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10 CFR 50.90

1CAN122101

December 2, 2021

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Response to Request for Supplemental Information Concerning Licensing Amendment Request to Revise Technical Specification 3.4.12 and 3.4.13

Arkansas Nuclear One, Unit 1
NRC Docket No. 50-313
Renewed Facility Operating License No. DPR-51

Entergy Operations, Inc. (Entergy) submitted a license amendment request (LAR) for Arkansas Nuclear One, Unit 1 (ANO-1) in Reference 1. The proposed amendment would revise the Dose Equivalent I-131 (DEI) and the Reactor Coolant System (RCS) primary activity limits required by Technical Specification (TS) 3.4.12, “RCS Specific Activity.” In addition, the primary-to-secondary leak rate limit provided in TS 3.4.13, “RCS Leakage,” would be revised. These proposed changes are due to non-conservative inputs used in the Steam Generator Tube Rupture (SGTR) accident, the Main Steam Line Break (MSLB) accident, and the Control Rod Ejection Accident (CREA) dose calculations.

The U.S. Nuclear Regulatory Commission (NRC) staff has determined that additional information is needed to complete its acceptance review (Reference 2). The requested supplemental information is provided in response to this request in the Enclosure. The supplemental information does not affect the no significant hazards consideration provided in Reference 1.

There are no new regulatory commitments contained in this submittal.

If there are any questions or if additional information is needed, please contact Riley Keele, Manager, Regulatory Assurance, Arkansas Nuclear One, at 479-858-7826.

I declare under the penalty of perjury that the foregoing is true and correct. Executed on December 2, 2021.

Respectfully,

Ronald W. Gaston Digitally signed by Ronald W. Gaston Date: 2021.12.02 17:01:01 -06'00'

Ron Gaston

RWG/rwc

References

1. Entergy Operations, Inc. (Entergy) letter to the U. S. Nuclear Regulatory Commission (NRC), "License Amendment Request Proposed Technical Specifications 3.4.12 and 3.4.13 revised Dose Calculations," (1CAN092101), ML21274A874, dated September 30, 2021.

2. NRC letter to Entergy, "Arkansas Nuclear One, Unit 1 – Supplemental Information Needed for Acceptance of Requested Licensing Action RE: Licensing Amendment Request Concerning Revised Dose Calculations (EPID L-2021-LLA-0181) " (1CNA112101), ML21320A212, dated November 17, 2021.

Enclosure: Response to Request for Supplemental Information Related to LAR to Revise Technical Specification 3.4.12 and 3.4.13

Attachments:

1. Basic Parameters Used in the Dose Consequence Analyses
2. Steam Generator Tube Rupture (SGTR) Model Information
3. Main Steam Line Break (MSLB) Model Information
4. Control Rod Ejection Accident (CREA) Model Information
5. SGTR RADTRAD Input Files
6. MSLB RADTRAD Input Files
7. CREA RADTRAD Input files

cc: NRC Region IV Regional Administrator

NRC Senior Resident Inspector – Arkansas Nuclear One

NRC Project Manager – Arkansas Nuclear One

Designated Arkansas State Official

Enclosure

1CAN122101

Response to Request for Supplemental Information
Related to LAR to Revise Technical Specification 3.4.12 and 3.4.13

RESPONSE TO REQUEST FOR SUPPLEMENTAL INFORMATION
RELATED TO LAR TO REVISE TECHNICAL SPECIFICATION 3.4.12 AND 3.4.13

By letter dated September 30, 2021 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21274A874), Entergy Operations, Inc. (Entergy) submitted a license amendment request (LAR) for Arkansas Nuclear One, Unit 1 (ANO-1). The proposed amendment would revise the Dose Equivalent I-131 (DEI) and the Reactor Coolant System (RCS) primary activity limits required by Technical Specification (TS) 3.4.12, "RCS Specific Activity." In addition, the primary-to-secondary leak rate limit provided in TS 3.4.13, "RCS Leakage," would be revised. These proposed changes are due to non-conservative inputs used in the Steam Generator Tube Rupture (SGTR) accident, the Main Steam Line Break (MSLB) accident, and the Control Rod Ejection Accident (CREA) dose calculations.

The U.S. Nuclear Regulatory Commission (NRC) staff performed an acceptance review of the LAR in accordance with Office of Nuclear Reactor Regulation (NRR) Office Instruction LIC-109, Revision 3, and "Acceptance Review Procedures," dated July 20, 2020 (ADAMS Accession No. ML20036C829), and determined that the application is unacceptable for review, with opportunity to supplement because it is missing sufficient information for the NRC staff to make an independent assessment regarding the acceptability of the proposed amendment in terms of regulatory requirements for the protection of public health and safety and the environment.

To make the application complete, the NRC staff requests that the licensee supplement the application to address the information requested, as described below.

REGULATORY BASIS FOR REQUEST

The regulation in Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.67, "Accident source term," requires that:

1) A licensee who seeks to revise its current accident source term in design basis radiological consequence analyses shall apply for a license amendment under § 50.90. The application shall contain an evaluation of the consequences of applicable design basis accidents previously analyzed in the safety analysis report.

2) The NRC may issue the amendment only if the applicant's analysis demonstrates with reasonable assurance that:

   (i) An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, would not receive a radiation dose in excess of 0.25 Sv (25 rem) total effective dose equivalent (TEDE).

   (ii) An individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage), would not receive a radiation dose in excess of 0.25 Sv (25 rem) total effective dose equivalent (TEDE).

(iii) Adequate radiation protection is provided to permit access to and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 0.05 Sv (5 rem) total effective dose equivalent (TEDE) for the duration of the accident.

SUPPLEMENTAL INFORMATION NEEDED FOR THE AMENDMENT REQUEST

A preliminary review of the LAR has determined that additional information is needed for the NRC staff to begin performing a meaningful review. Although detailed information appears to be provided for other non-radiological analyses, the critical inputs to the dose analyses are not readily displayed in the amendment request. Therefore, the following information is needed:

1. **Please provide additional information describing, for each design basis accident affected by the proposed changes, all the basic parameters used in the dose consequence analyses. This information should include the current licensing basis (CLB) values, the revised values, where applicable, as well as the basis for any changes to the CLB values. For clarity, please provide the requested information in separate tables for each affected design basis accident.**

   Entergy's Response

   Attachment 1 provides additional information describing, for each design basis accident affected by the proposed changes, all the basic parameters used in the dose consequence analyses.

2. **In addition, please provide additional information describing the models and assumptions used in the dose consequence analyses affected by the proposed changes. Alternatively, to support a timely NRC staff review, the calculation packages that typically contain this information may be provided for the affected design basis accidents.**

   Entergy's Response

   Source Term

   The reactor coolant source terms in the CLB analyses are based on coolant measurements from 2007. In an effort to standardize the reactor coolant source term methodologies among the Entergy units, these source terms are being updated to ANSI/ANS-18.1-2020 as they are revised. This standard identifies (i) the radiologically-applicable isotopes and (ii) the relative concentrations among the isotopes to ensure a consistent fleet approach to performing these radiological calculations. In order to minimize periodic updates, this methodology eliminates or minimizes the need for measured plant data that may change over time and is as independent as possible from fuel parameters such as fuel mechanical design, burnup, and enrichment that can change each cycle. The ANO-1 reactor coolant sources were revised to this standard as part of this application.

Once the normal reactor coolant sources are developed based on this standard, the reactor coolant sources are increased to meet the applicable ANO-1 Technical Specifications (TSs). Current TS Surveillance Requirement (SR) 3.4.12.2 limits the Dose Equivalent I-131 (DEI) to less than 1.0 microcurie per gram (µCi/g) while TS SR 3.4.12.1 limits the Dose Equivalent Xe-133 (DEX) to less than 2200 µCi/g. The DEI is calculated with the Committed Effective Dose Equivalent (CEDE) dose conversion factors using Table 2.1 of Environmental Protection Agency (EPA) Federal Guidance Report No. 11, while the DEX applies the effective dose conversion factors for air submersion listed in Table III.1 of EPA Federal Guidance Report No. 12. Consistent with Regulatory Issue Summary (RIS) 2006-04, the alkali metals are also included in the reactor coolant source terms.

The CREA applies the core source term inventory since this accident involves a gap release.

The coolant and core activities applied in these analyses are listed below.

ANO-1 Reactor Coolant Activities (µCi/g)

Isotope	DEI		DEX
	1.0	0.1	2200
	Primary	Secondary	Primary
Kr-85m			3.51E+00
Kr-85			1.45E+02
Kr-87			5.98E+00
Kr-88			7.01E+00
Xe-131m			1.61E+03
Xe-133m			3.14E+00
Xe-133			7.90E+01
Xe-135m			1.50E+01
Xe-135			2.69E+01
Xe-137			7.00E+01
Xe-138			1.81E+01
Br-84	3.85E+00	1.23E+00	
I-131	5.65E-01	5.61E-02	
I-132	2.00E+00	1.99E-01	
I-133	1.74E+00	1.75E-01	

Isotope	DEI		DEX
	1.0	0.1	2200
	Primary	Secondary	Primary
I-134	2.93E+00	3.06E-01	
I-135	2.45E+00	2.51E-01	
Rb-88	1.49E-01	2.63E-02	
Cs-134	2.95E-01	5.33E-02	
Cs-135	4.52E-02	8.23E-03	
Cs-137	1.88E-01	2.29E-02	

ANO-1 Core Activity of Gap Isotopes (Ci)

Isotope	Core Activity (Ci)		Isotope	Core Activity (Ci)
Kr-83m	8.77E+06		I-130	1.36E+06
Kr-85	9.61E+05		I-131	7.22E+07
Kr-85m	1.90E+07		I-132	1.05E+08
Kr-87	3.73E+07		I-133	1.48E+08
Kr-88	5.01E+07		I-134	1.67E+08
Xe-131m	7.55E+05		I-135	1.41E+08
Xe-133	1.48E+08		Cs-134	1.46E+07
Xe-133m	4.60E+06		Cs-136	2.98E+06
Xe-135	3.51E+07		Cs-137	9.88E+06
Xe-135m	3.09E+07		Cs-138	1.38E+08
Xe-138	1.27E+08		Rb-86	1.29E+05

Attachments 2, 3, and 4 address the SGTR, MSLB, and CREA analyses, respectively. These attachments provide information to understand the RADTRAD input files provided in response to request 3, below.

3. **Due to the small margins to the acceptance criteria for several assessments, the NRC staff plans to perform confirmatory analyses. To increase the efficiency of the staff review, please provide the RADTRAD 3.03 input and output files, if available.**

Entergy's Response

Attachments 5, 6, and 7 provide a listing of the RADTRAD input files for the SGTR, MSLB, and CREA events, respectively. In discussions with the NRC Staff, it was determined that the output files were not necessary,

Electronic copies of the files were provided separately.

