# D R A F T

# ILRT Type A Test Interval Optimization Methodology
# Problem Statement

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## 1.0 INTRODUCTION

NEI has initiated a project to revise the industry guidance and associated requirements for containment integrated leakage rate testing (ILRT). Based on performance history, risk insights, and other containment testing and inspections, it is believed that the required ILRT Type A testing interval, presently minimum of one test in ten years, can be optimized to one test in up to twenty years.

This project builds on the previous work performed in EPRI TR-104285, Risk Impact Assessment of Revised Containment Leak Rate Testing Intervals [1] and NUREG-1493, Performance-Based Leakage Test Program [2]. In fact, NUREG-1493 states, "*Reducing the frequency of Type A tests (ILRTs) from the current three per 10 years to one per 20 years was found to lead to imperceptible increase in risk*". Since the publication of NUREG-1493 additional containment inspections are now performed at all nuclear power plants (i.e., IWE and IWL) and historical ILRT performance has been good. Using new methods and the additional more recent data, this project will demonstrate that this conclusion remains valid.

## 2.0 BACKGROUND

A revision to the NEI Guidance (NEI 94-01) permitting an optimized ILRT Type A testing interval of up to once per twenty years is planned. The revision will be based on a risk impact assessment that will be documented in a revision to EPRI TR-104285, Risk Impact Assessment of Revised Containment Leak Rate Testing Intervals [1]. The risk impact assessment will generically assess the risk impact of the up to once per twenty-year testing interval and consider industry experience and appropriate regulatory guidance (RG 1.174) [4].

This document focuses on a "problem statement" that illustrates the need for, and the role of, the expert elicitation in process of developing the risk impact assessment of the revised containment leak rate testing intervals. Additional details on the expert elicitation process are contained in the "ILRT Type A Test Interval Optimization Methodology - Expert Elicitation Process".

## 3.0 FRAMEWORK

Risk is defined as the product of probability and consequence, where probability is the periodic occurrence of an undesired event and the consequence is defined as the magnitude of the undesired event.

RISK = PROBABILITY x CONSEQUENCE

In the case of the risk associated with the revised ILRT testing interval, the probability is defined as the probability of a significant containment leakage event that would not be detected by alternative means such as a local leak rate test or other inspection. Note that containment leakage or degradation detectable by alternative means does not impact the risk associated with revising the ILRT interval.

The consequence is defined as the increase, or delta, large early release frequency (LERF). The large early release frequency figure of merit is one traditional figure of merit in risk informed applications [4]. In the case of the risk impact assessment of the revised ILRT testing interval, the delta LERF is determined by multiplying the core damage frequency (CDF) by the change in the probability of a significant containment leakage event that would not be detected by means other than an ILRT.

An additional figure of merit, the increase, or delta, population dose is also developed. The delta population dose is calculated by multiplying the base population dose by the change in the probability of a significant containment leakage event for the affected core damage frequency endstates.

| | | | | |
|---|---|---|---|---|
| RISK | = | Probability | x | Consequence |
| Δ LERF | = | Δ ILRT Failure [1] Probability | x | CDF |
| Δ Population Dose | = | Δ ILRT Failure [1] Probability | x | Population Dose |

In the previous "one time" ILRT extension submittals [3] [6], and as a matter of course in most risk informed applications, a bounding approach was taken. This

[1] The term "ILRT failure" is used in this report. The reader is reminded that "ILRT failure" is not a failure of the ILRT test to measure the containment leakage. Rather, the term "ILRT failure" is used to describe those ILRT tests in which containment leakage was identified above the acceptance criteria that would not be detected by a local leak rate test, containment inspections, or other alternate means.

bounding approach utilized very conservative assumptions with respect to assessing the risk increase as a function of a revised ILRT testing interval. These assumptions include conservatisms associated with the determination of the ILRT failure probability as well as conservatisms associated with the determination of the consequences (delta population dose and delta LERF):

- **Data Applicability.** Data used to estimate the initial probability of ILRT failure is conservatively classified. Containment leakage events, that would not significantly affect population dose and/or LERF calculations are included in the estimation of the ILRT failure probability. For example, events such as steam generator manway leakage are included in the estimation of ILRT failure probability. Steam generator manway leakage would be discovered during reactor startup or during normal operation.

- **No Alternate Means of Detection.** The probability of alternate means of detection such as local leak rate tests, inspections or other means is not always considered.

