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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station OP1-17
Washington, DC 20555

**SUSQUEHANNA STEAM ELECTRIC STATION
SUPPLEMENT TO PROPOSED AMENDMENT NO. 241
TO LICENSE NPF-14 AND PROPOSED
AMENDMENT NO. 206 TO LICENSE NPF-22:
REQUEST FOR A ONE TIME DEFERRAL OF THE
TYPE A CONTAINMENT INTEGRATED LEAK
RATE TEST (ILRT)
PLA-5361**

**Docket No. 50-387
and 50-388**

Reference: 1. PLA-5342, G. T. Jones (PPL) to USNRC Document Control Desk, "Proposed Amendment No. 241 to License NPF-14 and Proposed Amendment No. 206 to License NPF-22: Request for a One Time Deferral of the Type A Containment Integrated Leak Rate Test (ILRT)," dated July 30, 2001.

2. Letter, NRC to M. Kansler (Entergy Nuclear Operations, Inc.), "Indian Point Nuclear Generating Unit No. 3 - Issuance of Amendment RE: Frequency of Performance -Based Leakage Rate Testing," dated April 17, 2001.

Reference 1 proposed a change to the Susquehanna Steam Electric Station (SSES) Unit 1 and Unit 2 Technical Specifications to defer the Type A Containment Integrated Leak Rate Test (ILRT).

In Reference 1, PPL committed to provide a risk assessment of the ILRT interval extension. Attachment A provides the risk assessment. This risk assessment was performed consistent with the assessment performed for Indian Point 3's ILRT deferral submittal (Reference 2). Attachment B provides the associated population dose consequence evaluation.

A017

The risk assessment concludes:

- The change in Type A test frequency from once-per-10 years to once-per-15 years increases the risk of those associated specific accident sequences by 0.3%. The risk impact on the total integrated plant risk for those accident sequences influenced by Type A testing is also 0.3%. Therefore, the risk impact of the proposed change is negligible.

- Regulatory Guide 1. 174 provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Regulatory Guide 1.174 defines very small changes in risk as resulting in increases of core damage frequency (CDF) below 1E-6/year and increases in Large Early Release Frequency (LERF) below 1E-7/year. Since the ILRT does not impact CDF, the relevant criterion is LERF. The increase in LERF resulting from a change in the Type A ILRT test interval from a once-per-10 years to a once per-15 years is 3.93E-10 / year. Because guidance in Regulatory Guide 1.174 defines very small changes in LERF as below 1E-07/year, increasing the ILRT interval from 10 to 15 years is therefore considered not risk significant.

If you have any questions, please contact Mr. C. T. Coddington at (610) 774-4019.

Sincerely,

R. G. Byram

Attachment

copy: NRC Region I
Mr. S. Hansell, NRC Sr. Resident Inspector
Mr. R. Schaaf, NRC Project Manager

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION

In the Matter of :

PPL Susquehanna, LLC: Docket No. 50-387

SUPPLEMENT TO PROPOSED AMENDMENT NO. 241 TO LICENSE NPF-14: ONE TIME DEFERRAL OF THE CONTAINMENT INTEGRATED LEAK RATE TEST (ILRT) UNIT NO. 1

Licensee, PPL Susquehanna, LLC, hereby files a supplement to Proposed Amendment No. 241 in support of a revision to its Facility Operating License No. NPF-14 dated July 17, 1982.

This amendment involves a revision to the Susquehanna SES Unit 1 Technical Specifications.

PPL Susquehanna, LLC
By:

R. G. Byram
Sr. Vice-President and Chief Nuclear Officer

Sworn to and subscribed before me
this 7th day of September, 2001.

Notary Public

Notarial Seal
Nancy J. Lannen, Notary Public
Allentown, Lehigh County
My Commission Expires June 14, 2004

BEFORE THE
UNITED STATES NUCLEAR REGULATORY COMMISSION

In the Matter of :

PPL Susquehanna, LLC : Docket No. 50-388

SUPPLEMENT TO PROPOSED AMENDMENT NO. 206 TO LICENSE NPF-22: ONE TIME DEFERRAL OF THE CONTAINMENT INTEGRATED LEAK RATE TEST (ILRT) UNIT NO. 2

Licensee, PPL Susquehanna, LLC, hereby files a supplement to Proposed Amendment No. 206 in support of a revision to its Facility Operating License No. NPF-22 dated March 23, 1984.

This amendment involves a revision to the Susquehanna SES Unit 2 Technical Specifications.

PPL Susquehanna, LLC
By:

R. G. Byram
Sr. Vice-President and Chief Nuclear Officer

Sworn to and subscribed before me this 7th day of September, 2001.

Notary Public

Notarial Seal
Nancy J. Lannen, Notary Public
Allentown, Lehigh County
My Commission Expires June 14, 2004

ATTACHMENT A

EC-RISK-1081
REVISION 0

NUCLEAR ENGINEERING
CALCULATION / STUDY COVER SHEET and
DCS TRANSMITTAL SHEET

1. Page 1 of 57
Total Pages 57

➢2. TYPE: CALC ➢3. NUMBER: EC-RISK-1081 ➢4. REVISION: 0

5. TRANSMITTAL#: ______ *➢6. UNIT: 3 *➢7. QUALITY CLASS: N

➢9. DESCRIPTION: Risk Impact Assessment of Extending Containment ILRT Interval *➢8. DISCIPLINE: 3

SUPERSEDED BY: ______

10. Alternate Number: None 11. Cycle: NA

12: Computer Code or Model used: NA Fiche ☐ Dis ☐ Am't ______

13. Application: None

*➢14 *Affected Systems:* 059 , , , , ,
* If N/A then line 15 is mandatory

**➢15. NON-SYSTEM DESIGNATOR: RADN
**If N/A then line 14 is mandatory

16. Affected Documents: None

☐ Lic. Doc Change Req'd

17. References: See body of calculation

18. Equipment / Component #: None

19. DBD Number: None

	Print Name	Signature
➢20. PREPARED BY	Michael A Adelizzi	Michael A Adelizzi 9/2/01
➢21. REVIEWED BY	Jack G Refling	JG Refling 9/2/2001
➢21A. VERIFIED BY	NA	
➢22. APPROVED BY	Casimir Kukielka	Casimir C. Kukielka 9/?/2001
➢23. ACCEPTED BY PP&L / DATE		Signature / DATE

TO BE COMPLETED BY DCS

NR-DCS SIGNATURE/DATE

Summary

Revisions to 10 CFR 50, Appendix J allow individual plants to extend Type A (ILRT) surveillance testing requirements from 3-in-10 years to once per 10 years. The revised Type A test frequency is based on an acceptable performance history defined as two consecutive periodic Type A tests at least 24 months apart in which the calculated performance leakage was less than normal containment leakage of 1.0 L_a.

The Susquehanna Steam Electric Station (SSES) selected the revised requirements as its testing program. SSES current 10 year Type A test is due to be performed during U1-12RIO (Spring 2002) and U2-11RIO (Spring 2003). However, SSES seeks a one-time exemption based on (1) the substantial cost savings of up to $2.4 million from eliminating the test from each outage, (2) flexibility to schedule the next ILRT during outages with turbine replacement, and (3) the belief that a rule change will be sought by the industry to extend the interval for Type A testing or eliminate the need for Type A testing.

To support the submittal to the NRC for this change, a risk assessment evaluation was performed to assess the risk impact of extending the current containment Type A integrated leak-rate test (ILRT) from a 10 year to a 15 year interval. The risk assessment followed the guidelines set forth in NEI 94-01, the methodology used in EPRI TR-104285 and the NRC regulatory guidance on the use of Probabilistic Risk Assessment (PRA) findings and risk insights in support of a licensee request for changes to a plants licensing basis, Reg. Guide 1.174.

Specifically the approach combined the use of the plants Individual Plant Examination (IPE) results and findings to the methodology described in ERPI TR-104285 to estimate plant risk on specific accident sequences impacted by Type A testing.

The change in plant risk was evaluated based on the change in the predicted person-rem/year frequency and Large Early Release Frequency (LERF).

The analysis examined the SSES IPE plant specific accident sequences in which the containment integrity remains intact or the containment is impaired. Specifically, the following were considered:

- Core damage sequences in which containment integrity is maintained. (Class 1)

- Large containment isolation failures due to random failures to close a containment path. (Class 2)

- Core damage sequences in which containment integrity is impaired due to random failures of plant components other than those associated with Type B or Type C test components, for example, hole in Primary Containment. (Class 3)

Small containment isolation 'failure-to-seal' events are not considered in this evaluation because the frequency is based on Type B and Type C testing program and the dose is accounted by Class 1 sequences. (Class 4 and 5)

- Core damage sequences in which containment integrity is impaired due to containment isolation failures of pathways left 'opened' following a plant post-maintenance test, for example, a valve failing to close following a valve stroke test. (Class 6)
- Containment failure induced by severe accident phenomena. (Class 7)
- Sequences in which Secondary Containment is bypassed. (Class 8)

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

Step 1 - Quantify the base-lined risk in terms of frequency per reactor year for each of the eight accident classes presented. (Table S-1)

Step 2 - Develop plant specific person-rem dose (population dose) per reactor year for each of the eight accident classes evaluated in EPRI TR-104285 (Table S-2.)

Step 3 - Evaluate risk impact of extending Type A test interval from 10-to-15 years.

Step 4 - Determine the change in risk in terms of LERF in accordance with Reg. Guide 1.174.

Table S-1
Mean Containment Frequencies Measures for 3 year test interval - Given Accident Class

Class	Description	Frequency (per Rx-year)
1	No Containment Failure	1.63E-07
2	Large Containment Isolation Failures (Failure-to-close)	5.35E-10
3a	Small Isolation Failures (Hole in Primary Containment)	2.39E-08
3b	Large Isolation Failures (Hole in Primary Containment)	7.85E-09
4	Small Isolation Failure – failure to seal (Type B Test)	NA
5	Small Isolation Failure – failure to seal (Type C Test)	NA
6	Containment Isolation Failures (dependent failures, personnel errors)	8.60E-10
7	Severe Accident Phenomena Induced Failure (Early and Late Failures)	1.60E-07
8	Secondary Containment Bypassed	1.75E-08
Core Damage		3.74E-07

Table S-2
Person-Rem Measures - Given Accident Class (10)

Class	Description	Person-Rem (50-Miles)
1	No Containment Failure	3.29E+05
2	Large Containment Isolation Failures (Failure-to-close)	4.38E+05
3a	Small Isolation Failures (Hole in Primary Containment)	4.41E+05
3b	Large Isolation Failures (Hole in Primary Containment)	4.38E+05
4	Small Isolation Failure – failure to seal (Type B Test)	Not Analyzed
5	Small Isolation Failure – failure to seal (Type C Test)	Not Analyzed
6	Containment Isolation Failures (dependent failures, personnel errors)	4.38E+05
7	Severe Accident Phenomena Induced Failure (Early and Late Failures)	6.27E+06
8	Secondary Containment Bypassed	4.24E+06

The impact associated with extending the Type A ILRT test frequency interval, measured as percent change with respect to the total integrated risk is presented in Table S-3 below.

Table S-3
Summary of Risk impact on Extending Type A ILRT Test Frequency

Class	Risk Impact (Base)	Risk Impact (10-years)	Risk Impact (15-years)
1,3a,and 3b	5.9% of integrated value based on 1La normal containment leakage for Class 1, 10La for Class 3a and 35La for Class 3b 0.068 person-rem/yr	6.8% of integrated value based on 2 La normal containment leakage for Class 1, 10La for Class 3a and 35La for Class 3b 0.079 person-rem/yr	7.1% of integrated value based on 2 La normal containment leakage for Class 1, 10La for Class 3a and 35La for Class 3b 0.082 person-rem/yr
Total Integrated Risk	1.147 person-rem/yr	1.159 person-rem/yr	1.162 person-rem/yr

The conclusions regarding the assessment of the plant risk associated with extending the Type A ILRT test frequency from 10 years to 15 years are as follows:

1. The risk assessment associated with implementation of a one-time exemption in extending the containment Type A ILRT from 10 years to 15 years predicts a slight increase in risk when compared to that estimated from current requirements. The change in risk for Classes 1, 3a and 3b as measured by person-rem/year increases by 0.3%. Also, the total integrated plant risk for those accident sequences

influenced by Type A testing, given the change from a once per 10 years test interval to a once per 15 years test interval increases by 0.3%. This value is a negligible increase in risk.

2. Reg. Guide 1.174 provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Reg. Guide 1.174 defines very small changes in risk as resulting in increases of core damage frequency (CDF) below 1.0E-06/year and increases in LERF below 1.0E-07/year. Since the ILRT does not impact CDF, the relevant criterion is LERF. The increase in LERF resulting from a change in the Type A ILRT test interval from once per 10 year test interval to once per 15 year test interval is 3.93E-10/yr. Since guidance in Reg. Guide 1.174 defines very small changes in LERF as below 1.0E-07/yr, increasing the ILRT interval to 15 years is therefore not risk significant.

1.0 OBJECTIVE

Provide a risk impact assessment on extending the plant's Integrated Leak Rate Test (ILRT) interval from 10 to 15 years. The risk assessment will be performed in accordance with the guidelines set forth in NEI 94-01 (1), the methodology used in EPRI TR-104285 (2), and the NRC regulatory guidance on the use of Probabilistic Risk Assessment (PRA) findings and risk insights in support of a licensee request for changes to a plant's licensing basis, Reg. Guide 1.174 (3).

Reg. Guide 1.174 provides guidance for determining the risk impact of plant-specific changes to the licensing basis. This calculation will demonstrate that the increased risk to the public (person-rem / year) is insignificant. This calculation will demonstrate per Reg. Guide 1.174 that the change in risk increases CDF less than 1E-06/year and increases LERF less than 1E-07/year.

The results and findings from the SSES Individual Plant Examination (IPE) (4) are used for this risk assessment calculation.

2.0 CONCLUSION

The conclusions regarding the assessment of the plant risk associated with extending the Type A ILRT test frequency from 10 years to 15 years are as follows:

1. The risk assessment associated with implementation of a one-time exemption in extending the containment Type A ILRT from 10 years to 15 years predicts a slight increase in risk when compared to that estimated from current requirements. The change in risk for Classes 1, 3a and 3b as measured by person-rem/year increases by 0.3%. Also, the total integrated plant risk for those accident sequences influenced by Type A testing, given the change from a once per 10 years test interval to a once per 15 years test interval increases by 0.3%. This value is a negligible increase in risk.

2. Reg. Guide 1.174 provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Reg. Guide 1.174 defines very small changes in risk as resulting in increases of core damage frequency (CDF) below 1.0E-06/year and increases in LERF below 1.0E-07/year. Since the ILRT does not impact CDF, the relevant criterion is LERF. The increase in LERF resulting from a change in the Type A ILRT test interval from once per 10 year test interval to once per 15 year test interval is 3.93E-10/yr. Since guidance in Reg. Guide 1.174 defines very small changes in LERF as below 1.0E-07/yr, increasing the ILRT interval to 15 years is therefore not risk significant.

3.0 ASSUMPTIONS

1. Containment leak rates greater than 2 La but less than 35 La indicate an impaired containment. The leak rate is considered 'small'. These releases have a break opening of 1-inch or less diameter.