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Attachment 1

Basic Parameters Used in the Dose Consequence Analyses

CONTROL ROOM PARAMETERS

Parameter	CLB Value	Current Value	Reason for Change
Volume	4.00E+05 ft^3	4.00E+05 ft^3	No change
Normal Air Intake Flow	35,200 cubic feet per minute (cfm)	35,200 cfm	No change
Recirculation Flow	1667 cfm	1667 cfm	No change
Recirculation Filtration	95% Elemental 95% Organic 99% Aerosol	95% Elemental 95% Organic 99% Aerosol	No change
Filtered Intake Flow	333 cfm	333 cfm	No change
Intake Filtration	95% Elemental 95% Organic 99% Aerosol	99% Elemental 99% Organic 99% Aerosol	The two ANO Control Room Emergency Ventilation System (CREVS) trains are different. One train consists of a single 4-inch charcoal bed with a high-efficiency particulate absorbing (HEPA). The other train consists of two 2-inch charcoal beds each with a HEPA filter in series.
Unfiltered In-leakage (post-isolation)	SGTR: 85 cfm MSLB: 85 cfm CREA: 82 cfm	82 cfm	Consistent in-leakage for all calculations
Isolation Time (based on high radiation in intake)	10 seconds	10 seconds	No change
Time of High Radiation Detected in Control Room Intake	SGTR: 11 minutes MSLB: 0 seconds CREA: 0 seconds	SGTR: 9.6 minutes MSLB: 0 seconds CREA: 0 seconds	Consistent with scram timing
Occupancy Factor 0 – 1 day 1 - 4 days 4 - 30 days	 1.0 0.6 0.4	 1.0 0.6 0.4	No change
Breathing Rate 0 - 30 days	3.5E-04 m^3/s	3.5E-04 m^3/s	No change

DISPERSION COEFFICIENTS (seconds/m^3)

Parameter	CLB Value	Current Value	Reason for Change
Offsite			
Exclusion Area Boundary 0-2 hours	 6.8E-04	 6.8E-04	No change
Low Population Zone 0-8 hours 8-24 hours 1-4 days 4-30 days	 1.1E-04 1.1E-05 4.0E-06 1.3E-06	 1.1E-04 1.1E-05 4.0E-06 1.3E-06	No change
Control Room			
Main Steam Safety Valve 0-2 hours 2-8 hours 8-24 hours 1-4 days 4-30 days	 1.90E-02 1.23E-02 5.83E-03 3.80E-03 3.10E-03	 1.90E-02 1.23E-02 5.83E-03 3.80E-03 3.10E-03	No change
Atmospheric Dump Valve 0-2 hours 2-8 hours 8-24 hours 1-4 days 4-30 days	 4.10E-03 2.59E-03 1.12E-03 8.32E-04 5.91E-04	 4.10E-03 2.59E-03 1.12E-03 8.32E-04 5.91E-04	No change
Main Steam Pipe 0-2 hours	 3.15E-03	 3.15E-03	No change

STEAM GENERATOR TUBE RUPTURE PARAMETERS

Parameter	CLB Value	Current Value	Reason for Change
Pre-Accident Iodine Spike DEI	60 μCi/g	6 μCi/g	Proposed License Amendment
Equilibrium Iodine Inventory	1.0 μCi/g	0.25 μCi/g	Proposed License Amendment
Secondary System DEI	0.1 μCi/g	0.1 μCi/g	No change
Primary-to-Secondary (PS) Leakage Rate	150 gpd/SG	150 gpd/SG	No change
Fraction of PS leakage That Is Vaporized	15%	100%	Original value is not supported
Fraction of Ruptured Flow That Is Vaporized	100% pre-scram 15% post-scram	100% pre-scram 100% for first 4.4 min post-scram 40% thereafter	Original value is not supported, new values based on Computational Fluid Dynamics (CFD) analysis
Time of Scram	11 min	9.6 min	Based on updated Thermal-Hydraulics (T/H) analyses
Noble Gas DEX	2200 μCi/g	2200 μCi/g	No change
RCS Mass	5.14E+05 lbs	5.37E+05 lbs	Updated calculation
Secondary System Mass	3.76E+04 lbs/SG	6.00E+04 lbs/SG	Maximum mass is applied to maximize initial source term inventory
Percentage of Failed Fuel Rods	0%	0%	No change
Density used for Leakage Volume-to-Mass Conversion	62.4 lb/ft^3	62.4 lb/ft^3	No change
Single Active Failure	Failure of ADV block valve to open	Failure of Atmospheric Dump Valve (ADV) block valve to open	No change
Response Time to Open Block Valve	30 min	30 min	No change

Parameter	CLB Value	Current Value	Reason for Change
Initial Ruptured Tube Flow Rate	34.56 lb/s	36.83 lb/s (varies with time)	Updated T/H analyses
Isolation Time of Ruptured Steam Generator (SG)	34 min	70 min	Based on updated T/H analyses and conservative operator response times
Isolation Time of Intact SG	237.8 hours	237.8 hours	No change
Accident Induced Spike Iodine Appearance Multiplier	335	335	No change
Duration of Iodine Spike	8 hours	8 hours	No change
SG Iodine Partition Coefficient	100	100	No change
SG Moisture Carryover Fraction	0.1%	0.1%	No change
Condenser Partition Coefficient	10,000	10,000	No change
Iodine Chemical Species	97% elemental 3% organic	97% elemental 3% organic	No change

MAIN STEAM LINE BREAK PARAMETERS

Parameter	CLB Value	Current Value	Reason for Change
Pre-Accident Iodine Spike DEI	60 μCi/g	60 μCi/g	No change
Equilibrium Iodine Inventory	1.0 μCi/g	1.0 μCi/g	No change
Secondary System DEI	0.1 μCi/g	0.1 μCi/g	No change
Primary-to-Secondary (PS) Leakage Rate	0.5 gpm/SG	0.5 gpm/SG	No change
Fraction of PS leakage that is vaporized	Affected SG 100% Intact SG 20%	Both SGs 100%	Original value is not supported
Time of Scram	0 sec	0 sec	No change
Noble Gas DEX	2200 μCi/g	2200 μCi/g	No change
RCS Mass	5.14E+05 lbs	5.37E+05 lbs	Updated calculation
Secondary System Mass	3.76E+04 lbs/SG	6.00E+04 lbs/SG	Maximum mass is applied to maximize initial source term inventory
Percentage of Failed Fuel Rods	0%	0%	No change
Density used for Leakage Volume-to-Mass Conversion	62.4 lb/ft^3	62.4 lb/ft^3	No change
Single Active Failure	Failure of ADV block valve to open	Failure of ADV block valve to open	No change
Response Time to Open Block Valve	30 min	30 min	No change
Isolation Time of Affected S/G	251.8 hours	251.8 hours	No change
Accident Induced Spike Iodine Appearance Multiplier	500	500	No change
Duration of Iodine Spike	8 hours	8 hours	No change

Parameter	CLB Value	Current Value	Reason for Change
Isolation Time of Intact SG	237.8 hours	237.8 hours	No change
Intact SG Iodine Partition Coefficient	100	100	No change
Intact SG Moisture Carryover Fraction	0.1%	0.1%	No change
Iodine Chemical Species	97% elemental 3% organic	97% elemental 3% organic	No change

CONTROL ROD EJECTION ACCIDENT PARAMETERS

Parameter	CLB Value	Current Value	Reason for Change
Source Terms	Core	Core	No change
Fraction of Damaged Fuel	14%	14%	No change
Peaking Factor of Damaged Rods	1.8	1.8	No change
Failure Mechanism	DNB	DNB	No change
Gap Fraction	Noble Gases: 10% Iodine: 10% Alkali Metals: 12%	Noble Gases: 10% Iodine: 10% Alkali Metals: 12%	No change
Time of Scram	0 sec	0 sec	No change
Primary-to-Secondary Leakage Case			
RCS Mass	5.14E+05 lbs	5.37E+05 lbs	Updated calculation
Primary-to-Secondary (PS) Leakage Rate	150 gpd/SG	39 gpd/SG	Proposed License Amendment
Fraction of PS leakage that is vaporized	15%	100%	Original value is not supported
Density used for Leakage Volume-to-Mass Conversion	62.4 lb/ft^3	62.4 lb/ft^3	No change
Isolation Time of SGs (PS Leakage Case)	38.25 hours	38.25 hours	No change
Single Active Failure	Failure of ADV block valve to open	Failure of ADV block valve to open	No change
Response Time to Open Block Valve	30 min	30 min	No change
Iodine Chemical Species (PS Leakage Case)	97% elemental 3% organic	97% elemental 3% organic	No change

Parameter	CLB Value	Current Value	Reason for Change
Containment Leakage Case			
Containment Volume	1.81E+06 ft^3	1.81E+06 ft^3	No change
Containment Leakage Rate	0-1 day: 0.2%/day > 1 day: 0.1 %/day	0-1 day: 0.2%/day > 1 day: 0.1 %/day	No change
Aerosol Deposition Rate (Containment Leakage Case)	0.1 hr^{-1} for 69 hours	0.1 hr^{-1} for 69 hours	No change
Containment Spray	No credit	No credit	No change
Iodine Chemical Species (Containment Leakage Case)	95% aerosol 4.85% elemental 0.15% organic	95% aerosol 4.85% elemental 0.15% organic	No change

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Attachment 2

Steam Generator Tube Rupture (SGTR)
Model Information

STEAM GENERATOR TUBE RUPTURE (SGTR)
MODEL INFORMATION

1.0 EVENT DESCRIPTION

While operating at full power, the double-ended rupture of a steam generator (SG) tube occurs with unrestricted discharge from each end. The initial leak rate exceeds the normal makeup (MU) to the reactor coolant system (RCS) and system pressure decreases. No initial operator action is assumed and the primary system pressure decreases until a reactor trip occurs on low reactor coolant pressure. The turbine trips as a result of the reactor trip. Consistent with Section 5.4 of Appendix F to Regulatory Guide (RG) 1.183, a coincident loss of offsite power (LOOP) is assumed coincident with the reactor scram and turbine trip rather than the tube rupture.

Due to the LOOP, the reactor coolant pumps (RCPs) trip, the main feedwater (MFW) pumps trip, and the condenser becomes unavailable. Emergency feedwater (EFW) actuates automatically to raise SG liquid levels. Closure of the turbine stop valves (TSVs) causes the main steam line pressure to increase and open the atmospheric dump valves (ADVs) and main steam safety valves (MSSVs). The fission products escaping from the ADVs and/or MSSVs are released directly to the atmosphere.

