CALCULATION IDENTIFICATION NUMBER				
J.O.OR W.O.NO. 02560	DIVISION & GROUP UR(B)	CALCULATION NO. 002 - 1	OPTIONAL TASK CODE NA	PAGE 5

1.0 Objective

The objective of this calculation is to determine the doses due to airborne radiation, at the Salem Generating Station EAB, LPZ and in the control room following a postulated Fuel Handling Accident in the Fuel Handling Bldg. The calculation assumes a simultaneous Loss of Offsite Power (LOOP) following the Control Room (CR) isolation signal generated by the CR intake radiation monitors, with the subsequent delay in switching from the normal operation mode to the emergency operation mode of the control room ventilation system. The calculation considers two CR Emergency Ventilation operation scenarios:

- The first scenario utilizes the automatic selection capability of the radiation monitors to select the less contaminated CR intake. In addition, it assumes that only one Unit's CR emergency ventilation system is available.
- The second scenario assumes that the CR emergency ventilation is already in operation at the time of an accident. This scenario assumes two train operation.

Additionally, the calculation considers two Fuel Building ventilation operation scenarios:

- The first scenario assumes that the Fuel Bldg. ventilation exhaust is administratively aligned through the Fuel Bldg. filters prior to fuel movement (i.e., takes credit for the Fuel Bldg. Exhaust filters for the duration of the accident).
- The second scenario assumes that the Fuel Bldg. Ventilation exhaust filters are bypassed for the duration of the accident.

3.0 Assumptions

1. Exhaust Lambda (λ) for FHA in Fuel Bldg .... 60 hr^{-1} Ref.[1]

   Design Lambda of the Fuel Pool Sweep Gas System.

2. Activity release Path Ref.[1]

   FHA in Fuel Building

   Fuel gap activity is released to the fuel pool. Noble gas and unscrubbed iodine escape to the air space above the pool where they are exhausted by the fuel pool sweep gas system and released via the main Unit vent.

3. Fuel Building Exhaust Filter Efficiency Ref.[1]

   90% Inorganic
   70% Organic

   The actual fuel building filter efficiency for organic iodine is greater than that stated above, however, for conservatism, the filter efficiency value for organic iodine provided in Safety Guide 25 is followed in lieu of using the actual technical specification efficiency.

   It is expected that the filter efficiency of inorganic iodine would be greater than the value presented above given that the filter is so effective in cleaning up organic iodine, however, for conservatism, the filter efficiency value for inorganic iodine provided in Safety Guide 25 is followed.

4. Delay time for the control room pressurization mode to be fully operational after receipt of the control room intake radiation monitor is : 48 seconds

   The normal intake damper closure time is assumed to be 20 seconds (Ref.[1]). The Loss Of Offsite Power (LOOP) is assumed to occur at the time the dampers are fully closed and the power to the EACS fans are lost. At the LOOP, the Diesel Generators start and it takes 13 seconds(Ref.[1]) for the DG's to become fully operational and the power is delivered to the EACS fans. The EACS fans are assumed to take 15 seconds (Ref.[1]) to gain full speed and the control room is considered fully pressurized at this time. Therefore, the total delay time from the issuance of the control room radiation monitor signal until the control room is in emergency pressurized mode is the sum of normal intake damper closure time (20 sec), the Diesel Generator speedup time (13 sec), and the EACS fans speedup time (15 sec) for a total of 48 seconds.

5. The unfiltered inleakage after the control room is pressurized due to ingress/egress is assumed to be 10 cfm [Ref.1]. The Unfiltered inleakage after the control room is pressurized due to ductwork is assumed to be 50 cfm [Ref.1].

6. It is assumed that the control room can be maintained at (+)1/8" W.G. with a makeup flow of 2000 cfm.

4.0 Data

1. Total gap activity released to pool from the rods that failed (curie) Ref.[1]

I-131	5.86E4
I-132	2.81E4
I-133	6.33E2
I-135	3.53E3
Xe-131m	8.895E2
Xe-133	8.096E4
Xe-133m	9.248E2
Xe-135	1.234E0
Kr-85	2.276E3

Values Based on:
Activity Values based on:
Thermal Power = 3600 Mwt
Number of Damaged Assemblies = 1
Enrichment = 4.5%
Decay Time = 168hr
Radial peaking factor = 1.7
Fraction of core noble gas and iodine activity in gap:
I-131(12%); Kr-85(30%); All others (10%)

2. Pool Decontamination Factors Ref.[1]

Halogens
Inorganic : 133
Organic : 1
Overall : 100

Noble Gas
All :1

Values Based on:
Minimum water depth for scrubbing = 23 ft

3. Iodine chemical form before scrubbing Ref.[1]

99.75% Inorganic
0.25% Organic

4. Offsite Breathing rate [Ref.1]

0 - 8 hr	3.47E-4 m^3/sec
8 - 24 hr	1.75E-4 m^3/sec
24- 720 hr	2.32E-4 m^3/sec

CALCULATION IDENTIFICATION NUMBER				
J.O.OR W.O.NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	PAGE 10
02560	UR(B)	002 - 1	NA	