- **Estimation of Population Dose.** Low containment leakage rates (i.e., low La values) with higher probabilities of occurrence are used to represent a large early release.

Despite the very conservative assumptions above, the submittals to date have been able to demonstrate that the revised ILRT testing interval has little impact on risk. That is, the risk or the delta population dose and delta LERF are small.

In the case of delta LERF, Regulatory Guide 1.174 describes changes to the licensing basis with a delta LERF impact below 1E-7 as “very small.” Such changes are generally acceptable. Proposed delta LERF impacts between 1E-6 and 1E-7 per year are described as “small” changes, and are acceptable, but result in increased NRC management and technical attention, including consideration of the plant's baseline LERF.

When applying the existing methods to the all plants, particularly those with higher CDF values, it is possible that a fraction of the calculated delta LERF values will fall into the "small" change region and therefore result in increased NRC management and technical attention. The increased NRC management and technical attention, when based on a conservative conclusion, is not an optimum use of either the NRC's or utility resources. By considering and reducing the conservatisms in the current methods most, if not all, calculated delta LERF values will be in the "very small" change region thereby optimizing resources associated with the ILRT testing as well as NRC and utility management and technical resources.

## 4.0 EXPERT ELICITION INPUT

In order to obtain more realistic values for delta LERF, the conservatisms in the current methodology and presented in Section 3 must be addressed. The report-sub-sections consider the conservative assumptions individually.

### 4.1 Data Applicability

Based on NEI utility surveys [8][9], data has been collected for 182 ILRT Type A tests that have been performed in the nuclear industry. Based on this data, the number of significant containment leakage events, found during the performance of these tests is very small. In fact, no large failures that would produce a large early release (LERF) have been found. As such, the testing data alone does not, without expert opinion, support the development of realistic values for the probability of a significant containment leakage event.

Consider the significant containment leakage or degradation event data contained in Attachment 1. This attachment is a compilation of data from two NEI utility surveys, NUREG-1493, and other events discovered in reviewing other industry data (LER's, reportable events, etc.). The first survey was performed in early 1994 [8] and represented the NEI (known as NUMARC at that time) input used in NUREG-1493. In this survey, the data from 144 ILRT Type A tests was collected. The second survey was performed in the fall of 2001 [9]. In the second survey, data was collected from 58 plants (91 units), reporting 38 ILRT Type A tests performed. The combined surveys do not represent all ILRTs performed. In the initial survey, utilities were chosen that represented a broad spectrum of reactor designs and was considered a representative sample of industry ILRTs performed. The response to the most recent survey was significant (91 nuclear units responded) and the data is considered a representative set of ILRT Type A test experience. Lastly, the data collected by the surveys is supplemented by additional literature searches including LERs and reportable events.

The data was then sorted by those events that resulted in excessive leakage when compared with the established acceptance criteria. This includes all causes that resulted in ILRT tests exceeding the acceptance criteria including those that are a result of local leak rate test penalties. A total of 70 significant leakage or degraded liner events are included in Attachment 1. The details associated with these 70 events are provided in the attachment.

From a review of the data in Attachment 1 and knowledge of the number of tests performed, a failure rate can be determined. In order to determine a failure rate, the number of failed events are divided by the number of demands, or in this case the number of ILRTs performed. Some previous submittals have conservatively assumed (based on reference 1) that three (3) failures have occurred (based on the 1994 NUMARC survey). However, based on a more comprehensive review of the data, no significant containment leakage events (where an increase in the ILRT surveillance interval would have increased the time the leak pathway was not detected) have been discovered. (Events that were initially counted as significant leakage events were due to steam generator manway leakage or other leakage events for which an alternate means of detection exists.) Therefore, there are zero (0) significant containment leakage events. Based on the data obtained by NUMARC and NEI surveys [8] [9] only, 182 ILRTs have been performed.

