PRA Evaluation:
Risk Impact of Extending the Frequency of Containment Integrated Leak Rate Testing from 10 Years to 16 Years

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June 22, 2001

Engineering Evaluation
EE-01-008, Rev.00

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1.0 Purpose

This evaluation addresses the impact on plant risk of extending Type A containment integrated leak rate testing (ILRT) from a 10-year interval to a 16-year interval.

2.0 Background

Three types of tests are used to assure containment leak-tight integrity:

- Type A, or integrated leak rate testing (ILRT), and
- Type B and C, or local leak rate testing (LLRT).

Local leak rate testing is performed on one penetration at a time and the impact on the overall leakage is the sum of individual penetrations' leakage. Integrated leak rate testing, on the other hand, is a global check of the containment isolation capability, conducted by pressurizing the containment to the peak DBA pressure (49.6 psig) and measuring the integrated impact of all leakage. The focus of this evaluation is on the frequency of ILRTs.

Technical Specification 6.15 sets the maximum allowed leakage (L_a)at 0.15% containment free volume by weight, per day at the peak DBA pressure. From EX1803.001, the procedural requirements for ILRT are an as-found value less than $1.0L_a$ and an as-left value of less than $0.75L_a$. The first three ILRTs performed at Seabrook Station have all been below $0.75L_a$.

Previous changes to the Appendix J of 10CFR Part 50 have allowed relaxation in the frequency of ILRT and LLRT testing, based on the performance of previous tests. Good performance of the Seabrook Unit 1 containment has allowed extension of the frequency for ILRT from 3 times in 10 years to once-in-10 years. This evaluation addresses the risk impact of further extending this frequency to once-in-16 years.

3.0 Evaluation

An extension to the ILRT frequency can impact risk by affecting the reliability of containment isolation due to unidentified leakage. It does not affect the Level 1 (core damage) risk and also does not impact the reliability of containment isolation valves failing to close on demand. Extending ILRT does increase the potential for unidentified containment leakage.

In general terms, ILRT-identified leakage can be grouped into three classes of containment isolation failure:

- Minor Containment Leakage (MCL) - leakage slightly above the TS leakage limit (L_a). This leakage is modeled as $2L_a$, i.e. two times allowable leakage.

- Small Containment Leakage (SCL) - significantly above the TS leakage limit but below the size that would qualify as large, early release (LERF). This leakage is modeled as $10L_a$, i.e. an order of magnitude above allowable leakage.
- Large Containment Leakage (LCL) - leakage that would qualify as LERF. This leakage is modeled as equivalent to the opening of the containment online purge line (8-inch nominal).

Risk can be decomposed into the *frequency* of unidentified leakage and the *consequences* of containment leakage. Extending ILRT has the potential to impact the *frequency* of containment leakage, but doesn't impact the *conditional consequences*. Thus, this evaluation first considers the impact on the frequency of leakage due to changing the ILRT interval to 16 years. Second, the consequences of minor, small, and large leakage are evaluated. Finally, the change in risk is calculated based on multiplying the change in frequency times the conditional consequences.

Note: the failure being evaluated is *not* failure of ILRT -- i.e., failure of the test to identify real leakage -- but failure of containment isolation that ILRT could uniquely identify. Due to the integral nature of the test, it is unlikely that leakage could be hidden from the test unless it was related to the isolation that is done to protect equipment and instrumentation. Failure of ILRT is not addressed quantitatively in this evaluation. This is conservative with regard to extending ILRT testing frequency because it would reduce the value of an ILRT.

3.1 Frequency

The accident sequences of interest are those core damage sequences with offsite releases through unidentified containment leakage -- leakage that could be identified through ILRT. These are core damage sequences where the containment is intact except for unidentified leakage - i.e., not gross containment failure, containment bypass, failure of active containment isolation, etc. Since the unidentified leak does not impact the likelihood or outcome of the core damage accident, the sequence frequency can be written as:

FREQ = Freq(Core damage with containment intact) x Prob(ILRT leak)

Where:

Freq(Core damage with containment intact) = Freq(release category S5) = 3.10E-5/yr (from Reference 1: SSPSS-1999a, Section 9.2), and

Prob(ILRT leak) = Prob(Unidentified containment leak detectable via ILRT). This probability is estimated in the following sections, for three different leakage sizes.

