004 – PM 1058 Rev 0 MSLB

(22)

Exelon Nuclear

CC-AA-309-1001
Revision 0

ATTACHMENT 1
Design Analysis Cover Sheet

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Analysis No. PM-1058 **Revision** 0
EC/ECR No. PB 02-00838 **Revision**
Title: Reanalysis of Main Steam Line Break (MSLB) Accident Using Alternative Source Terms

		Component(s)	
Station(s)	Peach Bottom Atomic Power Station	N/A	
Unit No.:	2 and 3		
Discipline	SEAQ		
Description Code/ Keyword	MSLB		
Safety Class	S		
System Code	912		
Structure	N/A		

CONTROLLED DOCUMENT REFERENCES

Document No.	From/To	Document No.	From/To
Calc. PM-740, Rev. 1A	From		
UFASR; Section 14.6.5, Rev 18	From/To		
Calc. PM-738, Rev A	From		

Is this Design Analysis Safeguards? Yes ☐ No ☒
Does this Design Analysis Contain Unverified Assumptions? Yes ☐ No ☒ ATI/AR#
Is a Supplemental Review Required? Yes ☐ No ☒ If yes, complete Attachment 3

Preparer: Harold Rothstein (Print Name) — [signature] (Sign Name) — 3/20/03 (Date)

Reviewer: Paul Reichert (Print Name) — [signature] (Sign Name) — 3/20/03 (Date)

Method of Review: ☒ Detailed Review ☐ Alternate Calculations ☐ Testing

Review Notes:

Approver: Harold Rothstein (Print Name) — [signature] (Sign Name) — 3/20/03 (Date)

(For External Analyses Only)
Exelon Reviewer: Thomas J. Mscisz (Print Name) — [signature] (Sign Name) — 3/21/03 (Date)

Approver: James Jordan (Print Name) — [signature] (Sign Name) — 3/28/03 (Date)

Description of Revision (list affected pages for partials):

THIS DESIGN ANALYSIS SUPERCEDES: N/A

CALCULATION TABLE OF CONTENTS

1.0 PURPOSE/OBJECTIVE

The purpose of this calculation is to determine the Control Room (CR), Exclusion Area Boundary (EAB), and Low Population Zone (LPZ) doses following a Main Steam Line Break (MSLB) Accident based on the assumptions on the break and resulting radiological releases to the Turbine Building as discussed in UFSAR [Reference 1] Sections 14.6.5 and 14.9.2.3, and the additional assumptions for use of Alternative Source Terms (AST) contained in Appendix D of Regulatory Guide (R. G.) 1.183 [Reference 6].

Inhalation Committed Effective Dose Equivalent (CEDE) Dose Conversion Factors (DCFs) from Federal Guidance Report No. 11 [Ref. 3] are used for calculation of normalized Iodine-131 Dose Equivalent activity in this calculation.

As per UFSAR Section 14.6.5, this event involves the postulation that one main steam line instantaneously and circumferentially breaks outside the secondary containment at a location downstream of the outermost isolation valve. Closure of the Main Steam Isolation Valves (MSIVs) terminates the mass loss when the full closure is reached. No operator actions are assumed to be taken during the accident, so the normal air intake into the Control Room continues unfiltered during the duration of the event.

The mass of coolant released during the MSLB was obtained from reference 1, which bases analysis on 10.5-second closure of main steam isolation valve. Specifically, as per UFSAR Section 14.9.1.5 and the Reference 2 MSLB Calculation for Power Rerate, a release of 165,120 pounds of reactor water and 25,800 pounds of steam is used.

2.0 METHODOLOGY AND ACCEPTANCE CRITERIA

2.1 *General Description*

The radiological consequences resulting from a design basis MSLB accident to a person at the EAB; to a person at the LPZ; and to an operator in the Control Room following an MSLB accident were performed using a Microsoft EXCEL spreadsheet, provided as Attachment A.

2.2 *Source Term Model*

No fuel damage is expected to result from a MSLB. Therefore, the activity available for release from the break is that present in the reactor coolant and steam lines prior to the break, with two cases analyzed, corresponding to the Reactor Coolant System Specific Activity limits in Technical Specification 3.4.6 and its Basis. Case 1 is for continued full power operation with a maximum equilibrium coolant concentration of 0.2 uCi/gm dose equivalent I-131. Case 2 is for a maximum coolant concentration of 4.0 uCi/gm dose equivalent I-131, based on a pre-accident iodine spike caused by power changes. In determining I-131 equivalence, inhalation CEDE DCFs from Ref. 3 are used. This accident source term basis meets the guidance in R.G. 1.183 for analysis of this event.

2.3 *Release Model*

The release model is identical to that historically used. The previously determined mass of reactor coolant release and mass of steam release, before the break is isolated by MSIV closure, are used. Reactor coolant radioactivity is based on the above reactor coolant concentrations.

Releases are assumed to be instantaneous and no credit is taken for dilution in turbine building air.

2.4 *Dispersion Model*

Offsite and Onsite X/Q determinations are handled differently, but conservatively in both cases.

2.4.1 EAB and LPZ

EAB and LPZ X/Q's are determined using the original methodology in R.G. 1.5 [Ref. 5]. Specifically:

$$\frac{\chi}{Q} = \frac{0.0133}{\sigma_y u}$$

where

σ_y = horizontal standard deviation of the plume (meters)

u = wind velocity (meters/second)

Horizontal standard deviations are taken from the PAVAN outputs for the EAB and LPZ included in Calculation PM-1055 [Ref. 9]. Per Regulatory Guide 1.5, F stability and a 1 meter/sec wind speed are used.

2.4.2 Control Room

For control room dose calculations, the plume was modeled as a hemispherical volume, the dimensions of which are determined based on the initial steam blowdown and that portion of the liquid reactor coolant release that flashed to steam.

