Interim Guidance for Performing Risk Impact Assessments In Support of One-Time Extensions for Containment Integrated Leakage Rate Test Surveillance Intervals

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Background

NEI has initiated a project to revise the industry guidance and associated requirements for containment integrated leakage rate testing (ILRT). Based on performance history and risk insights, it is believed that the required frequency (presently minimum of one test in a ten-year interval) for performing Type A ILRT's can be reduced to as low as one test in a twenty-year interval. It is expected that it will take some time to develop, negotiate, obtain approval and promulgate generic guidance material (e.g., revised EPRI Risk Impact Assessment, revised NEI guidance [94-01], and NRC Regulatory Guidance).

Several licensees have submitted or in the process of preparing to submit license amendment requests to the NRC for one-time extensions of their ILRT surveillance intervals. As more licensees approach the end of their current ILRT surveillance intervals, more one-time interval extension requests are being submitted. There has been some variability in the methodology employed by licensees in their supporting risk assessments. The purpose of this document is therefore to provide interim guidance to licensees for developing uniform risk impact assessments supporting one-time extensions of ILRT surveillance intervals. Because of the differences in approaches and risk assessment methods presently in use, this guidance is general, particularly with respect to extracting information from PRAs or IPEs for use in this type of an evaluation.

Framework

The guidance provided in this document builds on the EPRI Risk Impact Assessment methodology (Ref. 3) and the NRC Performance-Based Containment Leakage Test Program (Ref.5), and considers approaches utilized in various utility submittals, including Indian Point 3 (and the NRC SER) and Crystal River, References 1, 2, and 6.

The guidance in this document improves on the above methods in three areas. The first area involves the methodology for determining the overall probability of leakage resulting from extending surveillance intervals. References 3 and 5 both considered the percentage increase in the probability of leakage as an appropriate multiplier to be used in risk impact dose calculations. For example, as stated in references 3 and 5, relaxing the test interval from three in ten years to one in ten years increases the average time that a leak detectable only by an ILRT goes undetected from 18 (3yrs/2) to 60 (10 yrs/2) months. This is a factor of 60/18=3.333. The baseline dose determined in the EPRI report was $7x10^{-3}$ person-rem/yr, and the dose associated with the ten-year interval was calculated as a 10% increase, or 1.1 times the baseline, $7.7x10^{-3}$ person-rem/yr. Using 3.33 would yield a ten-year dose of $3.33x7x10^{-3}=2.3x10^{-2}$ person-rem/yr.[1] This notable factor increase is still a very small incremental risk contribution, only 0.11%, an increase in risk of 0.078% from the baseline contribution of 0.032%. The small increase in total dose results because ILRTs address a very small portion of the severe accident risk. NUREG-1493 reported a similar 0.07% risk increase for Surry under the same assumptions and interval extension.

The second improvement area is in the methodology used to determine the frequencies of leakages detectable only by ILRTs, classes 3a and 3b. The method utilized in the aforementioned utility submittals involved using a 95% confidence of a $\chi 2$ distribution of the noted ILRT failures (4 of 144 reported in NUREG-1493). Data collected recently by NEI from 91 nuclear power plants indicates that 38 plants have conducted ILRTs since 1/1/95, with only one failure (due to construction debris from a penetration modification). This would indicate that the statistical information should be based on 5/182. Rather than using the $\chi 2$ distribution, it has been considered more appropriate to utilize the mean (5/182=0.027) for the class 3a distribution, and Jeffery's non-informative prior distribution (Reference 7) for the class 3b distribution:

$$Failure\ Probability = \frac{NumberofFailures(0) + 1/2}{NumberofTests(182) + 1}$$

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

The impact of the second improvement on the overall results is small for class 3a, but larger for class 3b, in which 0 failures have occurred. However, it is also important to remember that no observed failure to date was even close in size to the size necessary to cause a large release.

The third improvement includes provisions for utilizing NUREG-1150 dose calculations, which is a necessary improvement to make the methodology usable for plants that do not have a Level-3 PRA. The NUREG-1150 doses (used in EPRI TR-104285) are included in the sample calculations. If a plant has developed this information in their PRA, they have the option to use their own information[2].

