SAIC-97/1008

ANALYSIS OF THE RADIOLOGICAL CONSEQUENCES OF A MAIN STEAM LINE BREAK OUTSIDE CONTAINMENT FOR THE ST. LUCIE UNIT 1 NUCLEAR POWER PLANT USING NUREG-0800 STANDARD REVIEW PLAN 15.1.5 APPENDIX A

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1.0 INTRODUCTION

SAIC has been contracted by APTECH Engineering Services, Inc. (APTECH) to perform a licensing analysis of the radiological consequences of an unisolable postulated main steam line break (MSLB) outside containment accident at the St. Lucie 1 Nuclear Power Plant. This analysis was performed in accordance with NUREG-0800, the U.S. Nuclear Regulatory Commission (USNRC) Standard Review Plan (SRP) Section 15.1.5 Appendix A, "Radiological Consequences of Main Steam Line Failures Outside Containment of a PWR", Revision 2, July, 1981.(4) The purpose of this analysis is to calculate whole body and thyroid doses to the site boundary (or EAB), low population zone, and occupants in the control room resulting from radionuclide releases during the postulated MSLB accident outside containment. In addition, skin doses to control room occupants were also calculated. These doses are calculated using suitable conservative licensing assumptions as delineated in the SRP and the St. Lucie Final Safety Analysis Report (FSAR) and presented in terms of the St. Lucie 1 steam generator tube primary-to-secondary side leak rate.

2.0 INPUT DATA

The input data for this analysis was developed by reviewing and evaluating information available in the St. Lucie Unit 1 Final Safety Analysis Report (FSAR)(1) and its Technical Specifications,(3) along with the FSAR for St. Lucie Unit 2.(2) In addition, The NRC Standard Review Plan (NUREG-0800) 15.1.5 Appendix A(4) was used for the determination of iodine spiking effects. The FP&L engineering staff provided some data directly and confirmed the appropriateness and applicability of all input parameter values used in this analysis.(16) All input data and source for the data is given in Table 1.

Table 1
List and Values of Input Parameters

Parameters	Numerical Values	Reference
atmospheric dispersion factor to site boundary (0-2 hour)	8.55E-5 sec./m^3	1
atmospheric dispersion factor to low population zone	7.97E-6 sec./m^3	1
breathing rate	3.47E-4 m^3/sec.	5
steam generator hot full power secondary side water mass	127,602 pounds	9
Primary coolant system (PCS) water volume	10,400 ft^3	1, 3
primary coolant system water mass	2.13E+8 grams	calculated
time to MSIV closure after MSLB	70 sec.	1, 2
I-131 Thyroid dose factor	1.08E+6 rem/Ci	7
time to SIAS after the MSLB	66.1 sec.	2
time to shutdown cooling condition after MSLB	12,240 sec.	2
Limit on SG secondary coolant I-131 concentration	0.1E-6 Ci/g	1
Iodine partition factor in SG and main steam line	1.0	assumed
Noble gas partition factor in the SG and main steam line	1.0	assumed
percent failed fuel following an MSLB	2.0	1, 11

Table 1
List and Values of Input Parameters (Continued)

Parameters	Numerical Values	Reference
CVCS PCS let down flow rate	40 gpm	1
CVCS I-131 decontamination factor	1,000	1
pre-existing PCS iodine concentration	60.0 μCi/g	3, 4
maximum time period for a 60 μCi/g iodine concentration	106 hours	3
control room volume	62,700 ft^3	1
normal control HVAC outside air intake flow	750 cfm	1
control room HVAC isolation damper closure time	35 seconds	1
unfiltered air leakage into the control room	100 cfm	1
control room recirculation flow rate	2,000 cfm	1
atmospheric dispersion factor to control room	4.86E-4 sec./m^3	1
Control Room HEPA filter efficiency	99 per cent	6
Control room occupancy factor for		
0 to 24 hours	1.0	1
24 to 96 hours	0.6	1
96 to 720 hours	0.4	1
control room HVAC charcoal filter iodine removal efficiency		1
Elemental iodine	95 per cent	1
Organic iodine	95 per cent	1
Particulate iodine	95 per cent	1
Xe-133 PCS concentration	$100/\bar{E}$ μCi/g	3
I-131 PCS concentration technical specification	1 μ Ci/g	3
primary to secondary leak rate	1 gpm	3

3.0 ASSUMPTIONS

The following conservative assumptions were made in performing this analysis in accordance with the licensing requirements set forth in NUREG-0800 SRP 15.1.5 Appendix A.

1. Three scenarios(4) are evaluated for I-131(DEC) in the primary coolant system (PCS): (a) pre-existing equilibrium concentration of 60 μCi/g,(3) (b) MSLB accident induced a release rate spike of 500 times the release rate that corresponds with the technical specification limit of 1 μCi/g, and (c) the PCS concentration associated with the maximum MSLB FSAR calculated fuel failure (fuel failure is assumed for all fuel that is calculated to experience departure from nucleate boiling (DNB)).

2. Xe-133 PCS concentration is 100/E bar where E bar is the average Beta and Gamma energy of all noble gas radioisotopes present in the PCS.(3)

3. For the pre-existing Iodine spike PCS scenario (assumption 1(a)), the maximum technical specification allowable time for this concentration to exist in the PCS prior to the plant being put into hot shutdown is 106 hours.(3) During these 106 hours, all iodine introduced into the steam generator secondary coolant by the steam generator (SG) tube leakage will accumulate in the SG secondary coolant water volume until the MSLB occurs. The iodine inventory also includes the initial concentration of 0.1 μCi/g of SG secondary water as specified in the FSAR.(1)

4. At the time of the MSLB, all Iodine present in the entire SG water inventory will be released to the atmosphere with no iodine removal within the SG internals or main steam line (i.e. iodine partition factor = 1.0).

5. The entire inventory of iodine present in both SGs is completely released directly to the atmosphere from the initiation of the MSLB to the time of MSIV closure.

6. After MSIV closure and up to the time of cooldown to shutdown cooling system operation, iodine and noble gases continue to be released directly to the environment from the unisolable SG at the same rate as the tube leak rate with no iodine or noble gas removal inside the SG or main steam line piping. The tube leak rate is the same constant value throughout the accident scenario even though the PCS pressure is being reduced from 2250 psia to 275 psia which would cause a lower tube leak rate.

7. The primary to secondary leak through SG tubes occurs in the unisolable SG.

8. The Xe-133 (DEQ) noble gas release directly to the environment is at the same rate as the SG tube leak rate with no removal within the SG or main steam lines.

9. Xe-133 (DEQ) noble gas does not accumulate in the SG secondary system prior to the MSLB, but is continuously released by the condenser air ejectors because of its chemical form.

10. The Iodine PCS concentration for the scenario source term assumption 1(b) above does not credit any iodine removal by the CVCS system or radioactive decay after the iodine release rate is increased by a factor of 500.

11. The Iodine and noble gas PCS concentration for the scenario source term assumption 1(c) above was obtained from an ANF report provided by FP&L(17) coupled with the assumption that 2% of the core gap inventory was released to the PCS.

12. Although the LPZ atmospheric dispersion factor in the FSAR is for the 2 to 8 hour period, this same value is also applied to the 0 to 2 hour time period.

13. The control room unfiltered inleakage throughout the MSLB Accident is 100 CFM in accordance with FSAR(1) control room dose calculations.

4.0 CALCULATIONS

Dose impacts for the MSLB outside containment accident were evaluated for three cases characterized by: 1) a pre-existing iodine spike, 2) a concurrent iodine spike, and 3) accident initiated 2% fuel failure with no iodine spike. Hypothetical receptors at the exclusion area boundary, low population zone, and control room were considered.