The operator performs normal post-trip verifications and then begins a cooldown of the reactor coolant system (RCS) using the ADV(s) in manual mode. After the RCS temperature has decreased to a value that corresponds to a saturation pressure which is below the lowest MSSV setpoint, the affected SG can be isolated. The RCS cooldown continues by steaming the unaffected SG. RCS pressure is maintained near the minimum adequate subcooling margin (SCM) by throttling high pressure safety injection (which started automatically on a low reactor coolant pressure signal or was started manually by the operator) and cycling the electromatic relief valve (ERV).

The SGTR scenario considers a single active failure and a coincident LOOP. The accident chronology applied in this analysis is reported below.

SGTR Chronology

Time	Event	Comments
0 seconds (sec)	SGTR occurs	
9.6 minutes	Reactor trip on low RCS pressure with consequential loss of offsite power ADV block valve on intact SG fails to open (single active failure), all releases are through the MSSVs.	Per Assumption 5.4 of Appendix F to RG 1.183

Time	Event	Comments
9.6 minutes + 10 sec	Control Room isolated on high radiation in intakes	
30 minutes	Operators begin plant cooldown	Cooldown is started using the intact SG but operators notice ADV on intact SG fails to open, so cooldown is started using ruptured SG. Operator is dispatched to address ADV on intact SG.
60 minutes	Failed ADV block valve manually opened.	
70 minutes	Ruptured SG is isolated. Tube and Primary-to-Secondary (PS) leakage no longer released to environment.	RCS temperature decreased to a value that corresponds to a saturation pressure which is below the lowest MSSV setpoint
237.8 hours	Decay Heat Removal (DHR) conditions reached. PS leakage from intact loop terminated	

2.0 RADIOLOGICAL CONSEQUENCES

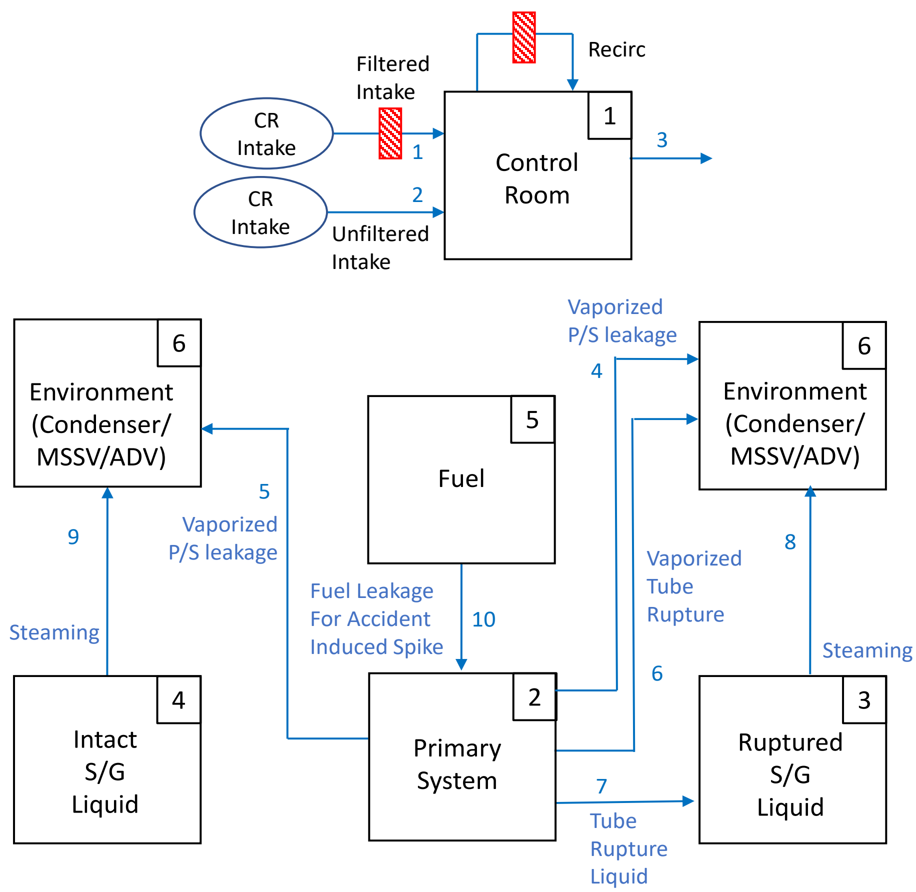
The RCS response to a SGTR was evaluated with Framatome's RELAP5/MOD2-B&W thermal-hydraulics (T/H) computer code with ANO-1's current enhanced once-through steam generators (EOTSGs). This T/H analysis yielded the scram timing, isolation time of the ruptured SG, and the time-dependent break flow rates.

The radiological consequences of the SGTR accident were then analyzed with RADTRAD 3.03. Due to code limitations, the scenario was broken down into six cases, which were evaluated separately and summed to develop total dose. For each case, the impact on control room dose from the plume was also evaluated using modified isotopic-specific dose conversion factors and was shown to be negligible. These cases are listed in the table below.

	Description
1	Secondary coolant iodine release from both SGs
2	Secondary coolant alkali metal release from both SGs
3	Primary coolant iodine release due to PS and ruptured tube leakage
4	Primary coolant alkali metal release due to PS and ruptured tube leakage

	Description
5	Primary coolant noble gas release due to PS and ruptured tube leakage
6	Primary coolant iodine release from accident-induced spike due to PS and ruptured tube leakage

The RADTRAD model developed to evaluate these cases is illustrated below.



2.1 COMPARTMENTS

The volumes of the compartments are listed below. Since the RCS inventories are typically reported in terms of mass, the RADTRAD runs applied the masses of these compartments in grams (rather than cubic feet [ft^3]) with corresponding flows between the compartments in grams/minute (rather than cubic feet per minute [cfm]).

Compartment	Name	Volume	Comments
1	Control Room	4.00E+05 ft^3	
2	RCS	2.44E+08 g	Equivalent to 5.37E+05 pounds (lbs)
3	Ruptured SG Liquid	2.72E+07 g	Equivalent to 6.00E+04 lbs
4	Intact SG Liquid	2.72E+07 g	
5	Fuel	1.00E+10 g	Large enough to minimize depletion effects over the 8-hour iodine spike

The control room is modeled with a recirculating filter that starts upon isolation at ten seconds after the scram with the following parameters.

Time (Hours)	Flow	Filters		
		Aerosol	Elemental	Organic
0.0	0 cfm	0%	0%	0%
0.163	1667 cfm	99%	95%	95%

2.2 PATHWAYS

Pathway 1: Filtered Control Room (CR) Intake

This pathway represents the filtered intake into the CR. This pathway starts ten seconds after the scram and is modeled with the following flows and filters.

Time (Hours)	Flow	Filters		
		Aerosol	Elemental	Organic
0.0	0 cfm	0%	0%	0%
0.163	333 cfm	99%	99%	99%

Pathway 2: Un-Filtered CR In-leakage

This pathway represents the unfiltered intake into the CR. The ANO-1 design basis in-leakage rate of 82 cfm was applied in this analysis. The unfiltered control room in-leakage is modeled with the following flows and filters.

Time (Hours)	Flow
0.0	35,200 cfm
0.163	82 cfm

Pathway 3: CR Exfiltration

This pathway represents the exfiltration from the CR. This flow is the sum of the flows entering the control room (Pathways 1 and 2).

Time (Hours)	Flow
0.0	35,200 cfm
0.163	415 cfm

Pathway 4: Vaporized PS Leakage (Ruptured SG)

This pathway represents the PS leakage into the ruptured SG that is vaporized. All of the PS leakage is assumed to be vaporized and immediately released to the environment. The leakage rate for this pathway is 150 gallons per day (gpd) based on Technical Specification (TS) 3.4.13. This leakage rate is based on 62.4 lb/ft^3 consistent with Section 5.2 of Appendix F to RG 1.183. This leakage is assumed to continue into the ruptured SG until the SG is isolated at 70 minutes.

$$150\ \frac{gallons}{day} * \frac{day}{24\ hours} * \frac{hour}{60\ minutes} * \frac{ft^3}{7.48\ gal} * \frac{62.4\ lb}{ft^3} * \frac{453.59\ g}{lb} = 394\ \frac{g}{min}$$

Time (Hours)	Flow (grams/min)
0.0	394
1.167	0.0

Pathway 5: Vaporized PS Leakage (Intact SG)

This pathway represents the PS leakage into the intact SG that is vaporized and immediately released to the environment. As discussed for Pathway 4, the flowrate is 150 gpd or 394 grams per minute.

Time (Hours)	Flow (grams/min)	Filters		
		Aerosol	Elemental	Organic
0.0	394	0%	0%	0%
237.8	0.0	0%	0%	0%

Pathways 6 & 7: Ruptured Tube Leakage

Based on the Framatome T/H analysis, the ruptured tube flow rates are listed below.

Break Flow Rate

Time		Average Break Flow	
Start (sec)	End (sec)	lbs/sec	grams/min
0	580	36.83	1.0022E+06
580	840	31.53	8.5823E+05
840	1200	31.34	8.5298E+05
1200	1800	36.15	9.8370E+05
1800	2400	36.45	9.9200E+05
2400	3000	33.33	9.0709E+05
3000	3600	33.88	9.2210E+05
3600	4200	30.51	8.3043E+05

Based on the computational fluid dynamics (CFD) analyses, 40% or less of this tube leakage is expected to be vaporized after 4.4 minutes post-scram (i.e., 14 minutes). Therefore, the breakdown of flows between Pathways 6 and 7 were calculated as follows.

Time		Starting Time	Vaporization Fraction	Average Break Flow (grams/min)	
Start (sec)	End (sec)	Hours		Vapor (Pathway 6)	Liquid (Pathway 7)
0	580	0.0000E+00	100%	1.0022E+06	0.0000E+00
580	840	1.6111E-01	100%	8.5823E+05	0.0000E+00
840	1200	2.3333E-01	40%	3.4119E+05	5.1179E+05
1200	1800	3.3333E-01	40%	3.9348E+05	5.9022E+05
1800	2400	5.0000E-01	40%	3.9680E+05	5.9520E+05
2400	3000	6.6667E-01	40%	3.6284E+05	5.4425E+05
3000	3600	8.3333E-01	40%	3.6884E+05	5.5326E+05
3600	4200	1.0000E+00	40%	3.3217E+05	4.9826E+05
4200		1.1667E+00		0.0000E+00	0.0000E+00

While the above table is applied to the iodine and alkali metals, the vaporization fraction for noble gases is modeled to be 100% such that Pathway 7 is always zero and Pathway 6 represents the entire break flow for this nuclide group.

Pathway 8: Ruptured SG Steaming

This pathway represents the steaming of the ruptured SG. Prior to receiving the trip signal at 9.6 minutes, the design full power steaming rate is 5.6E+06 lbs/hr/SG.

$$5{,}600{,}000\ \frac{lbs}{hr} * \frac{hr}{60\ min} * \frac{453.59\ g}{lb} = 4.234E7\ \frac{g}{min}\ per\ SG$$

As the core decay heat is removed through the ruptured SG, the secondary coolant is vaporized and released via the MSSV or ADV. The steaming rate is modeled to drop after the scram until the ruptured S/G is isolated at 70 minutes.