3.1.1 Minor Containment Leakage (MCL)

Baseline Probability

The probability of Minor Containment Leakage detectable from ILRT can be estimated from generic industry data. Section 4.1 of NUREG-1493 (Reference 2) discusses the results of approximately 180 ILRTs throughout the industry during the period 6/87 to 4/93. Of those 180 tests, 42 were classified as failures but only 5 were found by ILRT which LLRT could not and did not detect. The generic containment leakage probability of leakage that ILRT alone could identify:

PROB(MCL-ILRT1) = 5/180 = 0.0278

NUREG-1493 also states that:

> "Of note in the ILRT failures observed that were not detected by Type B and C testing, the actual leakage rates were very small, only marginally in excess of current leak-tightness requirements."

The leakage definition used for MCL ($2L_a$) is conservative compared to the above industry experience.

NUMARC conducted a similar survey of 144 ILRTs (also documented in NUREG-1493). This survey found 23 ILRT-related isolation failures but only 4 failures that ILRT alone could detect (code A1 and A3). This results in an identical failure rate (4/144 = 0.0278) as from the NUREG data. The 4 failures were all steam generator in-leakage, with as-found leakage of $0.88L_a$ to $1.3L_a$. At Seabrook, the integrity of secondary side leakage paths is verified by either a pressurization test of the SGs with the primary system depressurized or on-line with the plant systems examined when pressurized. Thus, the likelihood of SG manway gasket leakage is even more remote than indicated by generic data. No credit is taken for this Seabrook inspection.

In addition, 2 events in the NUMARC survey involved Type B & C leakage that was not discovered by LLRT (code A2). These events represent the failure of LLRT that ILRT could discover. These two events also involved leakage below $2L_a$. The probability of containment leakage identified by ILRT that LLRT failed to discover:

PROB(MCL-ILRT2) = 2/144 = 0.0139

Of the other 17 failure events in the NUMARC database, the leakages were less than $2L_a$ except for two events -- one less than $3L_a$ and a second approaching $10L_a$. However, these involved exceedances due to additions from LLRT-identified leakage or testing errors. These events did not involve direct ILRT-identified failures.

These two probabilities can be summed to give an overall probability of containment leakage that was not detected by means other than ILRT. Thus, the probability of a minor containment leak that could be detected by ILRT:

PROB(MCL-ILRT) = 0.0278 + 0.0139 = 0.0417

These probabilities are based on industry events that involved small leakage, bounded by $2L_a$ -- consistent with the leakage definition of MCL.

Adjusted Probabilities

To evaluate the impact of the change in ILRT frequency on the probability of containment leakage, the failure probabilities calculated above need to be converted to a *failure rate per time*.

These failure events are associated with processes that can be seen as randomly generating leakage that could be detected by ILRT. For example, the SG secondary manway leakage could be present following the SG sludge lancing that occurs each refueling outage. Also, the Type B & C leakage not identified by LLRT could happen in any outage where the penetration seal is opened and reclosed. Thus, the processes that generate leakage can be thought of as a random process with a failure rate of λ_{ILRT}.

For minor containment leakage, the NUREG and NUMARC data are based on plant experience from 1993 and earlier, when the ILRT Technical Specifications required Type A testing 3 times in 10 years. Thus, the probability calculated above should be identified as:

PROB(MCL-ILRT, 3-in-10-year) = 0.0417

Then, if we assume a constant probability (0.0417) over this time, the failure rate per hr:

$\lambda_{ILRT,MCL}$ = 0.0417 / (10yr x 8760hr/yr / 3) = 1.43E-6/hr

Now, for a 10-year interval (the current requirement) and assuming a constant failure rate, the average failure probability is:

PROB(MCL-ILRT, 1-in-10-year) = 1.43E-6/hr x 10yr x 8760hr/yr = 0.125, or a factor of 3 increase (consistent with the factor of 3 increase in duration between ILRTs).

For a further increase to 16 years:

PROB(MCL-ILRT, 1-in-16-year) = 1.43E-6/hr x 16yr x 8760hr/yr = 0.200, a factor of 4.8 increase over the initial 3 tests in 10 years, or a factor of 1.6 increase over the once-in-10 year requirement.

3.1.2 Small Containment Leakage (SCL)

The NRC and NUMARC databases have no leakage events detected by ILRT (alone) that were above *minor* in size. Using the NUREG-1493 data with the evidence of 0 SCL failures, the χ^2 distribution can be used to provide a conservative estimate of the failure probability.

