 years) to 15 years is the value from Section 11.4 plus the above or

**Total Delta LERF = 7.64E-07 + 2.16E-08 = 7.86E-07 per year**

The total LERF for KNPP including external events prior to the impact of this request is 7.45E-06 per year (Reference 13).

***Therefore, the LERF with the above changes due to the increase in ILRT interval from 3 years (or the equivalent 3 in10 years) to 15 years including age-related corrosion is***

***7.45E-06 + 7.86E-07 = 8.24E-06/year***

The person-rem/year impact of the above age-related corrosion can be estimated by assuming that the delta LERF due to age-related corrosion contributes to the EPRI containment failure Class 3b leakage. From Section 11.2 of the body of this analysis, the population exposure (50 mile person-rem) given an accident of this class is 4.20E+03 person-rem. The increase in person-rem/year due to the above assessment of age-related corrosion is therefore

4.20E+03 * 2.16E-08 = 9.1E-04 person-rem/year

This increase is small compared to the increase estimated in Section 11.3 of the body of this analysis of 2.60E-02 person-rem/year for the increase in ILRT interval from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years. The total increase in population risk is

2.60E-02 + 9.1E-04 = 2.69E-02 person-rem/year

This corresponds to an increase of

(2.69E-02 / 8.73) * 100 = 0.31%

of the baseline total risk.

The increase in containment leakage due to age-related liner corrosion will also lead to an increase in the conditional containment failure probability (CCFP) equal to the total likelihood of non-detected containment leakage as calculated above or 0.0306% (or 0.000306). This added to the increase estimated in Section 11.5 of the body of this analysis of 0.0044 gives a total increase in CCFP of 0.0047 for the increase in ILRT interval from that corresponding to 3 tests in 10 years to 1 test in 15 years including the effect of corrosion.

All of the above analysis and results are for the impact of increasing the ILRT interval from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years. The impact in going from 1 in 10 years to 1 in 15 years may be estimated from the information in Table 6 of Reference A1. The delta between 1 in 10 and 1 in 15 years can be obtained from this table as 5.3% compared to the delta of 8.7% for the delta between 3 in 10 years (or the equivalent 1 in 3 years) and 1 in 15 years. The delta risk values for increasing the ILRT interval from 10 years to 15 years is then 61% (5.3/8.7) of the above values. This relative increase from Reference A1 is generic in nature and equally applicable to the present analysis.

## A.12.0 COMPUTER INPUT AND OUTPUT

None

## A.13.0 SUMMARY OF RESULTS

Table 1 below summarizes the major steps of the analysis and the results for the increase in LERF due to age-related corrosion of the containment liner for an ILRT interval increase from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years. The impact of these results on the major results of the ILRT extension analysis from the body of this analysis is provided in Table 2.

**Table 1: Liner Corrosion Analysis Steps and Results**

| Step | Description | Regions Not Potentially Contacted by Foreign Material ($57,700\ ft^2$ or 80% of total) | | Regions Potentially Contacted by Foreign Material ($13,800\ ft^2$ or 20% of total) | |
|---|---|---|---|---|---|
| 1 | **Historical Flaw Likelihood**<br>Failure Data: Assumed to be applicable to only region susceptible to accelerated corrosion<br>Success Data: Based on 104 steel-lined or steel shell containments and 5.5 years since the 10 CFR 50.55a requirements for periodic visual inspection of containment surfaces. | Events: none applicable to this region. Assume 0.5 events<br>0.5 / (104 * 5.5)<br>**= 8.74E-04/year** | | Events: 4 through wall corrosion-related flaws. (Brunswick 2, North Anna 2, Cook and Oyster Creek)<br>4 * (13,800/61,900)/ (104 * 5.5)<br>**= 1.56E-03/year** | |
| 2 | **Age-Adjusted Liner Flaw Likelihood**<br>During 15-year interval, assume failure rate doubles every five years (14.9% increase per year). The average for the 5th to 10th year set equal to the historical failure rate. | Year | Failure Rate | Year | Failure Rate |
| | | 1 | 3.5E-04 | 1 | 6.3E-04 |
| | | avg. 5 – 10 | 8.6E-04 | avg. 5 – 10 | 1.6E-03 |
| | | 15 | 2.3E-03 | 15 | 4.2E-03 |
| | | **15-year avg = 1.03E-03** | | **15-year avg = 1.88E-03/year** | |
| 3 | **Increase in Flaw Likelihood Between 3 and 15 Years**<br>Uses age-adjusted liner flaw likelihood (step 2). | **1.44%** | | **2.61%** | |
| 4 | **Likelihood of Breach in Containment Given Liner Flaw**<br>The upper end pressure is consistent with the KNPP PRA Level 2 analysis. 0.1% is assumed for the lower end. Intermediate failure likelihood's are determined through logarithmic interpolation. Region potentially in contact with foreign material assumed to be the same as for the cylinder/dome region. | Pressure (psia) | Likelihood of Breach | Pressure (psia) | Likelihood of Breach |
| | | 20 | 0.10% | 20 | 0.1% |
| | | 60.7 (ILRT) | 1.11% | 60.7 (ILRT) | 1.11% |
| | | 80 | 3.45% | 80 | 3.45% |
| | | 137 | 100% | 137 | 100% |