With zero (0) failed events a variety of statistical methods are available to estimate a failure rate. Each method assumes a number of failed events to obtain a failure rate. The number of assumed failed events varies by the statistical method as illustrated in the table below. The comments section of the table provides the basis for the use of the statistical method.

| Statistical Method | Assumed No. of failures | No. of Demands | ILRT "Failure" Probability | Comments |
|---|---|---|---|---|
| Chebychev | 1 | 182 | 5.5E-3 | Upper bound estimate |
| Jeffery's Non-Informative Prior | 0.5 | 182 | 2.7E-3 | Based on no physical or engineering information available |
| Typical range | 0.3 | 182 | 1.6E-3 | Typical range of values for a non-informative basis |
| | 0.1 | 182 | 5.0E-4 | |

As can be seen from the table above the resulting ILRT failure probabilities vary widely depending on the statistical method employed. The statistical method is in turn dependent on the uses of the final information (i.e. upper bound estimate) or assumptions concerning the amount of physical or engineering information concerning failure rates or failure modes and causes. Choosing the statistical method and resulting significant containment leakage event probability is therefore a matter for expert elicitation.

## 4.2 No Alternate Means of Detection

Various alternative methods of detecting a significant leakage pathway ("ILRT failure") in containment exist. These methods include local leak rate tests (LLRT), reactor startup, normal operation and other containment and piping inspections. Since the publication of NUREG-1493, additional containment inspections are now performed at all nuclear plants (i.e., IWE and IWL). In addition, during normal reactor startup and during normal power operation is it fairly routine, for most containment designs, to either vent the overpressure that has built up or to provide nitrogen makeup (for inerted containment designs). Significant changes in the venting or makeup rate during normal operation may provide an indication of the existence of a leakage pathway. These factors, as well as others, provide additional means of detection of significant containment leakage pathways. Expert opinion will assist in the determination of the appropriate alternative means ILRT failure detection as well as the probability of detection over an increased ILRT interval.

## 4.3 Estimation of Population Dose

ILRT extension submittals have used an estimated leakage rate as a result of an assumed large ILRT failure of 35 La. The leakage value of 35 La is then assumed to represent the leakage rate associated with a large early release as calculated in the Level 2 probabilistic risk assessment (PRA). However, the definition of LERF is generally given as the exchange of a single containment volume before the effective implementation of the offsite emergency response and public protective actions [7]. In turn, public protective actions, are generally assumed to be taken approximately 2 to 4 hours following a core damage event. The exchange of a single containment volume within a 4 hour period corresponds to a leakage rate of 600% per day or 600 – 6000 times La assuming that the ILRT acceptance criteria for the plant in question is between 1% and 0.1% per day.

From an examination of the events in Attachment 1, one event (No. 35) discovered during performance of an ILRT, with a stated leak rate, was greater than 2 La (15.3La). There were several events reported with leakage rates greater 2 La, with a maximum of ~21 La. However, with the single exception, all these events were identified by local leak rate tests. In any event, it does not appear that extension of the ILRT interval would increase the time that a leak path was not detected, as the single exception should have been identified by local leak rate testing[2] and has not repeated. Two ILRTs have been conducted at the plant since the event. With no increase in the non-detection time, there would be no increase in risk attributable to ILRT extension.

Three events were identified which could have been detected only by conducting an ILRT (Nos. 1, 45, and 57). However, these events had leakage rates less than 2 La or did not have state leakage rates. One involved two holes drilled in a liner (no stated leakage rate), one was a construction deficiency where pipes were not capped (0.9 La), and the third involved the ejection of a radiation monitor during an ILRT (1.3 La). None of the three events have repeated and the maximum measured leakage rate was less than 1.3 La.

In summary, from a detailed review of the available data, there have been no events that could have resulted in a large early release as currently defined.

[2] Section 9.1.1 of NEI 94-01 discusses the performance criteria for establishing Type A test intervals and states that if leakage cannot be determined by local leak rate testing, the performance criteria are not met. I.e., if an ILRT fails due to excessive local penetration leakage after a local test of the penetration, then the performance criteria for extending the ILRT intervals have not been met.

## 4.4 Expert Elicitation Example

As stated in Section 3, the generic application of the existing statistical treatment of ILRT events (e.g., Jeffery's Non Informative Prior) can result in some plants having a delta LERF in the "small" increase versus the "very small" increase region of Regulatory Guide 1.174 when calculating the risk impact of revised ILRT intervals. Given the minimal number of significant leakage events in the ILRT testing experience, the expert elicitation process will be used to develop a more informed basis for the determination of the probability of a significant containment leakage event.