4.1 Site Boundary and Low Population Zone Dose Calculations

The following equations were used to perform the thyroid and the external whole body dose calculations associated with the releases of I-131 and noble gases (in terms Xe-133 dose equivalent concentration) after a postulated outside containment main steam line break accident.

a. Thyroid dose from I-131

$$D_{th} = [A_{131}] \; x \; [\chi/Q] \; x \; [DCF_{131\text{-}th}] \; x \; [BR]$$

b. External whole body dose from β particles and γ rays[(5)]

$$D_{W.B.} = [0.25 \; \bar{E}\gamma + 0.23 \; \bar{E}_{\beta}] \; [A_{133}] \; x \; (\chi/Q)$$

Where:

D_{th}	Thyroid dose from I-131 inhalation, (rem).
A_{131}	Dose equivalent activity of released I-131, (Ci).
χ/Q	0-2 hour dispersion coefficient for site boundary, or 0-8 hour dispersion coefficient for low population zone , (sec/m^3).
$DCF_{131\text{-}th}$	I-131 Thyroid dose conversion factor, (rem/Ci).
BR	Breathing rate, (m^3/sec).
$D_{W.B.}$	Whole body dose (rem) from immersion in a semi-infinite cloud of Xe-133.
$\bar{E}_{\gamma}$	Average energy release by γ decay (MEV/disintegration).
$\bar{E}_{\beta}$	Average energy release by β decay (MEV/disintegration).
A_{133}	Dose equivalent noble gas (Xe-133) activity release (Ci).

The relevant data for each of the above parameters are given in Table 1. It was assumed that the total primary to secondary leak rate through steam generators is 1 gpm, (2702.8 g/min). [The PCS water specific density of 0.724 is based on 2250 Psia and 575°F.]

4.1.1 Pre-existing Transient with an I-131 PCS Equilibrium Concentration of 60 μCi/g

In this scenario, it was assumed that I-131 concentration in the PCS has reached an equilibrium value of 60 μCi/g well before the MSLB accident. Based on the St. Lucie 1 technical specification limiting condition for operation,(3) this condition could exist for about 100 hours before the plant is brought down to hot shut down condition within 6 hours. The noble gas concentration is at the technical specification(3) limit of $100/\bar{E}$ μCi/g. Using the assumptions and the data listed in Section 3.0, and Table 1, the following doses where calculated.

a. Site boundary (exclusion area boundary)

1. Thyroid Dose

I-131 activity release during the time period after MSLB to shutdown cooling condition:
Pre-break PCS to SCS I-131 activity transfer
$2702.8 \times 60 \times 10^{-6} \times 106 \times 60 = 1032.39$ Ci
initial activity of I-131 in the SCS,
$2 \times 127{,}602 \times 453.6 \times 0.1 \times 10^{-6} = 11.58$ Ci
⇒ sum of I-131 released prior to MSIV closure
$1032.39 + 11.58 + 2702.8 \times 70/60 \times 60 \times 10^{-6} = 1044.16$
Iodine release after MSIV closure
$2702.8 \times 60 \times 10^{-6} \times 202.83 = 32.89$ Ci over remaining minutes (12,240 / 60 - 70/60).

$$D_{th} = [1044.16 + 32.90] \times [8.55 \times 10^{-5}] \times [1.08 \times 10^{6}] \times [3.47 \times 10^{-4}]$$
$$= 34.51 \text{ rem}$$

2. External whole body dose

Noble gases are directly released to atmosphere after the break for 204 minutes.
⇒ $2702.8 \times 100/\bar{E} \times 10^{-6} \times 204 = 55.14/\bar{E}$ Ci

The value of $\bar{E}$ for noble gases in the PCS was calculated to 0.23 MEV based on the concentration of the gases given in Table 12.1-3 and the average energy per disintegration given in ICRP publication No. 38. The calculated beta and gamma average energy per disintegration were 0.15, and 0.08 MEV, respectively. For this average energy, the total noble gas activity released would be 239.7 Ci.

$$D_{W.B.} = [0.25 \times 0.08 + 0.23 \times 0.15] \times [8.55 \times 10^{-5}] \times [239.7]$$
$$= 1.2 \times 10^{-3} \text{ rem}$$

b. Low population zone

An individual in this low population zone is subjected to a different diffusion coefficient than that of the site boundary. All other parameters are similar to those calculated above.

1. Thyroid Dose

D_{th} $= [1044.16 + 32.90] \times [7.97 \times 10^{-6}] \times [1.08 \times 10^{6}] \times [3.47 \times 10^{-4}]$
$= 3.22$ rem

2. External whole body dose

$D_{W.B.}$ $= [0.25 \times 0.08 + 0.23 \times 0.15] \times [7.97 \times 10^{-6}] \times [239.7]$
$= 1.1 \times 10^{-4}$ rem

4.1.2 Concurrent Iodine Spike with the Outside Containment Main Steam Line Break Accident

In this scenario the reactor trip resulting from primary system depressurization associated with the MSLB creates an iodine spike in the primary system. SRP Section 15.1.5 assumes that the iodine release from the fuel rods to the PCS would increase to a value 500 times greater than the release rate corresponding to the iodine concentration at the equilibrium value stated in the plant technical specifications. The equilibrium iodine (I-131) concentration prior to the spike is assumed to be the technical specification(3) limit of 1 µCi/g. Using the data provided in Table 1, the iodine production rate producing this equilibrium concentration is calculated based on the following equations:

$R = \lambda \times A$
$A = C_s \times M$
$\lambda = \lambda_D + \lambda_R$
$\lambda_D = 0.693 / T_{1/2}$
$\lambda_R = F \times (1.0 - 1/DF) / V$

where:

R	Iodine production rate, (Ci/sec)
λ	I-131 decay and removal rate, (per sec).
A	equilibrium activity of the I-131 in the PCS, (Ci)
$T_{1/2}$	8.02 days, Half life of I-131, (6.93×10^{5}, sec)
F	letdown flow rate, (40 gpm, or 0.667 gals/sec)
V	Primary system coolant volume, (10, 400 ft^3, or 7.78×10^{4} gallons)
DF	I-131 decontamination factor in the CVCS, (1000)
M	Primary system coolant mass (2.13×10^{8} grams)
λ_D	1.0×10^{-6} (per sec)

λ_R 8.56 x 10^{-6} (per sec)
C_s 1.0 x 10^{-6} (Ci/g)

The equilibrium I-131 production rate prior to the accident is **2.04 x 10^{-3} Ci/sec.** Using the SRP(4) assumption, the spike would produce an I-131 production rate of **0.102 Ci/sec,** (500 x 0.00204). To calculate the time dependent I-131 concentration in the PCS after the accident, the following conservative assumptions were made:

a. The released iodine instantaneously mix with the PCS water,
b. No credit will be taken for the iodine dilution due to ECCS injection.
c. No credit will be taken for iodine decay and removal.
d. Losses in PCS mass during the accident is negligible.

Based on the above assumptions, the iodine concentration is:

$$C(t) = C_s + K\,t$$

Where:

K = [0.102 /M] x 10^6 = 4.79 x 10^{-4} μCi/sec
t time after the accidents, (sec)

At the end of accident, 204 minutes after the break, the iodine concentration would be **6.86 μCi/g.** Iodine release using this concentration would result in a much smaller (a factor of 285 smaller) consequences that those analyzed earlier in Section 4.1.1. Therefore the calculated doses, (thyroid and external whole body) at the site boundary and the LPZ would be much smaller than those specified in the SRP, Section 15.1.5.