2. Containment leak rates greater than 35 La indicate a containment breach. This leak rate is considered 'large'.

3. Containment leak rates less than 2 La indicate an intact containment. This leak rate is considered as 'negligible'.

4. The maximum containment leakage for Class 1 sequences is 2 La.

5. The maximum containment leakage for Class 2 sequences is 35 La.

6. The maximum containment leakage for Class 3a sequences is 10 La.

7. The maximum containment leakage for Class 3b sequences is 35 La.

8. The maximum containment leakage for Class 6 sequences is 35 La.

9. The maximum containment leakage for Class 7 sequences is 100 La.

10. The maximum containment leakage for Class 8 sequences is 100 La

11. Total CDF equals 3.74E-07 / year. This represents the IPE value of 2.14E-07 / year plus 1.60E-07 / year which is 50% of the COPF (Prior to Core Damage). Not all COPF sequences lead to core damage. A sensitivity analysis shows that relative increased dose to the public varies from 0.1% if all COPF sequences lead to core damage to 2.3% if no COPF sequences lead to core damage (4).

4.0 METHOD

A simplified bounding analysis approach for evaluating the change in risk associated with increasing the interval from 10 years to 15 years for Type A test was used. This approach is similar to that presented in EPRI TR104285 (2) and NUREG-1493 (5). Namely, the analysis performed examined SSES IPE (4) plant specific accident sequences in which the containment integrity remains intact or the containment is impaired. Specifically, the following were considered:

- Core damage sequences in which containment integrity is maintained. (Class 1)

- Large containment isolation failures due to random failures to close a containment path. (Class 2)
- Core damage sequences in which containment integrity is impaired due to random failures of plant components other than those associated with Type B or Type C test components, for example, hole in Primary Containment. (Class 3)
- Small containment isolation 'failure-to-seal' events are not considered in this evaluation because the frequency is based on Type B and Type C testing program and the dose is accounted by Class 1 sequences. (Class 4 and 5)
- Core damage sequences in which containment integrity is impaired due to containment isolation failures of pathways left 'opened' following a plant post-maintenance test, for example, a valve failing to close following a valve stroke test. (Class 6)
- Containment failure induced by severe accident phenomena. (Class 7)
- Sequences in which Secondary Containment is bypassed. (Class 8)
- Table 1 presents the SSES IPE frequencies for the accident classes.

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

Step 1 - Quantify the base-lined risk in terms of frequency per reactor year for each of the eight accident classes presented in Table 1.
Step 2 - Develop plant specific person-rem dose (population dose) per reactor year for 3 year test interval for each of the eight accident classes evaluated in EPRI TR-104285 (2) and presented in Table 2.
Step 3 - Evaluate risk impact of extending Type A test interval from 10 to15 years.
Step 4 - Determine the change in risk in terms of Large Early Release Frequency (LERF) in accordance with Reg. Guide 1.174 (3)

Step 1 - Quantify the base-lined risk in terms of frequency per reactor year.

This step involves the review of the SSES IPE (4). The IPE characterizes the response of the containment to important severe accident sequences. The IPE used in this evaluation is based on important phenomena and systems-related events identified in NUREG-1335 (9).

As previously described, the extension of the Type A interval does not influence those accident progressions that involve large containment isolation failures, Type B or Type C testing, or containment failure induced by severe accident phenomena. As a result, the plant design was reviewed for applicable isolation failures and their impact on the overall plant risk. Also, a simplified model to predict the likelihood of having a small/large breach in the containment liner that is undetected by the Type A ILRT test was developed.

SSES examined the five issues associated with containment isolation in NUREG-1335 (9):

(1) the identity of pathways that could significantly contribute to containment isolation failure,
(2) the signals required to automatically isolate the containment penetration,
(3) the potential generating signals for all initiating events,
(4) the examination of testing and maintenance procedures, and
(5) the quantification of each containment isolation mode.

These issues were addressed as follows:

1) Pathways that could significantly contribute to containment isolation failure. Significant fission product release to the environment may occur through containment penetrations that communicate directly with the containment atmosphere and exceed 1 inch in diameter. It will be noted that this latter piping diameter criterion excludes from further consideration valves in piping that interacts directly with the containment atmosphere and has a diameter of 1 inch or less. The rationale for this exclusion is that containment leakage through smaller diameter piping will not preclude further containment pressurization, and, in any case, any release of fission products from a pipe 1 inch or less will be small and therefore pose a minimal public risk.

Piping that communicates directly with the Reactor Pressure Vessel (RPV) was not considered in the containment isolation failure analysis because such failures are considered to be failures of the pressure boundary between the RCS and low pressure systems (i.e., an interfacing system LOCA). In addition, manual valves were not examined in this review of containment isolation valve failures as their failures are considered passive and therefore most unlikely. Penetrations that are hydraulically tested are excluded because they are expected to remain full of water during the accident.

Based on the above, 27 lines were selected for examination as potential fission product release paths (Appendix A) (13).

2&3) The signals required to automatically isolate the containment penetration and potential generating signals for all initiating events. This analysis is for Class 2 failures. Containment isolation signals, including those generated by unique plant initiators, required to automatically isolate the containment penetration, were not modeled in detail. They were, however, addressed in the containment isolation analysis as a containment isolation failure event.

The total failure probability is the sum of the probability for each penetration.

Penetration failure = open factor * demand failure probability * failure of operator to isolate.

Open factor is less than 1.0 for penetrations that are normally closed but are allowed to open during operation. Penetrations X-25, X-26, X-201A, and X-202 are allowed to be open for 90 hours per year (1%). Penetrations X-204A, and X-204B are allowed to be open for 876 hours per year (10%). Penetrations X-39A, X-39B, X-205A, and X-205B are not opened except for testing, so a value of 0.1% was applied. (Appendix A)

The 1.0 E-03/demand-failure probability selected for this event is conservative. (15)

Failure of operator to isolate an open penetration is 1.0E-01. This is the industry standard. (14)

4) <u>The examination of testing and maintenance procedures.</u> IST program procedures perform testing and inspections for valves. Failures caused by these procedures can be test restoration errors or testing not identifying that the valve will not isolate (Class 6). Failure probabilities attributed to valve test and maintenance procedures were given the value of 2.3E-03 (12). Given control room indication of valve positions to prevent restoration errors and valve failure rates, this value is conservative.

5) <u>The quantification of each containment isolation mode</u>. The containment isolation analysis considered failure modes for normally open valves that fail to close on demand, and operator action in closing normally open valves. Normally closed valves that fail to remain closed had no effect on the analysis given the low probability of such events.

For this analysis, the question on containment isolation was modified to include the probability of a hole in primary containment at the time of core damage. Two basic events were included in the containment isolation analysis These are Event Class 3a (small hole) and Event Class 3b (large hole). (This event models the Class 3 sequence depicted in EPRI TR-104285 (2).

To calculate the probability that a hole in primary containment will be large (Event Class 3b), data in NUREG-1493 (5) was used. The data found in NUREG-1493 states that 144 ILRTs were conducted. The largest reported leak rate from those 144 tests was 21 times the allowable leakage rate (La). Since 21 La, does not constitute a large release (refer to the write-up in Step 4), no large releases have occurred based on the 144 ILRTs reported in NUREG-1493 (5).

To estimate the failure probability given that no failures have occurred, a conservative estimate is obtained from the 95th percentile of the chi-squared distribution (16). In statistical theory, the chi-squared distribution can be used for statistical testing, goodness-of-fit tests, and evaluating s-confidence. The chi-squared distribution is really a family of distributions, which range in shape from that of the exponential to that of the normal distribution. Each distribution is identified by the degrees of freedom, v. For time truncated tests (versus failure-truncated tests), an estimate of the probability of a large leak using the chi-squared distribution can be calculated as chi-squared (95^{th}) (v = 2n+2)/2N, where n represents the number of large leaks and N represents the number of ILRTs performed to date. With no large leaks (n = 0) in 144 events (N = 144) and chi-squared (95^{th}) (2) = 5.99, the 95^{th} percentile estimate of the probability of a large leak is calculated as 5.99/(2*144) = 0.021.

To calculate the probability that a hole in primary containment will be small (Event Class 3a), data in NUREG-1493 (5) was used. The data found in NUREG-1493 states that 144 ILRTs were conducted. The data reported that 23 of 144 tests had allowable leak rates in excess of 1.0La. However, of these 23 'failures' only 4 were found by an ILRT. The other failures were found by Type B and C testing, or by errors in test alignments. Therefore, the number of failures considered for 'small releases' are 4-of-144. Similar to the event Class 3b probability, the estimated failure probability for small release is found by using the chi-squared distribution. The chi-squared distribution is calculated by n=4 (number of small leaks) and N=144 (number of events) which yields a chi-squared (10) =18.3070. Therefore, the 95^{th} percentile estimate of the probability of a small leak is calculated as 18.3070/(2*144) = 0.064.

After modifying the containment isolation analysis and including the respective 'large' and 'small' hole in primary containment leak rate probabilities, the SSES IPE was quantified to predict the eight severe accidents class frequencies for 3 year testing interval presented in Table 1 and described below.

Class 1 Sequences. This group consists of all core damage accident progression bins for which the containment remains intact. This frequency is the total CDF minus the frequency of all other accident classes. The frequency per year for 3 year testing interval is 1.63E-07 / year. For this analysis the associated maximum containment leakage for this group is 1.0 La for 3 year test interval.

Class 2 Sequences. This group consists of all core damage accident progression bins for which a pre-existing leakage due to failure to isolate the containment occurs. These sequences are dominated by failure-to-close of large (>1-inch diameter) containment isolation valves. The frequency per year for these sequences is determined as follows:

CLASS_2_FREQUENCY = PROB (large CI) * CDF

Where:
PROB (large CI) = random large containment isolation failure probability (i.e. large valves)

= 1.43E-03 Appendix A

CDF = SSES IPE core damage frequency = 3.74E-07 Appendix B

CLASS_2_FREQUENCY = 1.43E-03 * 3.74E-07
CLASS_2_FREQUENCY = 5.35E-10 / year

For this analysis the associated maximum containment leakage for this group is 35 La.

Class 3 Sequences. This group consists of all core damage accident progression bins for which a pre-existing leakage in the containment structure (i.e. containment liner) exists. The containment leakage for these sequences can be either small (2La to 35La) or large (>35La).

The respective frequencies per year are determined as follows:

CLASS_3A_FREQUENCY = PROB (Class_3a) * CDF

CLASS_3B_FREQUENCY = PROB (Class_3b) * CDF

Where:
PROB (Class_3a) = probability of small pre-existing containment liner leakage
= 0.064 (see above write-up)

PROB (Class_3b) = probability of large pre-existing containment liner leakage
= 0.021 (see above write-up)

CLASS_3A_FREQUENCY = 0.064 * 3.74E-07
CLASS_3A_FREQUENCY = 2.39E-08 / year

CLASS_3B_FREQUENCY = 0.021 * 3.74E-07
CLASS_3B_FREQUENCY = 7.85E-09 / year

For this analysis the associated maximum containment leakage for Class 3a is 10 La and for Class 3b is 35 La.

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

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

Class 6 Sequences. This group is similar to Class 2. These are sequences that involve core damage accident progression bins for which a failure-to-seal containment leakage due to failure to isolate the containment occurs. These sequences are dominated by misalignment of containment isolation valves following a test/maintenance evolution.

The frequency per year for these sequences is determined as follows:

CLASS_6_FREQUENCY = PROB (large T&M) * CDF

Where:
PROB (large T&M) = random large containment isolation failure probability due to valve misalignment
= 2.3E-03 (12)

CLASS_6_FREQUENCY = 2.3E-03 * 3.74E-07
= 8.60E-10 / year

For this analysis the associated maximum containment leakage for this group is 35La.

Class 7 Sequences. This group consists of all core damage accident progression bins in which containment failure induced by severe accident phenomena occurs. For this analysis the associated maximum containment leakage for this group is 100 La.

CLASS_7_FREQUENCY = CFL + CFE + (0.5 *COPF)

Where:

CFL = Late Containment Failure = 1.02E-10
CFE = Large Early Release Frequency = 1.95E-10
COPF = Containment Over Pressure Failure (prior to core damage) = 3.2E-07

50% of the COPF is assigned to Class 7. There are some events that will not have a release because the event ends before core damage occurs.

Therefore,

CLASS_7_FREQUENCY = 1.02E-10 + 1.95E-10 + (0.5 * 3.2E-07)
= 1.60E-07 / year

Class 8 Sequences. This group consists of all core damage accident progression bins in which secondary containment bypass occurs.

CLASS_8_FREQUENCY = ISLOCA + SC_ Byp

ISLOCA = Interfacing System LOCA = 1.0E-08 (4)
SC_Byp = Secondary Containment Bypasses = CDF * 2% = 3.74E-07 * 0.02
= 7.48E-09 (4,Vol 6, p.13)

Therefore,

CLASS_8_FREQUENCY = 1.0E-08 + 7.48E-09
= 1.75E-08 / year

Note: for this class the maximum release is based on 100 La.

Table 1

Mean Containment Frequencies Measures For 3 Year Testing Interval - Given Accident Class

Class	Description	Frequency (per Rx-year)
1	No Containment Failure	1.63E-07
2	Large Containment Isolation Failures (Failure-to-close)	5.35E-10
3a	Small Isolation Failures (Hole in Primary Containment)	2.39E-08
3b	Large Isolation Failures (Hole in Primary Containment)	7.85E-09
4	Small Isolation Failure – failure to seal (Type B Test)	NA
5	Small Isolation Failure – failure to seal (Type C Test)	NA
6	Containment Isolation Failures (dependent failures, personnel errors)	8.60E-10
7	Severe Accident Phenomena Induced Failure (Early and Late Failures)	1.60E-07
8	Containment Bypassed (Secondary Containment Bypass Leakage)	1.75E-08
Core Damage		3.74E-07

Step 2 - Develop plant specific person-rem dose (population dose) per reactor year

Plant-specific release analysis was performed to evaluate the person-rem doses to the population, within a 50 mile radius from the plant (11).

The classes analyzed cover a range of containment behaviors ranging from the case of no containment failure to cases of containment bypass and severe accident-induced failure. The dose calculations were performed using the MACCS2 code system, with input based upon BWR source terms developed from NUREG-1465 research. (10)

The values are summarized in Table 2 below.

Table 2
Person-Rem Measures - Given Accident Class (10)

Class	Description	Person-Rem (50-Miles)
1	No Containment Failure	3.29E+05
2	Large Containment Isolation Failures (Failure-to-close)	4.38E+05
3a	Small Isolation Failures (Hole in Primary Containment)	4.41E+05
3b	Large Isolation Failures (Hole in Primary Containment)	4.38E+05
4	Small Isolation Failure – failure to seal (Type B Test)	Not Analyzed
5	Small Isolation Failure – failure to seal (Type C Test)	Not Analyzed
6	Containment Isolation Failures (dependent failures, personnel errors)	4.38E+05
7	Severe Accident Phenomena Induced Failure (Early and Late Failures)	6.27E+06
8	Containment Bypassed (Secondary Containment Bypass Leakage)	4.24E+06

The above results when combined with the results presented in Table 1 yields the SSES Mean Consequence Measures for 3-Year Test Interval for given accident class. These results are presented in Table 3 below.