Activity release is conservatively assumed to effectively occur at the Control Room intake elevation and, again conservatively, no credit is taken for plume buoyancy. A conservative translation time of the plume over the intake is assumed.

The activity of the cloud is based on the total mass of water released from the break, not just the portion that flashes to steam. This assumption is conservative because it considers the maximum release of fission products.

2.5 *Dose Model*

Dose models for both onsite and offsite are simplified and meet R.G. 1.183 [Ref. 6] requirements, providing results in units of Total Effective Dose Equivalent (TEDE). Dose conversion factors are based on Federal Guidance Reports 11 and 12 [Refs 3 & 4].

2.5.1 EAB and LPZ

Doses at the EAB and LPZ for the MSLB are based on the following formulas:

$$Dose_{CEDE}\ (rem) = Release\ (Curies) * \frac{\chi}{Q}(sec/m^3) * Breathing\ Rate\ (m^3/sec) * Inhalation\ DCF\ (rem_{CEDE}/Ci\ inhaled)$$

and

$$Dose_{EDE}\ (rem) = Release\ (Curies) * \frac{\chi}{Q}(sec/m^3) * Submersion\ DCF\ (rem_{EDE} - m^3/Ci - sec)$$

and finally,

$$Dose_{TEDE}\ (rem) = Dose_{CEDE}\ (rem) + Dose_{EDE}\ (rem)$$

2.5.2 Control Room

CR operator doses are determined somewhat differently, because steam cloud concentrations are used, rather than X/Q times a curie release rate. No CR filter credit is taken and, therefore, for inhalation, a dose for a location outside of the CR can be and is used. For cloud submersion, a geometry factor is used to credit the reduced plume size seen in the control room. This is a conservative implementation of RG 1.183 guidance. The formulas used are:

$$Dose_{CEDE}\ (rem) = Plume\ Concentration\ (Ci/m^3) * Transit\ Duration\ (sec) * Breathing\ Rate\ (m^3/sec) * Inhalation\ DCF\ (rem_{CEDE}/Ci\ inhaled)$$

and

$$Dose_{EDE}\ (rem) = Plume\ Concentration\ (Ci/m^3) * Transit\ Duration\ (sec) * Submersion\ DCF\ (rem_{EDE} - m^3/Ci - sec)$$

and finally,

$$Dose_{TEDE}\ (rem) = Dose_{CEDE}\ (rem) + Dose_{EDE}\ (rem)$$

2.6 *Acceptance Criteria*

Dose acceptance criteria are per 10CFR50.67 [Ref. 7] and R.G. 1.183 [Ref. 6] guidance.

Table 1 lists the regulatory limits for accidental dose to 1) a control room operator, 2) a person at the EAB, and 3) a person at the LPZ boundary.

Table 1. Regulatory Dose Limits (Rem TEDE) per Refs. 7 and 6.

I-131 Dose Equivalent	CR (30 days)	EAB (2 hours)	LPZ (30 days
Normal Equilibrium	5	2.5	2.5
Iodine Spike	5	25	25

3.0 ASSUMPTIONS

3.1 *Activity Release and Transport Models*

- Iodine activity distribution in the coolant is taken from UFSAR [Ref. 1] Section 14.6.5.2.1, assumption 2.
- Total release quantities from the break are taken from UFSAR [Ref. 1] Section 14.9.1.5, with Section 14.6.5 break flow and MSIV closure characteristics, including the conservative10-second valve closure time in comparison to the less than or equal to 5 seconds isolation time limit of Surveillance Requirement 3.6.1.3.9 [Ref. 8].
- Release from the break to the environment is assumed instantaneous. No holdup in the Turbine Building or dilution by mixing with Turbine Building air volume is credited.
- The steam cloud is assumed to consist of the initial steam blowdown and that portion of the liquid reactor coolant release that flashed to steam.
- The activity of the cloud is based on the total mass of water released from the break, not just the portion that flashes to steam. This assumption is conservative because it considers the maximum release of fission products.
- The fraction of liquid water contained in steam, which carries activity into the cloud, is assumed to be 2%, a conservatively high value consistent with current Boiling Water Reactor practice.
- A conservatively high flashing fraction of liquid water released of 40% is assumed. However, all activity in the water is assumed to be released.
- For offsite dose calculations, the release is treated per Regulatory Guide 1.5 [Ref. 5]. Buoyancy effect of the cloud was conservatively ignored.
- For the control room dose calculations,
  - the plume is modeled as a hemispherical volume. This is consistent with the assumption of no Turbine Building credit. It is also reasonable for the more likely release paths through multiple large openings above the Turbine Building operating deck.
  - dispersion of the activity of the plume is conservatively ignored.
  - The cloud is assumed to be carried away by a wind of speed 1 m/s. Credit is not taken for decay.

3.2 *Control Room Model*

- No credit is taken for the operation of the control room emergency filtration systems during the MSLB.
- Inhalation doses are determined based on concentrations at the intake, and exposures for the duration of plume traverse.
- External exposure doses are determined based on concentrations at the intake, exposures for the duration of plume traverse, and a geometry factor credit based on the control room envelope volume of 176,000 cubic feet.

3.3 *Site Boundary Model*

This model is as discussed in Subsection 2.5 above.