The expert elicitation process is used to determine the probability of a significant containment leakage event. The expert elicitation would be based on the expert elicitation methods outlined in reference [11] and [12] as well as experts whose areas of expertise include one or more of the following:

- Available ILRT off-normal events
- Knowledge of containment systems
- Knowledge of ILRT
- Knowledge of containment inspections (IWE/IWL, maintenance)
- Knowledge of containment failure modes and causes
- Typical range of failures for non-informative priors

The expert panel would be asked to provide an estimate of the probability of a significant containment leakage event as a function of the magnitude of the failure. That is, the expert panel would be asked to estimate the probability of a significant containment leakage event for various La. The magnitudes, or La, would be provided for at least three points. The expert panel would also be asked to determine the shape of the probability distribution for a significant containment leakage event as a function of the magnitude (La) of the leakage.

The expert panel estimates would be based on the existing data and knowledge of the panel.

Following the solicitation of the estimates from the expert panel, the curve of probability of a significant containment leakage event versus magnitude of the leakage would be extrapolated for larger magnitudes (La). A bounding La that represents LERF would be chosen. Using the extrapolated curve and the bounding value of LERF chosen, a probability of a significant containment leakage event will be determined at the bounding LERF leakage value. The base population dose and LERF would be determined using the guidance in reference 10. Continuing to assume that the ILRT failure probability is linear with time, the ILRT failure probability and magnitude will be used to estimate the risk in terms of population dose for the revised ILRT test interval. The methods for estimating the delta population dose and the delta LERF would be also be based on the interim guidance contained in reference 10.

## 5.0 REFERENCES

1. Electric Power Research Institute, “Risk Impact Assessment of Revised Containment Leak Rate Test Intervals”, EPRI TR-104285, August 1994.

2. Nuclear Regulatory Commission, “Performance-Based Containment Leak-Testing Programs”, NUREG-1493, September 1995.

3. Entergy Nuclear Northeast, Indian Point 3 Nuclear Power Plant Letter of January 18, 2001, “Supplemental Information Regarding Proposed Change to Section 6.14 of the Administrative Section of Technical Specifications”.

4. Nuclear Regulatory Commission, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis”, Regulatory Guide 1.174, July 1998.

5. Nuclear Regulatory Commission, "Indian Point Nuclear Generating Station Unit No. 3 – Issuance of Amendment Re: Frequency of Performance-Based Leakage Rate Testing", April 17, 2001.

6. Florida Power – Progress Energy, Crystal River Nuclear Plant Letter of June 20, 2001, "Supplemental Risk Informed Information in Support of License Amendment Request No. 267".

7. Electric Power Research Institute, "PSA Applications Guide", EPRI TR-105396, August 1995.

8. NUMARC, "ILRT Survey Data", February 18, 1994.

9. NEI ILRT Survey, 2001

10. Nuclear Energy Institute, "Interim Guidance for Performing Risk Impact Assessments in Support of One-Time Extensions for Containment Leakage Rate Test Surveillance Intervals", Developed for NEI by EPRI and DS&S, November 2001.

11. Nuclear Regulatory Commission, "Branch Technical Position on the Use of Expert Elicitation in the High-Level Radioactive Waste Program", NUREG-1563, 1996.