The containment failure process can be modeled as a binomial distribution. Then the 95% upper confidence limits can be approximated as:

$P_U(95\%) = \chi^2(\nu=2f+2; 0.95) / 2N$,

where f represents the number of SCLs, N represents the number of ILRTs in the database, ν represents the number of degrees of freedom, and $\chi^2(\nu;0.95)$ represents the chi-square probability with ν degrees of freedom at the 95% confidence level (Reference 3: NUREG/CR-2300, Section 5.5.1.3).

f = 0

N = 180

$\nu = 2$

$\chi^2(\nu=2;0.95) = 5.99$ (from Table C in Reference 6).

Thus, an upper limit on the probability of a small containment leakage that could be detected only by ILRT:

PROB(SCL-ILRT-95%) = 5.99 / (2*180) = 0.0166

A similar process can be used to calculate a 50% confidence upper limit probability:

$\chi^2(\nu=2;0.50) = 1.39$

PROB(SCL-ILRT-50%) = 1.39 / (2*180) = 0.00386

These values can be compared with the small pre-existing leakage basic event probability currently used in the Seabrook PRA (SSPSS-1999a):

EE.CIPEL.GL = 3.74E-3, or a factor of 4 smaller than the 95% chi-square estimate but consistent with the 50% confidence value.

This basic event, documented in PLG-0631, Section 3.2.3.2 (Ref. 7), is based on a review of containment isolation data from NUREG/CR-4220. This data is pre-1985 and includes leakage that could be detected by LLRT as well as ILRT. It is expected that this probability is conservative since the reliability of containment isolation has likely improved over the decades and since this includes LLRT- as well as ILRT-identified leakage.

For this analysis, the conservative 95% confidence value will be used for the 3-in-10 year case. As discussed in Section 3.1.1, increasing the interval between ILRTs to 10 years and to 16 years increases the failure probability by factors of 3 and 4.8, respectively. Thus,

PROB(SCL-ILRT, 3-in-10-year) = 0.0166

PROB(SCL-ILRT, 1-in-10-year) = 0.0166 x 3.0 = 0.0498

PROB(SCL-ILRT, 1-in-16-year) = 0.0166 x 4.8 = 0.0797

3.1.3 Large Containment Leakage (LCL)

One would expect the probability of LCL to be much lower than SCL since it would require a defect that would likely be detected by other means - visual, leakage from other systems, etc. The Seabrook PRA has a value for large pre-existing leakage:

EE.C2PEL.GL = 9.34E-5, or a factor of 40 smaller than the small pre-existing leak probability above.

It is reasonable to assume the LCL probability would be at least an order of magnitude less than the SCL probability. Since the SCL probability is based on a conservative estimate, the factor of 40 will be used to estimate a probability for LCL:

PROB(LCL-ILRT) = 0.0166 / 40 = 4.15E-4

The probabilities for extended frequencies are modified as discussed in the previous section:

PROB(LCL-ILRT, 3-in-10-year) = 4.15E-4

PROB(LCL-ILRT, 1-in-10-year) = 4.15E-4 x 3.0 = 1.25E-3

PROB(LCL-ILRT, 1-in-16-year) = 4.15E-4 x 4.8 = 1.99E-3

3.1.4 Frequency Results

The following summarizes the probabilities for different ILRT frequencies:

	Probability of Unidentified Containment Leakage		
ILRT Frequency	**MCL**	**SCL**	**LCL**
3 per 10 years	0.0417	1.66E-2	4.15E-4
1 per 10 years	0.125	4.98E-2	1.25E-3
1 per 16 years	0.200	7.97E-2	1.99E-3

As discussed above, the frequency of core damage with intact containment, release category S5, is 3.10E-5. Thus, the frequency of core damage with unidentified leakage is:

	Frequency of Core Damage with Unidentified Containment Leakage		
ILRT Frequency	**MCL**	**SCL**	**LCL**
3 per 10 years	1.29E-6	5.15E-7	1.29E-8
1 per 10 years	3.88E-6	1.54E-6	3.86E-8
1 per 16 years	6.20E-6	2.47E-6	6.18E-8

Note, the frequency of LCL is approximately a factor of 100 below MCL. While this was coincidental, it is consistent with the data and experience that large containment leakage would be rare in comparison to minor leakage.

3.2 Consequence

The consequences for the three leakage sizes are derived from the Base Case Level 3 consequence model.

3.2.1 Base Case Model

Table 1 provides a summary of the Base Case risk results for the best estimate source term and consequence assumptions (from Reference 4: PLG-0432, Table D-5). This table presents the seven release category groups that have been used in the Seabrook

PRA to bin the impact of containment performance - early vs late failure; large vs small leakage; structural failure vs isolation failure vs bypass failure.