4.0 DESIGN INPUT

4.1 *Mass Release Data*

- The mass of steam released is 25,800 lb. [Section 14.9.1.5 of Ref. 1 and Ref. 2]
- The mass of liquid water released is 165,120 lb. [Section 14.9.1.5 of Ref. 1 and Ref. 2]

4.2 *Iodine Distribution*

The PBAPS UFSAR [Ref. 1] Section 14.6.5.2.1 provides the following design basis concentrations of significant radionuclides contained in the coolant:

Iodine Isotope	Activity (μCi/cc)
I-131	0.17
I-132	1.02
I-133	1.04
I-134	1.47
I-135	1.30

4.3 *Noble Gas Distribution*

The MSLB Power Rerate Calculation [Ref. 2] provides the following Noble Gas concentrations for potentially significant radionuclides contained in the coolant:

Noble Gas Isotope	Concentration uCi/g
Kr-83M	1.92E-03
Kr-85M	3.44E-03
Kr-85	1.13E-05
Kr-87	1.13E-02
Kr-88	1.13E-02
Kr-89	7.33E-02
Xe-131M	8.46E-06
Xe-133M	1.63E-04
Xe-133	4.62E-03
Xe-135M	1.47E-02
Xe-135	1.24E-02
Xe-137	8.46E-02
Xe-138	5.02E-02

4.4 *Control Room Data*

- Control Room Envelope = 176,000 ft^3. [Ref. 10]
- *No Emergency Filtration Credit taken.*

4.5 *EAB and LPZ Data*

- EAB Distance from Release, m 915 [Ref. 1]
- LPZ Distance from Release, m 7300 [Ref. 1]

5.0 REFERENCES

1. PBAPS UFSAR, Rev. 18.
2. PBAPS Calculation PM-740, Rev. 1A, "Power Rerate MSLB Dose Verification and Rerated Doses".
3. Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion", 1988.
4. Federal Guidance Report No. 12, "External Exposure to Radionuclides in Air, Water, and Soil", 1993.
5. Regulatory Guides 1.5, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accidents for Boiling Water Reactors," 3/10/71.
6. Regulatory Guide 1.183, "Alternative Radiological Source Terms For Evaluating Design Basis Accidents At Nuclear Power Reactors", July 2000.
7. 10 CFR Part 50.67, "Accident Source Term".
8. PBAPS Technical Specification 3.6.1.3, "Primary Containment Isolation Valves", Surveillance Requirement 3.6.1.3.9.
9. Design Analysis No. PM-1055, Rev. 0 "Calculation of Alternative Source Terms Onsite and Offsite X/Q Values".
10. PBAPS Calculation PM-738, Rev. A, "Power Rerate Control Rod Drop Dose Verification and Rerated Doses".

6.0 CALCULATIONS

No or minimal fuel damage is expected for the limiting MSLB. As discussed in section 2, two iodine concentrations will be used (0.2 μCi/g and 4.0 μCi/g) [per Refs. 6 and 8] when determining the consequences of the main steam line break. All of the radioactivity in the released coolant is assumed to be released to the atmosphere instantaneously as a ground-level release. No credit is taken for plateout, holdup, or dilution within facility buildings.

The spreadsheets in Attachment A perform this analysis using data and formulations discussed above. The following summarizes parameters and their treatment in the spreadsheet.

6.1 *Cloud Volumes, Masses, and Control Room Intake Transit Times*

As stated in Section 3.1, the cloud is assumed to consist of the initial steam blowdown and that portion of the liquid reactor coolant release that flashes to steam. The flashing fraction (FF) is derived as follows:

FF x (steam enthalpy at 212 F) + (1-FF) x (liquid enthalpy at 212 F) =
(liquid enthalpy at temperature of steam at reactor vessel outlet)

A 548 F vessel outlet temperature is used, with liquid enthalpy of 546.9 BTU/lb.
At 212 F, a steam enthalpy of 1150.5 BTU/lb and a liquid enthalpy of 180.17 BTU/lb are used (these enthalpies are taken from the ASME Steam Tables).

Substituting,

FF = (546.9 - 180.17) / [(1150.5 – 180.17)] = .378

For conservatism, a value of .40 or 40% is used below.

Mass of water carrying activity into the cloud is calculated as the sum of the fraction of water in the steam and the liquid blowdown.

The mass steam released	= 25,800 lb
The mass liquid water released	= 165,120 lb
Flashing fraction for calculating cloud volume	= 40%
The mass water contained in steam released	= (25,800 lb) * 2%
	= 516 lb
The mass of water carrying activity into the cloud	= 516 + 165,120 lb
	= 165,636 lb
	= (165,636 lb)(453.59 g/lb)
	= 7.5131E7 g
The mass of steam in the cloud	= (25,800 - 516) + 40%*165,120 lb
	=25,284 + 66,048
	= 91,332 lb

The release is assumed to be a hemisphere with a uniform concentration. The cloud dimensions (based on 91,332 lb of steam at 14.7 psi and 212 °F, v_g = 26.799 ft^3/lb) are calculated as follows:

$$\begin{aligned} \text{Volume} &= (91{,}332 \text{ lb})(26.799 \text{ ft}^3/\text{lb}) \\ &= 2{,}447{,}600 \text{ ft}^3 \\ &= (2{,}447{,}600 \text{ ft}^3)/(35.3 \text{ ft}^3/\text{m}^3) \\ &= 69{,}337 \text{ m}^3 \end{aligned}$$

The volume of a hemisphere is $\pi d^3/12$. Thus, the diameter of the hemispherical cloud is 64.2 meters.

The period of time required for the cloud to pass over the control room intake, assuming a wind speed of 1 m/s is 64.2 s (=(64.2 m)/(1 m/s)).

Therefore, at a wind speed of 1 m/s, the base of the hemispherical cloud will pass over the control room intake in 64.2 seconds.

6.2 *Dispersion for Offsite Dose Assessment*

As discussed in Section 2.4.2 the following formulation was used for Offsite Dose X/Q assessment, with F Pasquill Stability and a 1 m/sec wind speed.

$$\frac{\chi}{Q} = \frac{0.0133}{\sigma_y u}$$

where

σ_y = horizontal standard deviation of the plume (meters)

u = wind velocity (meters/second)

As calculated in the PAVAN run in Reference 9, at the 1040 meter EAB distance σ_y is 38.3, and at the 7300 meter LPZ distance σ_y is 222.6. The resulting EAB and LPZ X/Qs are 3.47E-04 and 5.97E-05 sec/m^3, respectively.