12. Nuclear Regulatory Commission, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts", NUREG/CR-6372, April 1997.

# ATTACHMENT 1:
# SIGNIFICANT CONTAINMENT LEAKAGE OR DEGRADED LINER EVENTS

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Mar-77 | NUMARC Note | NUMARC Letter 2/18/94 to NRC | Unknown | Unknown | ILRT | Holes inadvertently drilled in liner | | | Yes |
| 2 | Apr-77 | NUMARC 24 | | >1La | 175000 | ILRT | SG manway gasket leak | Excessive leakage identified by ILRT | Manway gasket leakage is detectable during startup and operation, releases through SG would be late and scrubbed. | No |
| 3 | Mar-78 | NUMARC 4 | | 0 .88 La+ ( B&C) | 346000 | ILRT | SG manway gasket leak | Excessive leakage identified by ILRT | Manway gasket leakage is detectable during startup and operation, releases through SG would be late and scrubbed. | No |
| 4 | Jun-80 | NUMARC 25 | | 0.072La+ (B&C) | 538000 | LLRT Penalty | | Excessive C local leakage identified by LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | Feb-81 | NUMARC 21 | | N/A | | Verification Test | | ILRT exceeded due to instrument verification test discrepancy | | No |
| 6 | Jun-82 | NUMARC 4 | | 0.43La+ (B&C) | 346000 | ILRT | Lineup Error | Excessive local leakage identified by ILRT due to lineup error | | No |
| 7 | Aug-83 | NUMARC 19 | | 1.3La | 83200 | LLRT | | Excessive C local leakage identified by LLRT | | No |
| 8 | Apr-84 | NUMARC 25 | | 0.031La+ (B&C) | 538000 | LLRT Penalty | | Excessive C local leakage identified by LLRT | | No |
| 9 | Aug-84 | NUMARC 28 | | 0.071La(A) 14.91La w/(B&C) | 95330 | LLRT Penalty | | Excessive C local leakage identified by LLRT | | No |
| 10 | Jun-85 | NUMARC 26 | | 0.19La(A) 20.82La w/(B&C) | 862307 | LLRT Penalty | | Excessive B&C local leakage identified by LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Nov-85 | NUMARC 3 | | 0.36La (A) 1.89La w/(B&C) | 211600 | LLRT Penalty | ` | Excessive C local leakage identified by LLRT | | No |
| 12 | Apr-86 | NUMARC 28 | | <0.05La(A) <9.55La w/(B&C) | 95330 | LLRT Penalty | | Excessive C local leakage identified by LLRT | | No |
| 13 | May-86 | NUMARC 23 | | 0.27La(A) 0.99La w/(B&C) | 135920 | LLRT Penalty | | Excessive B&C local leakage identified by LLRT | | No |
| 14 | Jun-86 | Susquehanna 2 | NUREG-1493 | 2.6La | 1.0% | ILRT | | ILRT without prior LLRT | | No |
| 15 | Nov-86 | Quad Cities-2 | NUREG-1493 | 0.88La | 1.0% | ILRT | Faulty drywell head gasket | Excessive local leakage identified by ILRT and not identified by LLRT | Drywell head gasket would have probably been replaced at each refueling | No |
| 16 | Nov-86 | TMI-1 | NUREG-1493 | 1.0La | 0.1% | ILRT | | ILRT without prior LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 17 | Nov-86 | NUMARC 24 | | 1.0La 1.0La w/(B&C) | 175000 | ILRT | SG manway gasket leak | Excessive leakage identified by ILRT | Manway gasket leakage is detectable during startup and operation, releases through SG would be late and scrubbed. | No |
| 18 | Aug-87 | NUMARC 27 | | 0.027La(A) 2.46La w/(B&C) | 236203 | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 19 | Sep-87 | Quad Cities-1 | NUREG-1493 | Unknown | | ILRT | | ILRT without prior LLRT | | No |
| 20 | Sep-87 | NUMARC 28 | | 0.43La+ (B&C) | 287407 | LLRT Penalty | | Excessive B&C local leakage identified by LLRT | | No |
| 21 | Sep-88 | NUMARC 30 | | Unknown | 218503 | LLRT Penalty | | Excessive C local leakage identified by LLRT | | No |
| 22 | Oct-89 | Harris-1 | NUREG-1493 | Unknown | | ILRT | | ILRT without prior LLRT | | No |
| 23 | Nov-89 | Hatch-2 | NUREG-1493 | 0.86La | 1.2% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Nov-89 | Fermi-2 | NUREG-1493 | 1.9La | 0.5% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 25 | Dec-89 | Beaver Valley-1 | NUREG-1493 | Unknown | 0.1% | ILRT | Two penetration leaks discovered during ILRT | Excessive local leakage identified by ILRT and not identified by LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |
| 26 | Feb-90 | Dresden 3 | NUREG-1493 | 0.78La | 1.6% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 27 | Feb-90 | Brunswick-2 | NUREG-1493 | 0.94La | 0.5% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 28 | May-90 | Sequoyah-1 | NUREG-1493 | 2.8La | 0.25% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 29 | May-90 | Sequoyah-2 | NUREG-1493 | <1.0La | .25% | ILRT | | Excessive local leakage identified by ILRT and not identified by LLRT | | No |
