ATTACHMENT 1

ADDITIONAL SENSITIVITY CASES REGARDING TECHNICAL SPECIFICATION FOR DEINERTED OPERATION

1.0 INTRODUCTION

The NRC in discussions with the BWROG on March 5, 2007 suggested that sensitivity cases regarding the impact of assumptions related to the number of outages per year on the conclusion that support deinerted times for Technical Specification consideration would be desirable. To this end, the following sensitivity cases are developed:

Case	No. of Refuel/yr	No. of Forced Outage/yr	No. of Trips/yr	Deinerted (Hours/yr)		
				Base	Sensitivity	Δ
S1	1	1	0	96	288	192
S2	1	0	1	72	216	144
S3	1	0	0	48	96	48
S4	0.5	0	1	48	144	96
S5	0.5	1	0	72	144	72
6	1	0	0	48	144	96

The additional discussion of requested sensitivity cases includes the following:

- Section 2.0: Description of the Sensitivity Cases
- Section 3.0: Sensitivity Calculations
- Section 4.0: Results Summary

2.0 SENSITIVITY CASE INPUTS

<u>Case S1:</u> Assume one refuel outage and one forced outage per calendar year applying the maximum allowed Technical Specification time deinerted for each.

<u>Definitions</u>

CDF_{BASE} = Base model PRA Core Damage Frequency

$LERF_{BASE}^{COND}$ = Conditional LERF probability given a core damage event occurring while the containment is inerted

$LERF^{COND}_{DEINERT}$ = Conditional LERF probability given a CDF occurring while the containment is deinerted

D^1_B = Base case duration of deinerted operations prior to two shutdowns (24 hrs + 24 hrs)

D^2_B = Base case duration of deinerted operation following two startups (24 hrs + 24 hrs)

D^1_P = Proposed duration of deinerted operation prior to two shutdowns (72 hrs + 72 hrs)

D^2_P = Proposed duration of deinerted operation following two startups (72 hrs + 72 hrs)

I^1_B = Base case duration of inerted operation prior to shutdown

I^2_B = Base case duration of inerted operation following startup

I^1_P = Proposed duration of inerted operation prior to shutdown

I^2_P = Base case duration of inerted operation following startup

<u>Assumption:</u>

- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains a constant for the Base Analysis and the proposed modified inerting times.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - <u>Base Case</u>

$$D^1_B + D^2_B = 96 \text{ hrs/yr}$$

$$I^1_B + I^2_B = 8760 \text{ hrs/yr} - 720 \text{ hrs/yr} - 96 \text{ hrs/yr} = 7944 \text{ hrs/yr}$$

– Proposed Case

$D_P^1 + D_P^2 = 288$ hrs/yr

$I_P^1 + I_P^2 = 8760$ hrs/yr – 720 hrs/yr – 288 hrs/yr
$= 7752$ hrs/yr

Analyzed Time Lines (schedules)

Base S1	I_B^1	D_B^1	SHUTDN	D_B^2	I_B^2
	Inerted	Deinerted		Deinerted	Inerted

Proposed S1	I_P^1	D_P^1	SHUTDN	D_P^2	I_P^2
	Inerted	Deinerted		Deinerted	Inerted

Case S2: Assume one refuel outage and one reactor trip per calendar year applying the maximum allowed Tech Spec time deinerted for each except the trip from power.

Definitions

CDF_{BASE} = Base model PRA Core Damage Frequency

$LERF_{BASE}^{COND}$ = Conditional LERF probability given a core damage event occurring while the containment is inerted

$LERF_{DEINERT}^{COND}$ = Conditional LERF probability given a CDF occurring while the containment is deinerted

D_B^1 = Base case duration of deinerted operations prior to one shutdown (24 hrs) and one reactor trip (0 hrs)

D_B^2 = Base case duration of deinerted operation following two startups (48 hrs)

D_P^1 = Proposed duration of deinerted operation prior to one shutdown (72 hrs) and one reactor trip (0 hrs)

D_P^2 = Proposed duration of deinerted operation following two startups (144 hrs)

I_B^1 = Base case duration of inerted operation prior to shutdown

I_B^2 = Base case duration of inerted operation following startup

I_P^1 = Proposed duration of inerted operation prior to shutdown

I_P^2 = Base case duration of inerted operation following startup

<u>Assumption:</u>

- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains a constant for the Base Analysis and the proposed modified inerting times.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - <u>Base Case</u>

    $D_B^1 + D_B^2 = 72$ hrs/yr

    $I_B^1 + I_B^2 = 8760$ hrs/yr – 720 hrs/yr – 72 hrs/yr
    = 7968 hrs/yr
  - <u>Proposed Case</u>

    $D_P^1 + D_P^2 = 216$ hrs/yr

    $I_P^1 + I_P^2 = 8760$ hrs/yr – 720 hrs/yr – 216 hrs/yr
    = 7824 hrs/yr

Analyzed Time Lines (schedules)

Base S2	I_B^1	D_B^1	SHUTDN	D_B^2	I_B^2
	Inerted	Deinerted		Deinerted	Inerted

Proposed S2	I_P^1	D_P^1	SHUTDN	D_P^2	I_P^2
	Inerted	Deinerted		Deinerted	Inerted

Case S3: Assume one refuel outage or forced shutdown per year and apply the maximum Tech Spec time to each for startups and 24 hours for shutdown. This is based upon the judgment that times deinerted for shutdowns is not expected to increase much beyond 24 hours, if at all.