6.3 *Release Isotopics and Quantification*

The iodine isotopic distribution given in Section 4.2 is used. The concentrations of this mix are adjusted to I-131 equivalence, using the inhalation Committed Effective Dose Equivalent (CEDE) Dose Conversion Factors (DCFs) from Federal Guidance Report No. 11 [Ref. 3]. This is a more conservative set of DCF assumptions for Control Room and off-site dose calculation than the use of ICRP 2 DCFs. It is also more conservative for these calculations than use of R. G. 1.109 or Federal Guidance Report No. 12 [Ref. 4] DCFs.

This I-131 equivalent mix is adjusted to the activity yielding the two design basis MSLB accident reactor coolant activities of 0.2 μCi/cc and 4.0 μCi/cc. The released activities are these concentrations times the 7.51E+07 grams of water carrying activity released, with the assumption that TS activities are based on laboratory temperature and pressure conditions.

For the Noble Gases, the isotopic distribution given in Section 4.3 is used. The released activities are these concentrations times the 25,800 lb mass of steam released, converted to 1.17E+07 grams using the 453.59 g/lb conversion factor.

6.4 *Dose Assessment*

Doses at the EAB and LPZ distances, and in the Control Room are calculated in Attachment A using the formulas in Section 2.5. Concentrations at the receptor locations are that in the steam plume for the Control Room or based on the release times the applicable X/Q for the EAB and LPZ.

Doses are calculated for inhalation (rem CEDE) and plume submersion (rem EDE) and totaled to yield rem TEDE. The breathing rate of 3.47E-04 m^3/sec is per RG 1.183 guidance without the round-off.

The resulting calculated doses are in the spreadsheet and in the Summary and Conclusions Section below.

7.0 SUMMARY AND CONCLUSIONS

- Accidental doses from a design basis MSLB were calculated for the control room operator, a person at EAB, and a person at LPZ. The results are summarized in the Table below. The doses at the Control Room, EAB, and LPZ resulting from a postulated design basis MSLB do not exceed, and are a small fraction of, the regulatory limits.

Location	***Case 1*** **(normal equilibrium limit of 0.2 μCi) Dose (rem TEDE)**	***Case 2*** **(Iodine spike limit of 4.0 μCi) Dose (rem TEDE)**
LIMITS	CR: 5.0; EAB&LPZ: 2.5	CR: 5.0; EAB&LPZ: 25
EAB	7.99E-02	1.60E+00
LPZ	1.38E-02	2.75E-01
CR	1.62E-01	3.23 E+00

8.0 Owners Acceptance Review Checklist for External Design Analysis

Page 1 of 1

DESIGN ANALYSIS NO. PM-1058 REV: 0

	Yes	No	N/A
1. Do assumptions have sufficient rationale?	☒	☐	☐
2. Are assumptions compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
3. Do the design inputs have sufficient rationale?	☒	☐	☐
4. Are design inputs correct and reasonable?	☒	☐	☐
5. Are design inputs compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
6. Are Engineering Judgments clearly documented and justified?	☒	☐	☐
7. Are Engineering Judgments compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
8. Do the results and conclusions satisfy the purpose and objective of the design analysis?	☒	☐	☐
9. Are the results and conclusions compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
10. Does the design analysis include the applicable design basis documentation?	☒	☐	☐
11. Have any limitations on the use of the results been identified and transmitted to the appropriate organizations?	☒	☐	☐
12. Are there any unverified assumptions?	☐	☒	☐
13. Do all unverified assumptions have a tracking and closure mechanism in place?	☐	☐	☒