| Step | Description | Regions Not Potentially Contacted by Foreign Material (57,700 ft² or 80% of total) | Regions Potentially Contacted by Foreign Material (13,800 ft² or 20% of total) |
|---|---|---|---|
| 5 | **Visual Inspection Detection Failure Likelihood** | **10%**<br><br>Assumed 10% failure rate inspection. | **100%**<br><br>Cannot be visually inspected. |
| 6 | **Likelihood of Non-Detected Containment Leakage**<br>(Steps 3*4*5) | **0.00160%**<br><br>(1.44% * 1.11% * 10%) | **0.0290%**<br><br>(2.61% * 1.11% * 100%) |
| | **Total Likelihood of Non-Detected Containment Leakage**<br>Sum of contributions from regions potentially in contact with foreign material and not potentially in contact with foreign material. | **0.0306%**<br><br>(0.0016% + 0.0290%) | |
| | **Delta LERF Due to Age-Related Corrosion**<br>Total likelihood of non-detected containment leakage times portion of the CDF that could lead to LERF and that would not otherwise always be a LERF. | **2.16E-08 per year**<br><br>( 0.000306 * 7.07E-05/yr) | |

Table 2: Major Results

| | Test Interval Extended | |
|---|---|---|
| | From 3 in 10 years to 1 in 15 years | From 1 in 10 years to 1 in 15 years |
| **Total person-rem/year increase** | | |
| Without Corrosion | 0.0260 | 0.0108 |
| Including Corrosion | 0.0269 | 0.0113 |
| | | |
| **The percentage increase in person-rem/year risk** | | |
| Without Corrosion | 0.30% | 0.12% |
| Including Corrosion | 0.31% | 0.13% |
| | | |
| **Change in LERF (per year)** | | |
| Without Corrosion | 7.6E-07 | 3.2E-07 |
| Including Corrosion | 7.9E-07 | 3.3E-07 |
| | | |
| **Total LERF after above Change (per year)** | | |
| Without Corrosion | 8.2E-06 | 7.8E-06* |
| Including Corrosion | 8.2E-06 | 7.8E-06* |
| | | |

| | Test Interval Extended | |
|---|---|---|
| | From 3 in 10 years to 1 in 15 years | From 1 in 10 years to 1 in 15 years |
| **Change in the Conditional Containment Failure Probability** | | |
| Without Corrosion | 0.0044 | 0.0019 |
| Including Corrosion | 0.0047 | 0.0021 |

* *This value assumes LERF before change is that for a one test in ten-year interval.*

## A.14.0 CONCLUSIONS

For the above results it is concluded that age-related containment corrosion has a negligible or very small impact on the risk associated with the extension of the Type A ILRT test frequency from 1 test in 10 years to 1 test in 15 years as well the extension from a frequency of 3 tests in 10 years to 1 test in 15 years.

Age-related corrosion increases the LERF due to the change in the Type A ILRT interval from that corresponding to 1 test in 10 years to that corresponding to 1 test in 15 years from 3.2E-07/yr to 3.3-07/yr and that due to a change in interval from that corresponding to 3 tests in 10 years to that corresponding to 1 test in 15 years from 7.6E-07/yr to 7.8E-07/yr. The total LERF for is unchanged due to the impact of age-related corrosion. Based on Reg. Guide 1.174, the change in LERF for the requested change in Type A ILRT interval from the current 1 test in 10 years to 1 test in 15 years represents a small change in LERF and meets the acceptance guidelines.