Table 3
Mean Consequence Measures for 3-Year Test Interval - Given Accident Class

Class	Description	Frequency (per Rx-yr)	Person-Rem (50-Miles)	Person-Rem/yr
1	No Containment Failure	1.63E-07	3.29E+05	5.36E-02
2	Large Containment Isolation Failures (Failure-to-close)	5.35E-10	4.38E+05	2.34E-04
3a	Small Isolation Failures (Hole in Primary Containment)	2.39E-08	4.41E+05	1.06E-02
3b	Large Isolation Failures (Hole in Primary Containment)	7.85E-09	4.38E+05	3.44E-03
4	Small Isolation Failure – failure to seal (Type B Test)	NA	NA	0.0
5	Small Isolation Failure – failure to seal (Type C Test)	NA	NA	0.0
6	Containment Isolation Failures (dependent failures, personnel errors)	8.60E-10	4.38E+05	3.77E-04
7	Severe Accident Phenomena Induced Failure (Early and Late Failures)	1.60E-07	6.27E+06	1.01E+00
8	Containment Bypassed (Secondary Containment Bypass Leakage)	1.75E-08	4.24E+06	7.41E-02
	Total	3.74E-07		1.147E+00

Based on the above values, the percent risk contribution (%$Risk_{BASE}$) for Class 1 and Class 3 is as follows:

%Risk = ((Class 1 + Class 3a + Class 3b) / Total) * 100

Where:
Class 1 = 5.36E-02 person-rem / year
Class 3a = 1.06E-02 person-rem / year
Class 3b = 3.44E-03 person-rem / year
Total = 1.147 person-rem / year

%Risk = ((5.36E-02 + 1.06E-02 + 3.44E-03) / 1.147) * 100
= 5.9%

Therefore, the total baseline risk contribution of leakage, represented by Class 1 and Class 3 accident scenarios is 5.9%.

Step 3 - Evaluate risk impact of extending Type A test interval from 10-to-15 years

According to NUREG-1493 (5), relaxing the Type A ILRT interval from 3-in-10 years to 1-in-10 years will increase the average time that a leak detectable only by an ILRT goes undetected from 18 to 60 months. (The average time for undetection is calculated by multiplying the test interval by 0.5 and multiplying by 12 to convert from "years" to "months"). If the test interval is extended to 1 in 15 years, the average time that a leak detectable only by an ILRT test goes undetected increases to 90 months (1/2 * 15 * 12). Since ILRTs only detect about 3% of leaks (the rest are identified during LLRTs), the result for a 10 year ILRT interval is a 10% increase in the overall probability of leakage. This value is determined by multiplying 3% and the ratio of the average time for undetection for the increased ILRT test interval (60 months) to the baseline average time for undetection of 18 months. For a 15 year test interval, the result is a 15% increase in the overall probability of leakage (i.e., 3 * 90/18). Thus, increasing the ILRT test interval from 10 years to 15 years results in a 5% increase in the overall probability of leakage.

Risk Impact due to 10 year Test Interval

As previously stated, Type A tests impact only Class 1 and Class 3 sequences.

For Class 1 sequences, the increased probability of not detecting excessive leakage has no impact on the frequency of occurrence. For Class 1 sequences, to determine the risk contribution of leakage for a 10 year test interval, the 3 year test interval person-rem/year result for Class 1 sequence is multiplied by the increase in overall probability of leakage (10% or 1.1) times dose for 2 La. 2 La is used instead of 1 La for the primary containment leakage rate to account for enlargement of the leak path due to aging.

For Class 3 sequences, the release magnitude is not impacted by the change in test interval. (small or large liner opening remains the same, even though the probability of not detecting the liner opening increases). Thus, only the frequency of Class 3 sequences is impacted. Therefore, for Class 3 sequences, the risk contribution is determined by multiplying the Class 3 accident frequency by the increase in probability of leakage of 1.1. (Recall that for a 10-year interval there is a 10% increase on the overall probability of leakage). The results of this calculation are presented in Table 4 below.

Table 4
Mean Consequence Measures for 10-Year Test Interval - Given Accident Class

Class	Description	Frequency (per Rx-yr)	Person-Rem (50-Miles)	Person-Rem/yr (50-Miles)
1	No Containment Failure	1.60E-07	3.99E+05	6.38E-02
2	Large Containment Isolation Failures (Failure-to-close)	5.35E-10	4.38E+05	2.34E-04
3a	Small Isolation Failures (Hole in Primary Containment)	2.63E-08	4.41E+05	1.16E-02
3b	Large Isolation Failures (Hole in Primary Containment)	8.64E-09	4.38E+05	3.78E-03
4	Small Isolation Failure – failure to seal (Type B Test)	NA	NA	0.0
5	Small Isolation Failure – failure to seal (Type C Test)	NA	NA	0.0
6	Containment Isolation Failures (dependent failures, personnel errors)	8.60E-10	4.38E+05	3.77E-04
7	Severe Accident Phenomena Induced Failure (Early and Late Failures)	1.60E-07	6.27E+06	1.01E+00
8	Containment Bypassed (Secondary Containment Bypass Leakage)	1.75E-08	4.24E+06	7.41E-02
Core Damage	All Containment Event Tree Endstates	3.74E-07		1.159E+00

Based on the above values, the Type A 10-year test frequency percent risk contribution ($\%Risk_{10}$) for Class 1 and Class 3 is as follows:

%Risk = ((Class 1 + Class 3a + Class 3b) / Total) * 100

Where:
Class 1 = 6.38E-02 person-rem / year
Class 3a = 1.16E-02 person-rem / year
Class 3b = 3.78E-03 person-rem / year
Total = 1.159 person-rem / year

%Risk = ((6.38E-02 + 1.16E-02 + 3.78E-03) / 1.159) * 100
= 6.8%

Therefore, the total Type A 10 year ILRT interval risk contribution of leakage, represented by Class 1 and Class 3 accident scenarios is 6.8%.

The percent risk increase ($\Delta\%Risk_{10}$) due to a ten-year ILRT over the baseline case is as follows:

Delta %Risk = ((Total-10 – Total-base) / Total-base) * 100

Where:

Total-base = total person-rem / year for baseline interval = 1.147 person-rem / year
Total-10 = total person-rem / year for 10-year interval = 1.159 person-rem / year

Delta %Risk = ((1.159 – 1.147) / 1.147) * 100
= 1.0%

Therefore, the increase in risk contribution because of relaxed ten-year ILRT test frequency from 3-in-10 years to 1-in-10 years is 1.0%

Risk Impact due to 15 year Test Interval

The risk contribution for a 15 year interval is similar to the 10 year interval. The difference is in the increase in probability of leakage value. For this case the value is 15 percent or 1.15. (Recall that for a 10-year interval there is a 10% increase on the overall probability of leakage). In addition, the containment leakage used for the 10 year test interval for both Class 1 and Class 3 are used in the 15 year interval evaluation. The results for this calculation are presented in Table 5.

Table 5
Mean Consequence Measures for 15-Year Test Interval - Given Accident Class

Class	Description	Frequency (per Rx-yr)	Person-Rem (50-Miles)	Person-Rem/yr (50-Miles)
1	No Containment Failure	1.58E-07	4.17E+05	6.61E-02
2	Large Containment Isolation Failures (Failure-to-close)	5.35E-10	4.38E+05	2.34E-04
3a	Small Isolation Failures (Hole in Primary Containment)	2.75E-08	4.41E+05	1.21E-02
3b	Large Isolation Failures (Hole in Primary Containment)	9.03E-09	4.38E+05	3.96E-03
4	Small Isolation Failure – failure to seal (Type B Test)	NA	NA	0.0
5	Small Isolation Failure – failure to seal (Type C Test)	NA	NA	0.0
6	Containment Isolation Failures (dependent failures, personnel errors)	8.60E-10	4.38E+05	3.77E-04
7	Severe Accident Phenomena Induced Failure (Early and Late Failures)	1.60E-07	6.27E+06	1.01E+00
8	Containment Bypassed (Secondary Containment Bypass Leakage)	1.75E-08	4.24E+06	7.41E-02
Core Damage	All Containment Event Tree Endstates	3.74E-07		1.162E+00

Based on the above values, the Type A 15-year test frequency percent risk contribution (%Risk) for Class 1 and Class 3 is as follows:

%Risk = ((Class 1 + Class 3a + Class 3b) / Total) * 100

Where:
Class 1 = 6.61E-02 person-rem / year
Class 3a = 1.21E-02 person-rem / year
Class 3b = 3.96E-03 person-rem / year
Total = 1.162 person-rem / year

%Risk = ((6.61E-02 + 1.21E-02 + 3.96E-03) / 1.162) * 100
= 7.1%

Therefore, the total Type A 15-year ILRT interval risk contribution of leakage, represented by Class 1 and Class 3 accident scenarios is 7.1%.

The percent increase in risk (in terms of person-rem/yr) of these associated specific sequences is computed as follows:

Delta %Risk = ((Class 1,3-15 – Class 1,3-10) / Class 1,3-10) * 100

Where:

Class1,3-10 = total person-rem / year for Class 1 & 3 for 10 year interval = 0.079 person-rem / year
Class 1,3-15 = total person-rem / year for Class 1 & 3 for 15 year interval = 0.082 person-rem / year

Delta %Risk = ((0.082 – 0.079) / 0.079) * 100
= 3.7%

Therefore, the change in Type A test frequency from once per 10 years to once per 15 years increases the risk of those associated specific accident sequences by 3.7%.

The percent increase on the total integrated plant risk for these accident sequences is computed as follows.

Delta %Risk = ((Total-15 – Total-10) / Total-10) * 100

Where:

Total-15 = total person-rem / year for 15 year interval = 1.162 person-rem / year
Total-10 = total person-rem / year for 10 year interval = 1.159 person-rem / year

Delta %Risk = ((1.162 – 1.159) / 1.159) * 100
= 0.3%

Therefore, the risk impact on the total integrated plant risk for these accident sequences influenced by Type A testing is only 0.3%.

The percent risk increase ($\Delta\%Risk_{15}$) due to a fifteen-year ILRT over the baseline case is as follows:

Delta %Risk = ((Total-15 – Total-base) / Total-base) * 100

Where:

Total-15 = total person-rem / year for 15 year interval = 1.162 person-rem / year
Total-base = total person-rem / year for 3 year interval = 1.147 person-rem / year

$$\text{Delta \%Risk} = ((1.162 - 1.147) / 1.147) * 100 = 1.3\%$$

Therefore, the total increase in risk contribution associated with relaxing the ILRT test frequency from three in ten years to once-per-fifteen years is 1.3%

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

The one time extension of increasing the Type A test interval involves establishing the success criteria for a large release. This criteria is based on two prime issues:

1) The containment leak rate versus breach size, and

2) The impact on risk versus leak rate.

SSES evaluated the effect of containment leak size on the containment leak rate (Appendix C). In addition, Oak Ridge National Laboratory (ORNL) (7) completed a study evaluating the impact of leak rates on public risk using information from WASH-1400 (8) as the basis for its risk sensitivity calculations.

For SSES, 1 La = 1% weight / day = 320 Standard Liters per minute (SLM) (13)
Therefore, 35 La = 11,200 SLM

From Appendix C, mass flow from a 1 inch pipe with 60 psia in containment is 0.474 lbm/sec.

The weight density of nitrogen is .0727 pounds / cubic feet (17)
The weight density of air is .0752 pounds / cubic feet (17)
The weight density of steam is .1394 pounds / cubic feet (saturated at 60 psia) (18)

Use value for nitrogen because it has the lowest density. This is a conservative assumption because the containment will not be 100% nitrogen.

Leakage Rate (SLM) =
(0.474 lb. /sec.) (1/0.0727 cubic feet / lb.) (60 sec. / min.) (28.32 liter / min.) (17)

= 11,100 SLM

Therefore, a 1 inch pipe will leak approximately 35 La.

Based upon the information provided by SSES and ORNL, it is judged that small leaks resulting from a severe accident (that are deemed not to dominate public risk) can be defined as those that change risk by less than 5%. This definition would include leaks of less than 35%/day. Based on the SSES data, a 35%/day containment leak rate equates to a diameter leak of greater than 1 inches. Therefore, this study defines small leakage as containment leakage resulting from an opening of 1 inch pipe diameter or less and large leakage as greater 1 inch pipe diameter.

Impact on Large Early Release Frequency (LERF)

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

Late releases are excluded regardless of the size of the leak because late releases are, by definition, not a LERF event. The frequency of Class 3b sequences (Table 4) is used to calculate the LERF increase for SSES. Sequences in the SSES IPE (4), which result in large releases (e.g., large isolation valve failures), are not impacted because a LERF will occur regardless of the presence of a pre-existing leak. The Class 3b frequency, based on a 10 year test interval is 8.64E-09 / year

Reg. Guide 1.174 (3) provides guidance for determining the risk impact of plant-specific changes to the licensing basis. Reg. Guide 1.174 (3) defines very small changes in risk as resulting in increases of core damage frequency (CDF) below 1E-06/yr and increases in LERF below 1E-07/yr. Since the ILRT does not impact CDF, the relevant metric is LERF. Calculating the increase in LERF requires determining the impact of the ILRT interval on the leakage probability.

As described in Step 3, extending the ILRT interval from once-per-10 years to once-per-15 years will increase the average time that a leak detectable only by an ILRT goes undetected from 60 to 90 months. Since ILRTs only detect about 3% of leaks (the rest are identified during LLRTs), the result for a 15-yr ILRT interval is a 15% increase in the overall probability of leakage (3 * 90/18) versus 10% for a 10-yr ILRT interval. Thus, increasing the ILRT test interval from 10 years to 15 years results in a 5% increase in the overall probability of leakage. The increase in LERF is 3.93E-10 / year. Since guidance in Reg. Guide 1.174 defines very small changes in LERF as below 1E-07/yr, increasing the ILRT interval to 15 years is non-risk significant.

It should be noted that if the risk increase is measured from the original 3-in-10-year interval, the increase in LERF is 1.18E-09 / year. This value is also below the 1E-07/yr screening criterion in Reg. Guide 1.174).

5.0 RESULTS

1. The baseline risk contribution of leakage, represented by Class 1 and Class 3 accident scenarios is 5.9%.
2. Type A 10-year ILRT interval risk contribution of leakage, represented by Class 1 and Class 3 accident scenarios is 6.8%.
3. Type A 15-year ILRT interval risk contribution of leakage, represented by Class 1 and Class 3 accident scenarios is 7.1%.
4. The total integrated increase in risk contribution from extending the ILRT test frequency from the current once-per-10-year interval to once-per-15 years is 0.3%
5. The risk increase in LERF from extending the ILRT test frequency from the current once-per-10-year interval to once-per-15 years is 3.93E-10 / year.
6. The risk increase in LERF from the original 3-in-10-year interval, to once-per-15 years is 1.18E-09 / year.
7. Other results are summarized in Table 6.

Table 6

Summary of Risk Impact on Extending Type A ILRT Test Frequency

Class	Risk Impact (Base)	Risk Impact (10-years)	Risk Impact (15-years)
1,3a,and 3b	5.9% of integrated value based on 1La normal containment leakage for Class 1, 10La for Class 3a and 35La for Class 3b 0.068 person-rem/yr	6.8% of integrated value based on 2 La normal containment leakage for Class 1, 10La for Class 3a and 35La for Class 3b 0.079 person-rem/yr	7.1% of integrated value based on 2 La normal containment leakage for Class 1, 10La for Class 3a and 35La for Class 3b 0.082 person-rem/yr
Total Integrated Risk	1.147 person-rem/yr	1.159 person-rem/yr	1.162 person-rem/yr

DATA

From reference (11) a summary of the population at SSES is presented in Table 7. From reference (10), radiological releases and accident class description used in this evaluation are presented in Table 8 and 9 below. Table 8 depicts the whole body dose to the population as person-rem within 50 miles.