EXELON REVIEWER: T. J. Mscisz / [signature] **DATE:** 3/21/03
Print / Sign

	A	B	C	D	E	F	G	H	I	J	K
1	**PBAPS MSLB Dose Spreadsheet**					Case 1:	Reactor Coolant at maximum value (DE I-131 of 0.2 uCi/cc) permitted for				
2							continued full power operation				
3	69,337	Volume of cloud (cubic meters)				Case 2:	Reactor Coolant at maximum value permitted (DE I-131 of 4.0 uCi/cc)				
4	7.51E+07	Mass of water in reactor coolant release (grams)					corresponding to an assumed pre-accident spike				
5	1.17E+07	Mass of steam release (grams)									
6	1	reactor coolant density when activity is measured (grams/cc)									
7	64.2	seconds for cloud to pass over CR intake for wind speed of 1 m/second									
8	176000	Volume of Control Room Envelope (cubic feet)									
9											
10	Halogens								Case 1	Case 2	
11		Activity							Release	Release	
12		Distribution		Normalized	Case 1	Case 2	Case 1	Case 2	Cloud	Cloud	
13	Isotope	(UFSAR	FGR 11	I-131 DE	Normalized	Normalized	Activity	Activity	Concentration	Concentration	
14		Sect. 14.6.5)	DCF[1]	Activity	Activity	Activity	Release	Release			
15		uCi/cc	Rem/Ci	uCi/cc	uCi/cc	uCi/cc	Ci	Ci	Ci/m^3	Ci/m^3	
16	I-131	0.17	3.29E+04	1.70E-01	8.07E-02	1.61E+00	6.07E+00	1.21E+02	8.75E-05	1.75E-03	
17	I-132	1.02	3.81E+02	1.18E-02	5.61E-03	1.12E-01	3.64E+01	7.28E+02	5.25E-04	1.05E-02	
18	I-133	1.04	5.85E+03	1.85E-01	8.78E-02	1.76E+00	3.71E+01	7.42E+02	5.35E-04	1.07E-02	
19	I-134	1.47	1.31E+02	5.85E-03	2.78E-03	5.56E-02	5.25E+01	1.05E+03	7.57E-04	1.51E-02	
20	I-135	1.3	1.23E+03	4.86E-02	2.31E-02	4.62E-01	4.64E+01	9.28E+02	6.69E-04	1.34E-02	
21				4.21E-01	2.00E-01	4.00E+00					
22					"non-spiked"	"spiked"					
23	Noble Gases										
24		Calc.			Case 1	Case 2					
25		PM-740-A			Release	Release					
26		Table 3	Case 1	Case 2	Cloud	Cloud					
27	Isotope	Noble Gas	Activity	Activity	Concentration	Concentration					
28		Activity	Release	Release							
29		uCi/gm	Ci	Ci	Ci/m^3	Ci/m^3					
30											
31	Kr-83M	1.92E-03	2.25E-02	2.25E-02	3.24E-07	3.24E-07					
32	Kr-85M	3.44E-03	4.03E-02	4.03E-02	5.81E-07	5.81E-07					
33	Kr-85	1.13E-05	1.32E-04	1.32E-04	1.91E-09	1.91E-09					
34	Kr-87	1.13E-02	1.32E-01	1.32E-01	1.91E-06	1.91E-06					
35	Kr-88	1.13E-02	1.32E-01	1.32E-01	1.91E-06	1.91E-06					
36	Kr-89	7.33E-02	8.58E-01	8.58E-01	1.24E-05	1.24E-05					
37	Xe-131M	8.46E-06	9.90E-05	9.90E-05	1.43E-09	1.43E-09					
38	Xe-133M	1.63E-04	1.91E-03	1.91E-03	2.75E-08	2.75E-08					
39	Xe-133	4.62E-03	5.41E-02	5.41E-02	7.80E-07	7.80E-07					
40	Xe-135M	1.47E-02	1.72E-01	1.72E-01	2.48E-06	2.48E-06					
41	Xe-135	1.24E-02	1.45E-01	1.45E-01	2.09E-06	2.09E-06					
42	Xe-137	8.46E-02	9.90E-01	9.90E-01	1.43E-05	1.43E-05					
43	Xe-138	5.02E-02	5.87E-01	5.87E-01	8.47E-06	8.47E-06					
44											

	A	B	C	D	E	F	G	H	I	J	K
45	Inhalation Doses										
46			Curies Released				Case 1 Dose (rem CEDE)			Case 2 Dose (rem CEDE)	
47			to the Environment				(Inhalation)			(Inhalation)	
48	Isotope		Case 1	Case 2	DCF[1]	CR	EAB	LPZ	CR	EAB	LPZ
49	I-131		6.07E+00	1.21E+02	3.29E+04	6.41E-02	2.41E-02	4.14E-03	1.28E+00	4.81E-01	8.28E-02
50	I-132		3.64E+01	7.28E+02	3.81E+02	4.46E-03	1.67E-03	2.88E-04	8.91E-02	3.34E-02	5.75E-03
51	I-133		3.71E+01	7.42E+02	5.85E+03	6.97E-02	2.61E-02	4.50E-03	1.39E+00	5.23E-01	9.00E-02
52	I-134		5.25E+01	1.05E+03	1.31E+02	2.21E-03	8.28E-04	1.42E-04	4.42E-02	1.66E-02	2.85E-03
53	I-135		4.64E+01	9.28E+02	1.23E+03	1.83E-02	6.88E-03	1.18E-03	3.67E-01	1.38E-01	2.37E-02
54					Totals	**1.59E-01**	**5.96E-02**	**1.02E-02**	**3.18E+00**	**1.19E+00**	**2.05E-01**
55											
56	External Doses										
57			Curies Released				Case 1 Dose (rem EDE)			Case 2 Dose (rem EDE)	
58			to the Environment				(External)			(External)	
59	Isotope		Case 1	Case 2	DCF[2]	CR	EAB	LPZ	CR	EAB	LPZ
60	I-131		6.07E+00	1.21E+02	6.73E-02	1.91E-05	1.42E-04	2.44E-05	3.82E-04	2.84E-03	4.88E-04
61	I-132		3.64E+01	7.28E+02	4.14E-01	7.06E-04	5.24E-03	9.01E-04	1.41E-02	1.05E-01	1.80E-02
62	I-133		3.71E+01	7.42E+02	1.09E-01	1.89E-04	1.40E-03	2.41E-04	3.78E-03	2.80E-02	4.82E-03
63	I-134		5.25E+01	1.05E+03	4.81E-01	1.18E-03	8.76E-03	1.51E-03	2.36E-02	1.75E-01	3.02E-02
64	I-135		4.64E+01	9.28E+02	2.95E-01	6.41E-04	4.76E-03	8.18E-04	1.28E-02	9.51E-02	1.64E-02
65	Kr-83M		2.25E-02	2.25E-02	5.55E-06	5.84E-12	4.33E-11	7.45E-12	5.84E-12	4.33E-11	7.45E-12
66	Kr-85M		4.03E-02	4.03E-02	2.77E-02	5.21E-08	3.87E-07	6.66E-08	5.21E-08	3.87E-07	6.66E-08
67	Kr-85		1.32E-04	1.32E-04	4.40E-04	2.72E-12	2.02E-11	3.48E-12	2.72E-12	2.02E-11	3.48E-12
68	Kr-87		1.32E-01	1.32E-01	1.52E-01	9.43E-07	7.00E-06	1.20E-06	9.43E-07	7.00E-06	1.20E-06
69	Kr-88		1.32E-01	1.32E-01	3.77E-01	2.34E-06	1.73E-05	2.98E-06	2.34E-06	1.73E-05	2.98E-06
70	Kr-89		8.58E-01	8.58E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
71	Xe-131M		9.90E-05	9.90E-05	1.44E-03	6.67E-12	4.95E-11	8.51E-12	6.67E-12	4.95E-11	8.51E-12
72	Xe-133M		1.91E-03	1.91E-03	5.07E-03	4.53E-10	3.36E-09	5.78E-10	4.53E-10	3.36E-09	5.78E-10
73	Xe-133		5.41E-02	5.41E-02	5.77E-03	1.46E-08	1.08E-07	1.86E-08	1.46E-08	1.08E-07	1.86E-08
74	Xe-135M		1.72E-01	1.72E-01	7.55E-02	6.08E-07	4.51E-06	7.76E-07	6.08E-07	4.51E-06	7.76E-07
75	Xe-135		1.45E-01	1.45E-01	4.40E-02	2.99E-07	2.22E-06	3.82E-07	2.99E-07	2.22E-06	3.82E-07
76	Xe-137		9.90E-01	9.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
77	Xe-138		5.87E-01	5.87E-01	2.13E-01	5.87E-06	4.36E-05	7.49E-06	5.87E-06	4.36E-05	7.49E-06
78	Sub-total					**2.75E-03**	**2.04E-02**	**3.51E-03**	**5.47E-02**	**4.06E-01**	**6.99E-02**
79	**Total (rem TEDE)**					**1.62E-01**	**7.99E-02**	**1.38E-02**	**3.23E+00**	**1.60E+00**	**2.75E-01**
80											
81	[1]	Dose Conversion Factor (rem/Curie) from Federal Guidance Report (FGR) 11 per Reg. Guide 1.183									
82	[2]	Dose Conversion Factor (rem-m^3/Curie-second) from FGR 12 per Reg. Guide 1.183									
83	3.47E-04	Breathing rate (m^3/second) per Regulatory Guide 1.183 (without round-off)									
84	5.05E-02	Control Room Geometry Factor per Reg. Guide 1.183, Regulatory Position 4.2.7									
85	3.83E+01	EAB σ_y (meters) for F stability, (taken from PAVAN runs in Ref. 9)									
86	2.226E+02	LPZ σ_y (meters) for F stability, (taken from PAVAN runs in Ref. 9)									
87	1.00E+00	Wind Speed (m/s)									
88	3.47E-04	X/Q (seconds/m^3) at EA Boundary - 0-2 hours based on RG 1.5 methodology									
89	5.97E-05	X/Q (seconds/m^3) at Low Population Zone - 0-2 based on RG 1.5 methodology									