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[1] The EPRI report was based on the logic that since ILRT's detect only 3% of leaks, the factor of 3.333 increase results in a change in the overall probability of leakage from 3% to 3*3.333=10%, or a 10% increase in the baseline dose. The baseline dose determined in the EPRI report was $7x10^{-3}$ person-rem/yr, and the dose associated with the ten-year interval was calculated as a 10% increase or 1.1 times the baseline, $7.7x10^{-3}$ person-rem/yr. It is now believed that the dose associated with the ten-year interval should have been calculated based on the change in the probability of leakage, 3.333, rather than the factor of 1.10. The argument above shows this difference to not affect the overall conclusions regarding ILRT interval changes.

[2] The original EPRI report justified the use of NUREG-1150 doses for analyses such as this See footnote 4 on page 4-5 of EPRI TR-104285.

The EPRI Methodology (Ref. 3) employed a simplified risk model. PRA containment event trees (CETs) provide a risk-based framework for evaluating the effect of containment isolation failures affected by leakage testing requirements. The complexity of the CET models, however is not necessary to evaluate the impact of containment isolation system failures. Therefore, a simplified risk model was developed to distinguish between those accident sequences that are affected by the status of the containment isolation system versus those that are a direct function of severe accident phenomena. The simplified risk model allowed for a smaller number of CET scenarios to be evaluated to determine the baseline risk as well as subsequent analysis to quantify risk effects of extending test intervals. The methodology regrouped core damage accident sequences reported in PRAs reviewed in the study into eight classifications to permit the aforementioned differentiation. See Table 1 for a description of the eight endstate classifications. The risk metric was defined as the product of frequency and consequence (person-rem/Rx-yr).

The Indian Point Methodology (Ref. 1), quantified leakage from accident sequences in endstates (3a and 3b). Accident sequence endstates 3a and 3b have the potential to result in a change in risk associated with changes in ILRT intervals since a pre-existing leak is assumed to be present for these endstates. By manipulating the probability of a pre-existing leak of sufficient leak size, an evaluation of the change in large early release frequency (LERF) can be performed. NRC (Ref. 2) considered this an improvement on the EPRI study. Similar information is contained in the Crystal River submittal (Ref. 6).

This interim assessment guidance incorporates these and other features of the above methodologies. The first seven steps of the interim methodology calculate the change in dose. The change in dose is the principal basis upon which the Type A ILRT interval extension was previously granted and is a reasonable basis for evaluating additional extensions. The eighth step in the interim methodology calculates the change in LERF and compares it to the decision criteria in RG 1.174. Because there is no change in CDF, the change in LERF suffices as the quantitative basis for a risk informed decision per current NRC practice, namely RG 1.174. The ninth and final step of the interim methodology calculates the change in containment failure probability. The NRC has previously accepted similar calculations (Ref. 2, referred to as conditional containment failure probability, CCFP) as the basis for showing that the proposed change is consistent with the defense in depth philosophy. As such this last step suffices as the remaining basis for a risk informed decision per RG 1.174.

The nine steps of the interim methodology are:

1. Quantify the base line (nominal three year ILRT interval) risk in terms of frequency per reactor year for the EPRI accident classes of interest. Note that classes 4, 5, and 6 are not affected by changes in ILRT test frequency. Therefore, these classes are not considered in this assessment methodology.
2. Determine the containment leakage rates for applicable cases, 3a and 3b.

3. Develop the baseline population dose (person-rem, from the plant IPE, or calculated based on leakage) for the applicable accident classes.
4. Determine the population dose rate (person-rem/year) by multiplying the dose calculated in step (3) by the associated frequency calculated in step (1). (Note: The method provides for use of the NUREG-1150 population dose methods. If plant-specific values are available, they may be used. The net result is expressed as a percentile change.)
5. Determine the change in probability of leakage detectable only by ILRT, and associated frequency for the new surveillance intervals of interest. Note that with increases in the ILRT surveillance interval, the size of the postulated leak path and the associated leakage rate are assumed not to change, however the probability of leakage detectable only by ILRT does increase.
6. Determine the population dose rate for the new surveillance intervals of interest.
7. Evaluate the risk impact (in terms of population dose rate and percentile change in population dose rate) for the interval extension cases.
8. Evaluate the risk impact in terms of LERF.
9. Evaluate the change in conditional containment failure probability.