Time (Hours)	Flow (grams/min)
0.0	4.234E+07
0.16	2.5352E+06
1.167	0

Before the scram, the condenser provides a substantial reduction in the source term release via partitioning and removal via the air removal system. These flows are consequently multiplied by 0.0001 for the iodine and alkali metal cases.

After the scram, these flows are multiplied by 0.01 and 0.001 for the iodine and alkali metal cases, respectively to model the partitioning of iodine and moisture carryover of the alkali metals in the SGs.

Pathway 9: Intact SG Steaming

This pathway represents the steaming of the intact SG. As the core decay heat is removed through the single intact SG, the secondary coolant is vaporized and released via the MSSV or ADV. The steaming rate is terminated when the intact SG is isolated.

Time (Hours)	Flow (grams/min)
0	4.234E+07
0.16	2.5352E+06
2	3.611E+05
237.8	0

Before the scram, the condenser provides a substantial reduction in the source term release via partitioning and removal via the air removal system. These flows are consequently multiplied by 0.0001 for the iodine and alkali metal cases.

After the scram, these flows are multiplied by 0.01 and 0.001 for the iodine and alkali metal cases, respectively to model the partitioning of iodine and moisture carryover of the alkali metals in the SGs.

Pathway 10: Fuel Leakage for Accident-Induced (AI) Spike

This pathway represents the iodine release from the fuel for the AI spike. As described in the source term section, the source term in the core compartment (Compartment 5) is based on the iodine generation rate into the RCS needed to maintain the equilibrium DEI (1.0 μCi/gm) with a 1 gram per minute flow from the core compartment. Consequently, for the accident-induced spike, the flow rate is increased by 335 times the initial rate.

Time (Hours)	Flow (grams/min)
0	335
8	0

2.3 SOURCE TERMS

Primary and Secondary Compartments

Based on the RCS mass of 2.44E+08 grams and the secondary coolant masses of 2.72E+07 grams/SG, the total activity in each compartment is reported below based on the specific inventories. The secondary coolant is initialized with a source term fraction of 0.50 set in either Compartment 3 or 4 (faulted or intact SG) such that the value in the table below is the total secondary activity.

ANO-1 Reactor Coolant Activities (Ci)

Isotope	DEI		DEX
	1.0	0.1	2200
	Primary	Secondary	Primary
Kr-85m			8.564E+02
Kr-85			3.538E+04
Kr-87			1.459E+03
Kr-88			1.710E+03
Xe-131m			3.928E+05
Xe-133m			7.662E+02
Xe-133			1.928E+04
Xe-135m			3.660E+03
Xe-135			6.564E+03
Xe-137			1.708E+04
Xe-138			4.416E+03
Br-84	9.394E+02	6.691E+01	
I-131	1.379E+02	3.052E+00	
I-132	4.880E+02	1.083E+01	
I-133	4.246E+02	9.520E+00	
I-134	7.149E+02	1.665E+01	

Isotope	DEI		DEX
	1.0	0.1	2200
	Primary	Secondary	Primary
I-135	5.978E+02	1.365E+01	
Rb-88	3.636E+01	1.431E+00	
Cs-134	7.198E+01	2.900E+00	
Cs-135	1.103E+01	4.477E-01	
Cs-137	4.587E+01	1.246E+00	

Fuel Sources

The fuel source is applied for the AI spike case. The core compartment is initialized with this source term to represent the release rate from the core based on a 1 gram/minute release to offset the system losses. To model a 335-fold iodine spike, Pathway 10 is modeled with a 335 gram/minute flow rate for the first 8 hours.

The source term for the core compartment is calculated by summing the losses from letdown, radioactive decay and PS leakage for an initial coolant activity at 1 μCi/g DEI. Then, with a compartment volume of 1E+10 grams and a 1 gram/minute flow (Pathway 10), the core inventories can be calculated by merely multiplying the loss rate (in Ci/minute) by 1E+10.

Isotope	Letdown (min-1)	Leakage (min^{-1})	Decay Constant (min^{-1})	Total Loss Rate (min^{-1})	Initial Activity (Ci)	Loss Rate (Ci/min)	Source (Ci)
I-131	1.360E-03	3.210E-06	5.984E-05	1.423E-03	1.379E+02	1.962E-01	1.962E+09
I-132	1.360E-03	3.210E-06	5.023E-03	6.386E-03	4.880E+02	3.116E+00	3.116E+10
I-133	1.360E-03	3.210E-06	5.553E-04	1.918E-03	4.246E+02	8.146E-01	8.146E+09
I-134	1.360E-03	3.210E-06	1.316E-02	1.452E-02	7.149E+02	1.038E+01	1.038E+11
I-135	1.360E-03	3.210E-06	1.747E-03	3.111E-03	5.978E+02	1.860E+00	1.860E+10

The iodine species of the initial and spike activity is assumed to the 97% elemental and 3% organic.

2.4 OTHER FACTORS

<u>Exclusion Area Boundary (EAB)</u>

Per Section 4.1.3 of RG 1.183, the breathing rate of persons offsite is assumed to be 3.5E-04 m^3/s.

The EAB dispersion coefficient is unchanged from the current value. Although it is a 2-hour value, it is modeled throughout the entire accident duration so that the worst-case 2-hour sliding window can be accurately identified.

Time (Hours)	χ/Q value (s/m^3)
0.0	6.8E-04
720	0.0

Low Population Zone (LPZ)

Per Section 4.1.3 of RG 1.183, for the first 8 hours, the breathing rate of persons at this location is assumed to be 3.5E-04 m^3/s. From 8 to 24 hours following the accident, the breathing rate is 1.8E-04 m^3/s. After that and until the end of the accident, the rate is assumed to be 2.3E-04 m^3/s.

Time (Hours)	Breathing Rate (m^3/s)
0.0	3.5E-04
8	1.8E-04
24	2.3E-04
720	0.0

The LPZ dispersion coefficients are unchanged from the current values.

Time (Hours)	χ/Q value (s/m^3)
0.0	1.1E-04
8	1.1E-05
24	4.0E-06
96	1.3E-06
720	0.0

Control Room

Per Section 4.2.6 of RG 1.183, the dose receptor for these analyses is the hypothetical maximum exposed individual who is present in the control room for 100% of the time during the first 24 hours after the event, 60% of the time between 1 and 4 days, and 40% of the time from 4 days to 30 days. For the duration of the event, the breathing rate of this individual is assumed to be 3.5E-04 m^3/s.

<table>
<tr><th>Time (Hours)</th><th>Occupancy Factor</th><th>Breathing Rate (m^3/s)</th></tr>
<tr><td>0.0</td><td>1.0</td><td rowspan="3">3.5E-04</td></tr>
<tr><td>24</td><td>0.6</td></tr>
<tr><td>96</td><td>0.4</td></tr>
<tr><td>720</td><td>0</td><td>0.0</td></tr>
</table>

The dispersion coefficients are based on the release point and the receptor locations. The control room χ/Qs applicable to this event are listed below for the worst-case (closest) intake. These values represent the closest MSSV or ADV to the nearest control room intake in either loop.

Control Room Dispersion Coefficients (s/m^3)

Time (Hours)	Main Steam Safety Valve	Atmospheric Dump Valve
0.0	1.90E-02	4.10E-03
2	1.23E-02	2.59E-03
8	5.83E-03	1.12E-03
24	3.80E-03	8.32E-04
96	3.10E-03	5.91E-04
720	0	0

The condenser releases are modeled with the same χ/Q as the ADV. In order to maximize the releases, the normally-closed motor-operated block valve isolating the ADV on the intact loop fails to open so that the releases are via the MSSV after the scram until an operator manually opens the block valve at 1 hour. The associated χ/Qs modeled to the environment are listed below.

Control Room Dispersion Coefficients (s/m^3)

Time (Hours)	MSSV/ADV	Description
0.0	4.10E-03	Condenser release – same χ/Qs as ADV
0.16	1.90E-02	MSSV release upon scram
1.0	4.10E-03	ADV release
2	2.59E-03	
8	1.12E-03	
24	8.32E-04	
96	5.91E-04	
720	0	

3.0 RESULTS

RADTRAD 3.03 was executed for the six cases identified above based on an initial DEI of 1.0 µCi/g in the RCS and secondary coolant DEI of 0.1 µCi/g.

Base RADTRAD Results for Each Case (Rem TEDE)
DEI = 1.0 µCi/g (RCS) and 0.1 µCi/g (Secondary)

			RADTRAD RESULTS		
	File Name	**Description**	**EAB**	**LPZ**	**CR**
		Airborne Dose			
1	sec_iodine	iodine release from secondary side	4.3784E-03	8.7894E-04	7.1424E-03
2	sec_alkali	alkali release from secondary side	3.9997E-04	9.0236E-05	1.6387E-03
3	rcs_iodine	iodine release from rcs	2.2519E-01	3.6608E-02	7.0076E-01
4	rcs_alkali	alkali release from rcs	1.0635E-01	1.7343E-02	4.0931E-01
5	rcs_ngas	noble gas release from rcs	3.4516E-01	5.5919E-02	2.7679E-01
6	ai_spike	additional iodine release from rcs in accident-induced spike case	7.7425E+00	1.2968E+00	7.4640E+00

Cloud Dose					
1	c_sec_iodine				3.5329E-05
2	c_sec_alkali				8.0403E-08
3	c_rcs_iodine				1.2545E-03
4	c_rcs_alkali				1.5199E-05
5	c_rcs_ngas				1.0418E-02
6	c_ai_spike				3.3945E-02

To develop appropriate DEI limits for the TSs, these results were ratioed. A reduction of the pre-accident spike from 60 to 6 µCi/g was determined to be sufficient to reduce the control room dose to below 5 rem TEDE. For the pre-existing spike case, the doses from the iodine releases from the RCS above (which are based on a DEI of 1.0 µCi/g) were multiplied by a factor of 6 representing an initial DEI of 6 µCi/g. The control room dose set the limit for this case. For the AI spike case, the initial iodine activity was reduced to 0.25 µCi/g to meet the acceptance criterion at the EAB.