5. Control Room Breathing rate - 3.47E-4 m^3/sec [Ref.1]

6. Control Room x/Qs (Atmospheric Dispersion Factors): Ref.[1]

Before Isolation (Unit 1 Main Vent, Unit 1 CR Intake) - s/m3

0-2 hr	1.72E-3
2-8 hr	1.22E-3
8-24 hr	1.03E-3
1-4 day	7.13E-4
4-30day	4.19E-4

After Isolation (Unit 1 Main Vent, Unit 2 CR Intake) - s/m3

0-2 hr	8.90E-4
2-8 hr	6.35E-4
8-24 hr	5.36E-4
1-4 day	3.72E-4
4-30day	2.20E-4

7. Offsite X/Q's (from all plant release points) [Ref.1]

	EAB (s/m^3)	LPZ (s/m^3)
0-2 hr	1.30E-4	1.86E-5
2-8 hr		7.76E-6
8-24 hr		5.01E-6
1-4 day		1.94E-6
4-30day		4.96E-7

8. CONTROL ROOM PARAMETERS - Modified design [Ref.1]

* Control room pressure envelope volume:
  81,420 ft^3
* Control Room Normal Operation & EACS Vent System margin:
  10%
* Normal unfiltered air intake rate:
  design value: 1200 cfm
  with margin: 1320 cfm
* Filtered emergency makeup flow:
  design value: 2000 cfm
  with margin: 2200 cfm
* Total unfiltered inleakage- 60 cfm (10 cfm from ingress/egress; 50 cfm from ductwork leakage)
* Filtered recirculation flow rate
  - one EACS fan operation
    design value: total EACS flow = 8000 cfm
    design value: recirc = 8000-2000 = 6000 cfm
    with margin: total EACS flow = 7200 cfm
    with margin: recirc = 7200-2200 = 5000 cfm

  - two EACS fans operation ++

design value: total EACS flow = 16000 cfm
design value: recirc = 16000-2000 = 14000 cfm
with margin: total EACS flow = 14400 cfm
with margin: recirc = 14400-2200 = 12200 cfm

* Intake and recirculating filter efficiencies:

Elemental iodine	- 95%
Organic iodine	- 95%
Particulate	- 95%

* Control room occupancy factors:

Time from Start of Accident	Occupancy Factors
0 to 8 hrs	1.0
8 to 24 hrs	1.0
1 to 4 days	0.6
4 to 30 days	0.4

9. Data for Control Room Intake Monitors [Ref.1]
* Monitor response time - Table 6-1 of Ref.[3] [Ref.3]
The Salem control room monitors are Sorrento Electronic in-duct monitor RD-25A with micro-Processor RM-2000. The monitor response time in Table 6-1 of Ref.[3] is for filter constant (FC) equal to 6. FC=6 is the SE recommended value (Ref.[1]).

* Noise reject delay time = 5 x 600 msec
= 3 sec [Ref.1]
The noise reject time count of 5 is recommended by SE (Ref.[1]). 600 msec is the RM-2000 shift register time segment.

* Detector Response - Xe133: 6.21E7 cpm/(μCi/cc) [Ref.4]
Kr85: 2.58E8 cpm/(μCi/cc)

++ ONE FAN PER EACS FILTRATION TRAIN.

CALCULATION IDENTIFICATION NUMBER				
J.O.OR W.O.NO. 02560	DIVISION & GROUP UR(B)	CALCULATION NO. 002 - 1	OPTIONAL TASK CODE NA	PAGE 21

8.0 Results / Conclusions

The calculated doses (rem) at the Salem Generating Station EAB, LPZ and control room from a postulated Fuel Handing Accident in the Fuel Building are:

EAB

	Thyroid	Whole Body
Filtered Release	4.31	0.16
Unfiltered Release	28.73	0.19

LPZ

	Thyroid	Whole Body
Filtered Release	0.62	0.03
Unfiltered Release	4.11	0.034

The exposure guidelines at the EAB and LPZ set forth in 10CFR100 are 300 rem thyroid and 25 rem whole body. The calculated doses at the EAB and LPZ, assuming (credit)/(no credit) for a filtered release, are well within the 10CFR100 exposure guidelines.

CONTROL ROOM

	Thyroid	Whole Body	Beta
CASE 1: Selection of Favorable Intake❶			
Filtered Release	6.66	0.18	2.14
Unfiltered Release	44.4	0.18	2.15
CASE 2: Pre-Existing Emergency Mode❷			
Filtered Release	0.7	0.32	3.86
Unfiltered Release	4.04	0.26	3.14

❶ Values reflect automatic selection of the control room favorable intake with only one unit EACS operating.
❷ Assumes worst case control room intake but that the CR EACS for both units are operational

The exposure guideline in the control room set forth in 10CFR50 General Design Criteria 19 is 5 rem to the Whole body or its organ dose equivalent (accepted as 30 rem to the thyroid from inhalation and 30 rem beta from submersion). The calculated doses in the control room, assuming the releases from the Fuel Building are filtered, are well within the 10CFR50 exposure guidelines. However, if the Fuel Bldg. releases are not filtered the calculated dose to the thyroid exceeds the 10CFR50 GDC 19 exposure guidelines.