Table 7
SSES Population (11)

Distance (Miles)	Population
0-10	61,343
10-20	261,900
20-30	351,200
30-40	419,000
40-50	553,600
Total	1,647,043

Table 8
SSES Population Dose (10)

Class	Dose (person-rem)	La
1	3.29E+05	1.0
1	3.63E+05	2.0
2	4.38E+05	35
3a	4.41E+05	10
3b	4.38E+05	35
6	4.38E+05	35
7	6.27E+06	100
8	4.24E+06	1.0
8	4.22E+06	2.0

Table 9
Accident Class Description (10)

CLASS	DESCRIPTION	Core Activity Release per NUREG-1465	Primary to Secondary Containment Leakage Rate (1,2)	Remarks
1	No Containment Failure	Gap Release + Early In-Vessel	1.0La ; 2.0La	Release to Primary Containment; SGTS functional
2	Large Containment Isolation Failure	Gap Release + Early In-Vessel	35.0La	Release to Primary Containment; SGTS functional
3a	Small Isolation Failure	Gap Release + Early In-Vessel	10.0La	Release to Primary Containment; SGTS functional
3b	Large Isolation Failure	Gap Release + Early In-Vessel	35.0La	Release to Primary Containment; SGTS functional
4	Small Isolation Failure – Type B Penetration	Gap Release + Early In-Vessel	N/A	N/A
5	Small Isolation Failure – Type C Penetration	Gap Release + Early In-Vessel	N/A	N/A
6	Containment Isolation Failures -- (dependent failures, personel error)	Gap Release + Early In-Vessel	35.0La	Release to Primary Containment; SGTS functional
7	Severe Accident Induced Failure	Gap Release + Early In-Vessel + Ex-Vessel + Late In-Vessel	100.0La	Release to Primary Containment with No SGTS Filtration; Reactor Building Leakage Rate = 100%/day of free volume
8	Containment Bypassed	Gap Release + Early In-Vessel	1.0La ; 2.0La with additional 100.0La secondary containment bypass	Release to Primary Containment; SGTS functional on 1.0La and 2.0La; No SGTS Filtration of 100La

Notes:
(1) La = total primary to secondary containment leakage rate = 1%/day
(2) Analysis shall include 9 SCFH secondary containment bypass leakage as part of the total primary containment leakage rate unless otherwise specified. Analysis shall also include 300 SCFH MSIV leakage taking credit for the Isolated Condenser Treatment Method (ICTM).

6.0 REFERENCES

1. NEI 94-01, "Industry Guideline for Implementing Performance-Based Option of 10 CFR Part 50, Appendix J, July 26, 1995, Revision 0
2. EPRI TR-104285, "Risk Assessment of Revised Containment Leak Rate Testing Intervals" August 1994.
3. Regulatory Guide 1.174, " An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis" July 1998.
4. Susquehanna Steam Electric Station Individual Plant Examination.
5. NUREG-1493, "Performance-Based Containment Leak-Test Program, July 1995.
6. Deleted
7. Burns, T.J., "Impact of Containment Building Leakage on LWR Accident Risk", Oak Ridge National Laboratory, NUREG/CR-3539, April 1984.
8. United States Nuclear Regulatory Commission, Reactor Safety Study, WASH-1400, October 1975.
9. United States Nuclear Regulatory Commission, "Individual Plant Examination: Submittal Guidance," NUREG-1335, August 1989.
10. EC-RADN-1110, Rev. 0, Calculation of the Whole Body Population Dose Associated with Integrated Leak Rate Test (ILRT) Extension Risk Assessment for PPL Susquehanna Using MACCS2
11. FSAR Table 2.1-20 Population Distribution 2000, 0-50 Miles
12. EC-RISK-1063, Rev 0, Evaluation of Operator Actions for Application in the Susquehanna Individual Plant Examination, p. 35
13. NDAP-QA-0412, Rev 6, Leakage Rate Test Program.
14. Gertman, D. & Blackman, H (1994) <u>Human reliability & safety analysis data handbook.</u> New York: Wiley, 163

15. NEDC-31677P-A, Technical Specification Improvement Analysis for BWR Isolation Actuation Instrumentation, July 1990, Table 5-1.

16. ANSI/IEEE Std 352-1975, IEEE Guide for General Principles of Reliability Analysis of Nuclear Power Generating Station Protection Systems

17. Crane Technical Paper No. 410, Flow of Fluids, 1982

18. ASME Steam Tables, 5th Edition, 1983

Appendix A
Penetrations Failure to Close Data

No.	Penetration	Description	Max Size (in)	Normal Status	Open Factor	Isolation Logic Failure	Operator Failure to Close	Probability
1	X-19	Instrument Gas	3	Open	1	0.001	0.1	1.00E-04
2	X-23	Closed Cooling Water Supply	4	Open	1	0.001	0.1	1.00E-04
3	X-24	Closed Cooling Water Return	4	Open	1	0.001	0.1	1.00E-04
4	X-25	Drywell & Suppression Chamber Purge Supply	24	Closed	0.01	0.001	0.1	1.00E-06
5	X-201A	Drywell & Suppression Chamber Purge Supply	18	Closed	0.01	0.001	0.1	1.00E-06
6	X-26	Drywell Purge Exhaust	2	Closed	0.01	0.001	0.1	1.00E-06
7	X-26	Drywell Purge Exhaust	24	Closed	0.01	0.001	0.1	1.00E-06
8	X-39A	RHR Containment Spray	12	Closed	0.001	0.001	0.1	1.00E-07
9	X-39B	RHR Containment Spray	12	Closed	0.001	0.001	0.1	1.00E-07
10	X-53	Chilled Water Supply	8	Open	1	0.001	0.1	1.00E-04
11	X-54	Chilled Water Return	8	Open	1	0.001	0.1	1.00E-04
12	X-55	Chilled Water Supply	8	Open	1	0.001	0.1	1.00E-04
13	X-56	Chilled Water Return	8	Open	1	0.001	0.1	1.00E-04
14	X-72A	Floor & Equipment Drain	3	Closed	0.01	0.001	0.1	1.00E-06
15	X-85A	Chilled Water to Recirc Pump	3	Open	1	0.001	0.1	1.00E-04

16	X-85B	Chilled Water from Recirc Pump	3	Open	1	0.001	0.1	1.00E-04
17	X-86A	Chilled Water to Recirc Pump	3	Open	1	0.001	0.1	1.00E-04
18	X-86B	Chilled Water from Recirc Pump	3	Open	1	0.001	0.1	1.00E-04
19	X-87	Instrument Gas	2	Open	1	0.001	0.1	1.00E-04
20	X-202	Suppression Chamber Purge Exhaust	2	Closed	0.01	0.001	0.1	1.00E-06
21	X-202	Suppression Chamber Purge Exhaust	18	Closed	0.01	0.001	0.1	1.00E-06
22	X-204A	RHR Pump Test Line and Containment Spray	18	Closed	0.1	0.001	0.1	1.00E-05
23	X-205A	RHR Pump Test Line and Containment Spray	6	Closed	0.001	0.001	0.1	1.00E-07
24	X-204B	RHR Pump Test Line and Containment Spray	18	Closed	0.1	0.001	0.1	1.00E-05
25	X-204B	RHR Pump Test Line and Containment Spray	6	Closed	0.001	0.001	0.1	1.00E-07
26	X-244	HPCI Vacuum Breaker	3	Open	1	0.001	0.1	1.00E-04
27	X-245	RCIC Vacuum Breaker	2	Open	1	0.001	0.1	1.00E-04
	Total							**1.43E-03**

Appendix B

Spreadsheets

Summary of IPE Results - with normal maintenance

Plant Status	Frequency per 15 months	Frequency per 12 months
Initiating Event	2.43E+00	1.94E+00
CD-UO-COK	1.66E-07	1.33E-07
CD-OH-COK	1.01E-07	8.10E-08
Total CD	2.67E-07	**2.14E-07**
CD-HPVF	7.97E-10	6.37E-10
CD-LPVF-COK	3.72E-10	2.97E-10
Total Vessel Failure	1.17E-09	9.35E-10
CD-UO-ECF	2.79E-11	2.23E-11
CM-VF-COTF	2.15E-10	1.72E-10
LERF	2.43E-10	1.95E-10
CM-VOK-COPF	7.66E-11	6.13E-11
CM-VF-COPF	5.11E-11	4.09E-11
Late Cont. Failure	1.28E-10	1.02E-10
COPF Prior to Core Damage		
COPF	4.0E-07	3.20E-07
50% of COPF	2.0E-07	**1.60E-07**
Add Total CD to 50% COPF to account for CD after Containment Failure		**3.74E-07**

SSES - 3 year ILRT interval

Class	Description	EPRI analysis	Probability (P) Frequency (/12 month)	Consequence (C) Person-Rem to 50 miles	Risk (P x C) Person-rem/yr	Basis Frequency
1	No Containment Failure - use 1 La	relevant	1.63E-07	3.29E+05	5.36E-02	Core Damage Frequency minus frequency of other classes. CDF = 3.74E-7
2	Large containment isolation failure - use 35 La	Random failures to close - Type A not relevant	5.35E-10	4.38E+05	2.34E-04	1.43E-3 times CDF - method based on failure of Containment Isolation of pentrations > 1 inch
3a	Small isolation failure - use 10La	relevant	2.39E-08	4.41E+05	1.06E-02	0.064 times CDF - based on NUREG ILRT results of 4 small failures out of 144 tests - 95th percentile of Chi squared distribution
3b	Large isolation failure - use 35La	relevant	7.85E-09	4.38E+05	3.44E-03	0.021 times CDF - IP3 method based on NUREG ILRT results of 0 large failures out of 144 tests - 95th percentile of Chi squared distribution
4	Small isolation failure (Type B penetration)	Based on Type B frequency - not relevant	0	0	0.0	
5	Small isolation failure (Type C penetration)	Based on Type C frequency - not relevant	0	0	0.0	
6	Containment isolation failures (dependent failures, personnel error) - use 35 La	Based on ISI/IST program - Type A test does not	8.60E-10	4.38E+05	3.77E-04	2.3E-3 times CDF - EC-RISK-1063

		affect				
7	Severe Accident induced failure - use 100 La	Type A test does not affect - not relevant	1.60E-07	6.27E+06	1.01E+00	SSES PRA results for LERF, Late Containment Failure, and 50% of Containment Over Pressure Failure (prior to core damage)
8	Secondary Containment bypassed - use 100 La	Type A test does not affect - not relevant	1.75E-08	4.24E+06	7.41E-02	ISLOCA plus Containment Bypass
Core Damage			3.74E-07		1.147E+00	

SSES - 10 year ILRT interval

Class	Description	EPRI analysis	Probability (P) Frequency (/12 month)	Consequence (C) Person-Rem to 50 miles	Risk (P x C) Person-rem/yr	Basis Frequency
1	No Containment Failure - use 2 La plus increase dose by 10%	relevant	1.60E-07	3.99E+05	6.38E-02	Same as 3 year - Core Damage Frequency minus frequency of other classes
2	Large containment isolation failure - use 35 La	Random failures to close - Type A not relevant	5.35E-10	4.38E+05	2.34E-04	Same as 3 year
3a	Small isolation failure - use 10 La	relevant	2.63E-08	4.41E+05	1.16E-02	3 year value times 1.10 - increased probability of failure - average time that leakge goes undetected increases from 18 to 60 months and 3% historical failure rate. (.03 * 60 / 18) = 0.10
3b	Large isolation failure - use 35La	relevant	8.64E-09	4.38E+05	3.78E-03	3 year value times 1.10 - increased probability of failure - average time that leakge goes undetected increases from 18 to 60 months and 3% historical failure rate. (.03 * 60 / 18) = 0.10
4	Small isolation failure (Type B penetration)	Based on Type B frequency - not relevant	0	0	0.0	
5	Small isolation failure (Type C penetration)	Based on Type C frequency - not relevant	0	0	0.0	

6	Containment isolation failures (dependent failures, personnel error) - use 35 La	Based on ISI/IST program - Type A test does not affect	8.60E-10	4.38E+05	3.77E-04	Same as 3 year
7	Severe Accident induced failure - use 100 La	Type A test does not affect - not relevant	1.60E-07	6.27E+06	1.01E+00	Same as 3 year
8	Secondary Containment bypassed - use 100 La	Type A test does not affect - not relevant	1.75E-08	4.24E+06	7.41E-02	Same as 3 year
Core Damage			3.74E-07		1.159E+00	

SSES - 15 year ILRT interval

Class	Description	EPRI analysis	Probability (P) Frequency (/12 month)	Consequence (C) Person-Rem to 50 miles	Risk (P x C) Person-rem/yr	Basis Frequency
1	No Containment Failure - use 2 La and increase dose by 15%	relevant	1.58E-07	4.17E+05	6.61E-02	Core Damage Frequency minus frequency of other classes
2	Large containment isolation failure - use 35 La	Random failures to close - Type A not relevant	5.35E-10	4.38E+05	2.34E-04	Same as 3 year
3a	Small isolation failure - use 10La	relevant	2.75E-08	4.41E+05	1.21E-02	3 year value times 1.15 - increased probability of failure - average time that leakge goes undetected increases from 18 to 90 months and 3% historical failure rate. (.03 * 90 / 18) = 0.15
3b	Large isolation failure - use 35La	relevant	9.03E-09	4.38E+05	3.96E-03	3 year value times 1.15 - increased probability of failure - average time that leakge goes undetected increases from 18 to 90 months and 3% historical failure rate. (.03 * 90 / 18) = 0.15
4	Small isolation failure (Type B penetration)	Based on Type B frequency - not relevant	0	0	0.0	
5	Small isolation failure (Type C penetration)	Based on Type C frequency - not relevant	0	0	0.0	

6	Containment isolation failures (dépendent failures, personnel error) - use 35 La	Based on ISI/IST program - Type A test does not affect	8.60E-10	4.38E+05	3.77E-04	Same as 3 year
7	Severe Accident induced failure - use 100 La	Type A test does not affect - not relevant	1.60E-07	6.27E+06	1.01E+00	Same as 3 year
8	Secondary Containment bypassed - use 100 La	Type A test does not affect - not relevant	1.75E-08	4.24E+06	7.41E-02	Same as 3 year
Core Damage			3.74E-07		1.162E+00	

Summary Results

	Base line - 3 year interval	10 year interval	15 year interval
Total Person-rem per year	1.147	1.159	1.162
Increase over 3 year		1.0%	1.3%
Increase over 10 year			0.3%
Class 1 & 3 total	0.068	0.079	0.082
Class 1 & 3 Increase over 3 year		17.1%	21.5%
Class 1 & 3 Increase over 10 year			3.7%

Class 1 & 3 portion of total	5.9%	6.8%	7.1%
Total Increase over 3 year		1.0%	1.3%
Total Increase over 10 year			0.3%
LERF (Class 3b)	7.85E-09	8.64E-09	9.03E-09
Increase over 3 year		7.85E-10	1.18E-09
Increase over 10 year			3.93E-10
Increase over 3 year (%)		10.0%	15.0%
Increase over 10 year (%)			4.5%

Appendix C

Leakage Rate Calculation

The in-house CONTAIN code was used to model this primary containment leaking process.

C.1 Assumptions and Input

There are three cells in the CONTAIN model. They are:

Cell #1	Wetwell
Cell #2	Drywell
Cell #3	Atmosphere

The flow path between cells is modeled as engineered vent. The engineered vent from Cell #2 to Cell #3 is an 1 inch diameter hole in the primary containment wall between the drywell and the secondary containment atmosphere.