The mean frequency values are based on specific release categories from SSPSS-1999a. Note, the sum of the release category frequencies is equal to the Core Damage Frequency total (4.63E-5/yr).

The Level 3 consequence analysis is based on Seabrook-specific site parameters, using the CRACIT computer code (documented in PLG-0432, Section 5 and Appendix D). Using the best estimate consequence modeling, there are no early fatalities projected on a conditional consequence basis. The health effects model for early fatalities has a threshold dose, below which no fatalities would occur. This is in contrast to the health effects for total cancers where a linear model with no threshold is used. Note that the Total Man-Rem and Total Cancer are related by the conversion 1 man-rem = 2.0E-4 cancers. As a result, these two columns give the same results, with regard to percentage change.

The absolute risk values are the produce of frequency times consequence. The total expected offsite exposure risk, the sum of the absolute risk from each release category, is 14.3 man-rem per year.

3.2.2 ILRT Sensitivities

Table 2 provides consequence and risk results for the three ILRT frequency cases - 3 in 10 years, 1 in 10 years, and 1 in 16 years. Each case includes the three containment leakage sizes - minor (MCL), small (SCL), and large (LCL).

The consequence model for the MCL size is based on the following:

- MCL = 2 x L_a (as discussed in Section 3.1),
- Seabrook value for L_a = 0.15% per day (based on TS 6.15),
- IntactS5 leakage = 0.10% per day (based on PLG-0432 assumption).

Thus, MCL / IntactS5 = (2 x 0.15%) / (0.10%) = 3, or MCL = 3 x intactS5. That is, the leakage from MCL is three times the intact containment category rather than two time, based on the calculation for "IntactS5" which used a leakage of 0.1%, rather than 0.15% (L_a).

Similarly, SCL / IntactS5 = (10 x 0.15%) / (.10%) = 15, or SCL = 15 x intactS5.

Based on Section 4.2 of EPRI TR-104285 (Reference 5), it is reasonable to assume a direct correlation of the population doses with release magnitudes for low fission product releases. Thus, for MCL and SCL, we assume the Conditional Consequences are directly proportional to the size of leak - factors of 3 and 15 larger than IntactS5.

As shown in Table 2, the LCL is modeled after release category "lerfS6." The large containment leakage size is modeled as equivalent to the opening of the containment online purge line, consistent with the definition of release category "lerfS6."

From Table 2, the consequence results for population dose can be summarized as follows:

ILRT Frequency	ILRT-Related Pop. Dose	Adjusted Total Pop. Dose	Percent of Adjusted Total	Change from 3 per 10 yr	Change from 1 per 10 yr
3 per 10 years	0.0128	14.31	0.09%	--	--
1 per 10 years	0.0385	14.34	0.27%	0.21%	--
1 per 16 years	0.0615	14.36	0.43%	0.35%	0.14%
BaseLine Total	--	14.3	--	--	--
	man-rem	man-rem			

Note, the BaseLine Total does not include an explicit contribution for ILRT-related consequences. As a result, an adjusted total population dose is calculated by adding the ILRT-related dose to the BaseLine total dose. In all cases, the ILRT-related dose is a very small percent of the total dose. Thus, the change in total population dose from extending the ILRT frequency is also very small. The change from the current frequency is only 0.14%. The cumulative change (from 3-in-10 yr to 1-in-16 yr) is only 0.35% increase.

3.2.3 Conservative Source Term / Consequence Sensitivity

Table 3 provides similar results using conservative source term and consequence assumptions (also from PLG-0432 Table D-5). PLG-0432 Section 5 explains the differences in assumptions between best estimate and conservative. With conservative assumptions, the conditional consequences are significantly greater, including a non-zero early fatality risk. The integrated risk results for the Conservative BaseLine case:

Early fatality risk = 6.05E-7/yr

Total man-rem risk = 36.7 man-rem / yr

Table 4 provides consequence and risk results for the three ILRT frequency cases - 3 in 10 years, 1 in 10 years, and 1 in 16 years - using the Conservative BaseLine model. The results for population dose are summarized below:

ILRT Frequency	ILRT-Related Pop. Dose	Adjusted Total Pop. Dose	Percent of Adjusted Total	Change from 3 per 10 yr	Change from 1 per 10 yr
3 per 10 years	0.156	36.9	0.42%	--	--
1 per 10 years	0.468	37.2	1.26%	0.81%	--

1 per 16 years	0.749	37.5	2.00%	1.62%	0.81%
BaseLine Total	--	36.7	--	--	--
	man-rem	man-rem			

Thus, for population dose, even with conservative consequence assumptions, the conclusion is still strong - that a change in ILRT frequency up to 1-in-16 year makes a small change in overall population dose risk.