Pre-Existing Spike RADTRAD Results for Each Case (Rem TEDE)
DEI = 6.0 µCi/g (RCS) and 0.1 µCi/g (Secondary)

		RADTRAD (DEI = 1.0)				PRE-EXISTING SPIKE		
		DOSE RESULTS (REM TEDE)			6.00	DOSE RESULTS (REM TEDE)		
	Airborne Dose	EAB	LPZ	CR		EAB	LPZ	CR
1	iodine release from secondary side	4.3784E-03	8.7894E-04	7.1424E-03	1.00	4.3784E-03	8.7894E-04	7.1424E-03
2	alkali release from secondary side	3.9997E-04	9.0236E-05	1.6387E-03	1.00	3.9997E-04	9.0236E-05	1.6387E-03
3	iodine release from rcs	2.2519E-01	3.6608E-02	7.0076E-01	6.00	1.3511E+00	2.1965E-01	4.2046E+00
4	alkali release from rcs	1.0635E-01	1.7343E-02	4.0931E-01	1.00	1.0635E-01	1.7343E-02	4.0931E-01
5	noble gas release from rcs	3.4516E-01	5.5919E-02	2.7679E-01	1.00	3.4516E-01	5.5919E-02	2.7679E-01
6	additional iodine release from rcs in ai spike case	7.7425E+00	1.2968E+00	7.4640E+00	0.00	0.0000E+00	0.0000E+00	0.0000E+00
	Cloud Dose to Control Room							
1	iodine release from secondary side			3.5329E-05	1.00	0.0000E+00	0.0000E+00	3.5329E-05
2	alkali release from secondary side			8.0403E-08	1.00	0.0000E+00	0.0000E+00	8.0403E-08
3	iodine release from rcs			1.2545E-03	6.00	0.0000E+00	0.0000E+00	7.5270E-03
4	alkali release from rcs			1.5199E-05	1.00	0.0000E+00	0.0000E+00	1.5199E-05
5	noble gas release from rcs			1.0418E-02	1.00	0.0000E+00	0.0000E+00	1.0418E-02
6	additional iodine release from rcs in ai spike case			3.3945E-02	0.00	0.0000E+00	0.0000E+00	0.0000E+00
						1.8074E+00	2.9388E-01	4.9174E+00

Accident-Induced Spike RADTRAD Results for Each Case (Rem TEDE)
DEI = 0.25 μCi/g (RCS) and 0.1 μCi/g (Secondary)

		RADTRAD (DEI = 1.0)			ACCIDENT-INDUCED SPIKE			
		DOSE RESULTS (REM TEDE)			0.25	DOSE RESULTS (REM TEDE)		
	Airborne Dose	EAB	LPZ	CR		EAB	LPZ	CR
1	iodine release from secondary side	4.3784E-03	8.7894E-04	7.1424E-03	1.00	4.3784E-03	8.7894E-04	7.1424E-03
2	alkali release from secondary side	3.9997E-04	9.0236E-05	1.6387E-03	1.00	3.9997E-04	9.0236E-05	1.6387E-03
3	iodine release from rcs	2.2519E-01	3.6608E-02	7.0076E-01	0.25	5.6298E-02	9.1520E-03	1.7519E-01
4	alkali release from rcs	1.0635E-01	1.7343E-02	4.0931E-01	1.00	1.0635E-01	1.7343E-02	4.0931E-01
5	noble gas release from rcs	3.4516E-01	5.5919E-02	2.7679E-01	1.00	3.4516E-01	5.5919E-02	2.7679E-01
6	additional iodine release from rcs in ai spike case	7.7425E+00	1.2968E+00	7.4640E+00	0.25	1.9356E+00	3.2420E-01	1.8660E+00
	Cloud Dose to Control Room							
1	iodine release from secondary side			3.5329E-05	1.00	0.0000E+00	0.0000E+00	3.5329E-05
2	alkali release from secondary side			8.0403E-08	1.00	0.0000E+00	0.0000E+00	8.0403E-08
3	iodine release from rcs			1.2545E-03	0.25	0.0000E+00	0.0000E+00	3.1363E-04
4	alkali release from rcs			1.5199E-05	1.00	0.0000E+00	0.0000E+00	1.5199E-05
5	noble gas release from rcs			1.0418E-02	1.00	0.0000E+00	0.0000E+00	1.0418E-02
6	additional iodine release from rcs in ai spike case			3.3945E-02	0.25	0.0000E+00	0.0000E+00	8.4863E-03
						2.4482E+00	4.0758E-01	2.7553E+00

1CAN122101

Attachment 3

Main Steam Line Break (MSLB)
Model Information

MAIN STEAM LINE BREAK (MSLB)
MODEL INFORMATION

1.0 EVENT DESCRIPTION

While operating at full power, the double-ended rupture of a main steam line outside containment occurs with unrestricted discharge from each end. Upon detection of a steam line break, the affected steam generator (SG) is isolated by closing its main steam isolation valve (MSIV). The reactor scrams on low Reactor Coolant System (RCS) pressure. The entire SG inventory on the affected loop is assumed to be released by the time the MSIV is fully closed.

Due to the Loss-of-Offsite Power (LOOP), the reactor coolant pumps (RCPs) trip, the main feedwater (MFW) pumps trip, and the condenser becomes unavailable. Emergency feedwater (EFW) actuates automatically to raise steam generator liquid levels. Closure of the turbine stop valves (TSVs) causes the main steam line pressure to increase and open the atmospheric dump valves (ADVs) and main steam safety valves (MSSVs). The fission products escaping from the ADVs and/or MSSVs are released directly to the atmosphere.

The MSLB scenario considers a single active failure and a coincident loss-of-offsite power. The accident chronology applied in this analysis is reported below.

MSLB Chronology

Time	Event	Comments
0 seconds	MSLB occurs outside containment Coincident LOOP	
~0 seconds	Reactor trip ADV block valve on intact SG fails to open (single active failure); all releases are through the MSSVs.	
10 seconds	Control Room Isolated	
1 minute	Faulted SG secondary side completely released MSIVs are closed.	Operators notice failed block valve and dispatch an operator to correct the issue in the field.
30 minutes	Failed ADV manually opened Cooldown is started using the intact SG	
237.8 hours	Decay Heat Removal (DHR) conditions reached. Primary-to-Secondary (PS) leakage from intact loop terminated	

Time	Event	Comments
251.8 hours	RCS temperature below 212 ºF. PS leakage into faulted loop is terminated.	

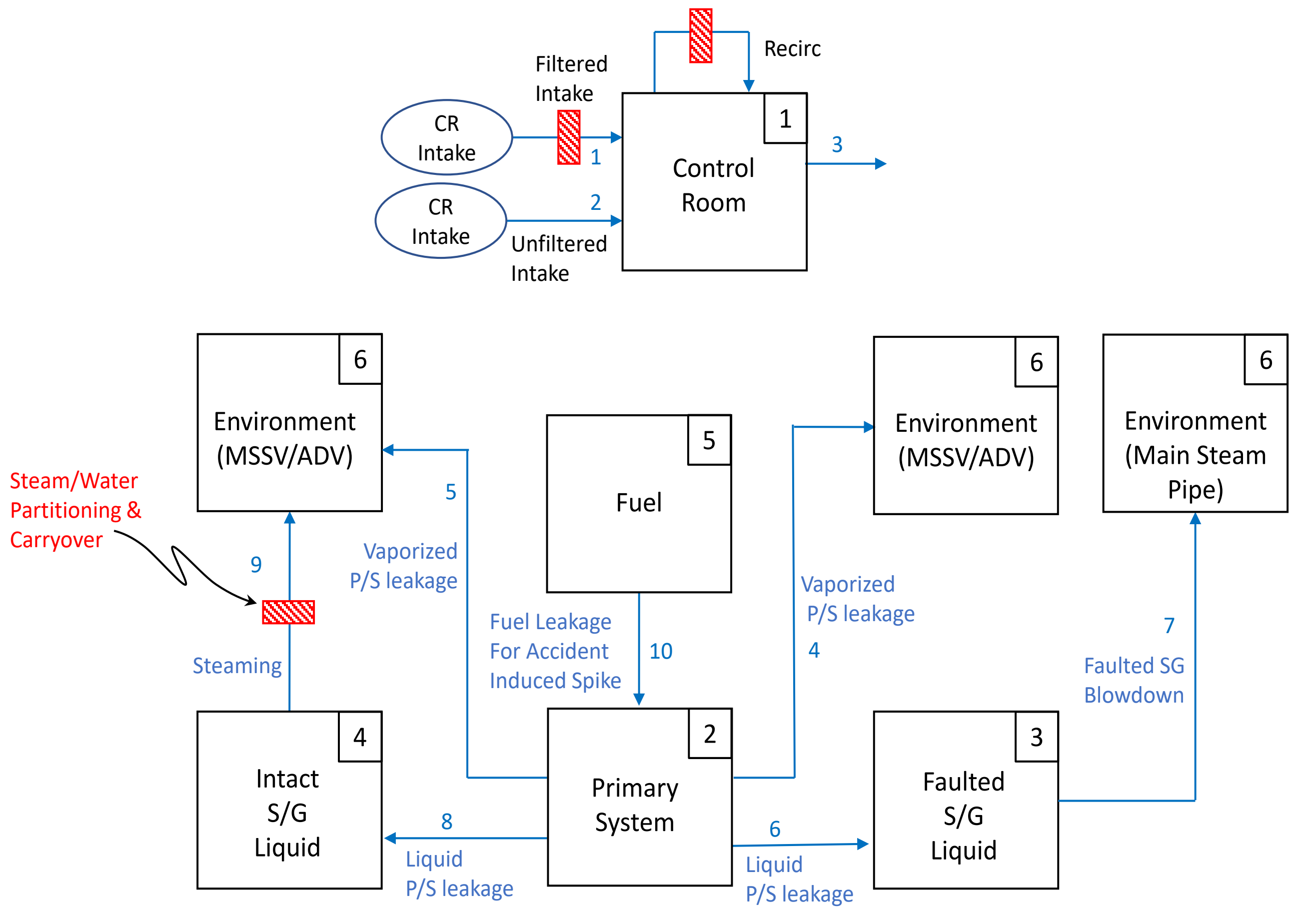
2.0 RADIOLOGICAL CONSEQUENCE MODEL

The radiological consequences of the MSLB accident were then analyzed with RADTRAD 3.03. Due to code limitations, the scenario was broken down into nine cases, which were evaluated separately and summed to develop to total dose. For each case, the impact on control room dose from the plume was also evaluated using modified isotopic-specific dose conversion factors and was shown to be negligible. These cases are listed in the table below.

ANO-1 MSLB Cases

	Description
1	Secondary coolant iodine release from faulted SG
2	Secondary coolant iodine release from intact SG
3	Secondary coolant alkali metal release from faulted SG
4	Secondary coolant alkali metal release from intact SG
5	Primary coolant iodine release due to PS leakage
6	Primary coolant alkali metal release due to PS leakage
7	Primary coolant noble gas release due to PS leakage
8	Primary coolant iodine release from pre-existing spike due to PS leakage
9	Primary coolant iodine release from accident-induced spike due to PS leakage

The RADTRAD model developed to evaluate these cases is illustrated below.