It is assumed that after a loss of decay heat removal accident, steam discharged
into the suppression pool displaced all nitrogen from the wetwell into the drywell.
The initial wetwell pressure is 60 psia. There is saturated steam in the airspace. The initial drywell pressure is also 60 psia. There are nitrogen and steam in its airspace.

C.1.1 The center of mass elevation of cells

Cell #1
Assume the suppression pool depth is 24 ft. The pool surface elevation is

SPEL = 648 + 24 = 672 ft

ELEVCL(1) = 672 + [(704 - 3.5) -672] / 2 = 686.25 ft = 209.17 m[1]

Cell #2
The center of mass of drywell airspace is assumed at one-third height of its volume

ELEVCL(2) = 704 + 87.75 / 3 = 733.25 ft = 223.5 m (Ref. 1)

[1] SSES DAR Fig. I-1.

Cell #3

The center of mass of this atmosphere cell is assumed to be the same as that of drywell

ELEVCL(3) = 223.5 m

C.1.2 Engineered Vent From Cell #2 to Cell #3

The flow path is an one inch hole in the drywell wall.

VAREA = cross-sectional area of vent = $A_p = \pi/4\ in^2 = .00545\ ft^2$
$= .00051\ m^2$

The length of flow path is

L = drywell wall thickness $\cong$ 6 ft = 1.83 m

VAVL = A_p / L = .00051 / 1.83 = .00028 m

VCFC = vent flow loss coefficient = Kp + Ken + Kex
where
Kp = loss coefficient of 1" hole = f_T x L / Dp
For an one inch hole in concrete wall it is assumed that the friction factor is $f_T = 0.05$
Dp = 1" = .0833 ft
Kp = 0.05 x 6 / 0.0833 = 3.6
Ken = loss coefficient for pipe entrance = 0.5 (p.A-29 of Ref. 2)[2]
Kex = loss coefficient for pipe exit = 1.0 (p.A-29 of Ref. 2)

VCFC = 3.6+ 0.5 + 1.0 = 5.1

VCOSN = cosine of the angle between the vent axis and the vertical direction = 0.

VDPF = pressure difference to open the vent in the forward direction
= 100 Pa (assumed)

[2] Crane, Technical Paper No.410

VDPB = pressure difference to open the vent in the backward direction
= 100 Pa (assumed)

VELEVB = elevation of the vent at the FROM cell = 223.5 m (assumed)

VELEVF = elevation of the vent at the TO cell = 223.5 m (assumed)

C.1.3 Suppression Pool Vent Flow Path

The input data is the same as in vac11$.dat of Ref.3.[3]

C.1.4 Vacuum Breaker Flow Path

The input data is the same as in vac11$.dat of Ref.3.

C.1.5 Cell Data

C.1.5.1 Cell #2-Drywell

Upper cell input data:

According to Ref.4,[4]
Free volume of airspace = Vdw = 239600 ft^3= 6785 m^3
Height of airspace = Hair = 26.75 m
Number of Lb-moles of nitrogen = N_{N2} = 554.28
Mass of nitrogen = M_{N2} = 15520 lbm = 7040 kg

It is assumed that after the loss of decay heat removal accident, all nitrogen in the wetwell was driven into the drywell. Before the accident there was 365.27 lb-moles or 4639 kg of nitrogen in the wetwell. (Ref.4) After the accident in the drywell:

N_{N2} = 554.28 + 365.27 = 919.55 lb-moles
M_{N2} = 7040 + 4639 = 11679 kg

[3] Calculation No. EC-THYD-1032.
[4] Calculation No. EC-THYD-1001.

Assume drywell temperature, Tdw = 252°F = 395.37°K , then

Partial pressure of nitrogen = P_{N2} = 919.55 x 10.731 x (460 + 252) / 239600 = 29.32 psia
Partial pressure of water vapor = P_{H2OV} = saturation pressure at 252°F = 30.88 psia
Then v_g = specific volume = 13.375 ft^3 / lbm
Mass of water vapor in upper cell = M_{H2OV} = 239600 / 13.375 = 17914 lbm = 8125.7 kg
Pdw = 29.32 + 30.88 = 60.2 psia

Lower cell input data:

Surface area of pool = Apl = 451 m^2 (Ref.4)
The following input values are arbitrarily assumed to initiate the drywell pool:
Temperature of pool = Tpl = 252°F = 395.37°K
Water mass in pool = M_{H2OL} = 1.0 kg

C.1.5.2 Cell #1-Wetwell

From Ref.4, when the suppression pool level is 24 ft,
Free volume of wetwell airspace = Vww = 148590 ft^3 = 4208 m^3
Suppression pool volume = Vp = 131550 ft^3
Total volume of wetwell = Vt = Vww + Vp = 280140 ft^3

Assume wetwell pressure is Pww = 60 psia and wetwell temperature equal to saturation temperature of water at 60 psia

Tww = 292.71°F = 417.99°K
Then v_g = specific volume = 7.1736 ft^3 / lbm
Mass of water vapor in upper cell = M_{H2OV} = 148590 / 7.1736 = 20713 lbm = 9395.6 kg

Assume suppression pool temperature = Tpl = Tww = 292.71°F = 417.99°K
Then v_f = specific volume = .017383 ft^3 / lbm
Water mass in the suppression pool = M_{H2OL} = 131550 / .017383 = 7567700 lbm = 3.43E6 kg

C.1.5.3 Cell #3-Atmosphere

The following input values are assumed for this cell:

Cell volume = V3 = 1.0E8 m^3 = 3.53E9 ft^3
Cell height = Hair = 1.0E3 m
Initial cell pressure = P3 = 1.014E5 Pa = 14.7 psia
Initial cell temperature = Tair = 305.4°K = 90°F
Initial mole fraction of nitrogen = 0.79
Initial mole fraction of oxygen = 0.21
Total number of Lb-moles of gases = Nt
= 14.7 x 3.53E9 / [10.731 x (90 + 460)] = 8.792E6
Initial mass of nitrogen = M_{N2} = 0.79 x 8.792E6 x 28 = 1.945E8 lbm
Initial mass of oxygen = M_{O2} = 0.21 x 8.792E6 x 32 = 5.908E7 lbm

C.1.6 Input File

The input file is vent4e.dat.

C.1.7 Results

The partial output of the CONTAIN run is listed in Section C.1.8. It can be seen there that the maximum flow rate of engineered vent from Cell #2 to Cell #3 within the first ten minutes is about 0.215 kg/sec or **0.474 lbm/sec**. This is the estimated leakage rate through an one inch hole in the primary containment wall.