	A	B	C	D	E	F	G
1	**PBAPS MSLB Do**					Case 1:	Reactor Coolant at maximum
2							
3	69337	Volume of cloud				Case 2:	Reactor Coolant at maximum
4	75131000	Mass of water in					
5	=25800*453.59	Mass of steam re					
6	1	reactor coolant d					
7	64.2	seconds for clou					
8	176000	Volume of Contr					
9							
10	Halogens						
11		Activity					
12		Distribution		Normalized	Case 1	Case 2	Case 1
13	Isotope	(UFSAR	FGR 11	I-131 DE	Normalized	Normalized	Activity
14		Sect. 14.6.5)	DCF[1]	Activity	Activity	Activity	Release
15		uCi/cc	Rem/Ci	uCi/cc	uCi/cc	uCi/cc	Ci
16	I-131	0.17	32900	=C16*B16/C$16	=D16*0.2/D$21	=E16*20	=E16*$A$4*0.000001/$A$6
17	I-132	1.02	381	=C17*B17/C$16	=D17*0.2/D$21	=E17*20	=E17*$A$4*0.000001/$A$6
18	I-133	1.04	5846	=C18*B18/C$16	=D18*0.2/D$21	=E18*20	=E18*$A$4*0.000001/$A$6
19	I-134	1.47	131	=C19*B19/C$16	=D19*0.2/D$21	=E19*20	=E19*$A$4*0.000001/$A$6
20	I-135	1.3	1230	=C20*B20/C$16	=D20*0.2/D$21	=E20*20	=E20*$A$4*0.000001/$A$6
21				=SUM(D16:D20)	=SUM(E16:E20)	=SUM(F16:F20)	
22					"non-spiked"	"spiked"	
23	Noble Gases						
24		Calc.			Case 1	Case 2	
25		PM-740-A			Release	Release	
26		Table 3	Case 1	Case 2	Cloud	Cloud	
27	Isotope	Noble Gas	Activity	Activity	Concentration	Concentration	
28		Activity	Release	Release			
29		uCi/gm	Ci	Ci	Ci/m³	Ci/m³	
30							
31	Kr-83M	0.00192	=B31*$A$5*0.000001	0.02246903424	=C31/$A$3	=D31/$A$3	
32	Kr-85M	0.00344	=B32*$A$5*0.000001	0.04025701968	=C32/$A$3	=D32/$A$3	
33	Kr-85	0.0000113	=B33*$A$5*0.000001	0.000132239628€	=C33/$A$3	=D33/$A$3	
34	Kr-87	0.0113	=B34*$A$5*0.000001	0.1322396286	=C34/$A$3	=D34/$A$3	
35	Kr-88	0.0113	=B35*$A$5*0.000001	0.1322396286	=C35/$A$3	=D35/$A$3	
36	Kr-89	0.0733	=B36*$A$5*0.000001	0.8578021926	=C36/$A$3	=D36/$A$3	
37	Xe-131M	0.00000846	=B37*$A$5*0.000001	0.000099004182	=C37/$A$3	=D37/$A$3	
38	Xe-133M	0.000163	=B38*$A$5*0.000001	0.001907527386	=C38/$A$3	=D38/$A$3	
39	Xe-133	0.00462	=B39*$A$5*0.000001	0.05406611364	=C39/$A$3	=D39/$A$3	
40	Xe-135M	0.0147	=B40*$A$5*0.000001	0.1720285434	=C40/$A$3	=D40/$A$3	
41	Xe-135	0.0124	=B41*$A$5*0.000001	0.1451125128	=C41/$A$3	=D41/$A$3	
42	Xe-137	0.0846	=B42*$A$5*0.000001	0.9900418212	=C42/$A$3	=D42/$A$3	
43	Xe-138	0.0502	=B43*$A$5*0.000001	0.5874716244	=C43/$A$3	=D43/$A$3	
44							