4.1.3 Evaluation of Effects of Fuel Failure after the MSLB Accident

In this scenario, it was conservatively assumed that the transient following the steam line break would result in 2% failed fuel,(11) even though the engineering analysis performed in support of the St. Lucie 1 FSAR,(1) indicated that no fuel failure is expected in an outside containment MSLB accident. The inside containment MSLB accident analysis resulted in a 1.6% fuel failure. Using the ANF calculation(17) of core and fuel gap nuclide inventories, and assuming that 2 percent of the fuel would fail following an MSLB accident, an I-131 and Xe-133 dose equivalent concentration (DEC) in the primary coolant system was calculated. For this calculation, it was assumed that the noble gas and iodine nuclides in the gap of the failed fuel would instantaneously release from the fuel and mix with the primary coolant system. Based on this assumption, the PCS I-131 (DEC) is calculated to be 1.089 x 10^{-2} Ci/g. Assuming that this concentration would remain constant throughout the accident duration, a total of 602 Ci of I-131 (dose equivalent quantities) would be released to the environment. The thyroid dose to an individual at the site boundary and low population zone would be :

a. Site boundary (exclusion area boundary) Dose

$D_{th} = [602] \times [8.55 \times 10^{-5}] \times [1.08 \times 10^{6}] \times [3.47 \times 10^{-4}]$
$= 19.3$ rem

b. Low population zone Dose

$D_{th} = [602] \times [7.97 \times 10^{-6}] \times [1.08 \times 10^{6}] \times [3.47 \times 10^{-4}]$
$= 1.8$ rem

Using the same assumptions as indicated above, an Xe-133 (DEC) value of 1.83×10^{-3} Ci/g was calculated. Assuming a constant concentration over the 204 minutes duration of the accident, an equivalent of 1009.6 Ci of Xe-133 would be released through the affected steam generator.

a. Site boundary (exclusion area boundary)

External whole body dose

$D_{W.B.} = [0.25 \times 0.046 + 0.23 \times 0.135] \times [8.55 \times 10^{-5}] \times [1009.6]$
$= 3.67 \times 10^{-3}$ rem

b. Low population zone

External whole body dose

$D_{W.B.} = [0.25 \times 0.046 + 0.23 \times 0.135] \times [7.97 \times 10^{-6}] \times [1009.6]$
$= 3.42 \times 10^{-4}$ rem

4.2 Control Room Dose Calculations

Radionuclides released from the broken steam line may be transported through the air to the auxiliary building where they may enter the control room ventilation system. Analysis of this potential scenario involves specification of the steam generator release rate, degree of atmospheric dispersion, operational conditions for the control room ventilation system, and estimation of radionuclide concentrations and doses in the control room. This section presents a discussion of methods of analysis, specification of source term, and estimation of control room doses for the hypothetical MSLB event.

4.2.1 Methods of Control Room Analysis

Section 15.1.5 of the SRP, Regulatory Guide 1.4, and the TMI Action Plan document(15) discuss elements of analyses appropriate for the estimation of control room doses under accident conditions. This guidance has been incorporated into versions of the control room habitability evaluation computer code(14) which was used in this analysis. The central feature of the code is solution of lumped parameter, transient radionuclide activity balances formulated around the control room. The time variation of atmospheric dispersion conditions, radionuclide ingress rates, and control room ventilation system function are represented through time periods defined by the analyst. Model parameters are constant during a time interval but are varied from one time interval to the next. The code considers filtered and unfiltered inflows and removal of contaminants in control room ventilation system recirculation filter trains. In any time interval, the concentration of a radionuclide in the control room represented in Figure 1 is calculated as:

$$C = C_b \; EXP[-a(t-t_b)] + ([R_{in}/(a \; V)] \; \{ 1 - EXP[-a(t-t_b)] \})$$

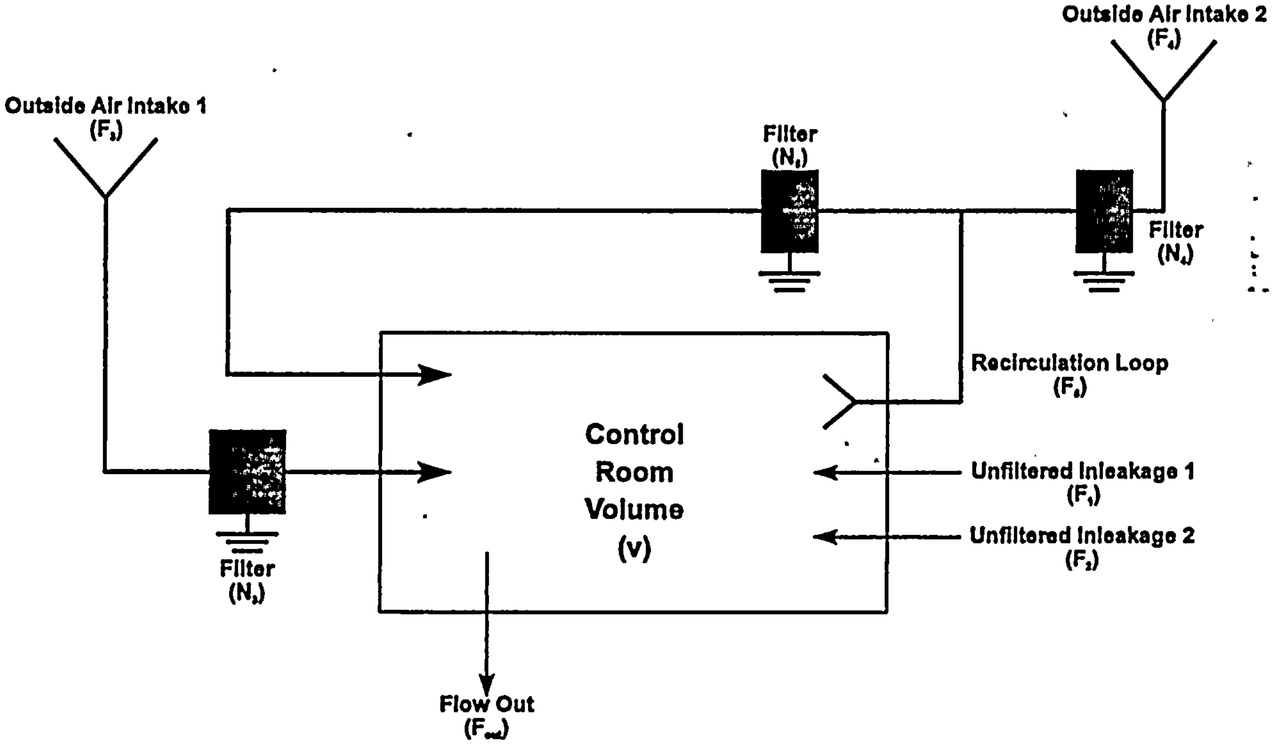
where:

R_{in} = $A_{in} + L_pF_pC_pV$
A_{in} = $C_1F_1 + C_2F_2 + C_3(1-E_3)F_3 + C_4(1-E_4)(1-E_5)F_4$
F_p = Fraction of parent decaying to daughter

a = $(F_o + E_5F_5 + L_dV)/V$
C_b = CR concentration at the beginning of a time interval
C_p = CR concentration of the nuclide's parent
t = time at the end of a time interval
t_b = time at the beginning of a time interval
C_1 = concentration at unfiltered inleakage point number 1
F_1 = unfiltered air inleakage rate at point 1
C_2 = concentration at unfiltered inleakage point number 2
F_2 = unfiltered air inleakage rate at point 2
C_3 = concentration at filtered inflow point 3
E_3 = filtration efficiency at filtered inflow point 3
F_3 = air inflow rate at filtered inflow point 3
C_4 = concentration at filtered inflow point 4 (CR recirculation train)
E_4 = filtration efficiency at filtered inflow point 4
F_4 = air inflow rate at filtered inflow point 4
E_5 = CR recirculation loop filter removal efficiency
F_5 = CR recirculation/filtration loop flow rate
F_o = CR effluent flow rate
L_d = radionuclide decay constant
L_p = radionuclide parent decay constant and
V = control room volume

Control room doses for a time interval are calculated as the time integral of the above concentration multiplied by the appropriate dose factor, breathing rate, and occupancy factor. Scenario conditions specified in Table 1 are such that control room ventilation system behavior does not change over the time for the postulated accident. As described in Section 4.1, the radionuclide source time does change over the time frame of the release event.