C.1.8 Partial CONTAIN Output

```
1
□
     INPUT <<<<<
<<<<< ECHO
□
     INPUT <<<<< &&                      vent4e.dat
<<<<< ECHO
     INPUT <<<<< CDC
<<<<< ECHO
     INPUT <<<<< EOI
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ***** Global Input.  This input is common to all cells
***************|       <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< CONTROL  NCELLS=3     && Number of cells
|      <<<<< ECHO
     INPUT <<<<<          NTITL=1      && Number of title cards
|      <<<<< ECHO
     INPUT <<<<<          NTZONE=4     && Number of time zones
|      <<<<< ECHO
     INPUT <<<<<          NUMTBG=1     && Number of global tables used
|      <<<<< ECHO
     INPUT <<<<<          MAXTBG=4     && Max # of entries used in global
table option    |      <<<<< ECHO
     INPUT <<<<<          NENGV=1
<<<<< ECHO
     INPUT <<<<< EOI &&
|      <<<<< ECHO
     INPUT <<<<< &&  *************** End of General Data
**********************************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ***** Global Material Data.  This input is used in all
cells **********|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< MATERIAL                && Keyword that initates material block
|      <<<<< ECHO
     INPUT <<<<<          COMPOUND  H2 O2 N2 CO2 H2OL H2OV SS CONC CO FE ZR
UO2 SIO2 FEO         <<<<< ECHO
     INPUT <<<<<                    SIO2 FEO ZRO2 CAO CR2O3 MNO PU U MGO K2O
<<<<< ECHO
     INPUT <<<<<          FP-NAMES     CSI  CSOH  SR  PI
<<<<< ECHO
     INPUT <<<<<          USERDEF      && Keyword to initiate specification of
<<<<< ECHO
     INPUT <<<<<                       && user-defined materials
<<<<< ECHO
```

```
     INPUT <<<<<                   CSTEEL    && Name assigned to carbon steel
<<<<< ECHO
     INPUT <<<<<                 USERDAT     && Keyword to begin specification of
carbon steel               <<<<< ECHO
     INPUT <<<<<                             && properties.
<<<<< ECHO
     INPUT <<<<<                   CSTEEL    && Name of material
<<<<< ECHO
     INPUT <<<<<                   SOLID     && Phase of material
<<<<< ECHO
     INPUT <<<<<                   MOLEW     && Keyword for specifying molec wt (use
value for Fe)            <<<<< ECHO
     INPUT <<<<<                   55.85     && Molec wt. (Use value for Fe)
<<<<< ECHO
     INPUT <<<<<                   RHO       && Keyword indicating density input
follows                     <<<<< ECHO
     INPUT <<<<<                   2         && No. of temp-density pairs
<<<<< ECHO
     INPUT <<<<<                   273.15  7857.  && Temp (K),  Density (kg/m**3)
<<<<< ECHO
     INPUT <<<<<                   475.    7857.  && Temp (K),  Density (kg/m**3)
<<<<< ECHO
     INPUT <<<<<                   COND      && Keyword for specifying thermal
conductivity                  <<<<< ECHO
     INPUT <<<<<                   2         && No. of Temp-Conductivity pairs
<<<<< ECHO
     INPUT <<<<<                   273.15  34.86  && Temp (K),  Conductivity (W/m-
K)                        <<<<< ECHO
     INPUT <<<<<                   475.    34.86  && Temp (K),  Conductivity (W/m-
K)                        <<<<< ECHO
     INPUT <<<<<                   ENTH      && Keyword for specifying enthalpy
input                          <<<<< ECHO
     INPUT <<<<<                   2         && No. of Temp-Enth pairs
<<<<< ECHO
     INPUT <<<<<                   273.15  0.0    && Temp (K), Enthalpy (J/kg)
<<<<< ECHO
     INPUT <<<<<                   475.    90348. && Temp (K), Enthalpy (J/kg)
<<<<< ECHO
     INPUT <<<<<                   SPH       && Keyword for specifying specific heat
<<<<< ECHO
     INPUT <<<<<                   2         && No. of Temp-Sp Heat pairs
<<<<< ECHO
     INPUT <<<<<                   273.15  447.6  && Temp (K), Sp Heat (J/kg-K)
<<<<< ECHO
     INPUT <<<<<                   475.    447.6  && Temp (K), Sp Heat (J/kg-K)
<<<<< ECHO
     INPUT <<<<<               EOI
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
|       <<<<< ECHO
     INPUT <<<<< &&  *************** End of Material Data
*********************************|          <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
```

```
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ***** Title block
*****************************************************|      <<<<< ECHO
     INPUT <<<<< TITLE && Put Title below
|      <<<<< ECHO
     INPUT <<<<<      FLOW RATE FROM DRYWELL AT 60 PSIA THROURH 1 INCH HOLE
|     <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< && **************** End of Title Block
***********************************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ************ Time Step Data
*******************************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< TIMES          &&
|      <<<<< ECHO
     INPUT <<<<<          1.E5   && cput   = CPU time limit (seconds)
|      <<<<< ECHO
     INPUT <<<<<           0.    && tstart = Problem Start time (sec)
|      <<<<< ECHO
     INPUT <<<<<           .01   && timinc = Maximum time step size (sec)
|      <<<<< ECHO
     INPUT <<<<<           0.2   && edtdto = Max interval for writing data to
tapes (sec)  |      <<<<< ECHO
     INPUT <<<<<           5.    && tstop  =  End Time of Time Zone (sec)
|      <<<<< ECHO
     INPUT <<<<<           0.1 10.0  365.  && Second Time Zone
<<<<< ECHO
     INPUT <<<<<           .01  0.2  375.
<<<<< ECHO
     INPUT <<<<<           0.1  40.   600.
<<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< && **************** End of Time Step Data
********************************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ******* Edit Frequency
************************************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< SHORTEDT=100   && Short edit printed every
(SHORTEDT)*(timinc) seconds      |      <<<<< ECHO
```

```
     INPUT <<<<< LONGEDT=1     && Long edit printed every (LONGEDT)*(edtdto)
seconds       |       <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< && *************** End of Edit Frequency Data
****************************|       <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ****** Specify Type of Output
*****************************************|       <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< PRLOW-CL  && Print detailed output from lower cell
|      <<<<< ECHO
     INPUT <<<<< PRFLOW    && Print detailed output from intercell flow
|      <<<<< ECHO
     INPUT <<<<< PRENGSYS  && Print detailed output for engineered systems
|      <<<<< ECHO
     INPUT <<<<<   PRAER2    && Print output of aerosol model for structures
|      <<<<< ECHO
     INPUT <<<<<   PRFISS2   && Output of fission product behavior for
structures          |       <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< && ******* End of Output Description Section
*****************************|       <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ****** Specify the reactor type
***************************************|       <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< THERMAL  && Water-cooled reactor
|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< && ******* End of reactor-type data
**************************************|       <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ******* Suppression Pool Vent Flow Path Model
*************************|       <<<<< ECHO
```

```
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< SPVENT  && Activates the model
|      <<<<< ECHO
     INPUT <<<<<        NWET=1        && Cell # containing the wetwell pool
|      <<<<< ECHO
     INPUT <<<<<        NDRY=2        && Cell # representing the drywell
|      <<<<< ECHO
     INPUT <<<<<        NSVNTS=82     && Number of downcomer vent pipes
|      <<<<< ECHO
     INPUT <<<<<        AVNT=0.274    && Flow area of a single vent pipe
(m**2)             |     <<<<< ECHO
     INPUT <<<<<        VNTLEN=13.87  && Vertical extent of the vent pipe (m)
|      <<<<< ECHO
     INPUT <<<<<        ELEVNT=3.66   && height of vent opening above bottom
of pool (m)    |     <<<<< ECHO
     INPUT <<<<<        DPDRY=1.E4    && DP for area ramping of gas flow area
(Pa)          |     <<<<< ECHO
     INPUT <<<<<        DPWET=1.E4    && DP for area ramping of gas flow area
(Pa)          |     <<<<< ECHO
     INPUT <<<<<        FDW=2.17      && loss coeff for liq flow from DW to WW
|      <<<<< ECHO
     INPUT <<<<<        FWD=2.17      && loss coeff for liq flow from WW to DW
|      <<<<< ECHO
     INPUT <<<<< EOI                  &&
|      <<<<< ECHO
     INPUT <<<<< && **************** End of SP Vent Data
*********************************|     <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ****** Data for Flow Path Model
**************************************|     <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< FLOWS     &&
|      <<<<< ECHO
     INPUT <<<<<        AVL(1,2)=0.163 && Ratio of flow path area to length (WW
to DW) (m) |     <<<<< ECHO
     INPUT <<<<<        CFC(1,2)=3.57  && Flow loss coefficient (WW to DW)
|      <<<<< ECHO
     INPUT <<<<<        VAR-AREA(1,2)  && Specifies table for flow from (WW to
DW)          |     <<<<< ECHO
     INPUT <<<<<        FLAG=2         && use linear interp in table below
|      <<<<< ECHO
     INPUT <<<<<        VAR-X=DELTA-P  && Delta-p is independent variable (Pa)
|      <<<<< ECHO
     INPUT <<<<<        X=4            && Specify 4 values of Delta-p
|      <<<<< ECHO
     INPUT <<<<<            -1.E9      &&
|      <<<<< ECHO
     INPUT <<<<<             0.345E4   &&
|      <<<<< ECHO
     INPUT <<<<<             1.943E4   &&
|      <<<<< ECHO
```

```
     INPUT <<<<<              1.E9      &&
|      <<<<< ECHO
     INPUT <<<<<          VAR-Y=AREA    && Flow area is dependent variable
|      <<<<< ECHO
     INPUT <<<<<          Y=4           && Specify 4 values of flow area (m**2)
|      <<<<< ECHO
     INPUT <<<<<              0.        &&
|      <<<<< ECHO
     INPUT <<<<<              0.        &&
|      <<<<< ECHO
     INPUT <<<<<              0.762     &&
|      <<<<< ECHO
     INPUT <<<<<              0.762     &&
|      <<<<< ECHO
     INPUT <<<<< EOI                    &&
|      <<<<< ECHO
     INPUT <<<<<          IMPLICIT      && Implicit integr method for flow calc
<<<<< ECHO
     INPUT <<<<<          DROPOUT       && Remove suspended liquid coolant from
atmosphere         <<<<< ECHO
     INPUT <<<<<            ELEVCL(1)=209.17
<<<<< ECHO
     INPUT <<<<<            ELEVCL(2)=223.5
<<<<< ECHO
     INPUT <<<<<            ELEVCL(3)=223.5
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< ENGVENT
<<<<< ECHO
     INPUT <<<<<            FROM = 2      TO= 3
<<<<< ECHO
     INPUT <<<<<            VAREA = .00051
<<<<< ECHO
     INPUT <<<<<            VAVL = .00028
<<<<< ECHO
     INPUT <<<<<            VCFC =  5.1
<<<<< ECHO
     INPUT <<<<<            VCOSN = 0.0
<<<<< ECHO
     INPUT <<<<<            VDPB = 100.
<<<<< ECHO
     INPUT <<<<<            VDPF = 100.
<<<<< ECHO
     INPUT <<<<<            VELEVB = 223.5
<<<<< ECHO
     INPUT <<<<<            VELEVF = 223.5
<<<<< ECHO
     INPUT <<<<< EOI
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && *************  End of Data for Flow Path Model
************************|       <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ************ Input Data for Cell #1 (Wetwell)
*************************|       <<<<< ECHO
```

```
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< CELL=1    && Specifies the cell number
|      <<<<< ECHO
     INPUT <<<<<        CONTROL   && Allocates storage space for cell 1
|      <<<<< ECHO
     INPUT <<<<<        JPOOL=1   && Indicates presence of pool layer
|      <<<<< ECHO
     INPUT <<<<< EOI              &&
|      <<<<< ECHO
     INPUT <<<<< && ************ End of Control Parameters
********************************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ******* Additional Data for Cell 1
************************************|      <<<<< ECHO
     INPUT <<<<< TITLE      && Next line is title for cell 1
|      <<<<< ECHO
     INPUT <<<<<    WETWELL CELL WITH WATER POOL (Cell 1)
<<<<< ECHO
     INPUT <<<<< GEOMETRY             && Geometry for Wetwell is on next two
lines         |      <<<<< ECHO
     INPUT <<<<<             4208.    && Volume of Wetwell air space (m**3)
|      <<<<< ECHO
     INPUT <<<<<              8.69    && Height of wetwell air space (m)
|      <<<<< ECHO
     INPUT <<<<< ATMOS                && Initial atmosphere cond in WW air
space         |      <<<<< ECHO
     INPUT <<<<<                 1    && Number of materials in atmosphere
|      <<<<< ECHO
     INPUT <<<<<               0.0    && Pressure will be calculated from eqn
of state     |      <<<<< ECHO
     INPUT <<<<<            417.99    && Gas temperature (K)
|      <<<<< ECHO
     INPUT <<<<<       H2OV=9395.6    && Initial mass of water vapor in WW air
space (kg)  |      <<<<< ECHO
     INPUT <<<<< EOI
<<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< && **** End of Data Block for Wetwell air Space
**************************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ****** Heat Transfer Options for Wetwell
********************************|     <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<    CONDENSE   && Natural conv. and condensation HT is
modelled                 <<<<< ECHO
     INPUT <<<<<    HT-TRAN    &&
|    <<<<< ECHO
     INPUT <<<<<           ON  && Atmosphere to Structure heat transfer is ON
|      <<<<< ECHO
```

```
     INPUT <<<<<           ON  && Heat trans from pool to substructure (at
const T) is ON  |        <<<<< ECHO
     INPUT <<<<<           OFF && Inter-layer heat trans in pool is OFF.
|      <<<<< ECHO
     INPUT <<<<<           ON  && Pool to Air space heat trans is ON.
|      <<<<< ECHO
     INPUT <<<<<           ON  && Radiative heat transfer is ON.
|      <<<<< ECHO
     INPUT <<<<< && ******* End of Heat Transfer Description for Cell 1
*******************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<<    OVERFLOW=1
<<<<< ECHO
     INPUT <<<<< && **** Input for Pool Model in Wetwell
**********************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<< LOW-CELL  && Input for suppression pool follows
|      <<<<< ECHO
     INPUT <<<<<    GEOMETRY  490.2  && surface area of lower cell (m**2)
|      <<<<< ECHO
     INPUT <<<<<    POOL              && Initial configuration of pool layer
follows        |      <<<<< ECHO
     INPUT <<<<<        TEMP=417.99  && Initial temperature of pool (K)
|      <<<<< ECHO
     INPUT <<<<<        COMPOS=1     && number of initial materials in the
pool             |      <<<<< ECHO
     INPUT <<<<<        H2OL=3.43E6  && Initial mass of liq water in pool (kg)
|         <<<<< ECHO
     INPUT <<<<<        PHYSICS      && Physics options for supp pool model
|      <<<<< ECHO
     INPUT <<<<<        BOIL         && Pool boiling is modelled
|      <<<<< ECHO
     INPUT <<<<< EOI                 && End of supp pool data
|      <<<<< ECHO
     INPUT <<<<< EOI                 &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ****** Substructure Boundary Condition for Supp Pool
*****************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<    BC=300.  && Temperature of layer beneath suppression pool
|      <<<<< ECHO
     INPUT <<<<<    EOI      &&
|      <<<<< ECHO
     INPUT <<<<< && **************** End of Subpool layer
********************************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && *******CELL DATA FOR DRYWELL
*******************************************|      <<<<< ECHO
```

```
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<  CELL=2          && Cell #2 is the Drywell
|      <<<<< ECHO
     INPUT <<<<<        CONTROL   && Allocates storage space for cell 2
|      <<<<< ECHO
     INPUT <<<<<        NAENSY=1  && Number of engineered systems
<<<<< ECHO
     INPUT <<<<<        JPOOL =1  && Indicates presence of pool layer
<<<<< ECHO
     INPUT <<<<<  EOI             &&
|      <<<<< ECHO
     INPUT <<<<< && ****************** End of Control Data for Drywell
******************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ************* TITLE FOR CELL 2
*****************************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<   TITLE
<<<<< ECHO
     INPUT <<<<<     DRYWELL CELL
<<<<< ECHO
     INPUT <<<<< &&
*************************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ********** GEOMETRIC DATA FOR DRYWELL
*********************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<    GEOMETRY          &&
|      <<<<< ECHO
     INPUT <<<<<              6785.   && Drywell volume (m**3)
|      <<<<< ECHO
     INPUT <<<<<                26.75 && Characteristic height of the drywell
(m)             |      <<<<< ECHO
     INPUT <<<<< &&
*************************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ************ DRYWELL ATMOSPHERE DATA
***********************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<    ATMOS=2     && Number of materials in the atmosphere
|      <<<<< ECHO
     INPUT <<<<<        0.0     && Initial drywell pressure will be calculated
<<<<< ECHO
     INPUT <<<<<        395.37  && Initial gas temperature (K)
|      <<<<< ECHO
```

```
     INPUT <<<<<    H2OV=8125.7 && Initial mass of water vapor (kg)
|        <<<<< ECHO
     INPUT <<<<<    N2=11679.
<<<<< ECHO
     INPUT <<<<< EOI
<<<<< ECHO
     INPUT <<<<< &&
***********************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && *************** Heat transfer options for DW  walls
******************|          <<<<< ECHO
     INPUT <<<<< &&
|        <<<<< ECHO
     INPUT <<<<<    CONDENSE     && Natural Conv and Condensation HT is
modelled                     <<<<< ECHO
     INPUT <<<<<    HT-TRAN      ON  OFF  OFF  ON  ON
<<<<< ECHO
     INPUT <<<<< &&
***********************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<<
<<<<< ECHO
     INPUT <<<<<     ENGINEER   FLOV  1  2  1  17.07
<<<<< ECHO
     INPUT <<<<<        OVERFLOW   2  1  0.4572
<<<<< ECHO
     INPUT <<<<<     EOI
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<<     OVERFLOW=2
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<<    LOW-CELL
<<<<< ECHO
     INPUT <<<<<      GEOMETRY  451.
<<<<< ECHO
     INPUT <<<<<      POOL
<<<<< ECHO
     INPUT <<<<<        TEMP=395.37
<<<<< ECHO
     INPUT <<<<<        COMPOS=1   H2OL=1.0
<<<<< ECHO
     INPUT <<<<<        PHYSICS   BOIL   EOI
<<<<< ECHO
     INPUT <<<<<      EOI
<<<<< ECHO
     INPUT <<<<<     EOI
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
```

```
     INPUT <<<<< && *******CELL DATA FOR ATMOSPHERRE
**************************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<  CELL=3          && Cell #3 is atmosphere
|      <<<<< ECHO
     INPUT <<<<<        CONTROL   && Allocates storage space for cell #3
|      <<<<< ECHO
     INPUT <<<<<  EOI             &&
|      <<<<< ECHO
     INPUT <<<<< && ****************** End of Control Data for Cell #3
******************|      <<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ************* TITLE FOR CELL #3
***************************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<   TITLE
<<<<< ECHO
     INPUT <<<<<     ATMOSPHERE CELL
<<<<< ECHO
     INPUT <<<<< &&
************************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ********** GEOMETRIC DATA FOR CELL #3
*********************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<    GEOMETRY        &&
|      <<<<< ECHO
     INPUT <<<<<            1.0E8   && Cell #3 volume (m**3)
|      <<<<< ECHO
     INPUT <<<<<            1.0E3   && Characteristic height of Cell #3
(m)              |      <<<<< ECHO
     INPUT <<<<< &&
************************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && ************ CELL #3 ATMOSPHERE DATA
*********************************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<    ATMOS=2     && Number of materials in the atmosphere
|      <<<<< ECHO
     INPUT <<<<<      1.014E5   && Initial cell pressure (Pa)
<<<<< ECHO
     INPUT <<<<<        305.37  && Initial gas temperature (K)
|      <<<<< ECHO
     INPUT <<<<<    N2=0.79     && Initial mole fraction of nitrogen in Cell
<<<<< ECHO
```

```
     INPUT <<<<<    O2=0.21     && Initial mole fraction of oxygen in Cell
<<<<< ECHO
     INPUT <<<<< EOI
<<<<< ECHO
     INPUT <<<<< &&
**********************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<< && *************** Heat transfer options for heat structures
*************|      <<<<< ECHO
     INPUT <<<<< &&
|      <<<<< ECHO
     INPUT <<<<<    CONDENSE     && Natural Conv and Condensation HT is
modelled                 <<<<< ECHO
     INPUT <<<<<    HT-TRAN      ON   ON   ON   ON   ON
<<<<< ECHO
     INPUT <<<<< &&
**********************************************************************|
<<<<< ECHO
     INPUT <<<<< &&
<<<<< ECHO
     INPUT <<<<<    EOF
<<<<< ECHO
```

ENGINEERED VENT FLOW CONDITIONS   AT TIME =   .000 (S)

FROM CELL	TO CELL	FLOW (KG/S)	VELOCITY (M/S)	AREA (M**2)
2	3	0.00000E+00	0.00000E+00	0.00000E+00

```
 >>>>> ENG. VENT <  1> BETWEEN CELLS <  2> AND <  3> IS BEING OPENED AT TIME=
1.00000E-02
    >
```

ENGINEERED VENT FLOW CONDITIONS   AT TIME =   1.000 (S)

FROM CELL	TO CELL	FLOW (KG/S)	VELOCITY (M/S)	AREA (M**2)
2	3	2.14885E-01	1.45889E+02	5.10000E-04

ENGINEERED VENT FLOW CONDITIONS   AT TIME =   3.000 (S)

FROM CELL	TO CELL	FLOW (KG/S)	VELOCITY (M/S)	AREA (M**2)
2	3	2.14878E-01	1.45887E+02	5.10000E-04

ENGINEERED VENT FLOW CONDITIONS   AT TIME =   600.000 (S)

FROM CELL	TO CELL	FLOW (KG/S)	VELOCITY (M/S)	AREA (M**2)
2	3	2.10025E-01	1.43561E+02	5.10000E-04

ATTACHMENT B

EC-RADN-1110
REVISION 0

NUCLEAR ENGINEERING
CALCULATION / STUDY COVER SHEET and
DCS TRANSMITTAL SHEET

➢2. TYPE: Calc ➢3. NUMBER: EC-RADN-1110 ➢4. REVISION: 0

5. TRANSMITTAL#: ______ *➢6. UNIT: 3 *➢7. QUALITY CLASS: N

➢9. DESCRIPTION: Calculation of the Whole Body Population Dose Associated with Integrated Leak Rate Test (ILRT) Extension Risk Assessment for PPL Susquehanna Using MACCS2 *➢8. DISCIPLINE: R

SUPERSEDED BY: ______

10. Alternate Number: C-254157-01 11. Cycle: ______

12: Computer Code or Model used: MACCS2 Fichee ☐ Dis ☒ Am't 1

13. Application: ILRT,

*➢14 *Affected Systems:* 059 , 059F , , , ,
* If N/A then line 15 is mandatory

**➢15. NON-SYSTEM DESIGNATOR: RADN RISK LOCA
**If N/A then line 14 is mandatory

16. Affected Documents: ______

☐ Lic. Doc Change Req'd

17. References: NUREG-1465, NUREG/CR-6604, RSICC Code Package CCC-652, EC-RADN-1028, EC-PUPC-1001, EP-PS-215, SSES FSAR Ch. 2.1.3

18. Equipment / Component #: ______

19. DBD Number: ______

➢20. PREPARED BY	Thomas E. Fenstermacher *Print Name*	Thomas E. Fenstermacher *Signature*
➢21. REVIEWED BY	Mark J. Abrams *Print Name*	Mark J. Abrams *Signature*
➢21A. VERIFIED BY	 *Print Name*	 *Signature*
➢22. APPROVED BY	Mark J. Abrams *Print Name*	Mark J. Abrams *Signature*
➢23. ACCEPTED BY PP&L / DATE	David A. Matchick *Print Name*	David A. Matchick 8/31/01 *Signature / DATE*

TO BE COMPLETED BY DCS

NR-DCS SIGNATURE/DATE

ADD A NEW COVER PAGE FOR EACH REVISION
FORM NEPM-QA-0221-1, Revision 5, Page 1 of 2, ELECTRONIC FORM

* Verified Fields
➢ REQUIRED FIELDS

EQE INTERNATIONAL

CALCULATION COVER SHEET

Calculation No.	C-254157-01
Project:	MACCS2 Calculations for PPL Susquehanna
Calculation Title:	Calculation of the Whole Body Population Dose Associated with Integrated Leak Rate Test (ILRT) Extension Risk Assessment for PPL Susquehanna Using MACCS2
References:	As incorporated herein. Please see References Section 5.0
Attachments:	Data CD

Total Number of Pages (Including Cover Sheet): 11

Revision Number	Approval Date	Description of Revision	Originator	Checker	Approver
0		Original Issue	J. S. [signature]	[signature]	[signature]

960000.200/calccov (6/14/96)

TABLE OF CONTENTS

1. INTRODUCTION

The purpose of this calculation is to determine the integrated population dose (person-rem) within 50 miles of the Susquehanna Steam Electric Station (SSES) operated by PPL Susquehanna, LLC (PPL) for a variety of accident scenarios using whole body effective dose equivalent dose factors. This calculation supports the risk assessment of the extension of the Integrated Leak Rate Test (ILRT) test interval on the SSES nuclear units. The scenarios analyzed cover a range of containment behaviors ranging from the case of no containment failure to cases of containment bypass and severe accident-induced failure. The dose calculations were performed using the MACCS2 code system (Reference 1), with input based upon BWR source terms developed from NUREG-1465 (Reference 2) research. The source term information was further processed using a Microsoft Excel® spreadsheet based on this data supplied and was supplied by PPL. The MACCS2 code has been SQA certified for quality related analyses performed by ABSG Consulting in Reference 3. Although the MSIV leakage pathway which is used in PPL design analyses was not explicitly included in the MACCS2 source term due to limitations of the MACCS2 code, the population dose impact from this pathway was accounted for in the final population dose results by scaling of the base case results using previously performed design results which assess MSIV leakage doses (Reference 4).