The results for early fatality risk are summarized below:

ILRT Frequency	ILRT-Related Early Fatality Risk	Adjusted Total Early Fatality Risk	Percent of Adjusted Total	Change from 3 per 10 yr	Change from 1 per 10 yr
3 per 10 years	1.18E-7	7.24E-7	16.4%	--	--
1 per 10 years	3.55E-7	9.60E-7	37.0%	32.6%	--
1 per 16 years	5.68E-7	1.17E-6	48.4%	61.6%	21.9%
BaseLine Total	--	6.05E-7	--	--	--

For early fatality risk, using conservative modeling assumptions, the change is more significant (than for population dose). This is not surprising because the early fatality risk is very small; conservative assumptions related to source terms and consequence modeling have a compounding effect. In fact, if these two areas of conservatism are included separately, the early fatality risk decreases more than 2 orders of magnitude (PLG-0432, Table D-5, cases S6B-H and S6C-M). At that point, the proposed change in ILRT frequency would have an insignificant impact on the calculated risk.

3.2.4 Large Early Release Frequency

The large early release frequency (LERF) is impacted only by Large Containment Leakage (LCL). The change in ILRT-related LERF, from Table 2, is as follows:

ILRT Frequency	ILRT-Related LERF (LCL)	Change from 3 per 10 yr	Change from 1 per 10 yr
3 per 10 years	1.29E-8	--	--
1 per 10 years	3.86E-8	2.57 E-8	--
1 per 16 years	6.18E-8	4.89 E-8	2.32E-8
BaseLine LERF Total	--	--	--

Thus, the ΔLERF from current 1-in-10 year to 1-in-16 year frequency is 2.3E-8/yr. The cumulative ΔLERF (from 3-in-10 year to 1-in-16 year) is 4.89E-8/yr. These ΔLERF values are both below the Reg Guide 1.174 guideline of 1E-7 for "Very Small Changes".

3.3 Qualitative Risk Considerations

Section 3.1 and 3.2 estimated a small potential increase in risk based on extending the frequency of ILRT. There are other considerations that are difficult to quantify but provide some potential for risk reduction with extending the ILRT frequency:

- Shortened outages. The ILRTs at Seabrook Station have taken 4 to 5 days of critical path time during refueling outages. Fewer ILRTs means shorter outages and less outage risk.
- Reduced potential for damaged equipment not discovered. Due to the internal pressure in the containment during the test, equipment has been damaged in past tests. While this is primarily a maintenance cleanup and repair issue, it does have the potential for damage that is not detected following the test.
- Reduced potential for misalignment/latent errors. In preparation for an ILRT, a list of instrumentation and equipment are isolated to assure they are not damaged from the internal containment pressure. The restoration form (Form R in EX1803.001) has a list of 47 pages of components and instrumentation that need to be modified following the test. While the restoration procedure provides significant assurance, there is the possibility of instrument or equipment being isolated or otherwise misaligned.
- Reduced personnel exposure - preparation for and recovery from an ILRT requires a significant number of activities within the containment.
- Reduced time when the containment is inaccessible. If a shutdown sequence occurred, local action in containment would not be possible for an extended period of time. For example, locally gagging an RHR relief valve that opened inadvertently would not be possible during the ILRT.

4.0 Safety Significance

This evaluation addresses extending the frequency of the ILRT to once in 16 years. Any significant hazards will be evaluated as part of the license amendment.

5.0 Conclusion

A change in the ILRT frequency from 1-in-10 years to 1-in-16 years will have an extremely small change in population dose consequences (0.8%). Also, the change in LERF (2.3E-8/yr) is well below the Reg Guide 1.174 1E-7 guideline for very small changes.

This finding is consistent the findings of NUREG-1493, Section 10.1.2:

> 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 an imperceptible increase in risk. The estimated increase in risk is very small because ILRTs identify only a few potential containment leakage paths that cannot be identified by Type B and C testing, and the leaks that have been found by Type A tests have been only marginally above existing requirements.