2.1 COMPARTMENTS

The volumes of the compartments are listed below. Since the RCS compartments are typically reported in terms of mass, the RADTRAD runs applied the masses of these compartments in grams (rather than cubic feet [ft^3]) with corresponding flows between the compartments in grams/minute (rather than cubic feet per minute [cfm]).

Compartment	Name	Volume	Comments
1	Control Room	4.00E+05 ft^3	
2	RCS	2.44E+08 g	Equivalent to 5.37E+05 pounds (lbs)
3	Ruptured SG Liquid	2.72E+07 g	Equivalent to 6.00E+04 lbs
4	Intact SG Liquid	2.72E+07 g	
5	Fuel	1.00E+10 g	Large enough to minimize depletion effects over the 8-hour iodine spike

The control room is modeled with a recirculating filter that starts upon isolation at ten seconds after the scram with the following parameters.

Time	Flow	Filters		
		Aerosol	Elemental	Organic
0.0	0 cfm	0%	0%	0%
10 sec	1667 cfm	99%	95%	95%

2.2 PATHWAYS

Pathway 1: Filtered Control Room (CR) Intake

This pathway represents the filtered intake into the CR. This pathway starts 10 seconds after the scram and is modeled with the following flows and filters.

Time	Flow	Filters		
		Aerosol	Elemental	Organic
0.0	0 cfm	0%	0%	0%
10 sec	333 cfm	99%	99%	99%

Pathway 2: Un-Filtered CR In-leakage

This pathway represents the unfiltered intake into the CR. The ANO-1 design basis in-leakage rate of 82 cfm was applied in this analysis. The unfiltered control room in-leakage is modeled with the following flows and filters.

Time	Flow
0.0	35,200 cfm
10 sec	82 cfm

Pathway 3: CR Exfiltration

This pathway represents the exfiltration from the CR. This flow is the sum of the flows entering the CR (Pathways 1 and 2).

Time	Flow
0.0	35,200 cfm
10 sec	415 cfm

Pathway 4: Vaporized PS Leakage (Faulted SG)

This pathway represents the PS leakage into the faulted SG that is vaporized. Since all of the PS leakage is assumed to be vaporized, this flow represents all of the PS leakage into the faulted SG. The leakage rate for this pathway is 0.5 gallons per minute (gpm). Since both PS leakage paths have identical vaporization fractions (i.e., 100%) and χ/Qs, the total 1 gpm leakage from Technical Specification (TS) 5.5.9.b.2 is simply split between the SGs.

As described in Section 5.2 of Appendix E to Regulatory Guide (RG) 1.183, the density of this PS leakage should be based on a cooled liquid at a density of 62.4 pound mass per cubic foot (lbm/ft^3). On these bases, the 0.5 gpm of PS leakage is calculated to be 1892 grams per minute. This leakage is assumed to continue into the faulted SG until the RCS has been cooled to below 212 ºF at 251.8 hours.

$$0.5\ \frac{gallons}{min} * \frac{ft^3}{7.48\ gal} * \frac{62.4\ lb}{ft^3} * \frac{453.59\ g}{lb} = 1892\ \frac{g}{min}$$

Time (Hours)	Flow
0.0	1892 grams/min
251.8	0.0 grams/min

Pathway 5: Vaporized PS Leakage (Intact SG)

This pathway represents the PS leakage into the intact SG that is vaporized. Since all of the PS leakage is assumed to be vaporized, this flow represents all of the PS leakage into the intact S/G.

As discussed for Pathway 4, the flowrate is 0.5 gpm or 1892 grams per minute. This leakage is assumed to continue into the intact SG until the RCS has been cooled to decay heat removal entry conditions at 237.8 hours.

Time (Hours)	Flow
0.0	1892 grams/min
237.8	0.0 grams/min

Pathways 6 & 8: Liquid PS Leakage

These pathways are no longer applied since this analysis assumes 100% vaporization of all P/S leakage.

Time (Hours)	Flow
0.0	0.0 grams/min

Pathway 7: Faulted SG Blowdown

This pathway represents the blowdown of the faulted loop. Once the main steam line breaks, the inventory in the faulted loop is assumed to be released to the environment through this pathway within the first minute. Consequently, this pathway has a very high flow rate for the first minute (0.0167 hours). This flow would equate to 2.72E+07 gram/min. To ensure that all the inventory is released, this flow is increased to 2.72E+10 for an additional 2 seconds.

Time (Hours)	Flow
0.0	2.72E+07 grams/min
0.0167	2.72E+10 grams/min
0.01722	0.0 grams/min

Pathway 9: Intact SG Steaming

This pathway represents the steaming of the intact SG. As the core decay heat is removed through the single intact SG, the secondary coolant is vaporized and released via the MSSV or ADV.

Time (Hours)	Flow
0.0	2.5352E+06 grams/min
2.0	3.611E+05 grams/min
237.8	0.0

After the scram, these flows are multiplied by 0.01 and 0.001 for the iodine and alkali metal cases, respectively to model the partitioning of iodine and moisture carryover of the alkali metals.

Pathway 10: Fuel Leakage for Accident-Induced (AI) Spike

This pathway represents the iodine release from the fuel for the accident-induced spike. As described in the source term section, the source term in the core compartment (Compartment 5) is based on the iodine generation rate into the RCS needed to maintain the equilibrium DEI

(1.0 µCi/gm) with a 1 gram per minute flow from the core compartment. Consequently, for the accident-induced spike, the flow rate is increased by 500 times the initial rate.

Time (Hours)	Flow (grams/min)
0	500
8	0

2.3 SOURCE TERMS

Primary and Secondary Compartments

Based on the RCS mass of 2.44E+08 grams and the secondary coolant masses of 2.72E+07 grams/SG, the total activity in each compartment is reported below based on the specific activities. The secondary coolant is initialized with a source term fraction of 0.50 set in either Compartment 3 or 4 (faulted or intact SG) such that the value in the table below is the total secondary activity.

ANO-1 Reactor Coolant Activities (Ci)

Isotope	DEI		DEX
	1.0	0.1	2200
	Primary	Secondary	Primary
Kr-85m			8.564E+02
Kr-85			3.538E+04
Kr-87			1.459E+03
Kr-88			1.710E+03
Xe-131m			3.928E+05
Xe-133m			7.662E+02
Xe-133			1.928E+04
Xe-135m			3.660E+03
Xe-135			6.564E+03
Xe-137			1.708E+04
Xe-138			4.416E+03
Br-84	9.394E+02	6.691E+01	
I-131	1.379E+02	3.052E+00	
I-132	4.880E+02	1.083E+01	

Isotope	DEI		DEX
	1.0	0.1	2200
	Primary	Secondary	Primary
I-133	4.246E+02	9.520E+00	
I-134	7.149E+02	1.665E+01	
I-135	5.978E+02	1.365E+01	
Rb-88	3.636E+01	1.431E+00	
Cs-134	7.198E+01	2.900E+00	
Cs-135	1.103E+01	4.477E-01	
Cs-137	4.587E+01	1.246E+00	

Fuel Sources

The fuel source is applied for the AI spike case. The core compartment is initialized with this source term to represent the release rate from the core based on a 1 gram/min release to offset the system losses. To model a 500-fold iodine spike, Pathway 10 is modeled with a 500 gram/min flow rate for the first 8 hours

The source term for the core compartment is calculated by summing the losses from letdown, radioactive decay and PS leakage for an initial coolant activity at 1.0 μCi/g DEI. Then, with a compartment volume of 1E+10 grams and a 1 gram/min flow (Pathway 10), the core inventories can be calculated by merely multiplying the loss rate (in Ci/min) by 1E+10.

Isotope	Letdown (min^{-1})	Leakage (min^{-1})	Decay Constant (min^{-1})	Total Loss Rate (min^{-1})	Initial Activity (Ci)	Loss Rate (Ci/min)	Source (Ci)
I-131	1.360E-03	3.210E-06	5.984E-05	1.423E-03	1.379E+02	1.962E-01	1.962E+09
I-132	1.360E-03	3.210E-06	5.023E-03	6.386E-03	4.880E+02	3.116E+00	3.116E+10
I-133	1.360E-03	3.210E-06	5.553E-04	1.918E-03	4.246E+02	8.146E-01	8.146E+09
I-134	1.360E-03	3.210E-06	1.316E-02	1.452E-02	7.149E+02	1.038E+01	1.038E+11
I-135	1.360E-03	3.210E-06	1.747E-03	3.111E-03	5.978E+02	1.860E+00	1.860E+10

The iodine species of the initial and spike activity is assumed to the 97% elemental and 3% organic.

2.4 OTHER FACTORS

Exclusion Area Boundary (EAB)

Per Section 4.1.3 of RG 1.183, the breathing rate of persons offsite is assumed to be 3.5E-04 m^3/s.

The EAB dispersion coefficient is unchanged from the current value. Although it is a 2-hour value, it is modeled throughout the entire accident duration so that the worst-case 2-hour sliding window can be accurately identified.

Time (Hours)	χ/Q value (s/m^3)
0.0	6.8E-04
720	0.0

Low Population Zone (LPZ)

Per Section 4.1.3 of RG 1.183, for the first 8 hours, the breathing rate of persons at this location is assumed to be 3.5E-04 m^3/s. From 8 to 24 hours following the accident, the breathing rate is 1.8E-04 m^3/s. After that and until the end of the accident, the rate is assumed to be 2.3E-04 m^3/s.

Time (Hours)	Breathing Rate (m^3/s)
0.0	3.5E-04
8	1.8E-04
24	2.3E-04
720	0.0

The LPZ dispersion coefficients are unchanged from the current values.

Time (Hours)	**χ/Q value (s/m^3)**
0.0	1.1E-04
8	1.1E-05
24	4.0E-06
96	1.3E-06
720	0.0

Control Room

Per Section 4.2.6 of RG 1.183, the dose receptor for these analyses is the hypothetical maximum exposed individual who is present in the control room for 100% of the time during the first 24 hours after the event, 60% of the time between 1 and 4 days, and 40% of the time from 4 days to 30 days. For the duration of the event, the breathing rate of this individual is assumed to be 3.5E-04 m^3/s.

Time (Hours)	**Occupancy Factor**	**Breathing Rate (m^3/s)**
0.0	1.0	3.5E-04
24	0.6	
96	0.4	
720	0	0.0

The dispersion coefficients are based on the release point and the receptor locations. The control room χ/Qs applicable to this event are listed below for the worst-case (closest) intake. These values represent the closest MSSV, ADV, or main steam pipe to the nearest control room intake in either loop.

Control Room Dispersion Coefficients (s/m^3)

Time (Hours)	Main Steam Safety Valve	Atmospheric Dump Valve	Main Steam Pipe
0.0	1.90E-02	4.10E-03	3.15E-03
2	1.23E-02	2.59E-03	2.16E-03
8	5.83E-03	1.12E-03	8.90E-04
24	3.80E-03	8.32E-04	6.61E-04
96	3.10E-03	5.91E-04	5.01E-04
720	0	0	0

Since the MSIV is expected to close in the faulted loop, the only release out of the main steam pipe would be the secondary coolant in the faulted loop. This dispersion value is consequently applied for the release of the secondary coolant in the faulted loop in Cases 1 and 3.