An example is provided at the end of the document to further illustrate the use of the methodology.

Interim Risk Assessment Methodology

General

Table 1 presents the eight EPRI accident classes and should be referred to in conjunction with the following:

- The purpose of this evaluation is to specifically determine the risk impact of extending the ILRT surveillance intervals. Impacts of type B and C local leak rate test interval extensions are not considered here.
- This methodology includes a simplified model, which predicts the likelihood of having a liner leak path detectable only with an ILRT.
- Although some industry information is provided for ILRT failure statistics (Ref. 5 and recent NEI survey information as discussed previously), it is necessary to obtain or derive plant specific information for total core damage frequency as well as frequencies for certain relevant accident endstates.

Methodology

- Step 1: Quantify the base line risk in terms of frequency per reactor year for the EPRI accident classes except 4, 5, and 6 (B&C tests, and multiple failures of redundant isolation valves to stroke closed which will not be considered because they are not impacted by changes in ILRT frequency and are of low impact):

  - Referring to the plant IPE, obtain values for CDF, and frequencies for classes 1,2,7 and 8.
  - Determine the frequencies for class 3a and class 3b as follows:

    frequency = CDF*class 3x leakage probability

    As indicated in the framework section above, the class 3a and 3b leakage probabilities have been calculated as 0.027 and 0.0027, respectively.
  - Adjust the accident class-1 frequency as (IPE class 1) minus(class 3a +class 3b). This is necessary to maintain the sum of the frequencies of the accident classes equal to the CDF.

- Steps 2 and 3: Determine the base-line accident dose for the accident classes, except for 4, 5, and 6:
  - Utilize the NUREG-1150 values for dose (column titled "EPRI Base Dose in the example below), or from the plant IPE, determine the relationship between offsite dose (person-rem) and containment leakage rate (e.g., the dose in person-rem for class 1, 1.0La.
  - From the EPRI Base Dose or plant IPE, determine the offsite dose (person-rem) for the accident classes where analysis is available, typically classes 1, 2, 7, and 8.
  - For those accident classes where analysis is not available in the IPE, determine the dose by first determining the class containment leak rate and multiplying by the 1.0La dose.
  - NUREG-1493 summarizes the 23 failed ILRT's as follows:
    - 14 failed due to addition of Type B and C leakage penalties
    - 4 failed due to steam generator in-leakage
    - 2 failed due to causes that should have been identified by type B and C testing
    - 2 failed due to ILRT line up errors
    - 1 test was repeated due to an unacceptable verification test.
    - Examination of the quantitative leakage data provided indicates that in about 1/3 of the cases exceeding allowable leakage, the as-found leakage was <2La; in one case the as-found leakage was <3La one case approached 10La; and in one case the leakage was approximately 21La.
    - The analysis of NUREG-1493, and EPRI both used 2La as a value, which characterized the leakages detectable by ILRT's.
  - As stated above, the recent NEI survey identified only one failure (about 2La) has been identified in the 38 ILRTs conducted since 1995.
  - For accident classes 3a and 3b leak rate, conservative value of 10La and 35La, respectively were used (Ref. 1).
- Step 4: Determine the baseline accident class dose rates (person-rem/year) by multiplying the dose by the frequency for each of the accident classes. Sum the accident class dose rates to obtain the total dose rate.
- Step 5: Determine the change in probability of leakage detectable only by ILRT (classes 3a and 3b) for the new surveillance intervals of interest:

- NUREG 1493 (Ref. 5) states that relaxing the ILRT frequency from 1 in 10 years to 3 in 10 years will increase the average time that a leak that is detectable only by ILRTs goes undetected from 18 to 60 months (1/2 the surveillance interval), a factor of 60/18=3.33 increase. The overall probability of leakage can then be expressed as 3*(surveillance interval of interest, months/2)/18, in percent. To determine the frequency for the new surveillance interval of interest, multiply the baseline (3 tests/ 10 yr interval) frequency by a factor=(interval in months/2)/18.