6.0 References

1. SSPSS-1999a, "Seabrook Station Probabilistic Safety Study, 1999a Update," January 2001.
2. NUREG-1493, "Performance-Based Containment Leak-Test Program," September 1995.
3. NUREG/CR-2300, "PRA Procedures Guide," January 1983.
4. PLG-0432, "Seabrook Station Risk Management and Emergency Planning Study," December 1985.
5. EPRI-104285, "Risk Impact Assessment of Revised Containment Leak Rate Testing Intervals," August 1994.
6. Statistical Data Analysis Handbook, Francis J. Wall, McGraw-Hill, 1986.
7. PLG-0631, "Probabilistic Risk Assessment of 40% Power operation at the Seabrook Station", November 1988.

TABLE 1

TABLE 2

TABLE 3

TABLE 4

TABLE 1 Risk Summary for Best Estimate Source Term/Consequence Modeling - Base Case *

Release Category Group	Description	Release Categories [a]	Frequency (per yr) [b]	Conditional Consequences [c]: Early Fatalities	Conditional Consequences [c]: Total Cancers	Conditional Consequences [c]: Total Man-Rem [d]	Absolute Risk (Freq x Conseq): Early Fatality Risk	Absolute Risk (Freq x Conseq): Total Cancer Risk	Absolute Risk (Freq x Conseq): Total Man-Rem Risk	CRACIT Case [e]
S1	Early containment failure	lerfS1A	1.05E-09	0.0	1230.4	6.15E+06	0.00E+00	1.29E-06	6.46E-03	S1B-M
S2	Early small containment leakage, late overpressure failure	serfS2A, serfS2B, serfS2R, serfS7S, serfS7V	2.97E-06	0.0	681.4	3.41E+06	0.00E+00	2.02E-03	1.01E+01	S2B-M
S3	Early intact, late overpressurization failure	lateS3A, lateS3B	1.23E-05	0.0	66.7	3.34E+05	0.00E+00	8.20E-04	4.10E+00	S3B-M
S4	Basemat melt-through	lateS4	1.06E-08	--	--	--	--	--	--	(f)
S5	Intact containment (TS Leakage)	intactS5	3.10E-05	0.0	0.1	5.00E+02	0.00E+00	3.10E-06	1.55E-02	S5HAT (g)
S6	Containment isolation failure	lerfS6	1.26E-08	0.0	109.2	5.46E+05	0.00E+00	1.38E-06	6.88E-03	S6B-M
S7	Containment bypassed	lerfS7I, lerfS7S, lerfS7V	3.74E-08	0.0	109.2	5.46E+05	0.00E+00	4.08E-06	2.04E-02	S7B-M
TOTAL			***4.63E-05***				***0.00E+00***	***2.85E-03***	***1.43E+01***	

Notes:
* Hand calculations in these tables may not exactly match the spreadsheet calculation because values displayed are rounded to three digits.
(a) Release Categories are from SSPSS-1999 Section 9.2. Note that "lerf" = large, early release frequency, "serf" = small, early release frequency, "late" = large, late release frequency, and "intact" = TS leakage frequency.
(b) The Frequency values are from the SSPSS-1999 Section 9.2, based on the Release Category designators in the previous column. Note that the frequency for "serfS7" is included in Group S2 frequency since this is the closest group with regard to consequences.
(c) Conditional Consequences come from PLG-0432 (Ref 4), Table D-5. These values are for 10-mile evacuation with best-estimate source term and best-estimate consequence modeling.
(d) Total Man-Rem and Total cancers are related by the equation: 2.0E-4 cancers = 1 man-rem (from PLG-0432, Table 5-1, Medium Case).
(e) The CRACIT cases are a series of consequence analyses documented in PLG-0432 Table D-5. The designator B = best estimate source terms (from PLG-0432, Table 4-13) and M =median consequence assumptions (from PLG-0432, Table 5-1).
(f) Category S4, basemat melt-through is combined with S3 since the consequences are similar and S4 has a low frequency relative to S3.
(g) S5HAT represents the conservative "intact" release, assuming a leakage of 0.1% per day with no credit for the enclosure building.