	A	B	C	D	E	F	G
45	Inhalation Doses						
46			Curies Released				Case 1 Dose (rem CEDE)
47			to the Environment				(Inhalation)
48	Isotope		*Case 1*	Case 2	DCF[1]	CR	EAB
49	I-131		=G16	=H16	32900	=I16*$E49*$A$83*$A$7	=C49*$E49*$A$83*$A$88
50	I-132		=G17	=H17	381	=I17*$E50*$A$83*$A$7	=C50*$E50*$A$83*$A$88
51	I-133		=G18	=H18	5846	=I18*$E51*$A$83*$A$7	=C51*$E51*$A$83*$A$88
52	I-134		=G19	=H19	131	=I19*$E52*$A$83*$A$7	=C52*$E52*$A$83*$A$88
53	I-135		=G20	=H20	1230	=I20*$E53*$A$83*$A$7	=C53*$E53*$A$83*$A$88
54					Totals	**=SUM(F49:F53)**	**=SUM(G49:G53)**
55							
56	External Doses						
57			Curies Released				Case 1 Dose (rem EDE)
58			to the Environment				(External)
59	Isotope		Case 1	Case 2	DCF[2]	CR	EAB
60	I-131		=C49	=D49	0.06734	=I16*$E60*$A$84*$A$7	=C60*$E60*$A$88
61	I-132		=C50	=D50	0.4144	=I17*$E61*$A$84*$A$7	=C61*$E61*$A$88
62	I-133		=C51	=D51	0.10878	=I18*$E62*$A$84*$A$7	=C62*$E62*$A$88
63	I-134		=C52	=D52	0.481	=I19*$E63*$A$84*$A$7	=C63*$E63*$A$88
64	I-135		=C53	=D53	0.29526	=I20*$E64*$A$84*$A$7	=C64*$E64*$A$88
65	Kr-83M		0.02246903424	0.02246903424	0.00000555	=E31*$E65*$A$84*$A$7	=C65*$E65*$A$88
66	Kr-85M		0.04025701968	0.04025701968	0.027676	=E32*$E66*$A$84*$A$7	=C66*$E66*$A$88
67	Kr-85		0.0001322396286	0.00013223962860.0004403		=E33*$E67*$A$84*$A$7	=C67*$E67*$A$88
68	Kr-87		0.1322396286	0.1322396286	0.15244	=E34*$E68*$A$84*$A$7	=C68*$E68*$A$88
69	Kr-88		0.1322396286	0.1322396286	0.3774	=E35*$E69*$A$84*$A$7	=C69*$E69*$A$88
70	Kr-89		0.8578021926	0.8578021926	0	=E36*$E70*$A$84*$A$7	=C70*$E70*$A$88
71	Xe-131M		0.00009900418212	0.0000990041821	0.0014393	=E37*$E71*$A$84*$A$7	=C71*$E71*$A$88
72	Xe-133M		0.001907527386	0.001907527386	0.005069	=E38*$E72*$A$84*$A$7	=C72*$E72*$A$88
73	Xe-133		0.05406611364	0.05406611364	0.005772	=E39*$E73*$A$84*$A$7	=C73*$E73*$A$88
74	Xe-135M		0.1720285434	0.1720285434	0.07548	=E40*$E74*$A$84*$A$7	=C74*$E74*$A$88
75	Xe-135		0.1451125128	0.1451125128	0.04403	=E41*$E75*$A$84*$A$7	=C75*$E75*$A$88
76	Xe-137		0.9900418212	0.9900418212	0	=E42*$E76*$A$84*$A$7	=C76*$E76*$A$88
77	Xe-138		0.5874716244	0.5874716244	0.21349	=E43*$E77*$A$84*$A$7	=C77*$E77*$A$88
78	*Sub-total*					**=SUM(F60:F77)**	**=SUM(G60:G77)**
79	**Total (rem TEDE)**					**=SUM(F54+F78)**	**=SUM(G54+G78)**
80							
81	[1]	Dose Conversion					
82	[2]	Dose Conversion					
83	0.000347	Breathing rate (m³					
84	=($A$8^0.338)/1173	Control Room Geo					
85	38.3	EAB σ_y (meters) fo					
86	222.6	LPZ σ_y (meters) fo					
87	1	Wind Speed (m/s)					
88	=0.0133/A$85/A$87	X/Q (seconds/m³)					
89	=0.0133/A$86/A$87	X/Q (seconds/m³)					

	H	I	J	K
1	value (DE I-131 of 0.2 uCi/cc) permitted for continued full power operation			
2				
3	value permitted (DE I-131 of 4.0 uCi/cc) corresponding to an assumed pre-accident spike			
4				
5				
6				
7				
8				
9				
10		Case 1	Case 2	
11		Release	Release	
12	Case 2	Cloud	Cloud	
13	Activity	Concentration	Concentration	
14	Release			
15	Ci	Ci/m^3	Ci/m^3	
16	=F16*$A$4*0.000001/$A$6	=G16/$A$3	=H16/$A$3	
17	=F17*$A$4*0.000001/$A$6	=G17/$A$3	=H17/$A$3	
18	=F18*$A$4*0.000001/$A$6	=G18/$A$3	=H18/$A$3	
19	=F19*$A$4*0.000001/$A$6	=G19/$A$3	=H19/$A$3	
20	=F20*$A$4*0.000001/$A$6	=G20/$A$3	=H20/$A$3	
21				
22				
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41				
42				
43				
44				