- <u>Step 6:</u> Determine the population dose rate for the new surveillance intervals of interest by multiplying the dose by the frequency for each of the accident classes. Sum the accident class dose rates to obtain the total dose rate.
- <u>Step 7:</u> Determine the percentage of the total dose attributable to classes 3a and 3b (those accident classes affected by change in ILRT surveillance interval).
- <u>Step 8:</u> Determine the change in the above (step 7) dose from the base dose attributable to changes in ILRT surveillance interval.
- <u>Step 8:</u> Evaluate the risk impact in terms of change in LERF. The risk associated with extending the ILRT interval involves a potential that a core damage event that normally would result in only a small radioactive release from containment could result in a large release due to an undetected leak path existing during the extended interval. As discussed in references (1 and 2), only class 3 sequences have the potential to result in <u>large</u> early releases if a pre-existing leak were present. Late releases are excluded regardless of size of the leak because late releases are not, by definition, LERF events. The frequency of class 3b sequences are used as a measure of LERF, and the change in LERF is determined by the change in class 3b frequency. ΔLERF=(frequency class 3b interval x)minus (frequency class 3b baseline). Refer to Regulatory Guide 1.174 (Ref. 4) for criteria defining acceptable changes in LERF.
- <u>Step 9:</u> Evaluate the change in CCFP:

  CCFP=1-(Intact Containment Containment Frequency/Total CDF)

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

Table 1: Accident Class Information

Class No.	Description	Frequency	Leakage	Population Dose, person-rem	Population Dose Rate, person-rem/RX-yr
1	Containment intact; accident sequences do not lead to failure; not affected by changes to ILRT leak testing frequencies.	(IPE class 1) minus (F3a+F3b)	La	Value from plant IPE or EPRI/ NUREG 1150	Dose 1* Frequency1
2	Failure of isolation system to operate from common cause or power failure; not affected by changes to ILRT leak testing frequencies.	Value from plant IPE	Value from plant IPE	Value from plant IPE or EPRI/ NUREG 1150	Dose 2* Frequency2
3a	Small pre-existing leak in containment structure or liner, identifiable by ILRT; affected by ILRT testing frequency.	0.027*CDF	10La	(Class 1 dose for La)*10La	(Dose3a)* Frequency3a
3b	Large pre-existing leak in containment structure or liner, identifiable by ILRT; affected by ILRT testing frequency.	0.0027*CDF	35La	(Class 1 dose for La)*35La	(Dose3b)* Frequency3b
4	Type B tested components fail to seal, not affected by ILRT leak testing frequencies.	NA	NA	NA	NA
5	Type C tested components fail to seal, not affected by ILRT leak testing frequencies.	NA	NA	NA	NA
6	Failure to isolate due to valves failing to stroke closed, not affected by ILRT testing frequency, low probability	NA	NA	NA	NA
7	Failure induced by severe accident phenomena, not affected by ILRT testing frequency.	Value from plant IPE	Value from plant IPE	Value from plant IPE or EPRI/ NUREG 1150	Dose7* Frequency7
8	Containment Bypass, not affected by ILRT testing frequency. (PWR SGTR; BWR MSIV leakage ISLOCA)	Value from plant IPE	Value from plant IPE	Value from plant IPE or EPRI/ NUREG 1150	Dose8* Frequency8
	Totals	CDF			Total Dose Rate

Example

Assume the following for this example calculation and evaluation:

Neutron Electric Corporation's PWR has an acceptable performance history for its ILRT's and is presently on a ten-year ILRT surveillance interval in accordance with 10CFR50, Appendix J, Option B, NEI 94-01, and its license. Its next ILRT is due in two years (end of the ten-year interval), and management has requested a risk impact assessment as part of the research necessary to support a one-time extension of the ILRT surveillance interval to 12 and 15 years.