Figure 1
Control Room Habitability System Model



4.2.2 Control Room Source Term Characterization

The estimation of radionuclide source terms for the pre-existing iodine spike and 2% failed fuel cases is described in Section 4.1. For the purposes of control room dose analysis, the pre-existing iodine spike case iodine source term expressed as DEC I-131 is converted into nuclide specific release quantities using the definition of dose equivalent. For iodines, the dose equivalency is expressed as:

$$A_{dec,i}\ DCF_i = \Sigma\ A_j\ DCF_j$$

where:

$A_{dec,i}$ = dose equivalent activity of nuclide i
DCF_i = thyroid dose conversion factor for nuclide I
A_j = activity of nuclide j
DCF_j = thyroid dose conversion factor for nuclide j

and the summation is taken over all nuclides. Using the iodine species relative distribution specified in FSAR Table 12.1-3, the above relation may be solved for individual species activities using the dose equivalent activity estimate derived in Section 4.1. The results of this calculation are summarized in Table 2 for iodine species. The source term for the first 70 seconds is due primarily to the pre-existing iodine inventory in the steam generator while the release for the remaining time interval is due to continuing leakage from the PCS. A similar relation may be proposed for the noble gas species with the substitution of average energy for dose conversion factor in the dose equivalency relation. As stated in Section 1.4 , the total activity of noble gas species released during 204 minutes for the pre-existing iodine spike case is 239.7 Ci. Using the relative concentrations of noble gas species reported in FSAR Table 12.1-3, the individual noble gas releases presented in Table 3 were calculated for the pre-existing iodine spike case. For the 2% failed fuel case, the distributions of iodine and noble gas nuclides are known directly as the distributions present in the gap inventory and conversion using the DEC concept is not required. Release estimates for the 2% failed fuel case for iodine and noble gas nuclides are presented in Tables 2 and 3, respectively.

4.2.3 Results of the Control Room Dose Analysis

Control room doses were estimated for the pre-existing iodine spike and 2% failed fuel cases using the models and source terms described in Section 4.2.1 and 4.2.2 and the control room ventilation system parameters presented in Table 1. These conditions are those defined in other analyses discussed in the St. Lucie Unit 1 FSAR. For these conditions, thyroid, skin, and whole body doses over the entire time frame of the event are summarized in Table 4. More detailed output of the computer code, including ventilation system conditions and doses at significant time steps are presented in Table 5 for the pre-existing iodine spike case. The results indicate

that, for the pre-existing iodine spike case, the major portion of the dose occurs after release of the initial steam generator inventory and during a time period in which the portion of this initial pulse of activity which entered the control room is removed by the recirculation filters. The portion of the activity which is due to continued leakage from the PCS subsequent to release of the initial steam generator inventory is a small contributor to the total dose. Unfiltered inleakage accounts for approximately 80% of the dose. The calculated control room dose for the bounding MSLB source term is 9.9 rem thyroid, 1.3E-4 rem whole body, and 9.1E-3 rem skin for a 1 gpm SG tube leak rate. Comparison of the doses for the pre-existing iodine spike and the 2% failed fuel cases indicates that thyroid dose is dominated by the iodines, but that both iodines and noble gases contribute to skin and whole body doses. The noble gas contribution to skin and whole body dose for the 2% failed fuel case is approximately 3 times the contribution of noble gases to the some tissues for the pre-existing iodine spike case. All of these calculated doses are less than their regulatory limits.(12)(16)

Table 2
Control Room Analysis Iodine Species Release Quantities

Nuclide	Releases (Ci)		
	Pre-Existing Iodine Spike		2% Failed Fuel
	Time Period (s)		
	0 to 70	0 to 12,240	0 to 12,240
I-131	836.4	862.7	528.0
I-132	215.0	221.8	111.0
I-133	1,192.7	1,230.3	402.0
I-134	132.5	136.7	103.0
I-135	568.4	586.3	215.0

Table 3
Control Room Analysis Noble Gas Release Quantities

Nuclide	Releases (Ci)		
	Pre-Existing Iodine Spike		2% Failed Fuel
	Time Period (s)		
	0 to 70	0 to 12,240	0 to 12,240
Kr-85m	0.011	1.92	8.80
Kr-85	0.007	1.20	8.70
Kr-87	0.005	0.96	8.39
Kr-88	0.018	3.12	19.70
Xe-131m	0.011	1.92	2.40
Xe-133	1.265	221.24	379.0
Xe-135	0.052	9.11	6.26
Xe-138	0.003	0.50	14.20

Table 4
Control Room Analysis for 1 gpm Steam Generator Tube Leak Rate

Tissue	**Dose (rem)**	
	Pre-Existing Iodine Spike	**2% Failed Fuel**
Thyroid	9.9	5.5
Skin	9.1E-3	9.2E-3
Whole Body	1.3E-4	1.1E-4

Table 5
Control Room Dose Analysis Results
Pre-Existing Iodine Spike Case

TIME STEP START:	0.000000E+00 hr
TIME STEP END:	2.000000E-02 hr

Building cross sectional area (m^2):	0.000000E+00
Building height (m):	0.000000E+00
Release height (m):	0.000000E+00
Effluent vertical velocity (m/s):	0.000000E+00
Effluent flow rate (m^3/s):	0.000000E+00
Horizontal distance to receptor (m):	0.000000E+00
Air intake height (m):	0.000000E+00
Windspeed (m/s):	0.000000E+00
Vertical dispersion class:	1
Horizontal dispersion class:	1
X/Q (s/m^3):	4.860000E-04
Flow in from unfiltered source 1 (m^3/s):	0.000000E+00
Flow in from unfiltered source 2 (m^3/s):	0.000000E+00
Filtered intake flow source 1 (m^3/s):	4.700000E-02
Filter efficiency #1:	
elemental fraction	.0000
organic fraction	.0000
particulate fraction	.0000
Recirculation flow rate (m^3/s):	9.440000E-01
Recirculation filter efficiency:	
elemental fraction	.9500
organic fraction	.9500
particulate fraction	.9900
Filtered intake flow 2 (feeds recirc):	2.120000E-01
Intake 2 filter efficiency:	
elemental fraction	.0000
organic fraction	.0000
particulate fraction	.0000
Bottled air flow rate (m^3/s):	0.000000E+00
Control room volume (m^3):	1775.200000

CUMULATIVE DOSE

END TIME HOURS	WH BODY REM	SKIN REM	THYROID REM	LUNG REM	BONE REM	LIVER REM
2.000E-02	2.535E-06	1.217E-04	2.221E-01	1.137E-08	7.989E-04	1.262E-03

Table 5
Control Room Dose Analysis Results
Pre-Existing Iodine Spike Case (Continued)

TIME STEP START: 2.000000E-02 hr
TIME STEP END: 3.400000E+00 hr

Building cross sectional area (m^2):	0.000000E+00
Building height (m):	0.000000E+00
Release height (m):	0.000000E+00
Effluent vertical velocity (m/s):	0.000000E+00
Effluent flow rate (m^3/s):	0.000000E+00
Horizontal distance to receptor (m):	0.000000E+00
Air intake height (m):	0.000000E+00
Windspeed (m/s):	0.000000E+00
Vertical dispersion class:	1
Horizontal dispersion class:	1
X/Q (s/m^3):	4.860000E-04
Flow in from unfiltered source 1 (m^3/s):	0.000000E+00
Flow in from unfiltered source 2 (m^3/s):	0.000000E+00
Filtered intake flow source 1 (m^3/s):	4.700000E-02
Filter efficiency #1:	
elemental fraction	.0000
organic fraction	.0000
particulate fraction	.0000
Recirculation flow rate (m^3/s):	9.440000E-01
Recirculation filter efficiency:	
elemental fraction	.9500
organic fraction	.9500
particulate fraction	.9900
Filtered intake flow 2 (feeds recirc):	2.120000E-01
Intake 2 filter efficiency:	
elemental fraction	.0000
organic fraction	.0000
particulate fraction	.0000
Bottled air flow rate (m^3/s):	0.000000E+00
Control room volume (m^3):	1775.200000