If the MSIV in the faulted loop failed to close, the vaporized RCS PS leakage would also be released from the main steam pipe; however, since the main steam pipe dispersion coefficients are lower than the ADV and MSSV values, this would not be a bounding single active failure. Instead, the normally-closed motor-operated block valve isolating the ADV on the intact loop fails to open so that the releases are via the MSSV until an operator manually opens the block valve at 30 minutes.

Modeled Control Room Dispersion Coefficients (s/m^3)

Time (Hours)	Main Steam Pipe	MSSV/ADV
0.0	3.15E-03	1.90E-02
0.5		4.10E-03
2		2.59E-03
8		1.12E-03
24		8.32E-04
96		5.91E-04
720	0	0

3.0 RESULTS

RADTRAD 3.03 was executed for the nine cases identified above. The initial DEI for the pre-accident spike case was 60.0 μCi/g in the RCS and secondary coolant DEI of 0.1 μCi/g.

The initial DEI for the accident-induced spike case was 1.0 μCi/g in the RCS and secondary coolant DEI of 0.1 μCi/g.

		PRE-EXISTING SPIKE (DEI=60 μCi/g)				**ACCIDENT-INDUCED SPIKE (DEI=1 μCi/g)**		
	File Name	**EAB**	**LPZ**	**CR**		**EAB**	**LPZ**	**CR**
	Airborne Dose							
1	sec_iodine_faulted	3.5890E-02	5.8057E-03	2.4879E-01		3.5890E-02	5.8057E-03	2.4879E-01
2	sec_iodine_intact	2.9590E-03	6.4807E-04	2.9885E-03		2.9590E-03	6.4807E-04	2.9885E-03
3	sec_alkali_faulted	2.1332E-02	3.4508E-03	2.3006E-01		2.1332E-02	3.4508E-03	2.3006E-01
4	sec_alkali_intact	2.3636E-04	6.3784E-05	3.4517E-04		2.3636E-04	6.3784E-05	3.4517E-04
5	rcs_iodine	4.2820E-03	2.8573E-03	9.8209E-03		4.2820E-03	2.8573E-03	9.8209E-03
6	rcs_alkali	2.1764E-03	2.0108E-03	8.5908E-03		2.1764E-03	2.0108E-03	8.5908E-03
7	rcs_ngas	2.3656E-03	1.4162E-03	2.6481E-03		2.3656E-03	1.4162E-03	2.6481E-03
8	pe_spike	2.5264E-01	1.6858E-01	5.7943E-01		0.0000E+00	0.0000E+00	0.0000E+00
9	ai_spike	0.0000E+00	0.0000E+00	0.0000E+00		1.1867E+00	6.9882E-01	2.0445E+00
	Cloud Dose to Control Room							
1	c_sec_iodine_faulted			1.5381E-04				1.5381E-04
2	c_sec_iodine_intact			2.5039E-05				2.5039E-05
3	c_sec_alkali_faulted			1.5155E-06				1.5155E-06
4	c_sec_alkali_intact			4.7938E-08				4.7938E-08
5	c_rcs_iodine			2.2257E-05				2.2257E-05
6	c_rcs_alkali			1.5658E-06				1.5658E-06
7	c_rcs_ngas			6.3859E-05				6.3859E-05
8	c_pe-spike			1.3132E-03				0.0000E+00
9	c_ai-spike			0.0000E+00				3.6689E-03
	Total	3.2188E-01	1.8483E-01	1.0843E+00		1.2559E+00	7.1507E-01	2.5517E+00

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Attachment 4

Control Rod Ejection Accident (CREA)
Model Information

CONTROL ROD EJECTION ACCIDENT (CREA) MODEL INFORMATION

1.0 EVENT DESCRIPTION

While operating at full power, a high-worth control rod is quickly ejected from the core, resulting in a reactor trip on high flux and a substantial number of fuel rods entering Departure from Nucleate Boiling (DNB). These rods are assumed to fail and release their gap activity to either the primary system or the reactor building. A loss-of-offsite power (LOOP) is assumed concurrent with the scram, making the condenser unavailable for decay heat rejection. The atmospheric dump valves (ADVs) and main steam safety valves (MSSVs) are used to cool down the plant. The fission products escaping from the ADVs and/or MSSVs are released directly to the atmosphere. The accident chronology applied in this analysis is reported below for each potential leakage path.

CREA Chronology – Primary-to-Secondary (PS) Leakage Pathway

Time	Event	Comments
0 seconds	CREA occurs Reactor trip on high neutron flux Source term release begins LOOP occurs ADV block valve on one SG fails to open (single active failure) releases are through the MSSVs for the affected loop	
10 sec	Control Room isolated on high radiation in intakes Source term release into the coolant ends	Operators notice failed block valve and dispatch an operator to correct the issue in the field.
30 minutes	Failed ADV block valve manually opened. Releases from the affected loop are via the ADV.	
38.25 hours	Shutdown cooling is initiated. Releases are terminated	

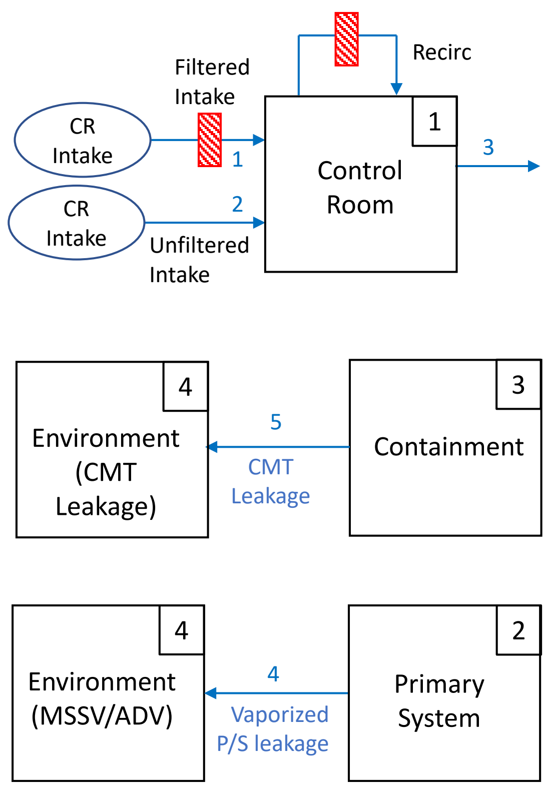
CREA Chronology – Containment Leakage Pathway

Time	Event	Comments
0 seconds	CREA occurs Reactor trip on high neutron flux Source term release begins LOOP occurs	

Time	Event	Comments
10 seconds	Source term release into the containment ends	
10 seconds	Control Room isolated on high radiation in intakes	
30 days	Releases are terminated	

2.0 RADIOLOGICAL CONSEQUENCE MODEL

The radiological consequences of the CREA accident were then analyzed with RADTRAD 3.03. For each case, the impact on control room dose from the plume was also evaluated using modified isotopic-specific dose conversion factors and was shown to be negligible. The RADTRAD model developed to evaluate these cases is illustrated below.



2.1 COMPARTMENTS

The volumes of the compartments are listed below. Since the RCS compartment is typically reported in terms of mass, the RADTRAD runs applied the mass of this compartment in grams (rather than cubic feet [ft^3]) with corresponding flows from this compartment in grams/minute (rather than cubic feet per minute [cfm]).

Compartment	Name	Volume	Comments
1	Control Room	4.00E+05 ft^3	
2	RCS	2.44E+08 g	Equivalent to 5.37E+05 pounds (lbs)
3	Containment	1.81E+06 ft^3	

The control room is modeled with a recirculating filter that starts upon isolation at ten seconds after the scram with the following parameters.

Time	Flow	Filters		
		Aerosol	Elemental	Organic
0.0	0 cfm	0%	0%	0%
10 sec	1667 cfm	99%	95%	95%

2.2 PATHWAYS

Pathway 1: Filtered Control Room (CR) Intake

This pathway represents the filtered intake into the CR. This pathway starts ten seconds after the scram and is modeled with the following flows and filters.

Time	Flow	Filters		
		Aerosol	Elemental	Organic
0.0	0 cfm	0%	0%	0%
10 sec	333 cfm	99%	99%	99%

Pathway 2: Un-Filtered CR In-leakage

This pathway represents the unfiltered intake into the CR. The ANO-1 design basis in-leakage rate of 82 cfm was applied in this analysis. The unfiltered CR in-leakage is modeled with the following flows and filters.

Time	Flow
0.0	35,200 cfm
10 sec	82 cfm

Pathway 3: CR Exfiltration

This pathway represents the exfiltration from the CR. This flow is the sum of the flows entering the CR (Pathways 1 and 2).

Time	Flow
0.0	35,200 cfm
10 sec	415 cfm

Pathway 4: Vaporized PS Leakage

This pathway represents the total PS leakage into both steam generators (SGs). All of this PS leakage is assumed to be vaporized and released. The leakage rate for this pathway is 150 gallons per day (gpd) per SG based on Technical Specification (TS) 3.4.13. This leakage rate is based on 62.4 lb/ft^3 consistent with Section 7.2 of Appendix H to Regulatory Guide (RG) 1.183. This leakage is assumed to continue until the reactor is brought to cold shutdown consistent with Table 6 to RG 1.183. This shutdown time is 38.25 hours with both SGs available.

$$2 * 150\ \frac{gallons}{day} * \frac{day}{24\ hours} * \frac{hour}{60\ minutes} * \frac{ft^3}{7.48\ gal} * \frac{62.4\ lb}{ft^3} * \frac{453.59\ g}{lb} = 788\ \frac{g}{min}$$

Time (Hours)	Flow (grams/min)
0.0	788
38.25	0.0

Pathway 5: Containment Leakage

This pathway represents the containment leakage into the environment. This rate is 0.2% of the containment air weight per day at a pressure of P_a per ANO-1 TS 5.5.16. This rate is applied in this calculation for the first 24 hours. After 24 hours, consistent with Section 6.2 of Appendix H to RG 1.183, this leakage rate drops by 50% at 24 hours. This leakage is assumed to continue for 30 days consistent with Table 6 to RG 1.183.

Time (Hours)	Flow (percent/day)
0.0	0.2
24	0.1
720	0.0

2.3 SOURCE TERMS

The source terms are based on 14% of the core departing from nucleate boiling. These control rods were assumed to have a bounding peaking factor of 1.8. Consistent with Section 1 of Appendix H to RG 1.183, the gap fractions for the iodine and noble gases are 10%. Since Appendix H to RG 1.183 is silent on the applicable gap fraction for alkali metals, this calculation applies a value of 12% consistent with non-LOCA gap fractions in Table 3 of RG 1.183. These released source terms are reproduced below.