| 30 | Jun-90 | LaSalle-2 | NUREG-1493 | >La | 0.63% | Unknown | | | | No |
| 31 | Jun-90 | Trojan | NUREG-1493 | Unknown | 1.3% | ILRT | Instrumentation Problems | | | No |
| 32 | Sep-90 | NUMARC 31 | | Unknown | 218503 | LLRT Penalty | | Excessive C local leakage identified by LLRT | | No |
| 33 | Oct-90 | Callaway | NUREG-1493 | >La | 0.2% | ILRT | Penetration Leakage | Excessive local leakage identified by ILRT and not identified by LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 34 | Oct-90 | NUMARC 20 | | 1.7La w/(B&C) | 188945 | ILRT | | Excessive B&C local leakage identified by ILRT and not identified by LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |
| 35 | Dec-90 | Dresden 2 | NUREG-1493 | 15.3La | 1.6% | ILRT | Vacuum breaker leakage discovered during ILRT | Excessive local leakage identified by ILRT and not identified by LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 36 | Feb-91 | Braidwood 1 | NUREG-1493 | 0.56La | 0.1% | ILRT | Type B failure found during ILRT, Airlock hatch shaft seal | Excessive local leakage identified by ILRT and not identified by LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |
| 37 | Feb-91 | Brunswick 1 | NUREG-1493 | 0.99 | 0.5% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 38 | Apr-91 | NUMARC 2 | | 0.47La (A) 0.84La w/(B&C) | 163000 | ILRT | | Excessive B&C local leakage identified by ILRT and not identified by LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |
| 39 | Jun-91 | Millstone-1 | NUREG-1493 | >0.75La | 1.2% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 40 | Jun-91 | NUMARC 27 | | 0.29La+ (B&C) | 236203 | LLRT Penalty | | Excessive C local leakage identified by LLRT | | No |
| 41 | Jul-91 | Pilgrim | NUREG-1493, LER 91-023-00 | 1.2La | 1.0% | ILRT | Drywell head bolts loose, improper spherical washer material | Failure of spherical washers led to loosening of 11 of 76 bolts, drywell head contribution to leak rate 0.74%/day | Had this not been identified in an ILRT, loose bolts and washer failures may have been identified in the next refueling outage. | No |
| 42 | Sep-91 | Braidwood 2 | NUREG-1493 | 0.55La | 0.1% | ILRT | Several local leaks found during ILRT | Excessive local leakage identified by ILRT and not identified by LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |
| 43 | Dec-91 | Brunswick 2 | NUREG-1493 | 0.79La | 0.5% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 44 | Dec-91 | PVNGS-2 | NUREG-1493 | 0.83La | 0.1% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 45 | Dec-91 | Cooper | NUREG-1493, LER 91-020-00 | 1.4La | 149623 | ILRT | Structural failure of radiation monitor; | Radiation monitor breached its shield chamber during ILRT pressurizatio n at 51 psig | Leakage from monitor path= 0.61La | Yes |
| 46 | Mar-92 | Dresden-3 | NUREG-1493 | >La | 1.6% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 47 | Mar-92 | LaSalle-2 | NUREG-1493 | 0.56La | 0.63% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 48 | Apr-92 | Sequoyah-2 | NUREG-1493 | 1.68La | 0.25% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 49 | Apr-92 | Vogtle-2 | NUREG-1493, NUMARC 1 | 0.62La(A) >.75La w/(B&C) | 360000 0.2% | LLRT Penalty | | Excessive B&C local leakage identified by LLRT | ILRT La exceeded due to B&C leakage penalty identified by LLRT | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 50 | May-92 | ANO-1 | NUREG-1493 | >La | 0.2% | LLRT Penalty | | Excessive local leakage identified by LLRT | ILRT La exceeded due to B&C leakage penalty identified by LLRT | No |
| 51 | Aug-92 | River Bend | NUREG-1493 | >La | 0.26% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 52 | Sep-92 | NUMARC 21 | | 1.3La+ (B&C) | 442525 | ILRT | SG manway gasket leak | Excessive leakage identified by ILRT | Manway gasket leakage is detectable during startup and operation, releases through SG would be late and scrubbed. | No |
| 53 | Oct-92 | Fermi-2 | NUREG-1493 | <2La | 0.5% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |
| 54 | Nov-92 | Hatch-2 | NUREG-1493 | 1.11La | 1.2% | LLRT Penalty | | Excessive local leakage identified by LLRT | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 55 | Nov-93 | NUMARC 3 | | 0.21La(A) 1.34La w/(B&C) | 211600 | ILRT | Lineup Error | Excessive local leakage identified by ILRT due to lineup error | | No |