CUMULATIVE DOSE

END TIME HOURS	WH BODY REM	SKIN REM	THYROID REM	LUNG REM	BONE REM	LIVER REM
3.400E+00	1.273E-04	8.280E-03	9.830E+00	1.297E-04	3.525E-02	5.559E-02

Table 5
Control Room Dose Analysis Results
Pre-Existing Iodine Spike Case (Continued)

TIME STEP START: 696.000000E+00 hr
TIME STEP END: 720.000000E+00 hr

Building cross sectional area (m^2):	0.000000E+00
Building height (m):	0.000000E+00
Release height (m):	0.000000E+00
Effluent vertical velocity (m/s):	0.000000E+00
Effluent flow rate (m^3/s):	0.000000E+00
Horizontal distance to receptor (m):	0.000000E+00
Air intake height (m):	0.000000E+00
Windspeed (m/s):	0.000000E+00
Vertical dispersion class:	1
Horizontal dispersion class:	1
X/Q (s/m^3):	6.360000E-05
Flow in from unfiltered source 1 (m^3/s):	0.000000E+00
Flow in from unfiltered source 2 (m^3/s):	0.000000E+00
Filtered intake flow source 1 (m^3/s):	4.700000E-02
Filter efficiency #1:	
elemental fraction	.0000
organic fraction	.0000
particulate fraction	.0000
Recirculation flow rate (m^3/s):	9.440000E-01
Recirc filter efficiency:	
elemental fraction	.9500
organic fraction	.9500
particulate fraction	.9900
Filtered intake flow 2 (feeds recirc):	2.120000E-01
Intake 2 filter efficiency:	
elemental fraction	.0000
organic fraction	.0000
particulate fraction	.0000
Bottled air flow rate (m^3/s):	0.000000E+00
Control room volume (m^3):	1775.200000

CUMULATIVE DOSE

END TIME HOURS	WH BODY REM	SKIN REM	THYROID REM	LUNG REM	BONE REM	LIVER REM
7.200E+02	1.337E-04	9.140E-03	9.872E+00	1.708E-04	3.540E-02	5.584E-02

5.0 SUMMARY AND CONCLUSIONS

An analysis of the radiological consequences of a postulated MSLB outside containment accident at the St. Lucie Unit 1 nuclear power plant was performed in accordance with SRP 15.1.15. Appendix A (4). This analysis was performed in the following three steps.

First, using the conservative assumptions in the SRP, three scenarios were used to calculate the radioisotope source term released to the environment from this postulated accident. These scenarios are: (1) pre-existing iodine spike, (2) accident induced iodine spike, and (3) accident induced fuel failure. The bounding iodine source term was calculated with the pre-existing iodine spike scenario, while the bounding noble gas source term was calculated with the accident induced fuel failure scenario.

The second step involved the calculation of the site boundary (exclusion area boundary) and low population zone thyroid and whole body doses. These doses were calculated using the bounding source terms from the first step and appropriate conservative parameters for atmospheric dispersion, breathing rate and dose conversion factor.

The third step calculated the thyroid, whole body, and skin doses inside the control room from the bounding source terms which were determined in the first step. The control room doses were calculated using conservative assumptions regarding the control room HVAC system operation and the performance of radionuclide absorbing filters in the HVAC system, and conservative atmospheric dispersion parameters.

The bounding results of this analysis are tabulated below and show the margin to the regulatory limits set forth in 10 CFR 100(12) and 10 CFR 50 GDC 19.(13) All doses are normalized to 1 gpm steam generator tube leak rate, but they can be linearly extrapolated to high leak rates.

MSLB Outside Containment Doses (rem) (for 1 gpm SG Tube Leak Rate)

	Thyroid		**Whole Body**		**Skin**	
	Maximum Calculated	**Limit**	**Maximum Calculated**	**Limit**	**Maximum Calculated**	**Limit**
EAB (Site Boundary)	34.51	300	0.00367	25	N/A	N/A
LPZ	3.22	300	0.000342	25	N/A	N/A
Control Room	9.9	30	0.00013	5	0.0092	30

A second comparison of calculated doses to the regulatory limits presented in SRP 15.1.5, Appendix A, Section II Acceptance Criteria is delineated below.

MSLB Source Term Scenario	Calculated Dose	SRP Criteria
Pre-Accident Iodine Spike	34.51 Rem Thyroid	300 Rem
	0.0012 Rem Whole Body	25 Rem
Accident Initiated Iodine Spike	0.12 Rem Thyroid	30 Rem
	0.0012 Rem Whole Body	2.5 Rem

As discussed in Section 4, the accident initiated iodine spike results in an iodine source term which is a factor of 285 lower than the pre-accident iodine scenario.

A licensing analysis of the radiological consequences of a main steam line break outside containment (MSLBOC) at the St. Lucie Unit 1 nuclear power plant has been performed. All input data and assumptions are based on appropriate conservative and consistent information from USNRC regulations (i.e. standard review plan and code of federal regulations) and St. Lucie 1 plant sources (i.e. FSAR and technical specifications). The assumptions and data have been confirmed(11) by Florida Power and Light Company, the licensee which is operating St. Lucie 1. For all postulated radiological source term scenarios for the MSLBOC accident, the calculated EAB(or site boundary), LPZ, and control room thyroid and whole body doses as well as control room skin doses are considerably less than the relevant regulatory limit.

6.0 REFERENCES

1. St. Lucie Unit 1 Updated Final Safety Analysis Report (UFSAR), Amendment 15.
2. St. Lucie Unit 2 Updated Final Safety Analysis Report (UFSAR).
3. St. Lucie Unit 1 Technical Specifications.
4. NUREG-0800, USNRC Standard Review Plan 15.1.5 Appendix A, "Radiological Consequences of Main Steam Line Failures Outside Containment of a PWR", Revision 2, July, 1981.
5. USNRC Regulatory Guide (R.G.) 1.4, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Pressurized Water Reactors", Revision 2, June, 1974.
6. USNRC R.G. 1.52, "Design, Testing, and Maintenance Criteria for Post Accident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light Water Cooled Nuclear power Plants", Revision 2, March, 1978.
7. ICRP 30, "Limits for Intake by Workers", International Commission on Radiological Protection.
8. ICRP 38, "Radionuclide Transformations - Energy and Intensity of Emissions", International Commission on Radiological Protection, Pergamon Press.
9. Memorandum NF-97-065 from J.N. Kabadi (FP&L) to G.L. Boyers(FP&L), "Initial Steam Generator Mass for St. Lucie Unit 1 MSLB Dose Calculations", February 18, 1997.
10. ABB-CE Calculation A-SL2-FE-0072, Rev. 00 (page 53 of 187).
11. Florida Power and Light Letter ENG-SPSL-97-0068, to Steven Mirsky (SAIC) from Carl Bible (FP&L), "St. Lucie Unit 1 Transmittal of Review & Verification of Values & Input Parameters - File: Engineering Evaluation JPN-PSL-SESS-96-076 Rev. 0", dated February 26, 1997.
12. 10 CFR Part 50, Appendix A, GDC 19, "Control Room".
13. 10 CFR Part 100.11, "Determining of Exclusion Area, Low Population Zone and Population Center Distance.

14. NUREG/CR-5659, Control Room Habitability System Review Models, H.Gilpin, Science Applications International Corporation, December 1990.

15. NUREG-0737, "Clarification of TMI Action Plan Requirements," Item III.D.3.4, "Control Room Habitability," November 1980.

16. NUREG-0800, USNRC Standard Review Plan 6.4, Control Room Habitability System, July, 1981.

17. Facsimile from J. Kabadi and Chris Buehrig of Florida Power and Light to Steve Mirsky at SAIC, "ANF-88-113(P), St. Lucie Unit 1 Assessment of Radiological and Rod Bow Effects for Increased Burnup", July 1988, Advanced Nuclear Fuels Corp., March 11, 1997.