2. INPUT DATA

2.1 Source Term Data

The data used to determine the source term used in the MACCS2 analysis was developed from NUREG-1465 research as incorporated in the NRC sponsored RADTRAD (Reference 5) computer code, and furnished by PPL on Excel® spreadsheet files named MACCS2DATA.xls and MACCS2SACCIDENTS.xls. These spreadsheets are shown in the Appendices. The NUREG-1465 research based release fraction and timing data from MACCS2DATA.xls and the risk analysis related containment behavior description from MACCS2SACCIDENTS.xls were used to model the concentration of each isotope group as a function of time for each of seven distinct cases. The relationship of the set of MACCS2 cases with the set of PPL risk analysis accident classes shown in MACCS2SACCIDENTS.xls is shown in Table 1. This table also shows the modeled release phases and containment leakage parameters. The isotopic release fractions and related data for each isotope group are shown in Table 2.

PPL Class	Gap	Early In-Vessel	Ex-Vessel	Late In-Vessel	Primary-> Secondary, La	SGTS Filtration	Unfiltered Bypass, La	MACCS Case
1a	Yes	Yes	No	No	1.0	Yes	0	1
1b	Yes	Yes	No	No	2.0	Yes	0	2
2	Yes	Yes	No	No	35.0	Yes	0	4
3a	Yes	Yes	No	No	10.0	Yes	0	3
3b	Yes	Yes	No	No	35.0	Yes	0	4
4	Yes	Yes	No	No	N/A	Yes	0	N/A
5	Yes	Yes	No	No	N/A	Yes	0	N/A
6	Yes	Yes	No	No	35.0	Yes	0	4
7	Yes	Yes	Yes	Yes	100.0	No	0	5
8a	Yes	Yes	No	No	1.0	Yes	100	6
8b	Yes	Yes	No	No	2.0	Yes	100	7

Table 1. Correspondence of MACCS2SACCIDENTS.xls to MACCS2 cases.

Release Phase	Times in Hours			Primary Containment Release Fractions By Group and Phase							
	Start	End	Duration	Kr-Xe	I	Cs-Rb	Te-Sb	Ba-Sr	Ru	Ce	La
Gap	0	0.5	0.5	0.0500	0.0500	0.0500	0.0000	0.0000	0.0000	0.0000	0.0000
Early I-V	0.5	2.0	1.5	0.9500	0.2500	0.2000	0.0500	0.0200	0.0025	0.0005	0.0002
E-V	2.0	5.0	3.0	0.0000	0.3000	0.3500	0.2500	0.1000	0.0025	0.0050	0.0050
Late I-V	5.0	15.0	10.0	0.0000	0.0100	0.0100	0.0050	0.0000	0.0000	0.0000	0.0000
SGTS Filter Efficiencies				0.00%	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%	99.00%

Table 2. Release Fractions to Primary Containment and Related Data.

2.2 Isotopic Inventory Data

The isotopic inventory data was also included in the spreadsheet MACCS2DATA.xls. The values were converted from Curies to Becquerels for input into MACCS2. This data is supplied from Reference 3 and the total curie inventory determined by multiplying the Ci/MWt for each isotope by the conservative thermal design power (3616 MWt) of the SSES (Reference 6).

2.3 Population Data

The population data as supplied in the SSES FSAR for year 2000 was supplied by PPL (Reference 7) for 16 radial directions and radial distance rings with outer boundaries at 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles. The year 2000 data was used as a basis because census information shows a trend of population decline for 2010 for this region.

2.4 Evacuation Data

A constant evacuation speed was selected based on the estimate of 6 hours for a daytime evacuation in fair weather provided by PPL. The evacuation was assumed to be preceded by a sheltering period of 2 hours. This data was estimated from Reference 8.

2.5 Meteorological Data

Hourly average meteorological data for MACCS2 was taken from data for SSES stored using a CR21 data logger and then downloaded to the ABS MIDAS system for the year 2000 (Reference 9) and converted to MACCS2 input format. Year 2000 meteorological data was used, as it was readily available from existing PPL studies and matched the population information in Section 2.3. Adjustments to small portions of bad data caused by systems calibration and instrumentation problems were performed because MACCS2 does not allow any bad meteorological data. For periods of missing data of two hours or less the missing values were interpolated from the last good hour and next valid hour. For longer periods, (there were two periods that were four hours each) a combination of interpolation between known valid hours, backup tower data, and time of day (for stability) were used. There were only about 24 total hours of invalid data during 2000.

3. METHODOLOGY

3.1 Determining the MACCS2 Source Term

The magnitude and species of the radioactivity release were determined using the NUREG-1465 based BWR Source Term supplied with the NRC sponsored RADTRAD computer code (Reference 2). The input of radionuclides into the primary containment, and the flow and filtering of radionuclides between compartments and into the environment were modeled on a minute-by-minute basis for 30 days following accident initiation. After this model had been completed, each release was divided into 4 puffs, 0-6 hours, 6-24 hours, 24-96 hours, and 96-720 hours, with a duration of the actual duration or 10 hours, whichever was smaller. Each puff was assumed to be released at the beginning of the time corresponding time interval. Each case was conservatively assumed to be at ground level and to release no sensible heat.

3.2 SSES Containment Model

The model that represents the SSES containment release pathways was patterned after Design Calculation EC-RADN-1028 (Reference 4). This containment release model includes release contributions to the environment from the three primary release pathways.

The first release pathway is from the primary containment to the secondary containment, which has a design value of 1% per day, designated L_a. The contents of the secondary containment are processed by the Standby Gas Treatment System (SGTS), an Engineered Safety Feature (ESF). The SGTS has a design flow of 4000 SCFM, a filtration of 99% for iodine, and an assumed filtration rate of 99% for particulates. The value of L_a is varied in each of the MACCS2 cases to model the severity of primary containment failure as shown in Table 1.

The second pathway is unfiltered leakage of 9 SCFH that is assumed to bypass the secondary containment. This is assumed constant in all the MACCS2 analyses, but is augmented by additional bypass flow of 100% per day in cases 6 and 7, as shown in Table 1.

The third release pathway accounts for assumed leakage through closed main steam isolation valves (MSIV) and accounts for possible leak-by flow of up to 300 SCFH through the closed MSIVs. This leakage is processed through the Isolated Condenser Treatment Method (ICTM) as identified and accepted for use at SSES in License Amendments #151 (Unit 1) and #121 (Unit 2) to the SSES Operating Licenses (Reference 10). Because the MACCS2 code system is not designed to explicitly model this pathway, the contribution to the integrated population dose was scaled from the design values determined in Reference 4. This contribution was then held fixed and added to all the PPL containment risk pathway doses as it was assumed that the flow through this pathway was unaffected by severe containment failure. In actuality, the pathway contribution would probably decrease as the driving pressure would be reduced in the more severe accident classes.

The input rate of each class of radionuclides was determined by dividing the release fraction for each phase by the duration of the phase, and was applied during that entire phase. Only the applicable phases were used for each release class. The containment model can then be reduced to a set of coupled linear differential equations. These equations were solved numerically on a Microsoft Excel® spreadsheet for each isotope group of each release class, and the resulting release fractions were used as input to MACCS2. The spreadsheets are voluminous, and are included on CD media (Reference 11) with this calculation. Each release was divided into four puffs as described in section 3.1. The release fractions for each MACCS2 case for each puff and total are shown in Table 3.

3.3 Assembling the MACCS2 Input Files

MACCS2 requires five input files for each run. These are the ATMOS input file, the EARLY input file, the CHRONC input file, the site data file, and the meteorological data file. The ATMOS input file contains the release data, and is the only file that changes between runs. The site-specific population, core inventory, and evacuation data was manually edited into the appropriate data files. The ATMOS input file was divided into three parts that are the same for all runs, with two sections between these portions that are release-dependent. Each of the seven MACCS2 source terms were transferred to a separate sheet of a spreadsheet, and this was used along with the fixed sections of text to generate the ATMOS input file for each MACCS2 case using a Visual Basic procedure.

Case Number	Start Time, h	End Time, h	Kr-Xe	I	Cs-Rb	Te-Sb	Ba-Sr	Ru	Ce	La
			Release By Case, Phase and Isotope Group							
1	0	6	3.928E-4	1.379E-5	1.157E-5	2.214E-6	8.855E-7	1.107E-7	2.214E-8	8.855E-9
	6	24	5.013E-3	6.085E-5	5.073E-5	1.013E-5	4.050E-6	5.063E-7	1.013E-7	4.050E-8
	24	96	2.886E-2	2.638E-4	2.198E-4	4.397E-5	1.759E-5	2.198E-6	4.397E-7	1.759E-7
	96	720	2.019E-1	1.814E-3	1.511E-3	3.023E-4	1.209E-4	1.511E-5	3.023E-6	1.209E-6
	Total Release		2.361E-1	2.152E-3	1.793E-3	3.586E-4	1.434E-4	1.793E-5	3.586E-6	1.434E-6
2	0	6	7.438E-4	1.488E-5	1.249E-5	2.384E-6	9.535E-7	1.192E-7	2.384E-8	9.535E-9
	6	24	9.834E-3	7.512E-5	6.264E-5	1.249E-5	4.995E-6	6.244E-7	1.249E-7	4.995E-8
	24	96	5.600E-2	3.410E-4	2.841E-4	5.683E-5	2.273E-5	2.841E-6	5.683E-7	2.273E-7
	96	720	3.433E-1	2.062E-3	1.718E-3	3.437E-4	1.375E-4	1.719E-5	3.437E-6	1.375E-6
	Total Release		4.099E-1	2.493E-3	2.078E-3	4.154E-4	1.662E-4	2.077E-5	4.154E-6	1.662E-6
3	0	6	3.534E-3	2.355E-5	1.981E-5	3.734E-6	1.494E-6	1.867E-7	3.734E-8	1.494E-8
	6	24	4.711E-2	1.854E-4	1.547E-4	3.075E-5	1.230E-5	1.538E-6	3.075E-7	1.230E-7
	24	96	2.375E-1	8.549E-4	7.124E-4	1.425E-4	5.702E-5	7.127E-6	1.425E-6	5.702E-7
	96	720	6.074E-1	2.174E-3	1.812E-3	3.627E-4	1.451E-4	1.813E-5	3.627E-6	1.451E-6
	Total Release		8.955E-1	3.238E-3	2.699E-3	5.397E-4	2.159E-4	2.699E-5	5.397E-6	2.159E-6
4	0	6	1.206E-2	5.000E-5	4.214E-5	7.860E-6	3.144E-6	3.930E-7	7.860E-8	3.144E-8
	6	24	1.500E-1	4.896E-4	4.084E-4	8.118E-5	3.247E-5	4.059E-6	8.118E-7	3.247E-7
	24	96	5.273E-1	1.661E-3	1.383E-3	2.773E-4	1.109E-4	1.386E-5	2.773E-6	1.109E-6
	96	720	2.912E-1	9.142E-4	7.614E-4	1.527E-4	6.110E-5	7.637E-6	1.527E-6	6.109E-7
	Total Release		9.806E-1	3.114E-3	2.595E-3	5.191E-4	2.076E-4	2.595E-5	5.191E-6	2.076E-6
5	0	6	3.288E-2	1.351E-2	1.242E-2	4.268E-3	1.707E-3	1.071E-4	6.924E-5	5.957E-5
	6	24	3.421E-1	2.003E-1	1.992E-1	9.765E-2	3.867E-2	1.650E-3	1.762E-3	1.660E-3
	24	96	5.810E-1	3.681E-1	3.702E-1	1.887E-1	7.397E-2	3.013E-3	3.408E-3	3.233E-3
	96	720	3.711E-2	2.387E-2	2.405E-2	1.234E-2	4.828E-3	1.951E-4	2.228E-4	2.117E-4
	Total Release		9.931E-1	6.058E-1	6.058E-1	3.029E-1	1.192E-1	4.966E-3	5.462E-3	5.164E-3
6	0	6	1.806E-1	5.526E-2	4.633E-2	8.930E-3	3.572E-3	4.465E-4	8.930E-5	3.572E-5
	6	24	4.320E-1	1.280E-1	1.065E-1	2.148E-2	8.590E-3	1.074E-3	2.148E-4	8.590E-5
	24	96	3.625E-1	1.065E-1	8.866E-2	1.788E-2	7.152E-3	8.940E-4	1.788E-4	7.152E-5
	96	720	1.807E-2	5.289E-3	4.401E-3	8.877E-4	3.551E-4	4.438E-5	8.876E-6	3.551E-6
	Total Release		9.932E-1	2.950E-1	2.459E-1	4.917E-2	1.967E-2	2.459E-3	4.917E-4	1.967E-4
7	0	6	1.808E-1	5.520E-2	4.628E-2	8.922E-3	3.569E-3	4.461E-4	8.922E-5	3.569E-5
	6	24	4.331E-1	1.273E-1	1.059E-1	2.136E-2	8.546E-3	1.068E-3	2.136E-4	8.546E-5
	24	96	3.618E-1	1.047E-1	8.710E-2	1.757E-2	7.027E-3	8.784E-4	1.757E-4	7.027E-5
	96	720	1.755E-2	5.035E-3	4.190E-3	8.452E-4	3.381E-4	4.226E-5	8.452E-6	3.381E-6
	Total Release		9.933E-1	2.922E-1	2.435E-1	4.870E-2	1.948E-2	2.435E-3	4.870E-4	1.948E-4

Table 3. Summary of the release fractions seven MACCS2 cases.