| 56 | Feb-94 | Ginna | LER 94-003-00 | Unknown | | I&C Observation | Instrument plug not installed | Instrument Plug not installed following I&C work. Procedures enhanced to insure installation in future | Leakage pathway from containment to atmosphere would exist only when the equipment hatch inner door was open | No |
| 57 | Feb-94 | Surry 1 | LER 94-003-00 | >La | | Piping Inspection | Failure of coal tar epoxy coating followed by corrosion | Hole in piping for recirculation spray water heat exchanger | A leak in this pathway would be scrubbed. Radiation monitors and isolation valves are also provided. Fluid leakage would be detected by subsequent piping inspections. | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 58 | Mar-94 | Braidwood 1 | LER 94-003 | 0.9La | 216908 0.1% | ILRT | Construction deficiency not previously identified | Concrete vent pipes associated with emergency hatch not capped | Leakage from vent pipes =0.09La | Yes |
| 59 | Apr-94 | Sequoyah-1 | LER 94-005-00 | .0.75-1.0La | .25% | Inability to maintain PRT P | Circumferential crack in RV bellows | This bellows failure was detected during normal operation | | No |
| 60 | Dec-94 | Pilgrim | LER 94-007-00 | >La | 1.0% | I&C inspection | Instrument plug not installed | Plug for torus-atmosphere dp transmitter not installed; corrective action includes verification surveillance | This pathway would probably have been identified in the next instrument calibration cycle | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 61 | Apr-95 | Vermont Yankee | NEI Survey | 2La | 0.8% | ILRT | Excessive local leakage | Valves contaminated with construction debris after passing LLRT | If leakage cannot be identified by local testing, Type A test does not meet NEI 94-01 performance criteria for ILRT interval extension | No |
| 62 | Sep-95 | Indian Point 3 | LER 95-019-00 | N/A | 0.1% | Inspection/ Radiograph | Excessive local leakage | Through wall cracks on pipe caps on spare penetration due to contaminated stagnant water | Containment integrity was not an issue as the penetration was pressurized and monitored. | No |
| 63 | Feb-96 | Surry 2 | LER 96001 | Unknown | | Observation at power | | Leaking weld on return pipe from refueling cavity to RWST | A leak in this pathway would be scrubbed, and leakage from piping would be observed. | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 64 | Oct-96 | Oyster Creek | LER 96-011-0 | 2La | | Low Pressure monitoring | Vacuum breaker valve cover leaking | Misalignment of valve cover during assembly, shifting during heatup | This pathway would probably have also been identified in the next local leak rate test. | No |
| 65 | Sep-99 | North Anna 2 | NEI Survey, LER 1999-002-00 | | | Liner coating inspection | 1/4" defect hole | Wooden timber in concrete in back of liner | Leakage thru defect 0.07La | No |
| 66 | Nov-99 | PVNGS 1 | LER 2000-004 | | 0.1% | ILRT | Inadequate procedure for LLRT of Purge valves, valve seat adjustment | Excessive local leakage identified by ILRT | Revised procedure | No |
| 67 | Nov-99 | Cook 2 | NEI Survey | | | Liner, Coatings Inspection | 3/16" hole in liner | Leak rate within limits | Cook 1 had identified pitting in 1998, but no thru wall penetration | No |
| 68 | 99 | Brunswick 2 | NEI Survey | <La | 0.5% | IWE Inspection | Three thru wall defects in liner | Pitting corrosion and debris in concrete | | No |

| No. | Date | Unit | Reference LER, report | Leakage, fraction of La | La Sccm or %/day | How Detected | Cause | Description | Comments | Preliminary Assessment Effect Non Detection Time? |
|---|---|---|---|---|---|---|---|---|---|---|
| 69 | Aug-01 | PVNGS-3 | Non-emergency event report 8/17/01 | Unknown | 0.1% | Operations monitoring containment sump | Quick opening closure device not properly closed, or loosening of device in service. | Fuel transfer tube quick operating closure device leak path. | Leak path should be detected during LLRT. | No |
| 70 | Oct-01 | Vermont Yankee | Non-emergency event report 10/30/2001 | >La | 0.8% | Operator observation and isolation | | Tube broke on discharge of H2O2 monitor sample pump. | Engineering evaluation determined that under accident conditions leakage would have exceeded allowable leakage limits | No |
| 71 | ? | Vermont Yankee | NUREG-1493 | 1.0La | 0.8% | ILRT | Drywell manway penetration leakage | | Leak path should be detected during LLRT. | No |