Appendix A
Memorandum NF-97-065 from J.N. Kabadi (FP&L) to G.L. Boyers(FP&L), "Initial Steam Generator Mass for St. Lucie Unit 1 MSLB Dose Calculations", February 18, 1997

[REFERENCE 9]

FPL

Inter-Office Correspondence

NF-97-065

To: G. L. Boyers **Date:** February 18, 1997

From: J. N. Kabadi Kabadi **Department:** ENG/NF/JB

Subject: Initial Steam Generator Mass for St. Lucie Unit 1 MSLB Dose Calculations

Reference: JPN Calculation PSL-1FJF-95-155, Revision 1

This memo provides the initial mass in the St. Lucie Unit 1 steam generators. The full power (HFP) values provided are verified to be those from the reference calculation which documents the St. Lucie Unit 1 Cycle 14 Groundrules.

Total mass per steam generator at HFP = 137,970 lbm

Liquid mass per steam generator at HFP = 127,602 lbm

Prepared By: Kabadi
2/18/97

Verified By: Carl G. O'Farrill
2/18/97

Distribution:

C. J. Buehrig
K. R. Craig
C. G. O'Farrill
C. Villard

Appendix B

Florida Power and Light Letter ENG-SPSL-97-0068, to Steven Mirsky (SAIC) from Carl Bible (FP&L), "St. Lucie Unit 1 Transmittal of Review & Verification of Values & Input Parameters - File: Engineering Evaluation JPN-PSL-SESS-96-076 Rev. 0", dated February 26, 1997

[REFERENCE 11]

FPL

ENG-SPSL-97-0068

FEB 26 1997

Scientific Applications International Corporation
20201 Century Boulevard
Germantown, Maryland 20874

Attention: Mr. Steven M. Mirsky
Manager, Nuclear Facilities Safety

St. Lucie Unit 1
Transmittal of Review & Verification of Values & Input Parameters
File: Engineering Evaluation JPN-PSL-SESS-96-076, Rev. 0

Reference:
1. NRC Letter dated January 23, 1997 from L.A. Wiens to T.F. Plunkett, "St. Lucie Unit 1 Steam Generator Run Time Analysis".
2. FPL Purchase Order 00019096, Blanket Release 002 to APTECH Engineering Services.
3. SAIC letter dated February 24, 1997, Steven M. Mirsky to Chris Buehrig.

Gentlemen:

This letter formally transmits to you our review and verification of values and input parameters identified by SAIC in Reference 3. These values and input parameters are to be used by SAIC to recalculate the dose assessment for MSLB outside containment in accordance with the guidance in SRP 15.1.5. This work was requested by NRC Staff in Reference 1 and authorized by FPL in Reference 2.

If you have any further questions or need additional information contact Chris Buehrig at (561) 467-7507 or Gary Boyers at (561) 694-4909.

Sincerely,

Carl R. Bible
Engineering Manager

H&B
CRB/GLB

Copies to:
K.R. Craig
C. Buehrig
G.L. Boyers
J. . Begley (APTECH)
W. Hannaman (SAIC)

Attachment: SAIC Letter, S.M. Mirsky to Chris Buehrig, dated 2/24/97 (4 Pages)

an FPL Group company

ITEM	PARAMETER	SAIC SOURCE	REVIEWERS COMMENTS
1	Site Boundary X/Q 8.55 E-5 sec/m^3	FSAR Sec 2.3.4.2	Values Correct, References Correct **Change Reference to : FSAR Sec. 2.3.4.3 for both items**
2	Low Population Zone X/Q 7.97 E-6 sec/m^3	FSAR Tbl 15.4.1-4	
3	Breathing Rates 0 to 8 hr : 3.47 E-4 m^3/sec 8 to 24 hr : 2.32 E-4 m^3/sec 24 to 720 hr : 1.75 E-4 m^3/sec	Reg Guide 1.4	Reference Correct Changes: 8 to 24 hr; 1.75 E-4 m^3/sec, 24 to 720 hr; 2.32 E-4 m^3/sec Note: **Accident does not use values past 8 hours**
4	I-131 Thyroid Dose Factor 1.08 E+6 rem/Ci *Inhaled*	ICRP 30	Value and reference is correct. Change: **ADD** : "Inhaled"
5	Primary to Secondary Leak 1 gpm	FSAR Section Technical Spec...	**Change Reference to just: Technical Specification 3.4.6.2.c**
6	Max. time of Opm at or above 1 uCi/gr if I-131(DEC) : 106 hours...	Technical Specifications 3.4.8	Value Correct Reference Correct Change: "Hot Shutdown to Hot Standby" (Ref. TS T1.2, pl-9)
7	I-131 (DEC) conc. in ...(PCS) 1 uCi/gm... 60 uCi/gm...	Technical Specifications 3.4.8 & fig. 3.4-1	Value Correct Reference Correct **Change Unit of measure to uCi/gm & add the "(DEC) "**
8	I-131 (DEC)conc in secondary : 0.1 uCi/gr	FSAR tbl 15.2.11-5	Value Correct Reference Correct **Change Unit of measure to uCi/gm & add the "(DEC) "**
9	PCS Gross Activity : 100/ Ebar	Technical Specification 3.4.8	Value Correct Reference Correct

Reviewed By: Date: ~~2-25-97~~ 2-26-97 cqb

Verified By: 2/26/97

ITEM	PARAMETER	SAIC SOURCE	REVIEWERS COMMENTS
14	Noble Gas Release	ICRP 38 & FSAR tbl 11.1-1 (example for Value) 239.7 Xe-131(DEQ) Ci No accumulation of noble gas in the SG prior to break. Noble gases...(existing words)...55.14/E Ci. Average E for noble gases is 0.23 (Ebar β of 0.23 + Ebar γ of 0.084). The Ci released would be 55.14/0.23 = 239.7 Ci (delete : "This Ci will ....(DEQ) release)	Value Correct References correct CHANGE DISPLAY OF VALUE & SOURCE (example for Source) ICRP 38, "Radio...." for the energies and yields. St. Lucie FSAR Table 11.1-1 for the noble gas concentrations
18	CVCS PCS radwaste removal Letdown flow = 40 gpm CVCS DF for Iodines = 1000	FSAR Sec. 9.3.4 and Table 11.2-4	Values Correct References Correct ADD (between DF and =) " for Iodines "
19	Control Room HVAC damper close times : a.SIAS @ 66.1 sec b.35 sec to close	St Lucie 2 FASR Table 15.1.5.1-1 FSAR 9.4	Values Correct References Correct
20	Control Room HVAC design features a.M/U 750 cfm b.recirc 2000 cfm c. X/Qs d.Char Filt Eff e.Occup Factors f.Post-Acc inflow	FSAR Pg 12.2-9, Sec 9.4.1.3 Pg 12.2-8 Pg 15.4.1-17 Sec 15.4.1 Sec 15.4.1Sec 9.4 Sec 9.4, Sec 6.4.1.3.1	Values Correct References Correct
21	Control Room Volume	FSAR Pg 12.2-8	Value Correct Reference Correct
22	Control Room Unfiltered Inleakage	FSAR Sec. 15.4.1	Value Correct Reference Correct
23	Iodine Chemical Composition	FSAR Sec 15.4.1	Value Correct Reference Correct
24	Control Room HEPA Eff.	Reg Guide 1.52	Value Correct Reference Correct