3.4 Running MACCS2

MACCS2 was run using a MS-DOS batch file that called another MS-DOS batch file with the appropriate file name arguments for each case.

3.5 Assembling the MACCS2 Results

The appropriate data was electronically copied from each MACCS2 output file into an Excel® spreadsheet and parsed to put each data item into a separate column. The results were converted from units of person-Sievert to person-rem, and the results for case 1 were multiplied by the ratio of the dose with and without considering

MSIV releases for the design basis accident to determine the final population dose for that case. The difference between the population doses with and without the MSIV contribution was determined, and the same amount was added on to each of the other cases. This is conservative because the other cases remove more from the containment via other pathways, leaving less to escape through the MSIV leakage pathway.

3.6 MACCS2 Software Quality Assurance

The MACCS2 computer code was purchased from the Radiation Safety Information Computational Center at Oak Ridge National Laboratory. The code was installed on a 600 MHz Pentium III computer with 128MB of RAM using the Microsoft Windows 98 operating system. All of the test cases supplied with the code were run, and the resulting output files were digitally compared to the original output files supplied with the code. The only differences in these runs were in header lines involving the date and time of the run, and in the final lines of each run which show the calculational time. These variations are normal and expected. The verification package is on file at the Bethesda office of ABSG Consulting. All of the runs for this calculation were performed on the same computer used to verify the code (Reference 3). Note also, the MACCS2 code family is the same as that used to perform population dose consequence estimates associated with NRC severe accident studies such as NUREG/CR-4551, "Evaluation of Severe Accident Risks: Peach Bottom, Unit 2", December 1990.

4. RESULTS

The whole body effective dose equivalent population dose for each of the seven cases run is shown in Table 4 for each case. The MSIV dose add-on is a constant 3.55E+04 person-rem for each case.

Case Number	No MSIV person-rem	With MSIV person-rem
1	2.93E+05	3.29E+05
2	3.27E+05	3.63E+05
3	4.05E+05	4.41E+05
4	4.02E+05	4.38E+05
5	6.23E+06	6.27E+06
6	4.20E+06	4.24E+06
7	4.18E+06	4.22E+06

Table 4. Population dose from MACCS2 runs.

A complete set of input and output files has been placed on a CD enclosed with this calculation (Reference 11).

5. REFERENCES

1. MELCOR Accident Consequence Code System for the Calculation of the Health and Economic Consequences of Accidental Atmospheric Radiological Releases, MACCS2 V.1.12, CCC-652, October 1998.

2. Accident Source Terms for Light-Water Nuclear Power Plants, NUREG-1465, February 1995.

3. Certification of Computer Program – MACCS2, Version 1.12, March 1998, May 2001.

4. SSES Design Basis LOCA Dose Consequence Evaluation Determining Allowable Containment Bypass Leakage Including the Effects of Suppression Pool Scrubbing, Calculation EC-RADN-1028.

5. RADTRAD – A Simplified Model for Radionuclide Transport and Removal And Dose Estimation, NUREG/CR-6604, April 1998.

6. Power Uprate Engineering Report For Susquehanna Steam Electric Station Units 1 and 2, Calculation EC-PUPC-1001, Revision 3, March, 2001.

7. Section 2.1.3, Population Distribution, Susquehanna Steam Electric Station Final Safety Analysis Report, Revision 54, October 1999.

8. Public Protective Action Recommendations, Tab 4, PPL Emergency Procedure EP-PS-215-4.

9. Certification of Computer Program – WK2MACCS, Version 1.0, June 15, 2001, June 2001.

10. PPL SSES Operating License Amendments #151 (Unit 1) and #121 (Unit 2), August 15, 1993.

11. Spreadsheets and data files on computer (CD) media, ABSG Consulting, August 29, 2001.

APPENDIX A: FILE MACCS2SACCIDENTS.XLS

The following shows the contents of file MACCS2SACCIDENTS.XLS as supplied by PPL.

CLASS	DESCRIPTION	Core Activity Release per NUREG-1465	Primary to Secondary Containment Leakage Rate (1,2)	Remarks
1	No Containment Failure	Gap Release + Early In-Vessel	1.0La ; 2.0La	Release to Primary Containment; SGTS functional
2	Large Containment Isolation Failure	Gap Release + Early In-Vessel	35.0La	Release to Primary Containment; SGTS functional
3a	Small Isolation Failure	Gap Release + Early In-Vessel	10.0La	Release to Primary Containment; SGTS functional
3b	Large Isolation Failure	Gap Release + Early In-Vessel	35.0La	Release to Primary Containment; SGTS functional
4	Small Isolation Failure -- Type B Penetration	Gap Release + Early In-Vessel	N/A	N/A
5	Small Isolation Failure -- Type C Penetration	Gap Release + Early In-Vessel	N/A	N/A
6	Containment Isolation Failures -- (dependent failures, personel error)	Gap Release + Early In-Vessel	35.0La	Release to Primary Containment; SGTS functional
7	Severe Accident Induced Failure	Gap Release + Early In-Vessel + Ex-Vessel + Late In-Vessel	100.0La	Release to Primary Containment with No SGTS Filtration; Reactor Building Leakage Rate = 100%/day of free volume
8	Containment Bypassed	Gap Release + Early In-Vessel	1.0La ; 2.0La with additional 100.0La secondary containment bypass	Release to Primary Containment; SGTS functional on 1.0La and 2.0La; No SGTS Filtration of 100La

Notes:
(1) La = total primary to secondary containment leakage rate = 1%/day
(2) Analysis shall include 9 SCFH secondary containment bypass leakage as part of the total primary containment leakage rate unless otherwise specified. Analysis shall also include 300 SCFH MSIV leakage taking credit for the Isolated Condenser Treatment Method (ICTM).

APPENDIX B: FILE MACCS2DATA.XLS

The following shows the contents of file MACCS2DATA.XLS as supplied by PPL.

Isotope	BWR Core Shutdown Activity (Ci/Mwt) from NUREG/ CR-6604	Core Activity Inventory Time= Shutdown @3616 MWt (Curies)	GAP Release to Primary Containment Duration = 0.5 Hours		Early In-Vessel release to Primary Containment Duration = 1.5 Hours		Ex-Vessel Release To Primary Containment Duration = 3.0 Hours		Late In-Vessel Release to Primary Containment Duration = 10.0 Hours	
			NUREG 1465 Release Fraction	Core Activity Released In This Period (Curies)	NUREG 1465 Release Fraction	Core Activity Released In This Period (Curies)	NUREG 1465 Release Fraction	Core Activity Released In This Period (Curies)	NUREG 1465 Release Fraction	Core Activity Release (Curies)
Co-58	1.529E+02	5.529E+05	0	0.000E+00	0.0025	1.382E+03	0.0025	1.382E+03	0	0.000E+00
Co-60	1.830E+02	6.617E+05	0	0.000E+00	0.0025	1.654E+03	0.0025	1.654E+03	0	0.000E+00
Kr-85	2.506E+02	9.062E+05	0.05	4.531E+04	0.95	8.609E+05	0	0.000E+00	0	0.000E+00
Kr-85m	9.110E+03	3.294E+07	0.05	1.647E+06	0.95	3.129E+07	0	0.000E+00	0	0.000E+00
Kr-87	1.657E+04	5.992E+07	0.05	2.996E+06	0.95	5.692E+07	0	0.000E+00	0	0.000E+00
Kr-88	2.236E+04	8.085E+07	0.05	4.043E+06	0.95	7.681E+07	0	0.000E+00	0	0.000E+00
Rb-86	1.402E+01	5.070E+04	0.05	2.535E+03	0.2	1.014E+04	0.35	1.774E+04	0.01	5.070E+02
Sr-89	2.774E+04	1.003E+08	0	0.000E+00	0.02	2.006E+06	0.1	1.003E+07	0	0.000E+00
Sr-90	1.963E+03	7.098E+06	0	0.000E+00	0.02	1.420E+05	0.1	7.098E+05	0	0.000E+00
Sr-91	3.604E+04	1.303E+08	0	0.000E+00	0.02	2.606E+06	0.1	1.303E+07	0	0.000E+00
Sr-92	3.765E+04	1.361E+08	0	0.000E+00	0.02	2.723E+06	0.1	1.361E+07	0	0.000E+00
Y-90	2.102E+03	7.601E+06	0	0.000E+00	0.0002	1.520E+03	0.005	3.800E+04	0	0.000E+00
Y-91	3.386E+04	1.224E+08	0	0.000E+00	0.0002	2.449E+04	0.005	6.122E+05	0	0.000E+00
Y-92	3.780E+04	1.367E+08	0	0.000E+00	0.0002	2.734E+04	0.005	6.834E+05	0	0.000E+00
Y-93	4.298E+04	1.554E+08	0	0.000E+00	0.0002	3.108E+04	0.005	7.771E+05	0	0.000E+00
Zr-95	4.456E+04	1.611E+08	0	0.000E+00	0.0002	3.223E+04	0.005	8.056E+05	0	0.000E+00
Zr-97	4.587E+04	1.659E+08	0	0.000E+00	0.0002	3.317E+04	0.005	8.293E+05	0	0.000E+00
Nb-95	4.216E+04	1.525E+08	0	0.000E+00	0.0002	3.049E+04	0.005	7.623E+05	0	0.000E+00
Mo-99	4.862E+04	1.758E+08	0	0.000E+00	0.0025	4.395E+05	0.0025	4.395E+05	0	0.000E+00
Tc-99m	4.195E+04	1.517E+08	0	0.000E+00	0.0025	3.792E+05	0.0025	3.792E+05	0	0.000E+00
Ru-103	3.691E+04	1.335E+08	0	0.000E+00	0.0025	3.337E+05	0.0025	3.337E+05	0	0.000E+00
Ru-105	2.458E+04	8.888E+07	0	0.000E+00	0.0025	2.222E+05	0.0025	2.222E+05	0	0.000E+00
Ru-106	1.002E+04	3.623E+07	0	0.000E+00	0.0025	9.058E+04	0.0025	9.058E+04	0	0.000E+00
Rh-105	1.835E+04	6.635E+07	0	0.000E+00	0.0025	1.659E+05	0.0025	1.659E+05	0	0.000E+00
Sb-127	2.324E+03	8.404E+06	0	0.000E+00	0.05	4.202E+05	0.25	2.101E+06	0.005	4.202E+04
Sb-129	8.067E+03	2.917E+07	0	0.000E+00	0.05	1.459E+06	0.25	7.293E+06	0.005	1.459E+05
Te-127	2.250E+03	8.136E+06	0	0.000E+00	0.05	4.068E+05	0.25	2.034E+06	0.005	4.068E+04
Te-127m	3.029E+02	1.095E+06	0	0.000E+00	0.05	5.476E+04	0.25	2.738E+05	0.005	5.476E+03
Te-129	7.569E+03	2.737E+07	0	0.000E+00	0.05	1.368E+06	0.25	6.842E+06	0.005	1.368E+05
Te-129m	1.990E+03	7.196E+06	0	0.000E+00	0.05	3.598E+05	0.25	1.799E+06	0.005	3.598E+04
Te-131m	3.821E+03	1.382E+07	0	0.000E+00	0.05	6.908E+05	0.25	3.454E+06	0.005	6.908E+04
Te-132	3.735E+04	1.351E+08	0	0.000E+00	0.05	6.753E+06	0.25	3.376E+07	0.005	6.753E+05
I-131	2.581E+04	9.333E+07	0.05	4.666E+06	0.25	2.333E+07	0.3	2.800E+07	0.01	9.333E+05
I-132	3.792E+04	1.371E+08	0.05	6.856E+06	0.25	3.428E+07	0.3	4.114E+07	0.01	1.371E+06
I-133	5.417E+04	1.959E+08	0.05	9.794E+06	0.25	4.897E+07	0.3	5.876E+07	0.01	1.959E+06
I-134	5.930E+04	2.144E+08	0.05	1.072E+07	0.25	5.361E+07	0.3	6.433E+07	0.01	2.144E+06
I-135	5.099E+04	1.844E+08	0.05	9.219E+06	0.25	4.609E+07	0.3	5.531E+07	0.01	1.844E+06
Xe-133	5.425E+04	1.962E+08	0.05	9.808E+06	0.95	1.864E+08	0	0.000E+00	0	0.000E+00
Xe-135	1.289E+04	4.661E+07	0.05	2.331E+06	0.95	4.428E+07	0	0.000E+00	0	0.000E+00
Cs-134	4.227E+03	1.528E+07	0.05	7.642E+05	0.2	3.057E+06	0.35	5.350E+06	0.01	1.528E+05
Cs-136	1.134E+03	4.101E+06	0.05	2.050E+05	0.2	8.201E+05	0.35	1.435E+06	0.01	4.101E+04
Cs-137	2.530E+03	9.148E+06	0.05	4.574E+05	0.2	1.830E+06	0.35	3.202E+06	0.01	9.148E+04
Ba-139	4.994E+04	1.806E+08	0	0.000E+00	0.02	3.612E+06	0.1	1.806E+07	0	0.000E+00
Ba-140	4.927E+04	1.782E+08	0	0.000E+00	0.02	3.563E+06	0.1	1.782E+07	0	0.000E+00
La-140	5.027E+04	1.818E+08	0	0.000E+00	0.0002	3.636E+04	0.005	9.089E+05	0	0.000E+00
La-141	4.642E+04	1.679E+08	0	0.000E+00	0.0002	3.357E+04	0.005	8.393E+05	0	0.000E+00
La-142	4.466E+04	1.615E+08	0	0.000E+00	0.0002	3.230E+04	0.005	8.075E+05	0	0.000E+00
Ce-141	4.473E+04	1.617E+08	0	0.000E+00	0.0005	8.087E+04	0.005	8.087E+05	0	0.000E+00
Ce-143	4.355E+04	1.575E+08	0	0.000E+00	0.0005	7.874E+04	0.005	7.874E+05	0	0.000E+00
Ce-144	2.901E+04	1.049E+08	0	0.000E+00	0.0005	5.245E+04	0.005	5.245E+05	0	0.000E+00
Pr-143	4.263E+04	1.542E+08	0	0.000E+00	0.0002	3.083E+04	0.005	7.708E+05	0	0.000E+00
Nd-147	1.905E+04	6.888E+07	0	0.000E+00	0.0002	1.378E+04	0.005	3.444E+05	0	0.000E+00
Np-239	5.677E+05	2.053E+09	0	0.000E+00	0.0005	1.026E+06	0.005	1.026E+07	0	0.000E+00
Pu-238	3.948E+01	1.428E+05	0	0.000E+00	0.0005	7.138E+01	0.005	7.138E+02	0	0.000E+00
Pu-239	1.001E+01	3.620E+04	0	0.000E+00	0.0005	1.810E+01	0.005	1.810E+02	0	0.000E+00
Pu-240	1.253E+01	4.531E+04	0	0.000E+00	0.0005	2.265E+01	0.005	2.265E+02	0	0.000E+00
Pu-241	2.157E+03	7.800E+06	0	0.000E+00	0.0005	3.900E+03	0.005	3.900E+04	0	0.000E+00
Am-241	2.193E+00	7.930E+03	0	0.000E+00	0.0002	1.586E+00	0.005	3.965E+01	0	0.000E+00
Cm-242	5.791E+02	2.094E+06	0	0.000E+00	0.0002	4.188E+02	0.005	1.047E+04	0	0.000E+00
Cm-244	3.125E+01	1.130E+05	0	0.000E+00	0.0002	2.260E+01	0.005	5.650E+02	0	0.000E+00