	H	I	J	K
45				
46			Case 2 Dose (rem CEDE)	
47			(Inhalation)	
48	LPZ	CR	EAB	LPZ
49	=C49*$E49*$A$83*$A$89	=J16*$E49*$A$83*$A$7	=D49*$E49*$A$83*$A$88	=D49*$E49*$A$83*$A$89
50	=C50*$E50*$A$83*$A$89	=J17*$E50*$A$83*$A$7	=D50*$E50*$A$83*$A$88	=D50*$E50*$A$83*$A$89
51	=C51*$E51*$A$83*$A$89	=J18*$E51*$A$83*$A$7	=D51*$E51*$A$83*$A$88	=D51*$E51*$A$83*$A$89
52	=C52*$E52*$A$83*$A$89	=J19*$E52*$A$83*$A$7	=D52*$E52*$A$83*$A$88	=D52*$E52*$A$83*$A$89
53	=C53*$E53*$A$83*$A$89	=J20*$E53*$A$83*$A$7	=D53*$E53*$A$83*$A$88	=D53*$E53*$A$83*$A$89
54	**=SUM(H49:H53)**	**=SUM(I49:I53)**	**=SUM(J49:J53)**	**=SUM(K49:K53)**
55				
56				
57			Case 2 Dose (rem EDE)	
58			(External)	
59	LPZ	CR	EAB	LPZ
60	=C60*$E60*$A$89	=J16*$E60*$A$84*$A$7	=D60*$E60*$A$88	=D60*$E60*$A$89
61	=C61*$E61*$A$89	=J17*$E61*$A$84*$A$7	=D61*$E61*$A$88	=D61*$E61*$A$89
62	=C62*$E62*$A$89	=J18*$E62*$A$84*$A$7	=D62*$E62*$A$88	=D62*$E62*$A$89
63	=C63*$E63*$A$89	=J19*$E63*$A$84*$A$7	=D63*$E63*$A$88	=D63*$E63*$A$89
64	=C64*$E64*$A$89	=J20*$E64*$A$84*$A$7	=D64*$E64*$A$88	=D64*$E64*$A$89
65	=C65*$E65*$A$89	=F31*$E65*$A$84*$A$7	=D65*$E65*$A$88	=D65*$E65*$A$89
66	=C66*$E66*$A$89	=F32*$E66*$A$84*$A$7	=D66*$E66*$A$88	=D66*$E66*$A$89
67	=C67*$E67*$A$89	=F33*$E67*$A$84*$A$7	=D67*$E67*$A$88	=D67*$E67*$A$89
68	=C68*$E68*$A$89	=F34*$E68*$A$84*$A$7	=D68*$E68*$A$88	=D68*$E68*$A$89
69	=C69*$E69*$A$89	=F35*$E69*$A$84*$A$7	=D69*$E69*$A$88	=D69*$E69*$A$89
70	=C70*$E70*$A$89	=F36*$E70*$A$84*$A$7	=D70*$E70*$A$88	=D70*$E70*$A$89
71	=C71*$E71*$A$89	=F37*$E71*$A$84*$A$7	=D71*$E71*$A$88	=D71*$E71*$A$89
72	=C72*$E72*$A$89	=F38*$E72*$A$84*$A$7	=D72*$E72*$A$88	=D72*$E72*$A$89
73	=C73*$E73*$A$89	=F39*$E73*$A$84*$A$7	=D73*$E73*$A$88	=D73*$E73*$A$89
74	=C74*$E74*$A$89	=F40*$E74*$A$84*$A$7	=D74*$E74*$A$88	=D74*$E74*$A$89
75	=C75*$E75*$A$89	=F41*$E75*$A$84*$A$7	=D75*$E75*$A$88	=D75*$E75*$A$89
76	=C76*$E76*$A$89	=F42*$E76*$A$84*$A$7	=D76*$E76*$A$88	=D76*$E76*$A$89
77	=C77*$E77*$A$89	=F43*$E77*$A$84*$A$7	=D77*$E77*$A$88	=D77*$E77*$A$89
78	**=SUM(H60:H77)**	**=SUM(I60:I77)**	**=SUM(J60:J77)**	**=SUM(K60:K77)**
79	**=SUM(H54+H78)**	**=SUM(I54+I78)**	**=SUM(J54+J78)**	**=SUM(K54+K78)**
80				
81				
82				
83				
84				
85				
86				
87				
88				
89				

Computer Disclosure Sheet

Discipline Nuclear

Client:: Exelon Corporation / Amergen
Date: February 5, 2003
Project: Peach Bottom Atomic Power Station MSLB AST
Job No.

Program(s) used: Attachment A spreadsheet
Rev No.
Rev Date: N/A
Calculation Set No.: PM-1058, Rev. 0
N/A

Status
[ ] Prelim.
[X] Final
[ ] Void

WGI Prequalification
[ ] Yes
[X] No

Run No.
Description:

Analysis Description: Spreadsheet used to perform dose assessment for MSLB, as described in calculation.

The attached computer output has been reviewed, the input data checked,
And the results approved for release. Input criteria for this analysis were established.

By: H. Rothstein
On: December, 2002

Run by: H. Rothstein *(signature)*

Checked by: P. Reichert *(signature)*

Approved by: H. Rothstein *(signature)*

Remarks: WGI Form for Computer Software Control
This spreadsheet is relatively straight-forward and was hand checked. Attachment includes the spreadsheet in both normal and formula display mode and so is completely documented.