Reviewed By: Peter G. B Date: ~~2-28-97~~ 2-26-97 cgb Verified By: 2-26-97

ITEM	PARAMETER	SAIC SOURCE	REVIEWERS COMMENTS
10	Activity Release for Steam Line Break Outside Containment	(100% of initial iodine in the secondary side) + (iodine transferred from the primary system after iodine spike equilibrium in the primary system) will provide conservative results.	Conservative Assumption
11a	MSIV Closure Signal Time	The value of 63.9 seconds is based on the St. Lucie Unit 2 FSAR Table 15.1.5.1-1 for steam line break outside containment. MSIV closure affects the unaffected steam generator releases. In the dose calculations where all the secondary mass will be assumed to be released from the steam generators, this timing will not affect the results. This value of 63.9 seconds is, therefore, acceptable for this purpose.	St. Lucie Unit 2 FSAR Table 15.1.5.1-1
11b	MSIV Closure Delay Time	6.9 seconds	St. Lucie Unit 1 FSAR Table 15.4.6-2 PSL-1FJF-95-155, Rev. 1
12	Cooldown Duration After Break (Shutdown Cooling Initiated)	St. Lucie Unit 2 analysis showed that shutdown cooling is initiated at 12,240 seconds after the break. It has been stated in the ABB-CE referenced calculation that the cooldown rate is not used in the dose calculation as it is assumed that all the SG activity is released to the atmosphere. Under similar conditions the time of 12,240 seconds for initiating shutdown cooling is acceptable for St. Lucie Unit 1.	St. Lucie Unit 2 FSAR Table 15..1.5.1-1 ABB-CE Calc A-SL2-FE-0072, Rev. 00 (page 53 of 187)
13	Steam Generator Hot Full Power Secondary Side Water Inventory	127,602 lbm	PSL-1FJF-95-155, Rev. 1
15	Iodine and Noble Gas Releases for 1% Failed Fuel	Iodine: Use FSAR Table values + 5% Noble gas: Use FSAR Table values	St. Lucie Unit 1 FSAR Table 12.1-3

Reviewed By: G L Boyers for Date: 2/26/97
Jay Kabadi

Verified By: C J Buehrig 2/26/97

ITEM	PARAMETER	SAIC SOURCE	REVIEWERS COMMENTS
16	Fraction of Core Fuel Failure	2.0% The St. Lucie Unit 1 inside the containment steam line break analysis has 1.61% failed fuel for the worst case. It has been stated in ANF-88-113(P), page 13, that no fuel failure is expected for outside the containment steam line break. Also per FSAR Section 15.4.6, inside the containment steam line break is more severe in terms of fuel failure than outside the containment steam line break event. A value of 2% fuel failure is therefore conservative for use in the dose calculations for outside the containment steam line break.	St. Lucie Unit 1 FSAR Section 15.4.6 ANF-88-113(P), July 1988
17	RCS Liquid Volume	10,400 ft^3 This value which appears in the FSAR Table 5.1-1 is also consistent with the Tech Spec value of ~11,100 ft^3 total RCS volume, which includes the pressurizer gas volume of 700 ft^3.	St. Lucie Unit 1 FSAR Table 5.1-1 St. Lucie Unit 1 Technical Specification 5.4.2

Shaded items represent changed values.

Reviewed By: ____________ Date: 2/26/97 Verified By: ____________ 2/26/97

Attachment to
ENG-SPSL-97-0068

SAIC
Science Applications International Corporation
An Employee-Owned Company

February 24, 1997

Chris Buehrig
Florida Power and Light Company
6501 South Ocean Drive
Jensen Beach, Florida 34957

Dear Mr. Buehrig:

In accordance with our milestone schedule for the MSLB outside containment SRP analysis task for St. Lucie 1, I am providing the following list of input data values and associated data sources that we have assumed for this analysis. To meet our schedule, please review these parameters and their assumed values and confirm in writing that they are appropriate for this licensing conservative analysis no later than February 26, 1997.

List and values of input parameters

EM	Parameters	Values	Source
1	**0-2 hour χ/Q (site boundary)**	8.55×10^{-5} sec/m^3	St. Lucie 1 FSAR Section 2.3.4.2
2	**0-8 hours χ/Q (low population zone)**	7.97×10^{-6} sec/m^3	St. Lucie 1 FSAR Section 15.4, Table 15.4.1-4
3	**Breathing rate**	3.47×10^{-4} m^3/sec for 0 t8 hrs.; 2.32E-4 for 8-24 hrs., and 1.75E-4 for 24 to 720 hrs.	USNRC Reg Guide 1.4 (c.2.c)
4	**I-131 Thyroid dose conversion factor**	1.08×10^6 rem/Ci	ICRP Publication 30.
5	**Primary to secondary leak rate and HFP primary coolant density**	1 gpm [or 2,702.8 gr/min (primary system condition; specific density of 0.724 based on 2250 psia and 575 F)]	St. Lucie 1 FSAR Section Technical Specification Leak Limit (Sec. 3.4.6.2)
6	**Maximum time of operation at above 1 μCi/gr of I-131 (DEC)**	106 hours, [100 hours of operation above 1 μCi/gr, and 6 hours to be in Hot Shut down.]	St. Lucie 1 Tech Spec. 3.4.8
7	**I-131 concentration in Primary Coolant System (PCS)**	≤ 1 μCi/gr Tech Spec. Limit, with a maximum of 60 μCi/gr in mode 1 with a ≥ 80% power level	St. Lucie 1 Tech. Spec Section 3.4.8, and Figure 3.4-1

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EM	Parameters	Values	Source
8	I-131 concentration in Secondary Coolant System (SCS)	0.1 µCi/gr	St. Lucie 1 FSAR table 15.2.11-5
9	PCS specific activity	≤ 100/E (E is the sum of the average β and γ energies per disintegration [MEV] for isotopes other than Iodide's.)	St. Lucie 1 Tech. Spec. 3.4.8
10	Steam line break outside containment:	main assumption is that 100% of Iodine in the SCS (initial amount plus that transferred after iodine spike equilibrium in the PCS) would be released to the atmosphere.	
11	1. MSIV closure time and timing	a) MSIS 63.9 seconds after the break, with a LOOP after turbine trip	St. Lucie 2 FSAR Table 15.1.5.1-1
		b) MSIV closure 6 seconds after MSIS	St. Lucie 1 FSAR Table 15.4.6-2
12	2. Cooldown duration after break	12,240 seconds, (using St. Lucie 2 time duration to shutdown cooling, from condition a above.)	St. Lucie 2 FSAR Table 15.1.5.1-1
3	Steam generator hot full power secondary side water inventory	127,602 lb	Kabadi to Boyers memo dated 2-18-1997 (FP&L)
14	Noble gas release	no accumulation of noble gases in the SG prior to break. Noble gases are directly released to atmosphere after the break for 204 minutes. → $2702.8 \times 100/E \times 10^{-6} \times 204 = 55.14/E$ Ci average E for noble gases per PCS concentration of FSAR Table 11.1-1 is = 0.23 ($0.15[E_\beta] + 0.084\,[E_\gamma]$) For this average energy, the Ci released would be 239.7 (55.14/0.23). This Ci will be used to represent the Xe-131 (DEQ) release.	Average E values were calculated based on data provided in ICRP Publication 38,"Radionuclide Transformations Energy and Intensity Emissions", St. Lucie 1 FSAR Table 11.1-1
15	Iodine and Noble gas release for 1% failed fuel	I-131 (DEC) =7.0 µCi/gr. (Thyroid equivalency) Xe-133 (DEC) =353.6 µCi/gr.	St. Lucie 1 FSAR Table 12.1-3, and USNRC R.G. 1.4
16	Fraction of core fuel failure for the MSLB	1.61 %	St. Lucie 1 FSAR Table 15.4.6-4
7	PCS liquid water volume	10,400 cubic feet	St. Lucie 1 FSAR Table 5.1-1