The plant IPE is reviewed, and the following information is obtained:

> **Note: This information and the evaluation are presented as examples regarding the use of the methodology and should not be used in any plant specific evaluations.**

Class	Frequency, /Rx-yr	Dose, person-rem	Person-rem/yr
CDF, Total	4.89E-05		3.86E+01
1, No Failures (not reduced for 3a, 3b)	3.98E-05	89.7	3.57E-03
2, Failure to isolate	2.7E-07	4.07E+06	1.1E+00
7, severe accident	8.6E-06	2.16E+06	1.86E+01
8, bypass SGTR	2.1E-07	1.24E+07	2.60E+00

The example uses the following discussion, as well as the table on the following page:

- Step 1: Bf3a=0.027*CDF=1.32E-06
  Bf3b=0.0027*CDF=1.32E-07
  Bf1=C1F-bf3a-bf3b=3.8/3E-05
- Steps 2 & 3:
  - 1*La dose (Class 1 no failure dose)=89.7rem
  - Class 1,2,7,8 dose from table above.
  - Class 3a leak rate=10*La
  - Class 3b leak rate=35*La
  - Class 3a dose=10*89.7=8.97E+02rem
  - Class 3b dose=35*89.7=3.14E+03rem
- Step 4: Multiply the frequency x dose (person-rem)
- Step 5: Multipliers: 10=3.33; 15=5; 20=6.667; note that the class 1 frequency changes as in step 1, and the rest classes 2, 7 and 8 remain the same.
- Step 6: Multiply the dose (same for all intervals) by the frequency for the new accident classes to obtain the value of person-rem/Rx-yr for each class
- Step 7: The % of population dose rate affected by ILRT frequency
  - =100*dose (3a+3b) /total dose
  - Calculate the change in % of total population dose
- Step 8:ΔLERF=(Interval frequency 3b)-(Base frequency 3b)
- Step 9: CCFP={1-([Class 1 frequency + Class 3a frequency]/CDF)}*100, %

Example Calculation Sheet

Class (PWR)	EPRI Base dose person-rem	Base EPRI Freq	Dose, person-rem	Base (3/10) freq.	Base dose rate person-rem/yr	10 yr freq/	10 yr dose rate person-rem/yr	10 yr metrics	15 yr freq/	15 yr dose rate person-rem/yr	15 yr metrics	20 yr freq Rx-yr	20 yr dose rate	20 yr metrics
				/Rx-yr		Rx-yr			Rx-yr					
1	**89.74**	**3.98E-05**	8.97E+01	3.83E-05	3.44E-03	3.50E-05	3.14E-03		3.25E-05	2.92E-03		3.01E-05	2.70E-03	
2	**4.07E+06**	**2.70E-07**	4.07E+06	2.70E-07	1.10E+00	2.70E-07	1.10E+00		2.70E-07	1.10E+00		2.70E-07	1.10E+00	
3a			8.97E+02	1.32E-06	1.18E-03	4.40E-06	3.95E-03		6.60E-06	5.92E-03		8.79E-06	7.89E-03	
3b			3.14E+03	1.32E-07	4.15E-04	4.40E-07	1.38E-03		6.60E-07	2.07E-03		8.79E-07	2.76E-03	
4					0.00E+00		0.00E+00			0.00E+00			0.00E+00	
5					0.00E+00		0.00E+00			0.00E+00			0.00E+00	
6					0.00E+00		0.00E+00			0.00E+00			0.00E+00	
7	**2.16E+06**	**8.60E-06**	2.16E+06	8.60E-06	1.86E+01	8.60E-06	1.86E+01		8.60E-06	1.86E+01		8.60E-06	1.86E+01	
8	**1.24E+07**	**2.10E-07**	1.24E+07	2.10E-07	2.60E+00	2.10E-07	2.60E+00		2.10E-07	2.60E+00		2.10E-07	2.60E+00	
		4.89E-05		4.89E-05	2.23E+01	4.89E-05	2.23E+01		4.89E-05	2.23E+01		4.89E-05	2.23E+01	
				(CDF)										
DR chg from base, rem								3.42E-03			5.88E-03			8.32E-03
ILRT DR % of tl dose					0.007			0.024			0.036			0.048
% Change in ILRT DR from base								0.017			0.029			0.041
LERF					1.32E-07			4.40E-07			6.60E-07			8.79E-07
ΔLERF from base								3.08E-07			5.28E-07			7.47E-07
CCFP, %					18.85			19.48			19.93			20.38
ΔCCFP, % from base								.63			1.08			1.53
CDF		**4.89E-05**												

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