CALCULATION IDENTIFICATION NUMBER				
J.O.OR W.O.NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	APP- A(1 of 2)
02560	UR(B)	002 - 1	N/A	

APPENDIX A

CALCULATION OF INTAKE MONITOR RESPONSE TIME TO A FUEL HANDLING ACCIDENT IN THE FUEL BUILDING

<u>Control Room Intake Monitor Response Time</u>

The intake monitor response time is determined by the final count rate at the detector (C_f), the monitor setpoint (C_s), the background count rate (C_o), and the time constant of the micro-processor (RC). The new Salem control room intake monitors consists of Sorrento Electronic beta sensitive inline detectors and RM-2000 micro-processor. The smoothing algorithm of RM-2000 will generate an effective time constant for a step change of the detector count rate. The effective time constant depends on the initial count rate, the final count rate, and the smoothing filter constant (fc). The time constant corresponding to the 95% observation time (i.e. 3RC) given in Table 6.1 of reference[3] if for fc=6 and will be used to determine the monitor response time.

The detector response function (cpm per μCi/cc) for Xe-133 and Kr-85 are listed below (see Assumptions Section):

Xe-133	- 6.21E7 cpm/(μci/cc)
Kr-85	- 2.58E8 cpm/(μci/cc)

The process safety setting for the intake monitors is determined in Ref.[5] to be 4E-5 μci/cc (Xe-133). This value will be conservatively used as the monitor alarm setpoint for response time calculation.

C_s = 4E-5 μci/cc x 6.21E7 cpm/(μci/cc) ≈ 2484 cpm

The initial Xe-133 and Kr-85 concentrations at the control room intake for the FHA are calculated as follows:

Conc = (gap activity)(bldg leak rate)(X/Q)

Cx = (60 hr^{-1}) (hr/3600sec)(1.72E-3 s/m3)
= 2.867E-05 m^{-3}

Conc $_{xe-133}$ = 2.867E-05 m^{-3} x 8.096E4 Ci = 2.32 Ci/m^3
Conc $_{Kr-85}$ = 2.867E-05 m^{-3} x 2.276E3 Ci = 0.0653 Ci/m^3

Count Rate $_{Xe-133}$ =2.32 μC/cc x 6.21E7 cpm/μCi/cc = 1.44E8 cpm
Count Rate $_{Kr-85}$ =0.0653 μC/cc x 2.58E8 cpm/μCi/cc = 1.69E7 cpm

CALCULATION IDENTIFICATION NUMBER				
J.O.OR W.O.NO.	DIVISION & GROUP	CALCULATION NO.	OPTIONAL TASK CODE	APP- A(2 of 2)
02560	UR(B)	002 - 1	N/A	

The step increase of the instantaneous detector raw count rate at the arrival of the contaminated air is:

$$C_f - C_o = 1.44E8 + 1.69E7 = \quad 1.61E8 \text{ cpm}$$

The monitor is saturated, however, per the control room intake radiation monitor specification, Ref. [6], the monitor will actuate even if the monitor saturates.

It is clear that the control room intake monitor will instantaneously reach it's high high alarm following an FHA in the fuel building. To demonstrate this assume that the count rate is one one-hundredth (1/100) of the calculated count rate then:

From Table 6.1 of ref.[3]. the three times time constant of the monitor response for a step increase of 1E+6 cpm is 0.36 min. Therefore, the effective time constant (RC) for a step increase of 1.61E6 cpm will be less than 0.36/3 = 0.12 min. The monitor response time, t*, is determined by:

$$C_s = C_o + (C_f - C_o)(1-e^{-t^*/RC})$$

$$(C_s - C_o)/(C_f - C_o) = (1-e^{-t^*/RC})$$

$$2484/1.61E6 = 1-e^{-t^*/0.12}$$

$$t^* = 0.00019 \text{ min} = 0.011 \text{ sec}$$

To avoid spurious alarm due to noise count rate, RM-2000 features a noise rejection algorithm. The noise rejection response time is equal to the reject time count (5, recommended by SE) multiplied by the shift register time segment (600 msec). Therefore, noise rejection response time = 5 x 600 msec = 3 sec

The over-all monitor response time = 3 + 0.011 = 3.01 sec

Four (4) seconds will be used as the monitor response time for the Fuel Handling accident in the Fuel Building. The monitor response time will be assumed to be one (1) second plus the three (3) second spurious alarm delay or four (4) seconds.