TABLE 2 Risk Summary for Best Estimate Source Term/Consequence Modeling - ILRT Sensitivities

ILRT Release Category	Description	Release Categories	Frequency (per yr)	*Conditional Consequences* Early Fatalities	Total Cancers	Total Man-Rem	*Absolute Risk (Freq x Conseq)* Early Fatality Risk	Total Cancer Risk	Total Man-Rem Risk
3 ILRTs per 10 Years									
MCL	Minor Containment Leakage (2La)	3 x intactS5	1.29E-06	0.0	0.3	1.50E+03	0.00E+00	3.88E-07	1.94E-03
SCL	Small Containment Leakage (10La)	15 x intactS5	5.15E-07	0.0	1.5	7.50E+03	0.00E+00	7.72E-07	3.86E-03
LCL	Large Containment Leakage	lerfS6	1.29E-08	0.0	109.2	5.46E+05	0.00E+00	1.40E-06	7.02E-03
						Subtotal (MCL, SCL, LCL) =	0.00E+00	2.56E-06	1.28E-02
						Baseline Total (from Table 1) =	0.00E+00	2.85E-03	1.43E+01
						Adjusted Total (Subtotal + Baseline Total) =	***0.00E+00***	***2.86E-03***	***1.43E+01***
						Percentage of Total =	0.0%	0.09%	0.09%
1 ILRT per 10 Years									
MCL	Minor Containment Leakage (2La)	3 x intactS5	3.88E-06	0.0	0.3	1.50E+03	0.00E+00	1.16E-06	5.81E-03
SCL	Small Containment Leakage (10La)	15 x intactS5	1.54E-06	0.0	1.5	7.50E+03	0.00E+00	2.32E-06	1.16E-02
LCL	Large Containment Leakage	lerfS6	3.86E-08	0.0	109.2	5.46E+05	0.00E+00	4.21E-06	2.11E-02
						Subtotal (MCL, SCL, LCL) =	0.00E+00	7.69E-06	3.85E-02
						Baseline Total (from Table 1) =	0.00E+00	2.85E-03	1.43E+01
						Adjusted Total (Subtotal + Baseline Total) =	***0.00E+00***	***2.86E-03***	***1.43E+01***
						Percentage of Total =	0.0%	0.27%	0.27%
1 ILRT per 16 Years									
MCL	Minor Containment Leakage (2La)	3 x intactS5	6.20E-06	0.0	0.3	1.50E+03	0.00E+00	1.86E-06	9.30E-03
SCL	Small Containment Leakage (10La)	15 x intactS5	2.47E-06	0.0	1.5	7.50E+03	0.00E+00	3.71E-06	1.85E-02
LCL	Large Containment Leakage	lerfS6	6.18E-08	0.0	109.2	5.46E+05	0.00E+00	6.74E-06	3.37E-02
						Subtotal (MCL, SCL, LCL) =	0.00E+00	1.23E-05	6.15E-02
						Baseline Total (from Table 1) =	0.00E+00	2.85E-03	1.43E+01
						Adjusted Total (Subtotal + Baseline Total) =	***0.00E+00***	***2.87E-03***	***1.43E+01***
						Percentage of Total =	0.0%	0.43%	0.43%

TABLE 3 Risk Summary for Conservative Source Term/Consequence Modeling - Conservative Base Case

Release Category Group	Description	Release Categories [a]	Frequency (per yr) [b]	Conditional Consequences [c]			Absolute Risk (Freq x Conseq)			CRACIT Case [e]
				Early Fatalities	Total Cancers	Total Man-Rem [d]	Early Fatality Risk	Total Cancer Risk	Total Man-Rem Risk	
S1	Early containment failure	lerfS1A	1.05E-09	127.7	8047.1	1.61E+07	1.34E-07	8.45E-06	1.69E-02	S1C-H
S2	Early small containment leakage, late overpressure failure	serfS2A, serfS2B, serfS2R, serfS7S, serfS7V	2.97E-06	0.0	3964.5	7.93E+06	0.00E+00	1.18E-02	2.35E+01	S2C-H
S3	Early intact, late overpressurization failure	lateS3A, lateS3B	1.23E-05	0.0	510.1	1.02E+06	0.00E+00	6.27E-03	1.25E+01	S3C-H
S4	Basemat melt-through	lateS4	1.06E-08	--	--	--	--	--	--	[f]
S5	Intact containment (TS Leakage)	intactS5	3.10E-05	0.0	0.1	2.00E+02	0.00E+00	3.10E-06	6.20E-03	S5HAT [g]
S6	Containment isolation failure	lerfS6	1.26E-08	9.2	5972.7	1.19E+07	1.16E-07	7.53E-05	1.51E-01	S6C-H
S7	Containment bypassed	lerfS7I, lerfS7S, lerfS7V	3.74E-08	9.5	5933.9	1.19E+07	3.55E-07	2.22E-04	4.44E-01	S7C-H
TOTAL			***4.63E-05***				***6.05E-07***	***1.84E-02***	***3.67E+01***	

Notes:

(a) Release Categories are from SSPSS-1999 Section 9.2. Note that "lerf" = large, early release frequency, "serf" = small, early release frequency, "late" = large, late release frequency, and "intact" = TS leakage frequency.