ANO-1 CREA Released Activity (Ci)

Isotope	Core Activity (Ci)	Fraction of Core Damaged	Peaking Factor	Gap Fraction	Released Activity (Ci)
Kr-83m	8.77E+06	14.00%	1.8	10.00%	2.210E+05
Kr-85	9.61E+05	14.00%	1.8	10.00%	2.422E+04
Kr-85m	1.90E+07	14.00%	1.8	10.00%	4.788E+05
Kr-87	3.73E+07	14.00%	1.8	10.00%	9.400E+05
Kr-88	5.01E+07	14.00%	1.8	10.00%	1.263E+06
Xe-131m	7.55E+05	14.00%	1.8	10.00%	1.903E+04
Xe-133	1.48E+08	14.00%	1.8	10.00%	3.730E+06
Xe-133m	4.60E+06	14.00%	1.8	10.00%	1.159E+05
Xe-135	3.51E+07	14.00%	1.8	10.00%	8.845E+05
Xe-135m	3.09E+07	14.00%	1.8	10.00%	7.787E+05
Xe-138	1.27E+08	14.00%	1.8	10.00%	3.200E+06
I-130	1.36E+06	14.00%	1.8	10.00%	3.427E+04
I-131	7.22E+07	14.00%	1.8	10.00%	1.819E+06
I-132	1.05E+08	14.00%	1.8	10.00%	2.646E+06
I-133	1.48E+08	14.00%	1.8	10.00%	3.730E+06
I-134	1.67E+08	14.00%	1.8	10.00%	4.208E+06
I-135	1.41E+08	14.00%	1.8	10.00%	3.553E+06
Cs-134	1.46E+07	14.00%	1.8	12.00%	4.415E+05
Cs-136	2.98E+06	14.00%	1.8	12.00%	9.012E+04
Cs-137	9.88E+06	14.00%	1.8	12.00%	2.988E+05
Cs-138	1.38E+08	14.00%	1.8	12.00%	4.173E+06
Rb-86	1.29E+05	14.00%	1.8	12.00%	3.901E+03

The iodine species of the released activity is assumed to the 97% elemental and 3% organic for the RCS release. For the containment release, the iodine species is assumed to be 95% aerosol, 4.85% elemental, and 0.15% organic.

2.4 OTHER FACTORS

Exclusion Area Boundary (EAB)

Per Section 4.1.3 of RG 1.183, the breathing rate of persons offsite is assumed to be 3.5E-04 m^3/s.

The EAB dispersion coefficient is unchanged from the current value. Although it is a 2-hour value, it is modeled throughout the entire accident duration so that the worst-case 2-hour sliding window can be accurately identified.

Time (Hours)	**χ/Q value (s/m^3)**
0.0	6.8E-04
720	0.0

Low Population Zone (LPZ)

Per Section 4.1.3 of RG 1.183, for the first 8 hours, the breathing rate of persons at this location is assumed to be 3.5E-04 m^3/s. From 8 to 24 hours following the accident, the breathing rate is 1.8E-04 m^3/s. After that and until the end of the accident, the rate is assumed to be 2.3E-04 m^3/s.

Time (Hours)	**Breathing Rate (m^3/s)**
0.0	3.5E-04
8	1.8E-04
24	2.3E-04
720	0.0

The LPZ dispersion coefficients are unchanged from the current values.

Time (Hours)	χ/Q value (s/m^3)
0.0	1.1E-04
8	1.1E-05
24	4.0E-06
96	1.3E-06
720	0.0

Control Room

Per Section 4.2.6 of RG 1.183, the dose receptor for these analyses is the hypothetical maximum exposed individual who is present in the control room for 100% of the time during the first 24 hours after the event, 60% of the time between 1 and 4 days, and 40% of the time from 4 days to 30 days. For the duration of the event, the breathing rate of this individual is assumed to be 3.5E-04 m^3/s.

<table>
<tr><th>Time (Hours)</th><th>Occupancy Factor</th><th>Breathing Rate (m^3/s)</th></tr>
<tr><td>0.0</td><td>1.0</td><td rowspan="3">3.5E-04</td></tr>
<tr><td>24</td><td>0.6</td></tr>
<tr><td>96</td><td>0.4</td></tr>
<tr><td>720</td><td>0</td><td>0.0</td></tr>
</table>

The dispersion coefficients are based on the release point and the receptor locations. The control room χ/Qs applicable to this event are listed below for the worst-case (closest) intake. These values represent the closest MSSV or ADV to the nearest control room intake in either loop. For the containment release, the highest values of the dispersion factors for a diffuse release from the ANO-1 containment to either control room intake are applied.

Control Room Dispersion Coefficients (s/m^3)

Time (Hours)	Main Steam Safety Valve	Atmospheric Dump Valve	Containment Release
0.0	1.90E-02	4.10E-03	3.55E-03
2	1.23E-02	2.59E-03	2.49E-03
8	5.83E-03	1.12E-03	9.85E-04
24	3.80E-03	8.32E-04	8.30E-04
96	3.10E-03	5.91E-04	6.31E-04
720	0	0	0

In order to maximize control room doses, the normally-closed motor-operated block valve on one loop is assumed to fail to open so that the releases are via the MSSV after the scram until an operator manually opens the block valve after 30 minutes. Since the releases from each loop are approximately equal, the control room χ/Q for the first 30 minutes would be the average of the MSSV and ADV values.

Control Room Dispersion Coefficients (s/m^3)

<table>
<tr><th>Time (Hours)</th><th>MSSV/ADV</th><th>Containment Release</th></tr>
<tr><td>0.0</td><td>1.155E-02</td><td rowspan="2">3.55E-03</td></tr>
<tr><td>0.5</td><td>4.10E-03</td></tr>
<tr><td>2</td><td>2.59E-03</td><td>2.49E-03</td></tr>
<tr><td>8</td><td>1.12E-03</td><td>9.85E-04</td></tr>
<tr><td>24</td><td>8.32E-04</td><td>8.30E-04</td></tr>
<tr><td>96</td><td>5.91E-04</td><td>6.31E-04</td></tr>
<tr><td>720</td><td>0</td><td></td></tr>
</table>

3.0 RESULTS

RADTRAD 3.03 was executed for the scenarios identified above.

		PS LEAKAGE (39 GPD/SG)		
Pathway	**File Name**	**EAB**	**LPZ**	**CR**
Airborne Dose	ps39.out	3.2868E+00	2.1977E+00	4.9540E+00
Cloud Dose	c_ps39.out			6.9013E-03
Total		3.2868E+00	2.1977E+00	4.9609E+00

		CONTAINMENT LEAKAGE		
Pathway	**File Name**	**EAB**	**LPZ**	**CR**
Airborne Dose	cmt.out	4.7183E+00	2.2730E+00	3.1183E+00
Cloud Dose	c_cmt.out			5.7096E-03
Total		4.7183E+00	2.2730E+00	3.1240E+00

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Attachment 5

SGTR RADTRAD Input Files

SGTR RADTRAD INPUT FILES

Nuclide Inventory Files

Release Compartment	File Name
Primary	rcs.nif
Secondary	secondary.nif
Core (Accident-Induced Spike case)	ai_spike.nif

Release Fraction Tables

Release Type	File Name
Noble Gases	ngas.rft
Iodine	iodine.rft
Alkali Metals	alkali.rft

Dose Conversion Factor Tables

Dose Type	File Name
Inhalation	adult.inp
Shine	cloud.inp

Plant Scenario Files

	Description	RADTRAD Case Name	
		Airborne	Shine
1	Secondary coolant iodine release from both steam generators	sec_iodine.psf	c_sec_iodine.psf
2	Secondary coolant alkali metal release from both steam generators	sec_alkali.psf	c_sec_alkali.psf
3	Primary coolant iodine release due to PS and tube leakage	rcs_iodine.psf	c_rcs_iodine.psf

	Description	RADTRAD Case Name	
		Airborne	**Shine**
4	Primary coolant alkali metal release due to PS and tube leakage	rcs_alkali.psf	c_rcs_alkali.psf
5	Primary coolant noble gas release due to PS and tube leakage	rcs_ngas.psf	c_rcs_ngas.psf
6	Primary coolant iodine release from accident-induced spike due to P/S and tube leakage	ai_spike.psf	c_ai_spike.psf

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Attachment 6

MSLB RADTRAD Input Files

MSLB RADTRAD INPUT FILES

Nuclide Inventory Files

Release Compartment	File Name
Primary	rcs.nif
Secondary	secondary.nif
Core (Acciden-Induced Spike case)	ai_spike.nif

Release Fraction Tables

Release Type	File Name
Noble Gases	ngas.rft
Iodine	iodine.rft
Alkali Metals	alkali.rft

Dose Conversion Factor Tables

Dose Type	File Name
Inhalation	adult.inp
Shine	cloud.inp

Plant Scenario Files

	Description	RADTRAD Case Name	
		Airborne	Shine
1	Secondary coolant iodine release from faulted steam generator	sec_iodine_faulted.psf	c_sec_iodine_faulted.psf
2	Secondary coolant iodine release from intact steam generator	sec_iodine_intact.psf	c_sec_iodine_intact.psf
3	Secondary coolant alkali metal release from faulted steam generator	sec_alkali_faulted.psf	c_sec_alkali_faulted.psf
	Description	RADTRAD Case Name	

		Airborne	Shine
4	Secondary coolant alkali metal release from intact steam generator	sec_alkali_intact.psf	c_sec_alkali_intact.psf
5	Primary coolant iodine release due to P/S leakage	rcs_iodine.psf	c_rcs_iodine.psf
6	Primary coolant alkali metal release due to PS leakage	rcs_alkali.psf	c_rcs_alkali.psf
7	Primary coolant noble gas release due to PS leakage	rcs_ngas.psf	c_rcs_ngas.psf
8	Primary coolant iodine release from pre-existing spike due to PS leakage	pe_spike.psf	c_pe_spike.psf
9	Primary coolant iodine release from accident-induced spike due to PS leakage	ai_spike.psf	c_ai_spike.psf

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Attachment 7

CREA RADTRAD Input Files

CREA RADTRAD INPUT FILES

Nuclide Inventory Files

Release Compartment	File Name
Core Gap	crea.nif

Release Fraction Tables

Release Type	File Name
Primary-to-secondary leakage and containment	crea.rft

Dose Conversion Factor Tables

Dose Type	File Name
Inhalation	adult.inp
Shine	cloud.inp

Plant Scenario Files

	Description	RADTRAD Case Name	
		Airborne	Shine
1	Primary-to-secondary leakage pathway	ps39.psf	c_ps39.psf
2	Containment leakage pathway	cmt.psf	c_cmt.psf