Attachment TO
ENG-SPSL-97-0068

[illegible]em	Parameters	Values	Source
18	**CVCS PCS radwaste removal**	letdown flow rate = 40 gpm CVCS DF = 1000	St. Lucie 1 FSAR Section 9.3.4, and Table 11.2-4
19	**Control room HVAC damper closure time**	a) SIAS on low pressurizer pressure at 66.1 sec.	St. Lucie 2 FSAR Table 15.1.5.1-1
		b) damper closure time after signal is 35 sec.(i.e. control room damper closes at 101.1 sec. After MSLB)	St. Lucie 1 FSAR Section 9.4
20	**Control Room HVAC design features**	a) normal unfiltered makeup flow rate is 750 cfm	St. Lucie 1 FSAR Page 12.2-9
		b) recirculation flow rate is 2000 cfm	St. Lucie 1 FSAR Page 12.2-8
		c) 0 to 8 hr. Atmospheric dispersion factor = 4.86E-4 sec/cubic meter, 8-24 hr value=4.17E-4, 24-96 hr value= 1.68E-4, 96-720 hr value = 6.36E-5	St. Lucie 1 FSAR Page 15.4.1-17
		d) charcoal filter iodine removal efficiency = 95% for elemental and organic and 99% for particulate	St. Lucie 1 FSAR Section 15.4.1
		e) occupancy factor = 1.0 for 0-24 hrs, 0.6 for 24-96 hrs., 0.4 for 96 to 720 hrs.	St. Lucie 1 FSAR Section 15.4.1
		f) controlled post-accident filtered inflow 450 cfm	St. Lucie 1 FSAR Section 9.4
21	**Control Room Volume**	62,700 cubic feet	St. Lucie 1 FSAR Page 12.2-8
22	**Control Room Unfiltered Inleakage**	100 cfm	St. Lucie 1 FSAR Section 15.4.1
23	**Iodine Chemical Composition**	91% elemental, 4% organic, 5% particulate	St.Lucie 1 FSAR Section 15.4.1
24	**Control Room HEPA filter efficiency**	99%	USNRC R.G. 1.52

Attachment To
ENG-SPSL-97-0068

The above list constitutes the second milestone of this task. On February 27, 1997, I will be verbally communicating our third milestone which will be the preliminary results of our analysis.

Sincerely,

Steven M. Mirsky, P.E.
Manager, Nuclear Facilities Safety

cc: Jim Begley, APTECH
Gary Boyers (FP&L)
Bill Hannaman (SAIC)

Appendix C
Facsimile from J. Kabadi and Chris Buehrig of Florida Power and Light to Steve Mirsky at SAIC, "ANF-88-113(P), St. Lucie Unit 1 Assessment of Radiological and Rod Bow Effects for Increased Burnup", July 1988, Advanced Nuclear Fuels Corp., March 11, 1997

[REFERENCE 17]

Facsimile Cover Sheet

SHOULD ORIGINAL COPIES BE DISCARDED? YES ☐ NO ☐

IF NOT, PLEASE ARRANGE FOR PICK-UP BY NEXT BUSINESS DAY

SUBMITTER'S NAME: ________ EXTENSION: ________

SEND TO: Steve Mirsky

TELEPHONE NUMBER: ________

COMPANY/DEPARTMENT: ________

FACSIMILE PHONE NUMBER: ________

FROM: Jay Kabadi / Chris Buehrig

DEPARTMENT: ________ TELEPHONE NO: ________

DATE: 3/11/97 TIME: ________

TOTAL PAGES (INCLUDING THIS SHEET) 3

SPECIAL INSTRUCTIONS: Reference "ANF-88-113(P), St. Lucie Unit 1 Assessment of Radiological and Rod Bow Effects for Increased Burnup", July 1988, ~~Siemens Power~~ Advanced Nuclear Fuels Corp

IF YOU DO NOT RECEIVE THIS MESSAGE CLEARLY PLEASE CONTACT US AT ________ (TELEPHONE NUMBER) use this with 2% failure (Gap)

TABLE 3.3 CORE AND GAP FISSION PRODUCT ACTIVITIES

	Design Base 14x14 Fuel Assembly EOL Averaged Core Exposure of 25 GWd/MTU Rated Reactor Power 2700 MWt			ANF 14x14 Fuel Assembly Design EOL Average Core Exposure of 40 GWd/MTU Rated Reactor Power 2700 MWt		
Isotope	Curies in Core	Fraction of Activity in Gap	Curies in Gap	Curies in Core	Fraction of Activity in Gap	Curies in Gap
I-129	2.32E+00	.166	3.84E-01	3.68E+00	.217	7.99E-01
I-131	7.88E+07	.104	8.20E+06	7.89E+07	.129	1.02E+07
I-132	1.12E+08	.014	1.57E+06	1.12E+08	.019	2.14E+06
I-133	1.48E+08	.04	5.92E+06	1.46E+08	.053	7.76E+06
I-134	1.69E+08	.009	1.52E+06	1.66E+08	.012	1.99E+06
I-135	1.31E+08	.024	3.16E+06	1.30E+08	.032	4.15E+06
Cs-134	*		*	2.75E+07	.155	4.26E+06
Cs-134M	*		*	6.61E+06	.012	7.93E+04
Cs-135	*		*	2.88E+01	.155	4.46E+00
Cs-136	*		*	6.43E+06	.098	6.31E+05
Cs-137	*		*	1.08E+07	.155	1.67E+06
Cs-138	*		*	1.38E+08	.005	6.91E+05
Cs-139	*		*	1.36E+08	.003	4.07E+05
Cs-140	*		*	1.24E+08	.0009	1.12E+05
Cs-141	*		*	8.77E+07	.0006	5.26E+04
Cs-142	*		*	7.03E+07	.0002	1.41E+04
Cs-143	*		*	3.61E+07	.0002	7.21E+03
Te-123M	*		*	7.61E+01	.336	2.56E+01
Te-125M	*		*	3.07E+05	.3	9.20E+04
Te-127	*		*	6.63E+06	.071	4.71E+05
Te-127M	*		*	1.42E+06	.333	4.74E+05

TABLE 3.3 CORE AND GAP FISSION PRODUCT ACTIVITIES (CONT.)

Use this with 2% failure (Gap)

	Design Base 14x14 Fuel Assembly EOL Averaged Core Exposure of 25 GWd/MTU Rated Reactor Power 2700 MWt			ANF 14x14 Fuel Assembly Design EOL Average Core Exposure of 40 GWd/MTU Rated Reactor Power 2700 MWt		
Isotope	Curies in Core	Fraction of Activity in Gap	Curies in Gap	Curies in Core	Fraction of Activity in Gap	Curies in Gap
Te-129	*		*	3.08E+07	.027	8.33E+05
Te-129M	*		*	5.26E+06	.271	1.43E+06
Te-131	*		*	6.92E+07	.017	1.18E+06
Te-131M	*		*	1.18E+07	.112	1.32E+06
Te-132	*		*	1.08E+08	.154	1.67E+07
Te-133	*		*	4.17E+07	.012	5.00E+05
Te-133M	*		*	1.14E+08	.024	2.74E+06
Te-134	*		*	1.47E+08	.022	3.24E+06
Te-135	*		*	1.27E+08	.002	2.55E+05
Kr-85	7.33E+05	.102	7.47E+04	1.12E+06	.149	1.68E+05
Kr-85M	1.79E+07	.008	1.43E+05	1.70E+07	.01	1.70E+05
Kr-87	3.46E+07	.004	1.38E+05	3.24E+07	.005	1.62E+05
Kr-88	5.04E+07	.006	3.02E+05	4.75E+07	.008	3.80E+05
Kr-89	6.30E+07	.0008	5.04E+04	5.91E+07	.001	5.91E+04
Xe-131M	6.38E+05	.055	3.51E+04	6.43E+05	.072	4.63E+04
Xe-133	1.48E+08	.038	5.63E+06	1.46E+08	.05	7.32E+06
Xe-133M	3.58E+06	.025	8.95E+04	3.56E+06	.034	1.21E+05
Xe-135	3.13E+07	.011	3.44E+05	3.12E+07	.014	4.36E+05
Xe-135M	3.97E+07	.002	7.94E+04	3.94E+07	.002	7.87E+04
Xe-137	1.44E+08	.0009	1.30E+05	1.43E+08	.001	1.43E+05
Xe-138	1.38E+08	.002	2.76E+05	1.37E+08	.002	2.75E+05

* Not examined in St. Lucie Unit 1 FSAR.