(b) The Frequency values are from the SSPSS-1999 Section 9.2, based on the Release Category designators in the previous column. Note that the frequency for "serfS7" is included in Group S2 frequency since this is the closest group with regard to consequences.

(c) Conditional Consequences come from PLG-0432 (Ref 4), Table D-5. These values are for 10-mile evacuation with conservative source term and conservative consequence modeling.

(d) Total Man-Rem and Total cancers are related by the equation: 5.0E-4 cancers = 1 man-rem (from PLG-0432, Table 5-1, High Case).

(e) The CRACIT cases are a series of consequence analyses documented in PLG-0432 Table D-5. The designator C = conservative source terms (from PLG-0432, Table 4-13) and H =high consequence assumptions (from PLG-0432, Table 5-1).

(f) Category S4, basemat melt-through is combined with S3 since the consequences are similar and S4 has a low frequency relative to S3.

(g) S5HAT represents the conservative "intact" release, assuming a leakage of 0.1% per day with no credit for the enclosure building (no change from best-estimate model).

TABLE 4 Risk Summary for Conservative Source Term/Consequence Modeling - ILRT Sensitivities

ILRT Release Category	Description	Release Categories	Frequency (per yr)	Conditional Consequences: Early Fatalities	Conditional Consequences: Total Cancers	Conditional Consequences: Total Man-Rem	Absolute Risk (Freq x Conseq): Early Fatality Risk	Absolute Risk (Freq x Conseq): Total Cancer Risk	Absolute Risk (Freq x Conseq): Total Man-Rem Risk
3 ILRTs per 10 Years									
MCL	Minor Containment Leakage (2La)	3 x intactS5	1.29E-06	0.0	0.3	6.00E+02	0.00E+00	3.88E-07	7.76E-04
SCL	Small Containment Leakage (10La)	15 x intactS5	5.15E-07	0.0	1.5	3.00E+03	0.00E+00	7.72E-07	1.54E-03
LCL	Large Containment Leakage	lerfS6	1.29E-08	9.2	5972.7	1.19E+07	1.18E-07	7.68E-05	1.54E-01
						Subtotal (MCL, SCL, LCL) =	1.18E-07	7.80E-05	1.56E-01
						Baseline Total (from Table 3) =	6.05E-07	1.84E-02	3.67E+01
						Adjusted Total (Subtotal + Baseline Total) =	***7.24E-07***	***1.84E-02***	***3.69E+01***
						Percentage of Total =	16.36%	0.42%	0.42%
1 ILRT per 10 Years									
MCL	Minor Containment Leakage (2La)	3 x intactS5	3.88E-06	0.0	0.3	6.00E+02	0.00E+00	1.16E-06	2.33E-03
SCL	Small Containment Leakage (10La)	15 x intactS5	1.54E-06	0.0	1.5	3.00E+03	0.00E+00	2.32E-06	4.63E-03
LCL	Large Containment Leakage	lerfS6	3.86E-08	9.2	5972.7	1.19E+07	3.55E-07	2.31E-04	4.61E-01
						Subtotal (MCL, SCL, LCL) =	3.55E-07	2.34E-04	4.68E-01
						Baseline Total (from Table 3) =	6.05E-07	1.84E-02	3.67E+01
						Adjusted Total (Subtotal + Baseline Total) =	***9.60E-07***	***1.86E-02***	***3.72E+01***
						Percentage of Total =	36.97%	1.26%	1.26%
1 ILRT per 16 Years									
MCL	Minor Containment Leakage (2La)	3 x intactS5	6.20E-06	0.0	0.3	6.00E+02	0.00E+00	1.86E-06	3.72E-03
SCL	Small Containment Leakage (10La)	15 x intactS5	2.47E-06	0.0	1.5	3.00E+03	0.00E+00	3.71E-06	7.41E-03
LCL	Large Containment Leakage	lerfS6	6.18E-08	9.2	5972.7	1.19E+07	5.68E-07	3.69E-04	7.38E-01
						Subtotal (MCL, SCL, LCL) =	5.68E-07	3.74E-04	7.49E-01
						Baseline Total (from Table 3) =	6.05E-07	1.84E-02	3.67E+01
						Adjusted Total (Subtotal + Baseline Total) =	***1.17E-06***	***1.87E-02***	***3.75E+01***
						Percentage of Total =	48.42%	2.00%	2.00%