Definitions

CDF_{BASE} = Base model PRA Core Damage Frequency

$LERF_{BASE}^{COND}$ = Conditional LERF probability given a core damage event occurring while the containment is inerted

$LERF_{DEINERT}^{COND}$ = Conditional LERF probability given a CDF occurring while the containment is deinerted

D_B^1 = Base case duration of deinerted operations prior to shutdown (24 hrs)

D_B^2 = Base case duration of deinerted operation following startup (24 hrs)

D_P^1 = Proposed duration of deinerted operation prior to shutdown (24 hrs)

D_P^2 = Proposed duration of deinerted operation following startup (72 hrs)

I_B^1 = Base case duration of inerted operation prior to shutdown

I_B^2 = Base case duration of inerted operation following startup

I_P^1 = Proposed duration of inerted operation prior to shutdown

I_P^2 = Base case duration of inerted operation following startup

Assumption:

- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains a constant for the Base Analysis and the proposed modified inerting times.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Case

    $D_B^1 + D_B^2 = 48$ hrs/yr

    $I_B^1 + I_B^2 = 8760$ hrs/yr – 720 hrs/yr – 48 hrs/yr
    $= 7992$ hrs/yr
  - Proposed Case

    $D_P^1 + D_P^2 = 96$ hrs/yr

    $I_P^1 + I_P^2 = 8760$ hrs/yr – 720 hrs/yr – 96 hrs/yr
    $= 7944$ hrs/yr

Analyzed Time Lines (schedules)

Base S3	I_B^1	D_B^1	SHUTDN	D_B^2	I_B^2
	Inerted	Deinerted		Deinerted	Inerted

Proposed S3	I_P^1	D_P^1	SHUTDN	D_P^2	I_P^2
	Inerted	Deinerted		Deinerted	Inerted

Case S4: Assume one refuel outage every other year and one trip per year. Assign the maximum Tech Spec deinerted time for each start up and for the refuel outage shutdown. No time deinerted for the trip.

Definitions

CDF_{BASE} = Base model PRA Core Damage Frequency

$LERF^{COND}_{BASE}$ = Conditional LERF probability given a core damage event occurring while the containment is inerted

$LERF^{COND}_{DEINERT}$ = Conditional LERF probability given a CDF occurring while the containment is deinerted

D^1_B = Base case duration of deinerted operations prior to shutdown (0.5 ∗ 24 hrs) and 0 hrs for trip

D^2_B = Base case duration of deinerted operation following startup (0.5 ∗ 24 hrs + 24 hrs)

D^1_P = Proposed duration of deinerted operation prior to shutdown (0.5 ∗ 72 hrs) and 0 hrs for trip

D^2_P = Proposed duration of deinerted operation following startup (0.5 ∗ 72 hrs + 72 hrs)

I^1_B = Base case duration of inerted operation prior to shutdown

I^2_B = Base case duration of inerted operation following startup

I^1_P = Proposed duration of inerted operation prior to shutdown

I^2_P = Base case duration of inerted operation following startup

Assumption:

- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains a constant for the Base Analysis and the proposed modified inerting times.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Case

    $D_B^1 + D_B^2 = 48$ hrs/yr

    $I_B^1 + I_B^2 = 8760$ hrs/yr – 720 hrs/yr – 48 hrs/yr
    $= 7992$ hrs/yr
  - Proposed Case

    $D_P^1 + D_P^2 = 144$ hrs/yr

    $I_P^1 + I_P^2 = 8760$ hrs/yr – 720 hrs/yr – 144 hrs/yr
    $= 7896$ hrs/yr

Analyzed Time Lines (schedules)

Base S4	I_B^1	D_B^1	SHUTDN	D_B^2	I_B^2
	Inerted	Deinerted		Deinerted	Inerted

Proposed S4	I_P^1	D_P^1	SHUTDN	D_P^2	I_P^2
	Inerted	Deinerted		Deinerted	Inerted

Case S5: Assume the 1 refuel outage every other year and 1 Forced Outage each year and change the Tech Spec to 48 hours instead of 24 hours for the proposed Tech Spec.

Definitions

CDF_{BASE} = Base model PRA Core Damage Frequency

$LERF^{COND}_{BASE}$ = Conditional LERF probability given a core damage event occurring while the containment is inerted

$LERF^{COND}_{DEINERT}$ = Conditional LERF probability given a CDF occurring while the containment is deinerted

D^1_B = Base case duration of deinerted operations prior to shutdown (0.5 ∗ 24 hrs + 24 hrs)

D^2_B = Base case duration of deinerted operation following startup (0.5 ∗ 24 hrs + 24 hrs)

D^1_P = Proposed duration of deinerted operation prior to shutdown (0.5 ∗ 48 hrs + 48 hrs)

D^2_P = Proposed duration of deinerted operation following startup (0.5 ∗ 48 hrs + 48 hrs)

I^1_B = Base case duration of inerted operation prior to shutdown

I^2_B = Base case duration of inerted operation following startup

I^1_P = Proposed duration of inerted operation prior to shutdown

I^2_P = Base case duration of inerted operation following startup

Assumption:

- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains a constant for the Base Analysis and the proposed modified inerting times.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Case

    $D_B^1 + D_B^2 = 72$ hrs/yr

    $I_B^1 + I_B^2 = 8760$ hrs/yr – 720 hrs/yr – 72 hrs/yr
    $= 7968$ hrs/yr
  - Proposed Case

    $D_P^1 + D_P^2 = 144$ hrs/yr

    $I_P^1 + I_P^2 = 8760$ hrs/yr – 720 hrs/yr – 144 hrs/yr
    $= 7896$ hrs/yr

Analyzed Time Lines (schedules)

Base S5	I_B^1	D_B^1	SHUTDN	D_B^2	I_B^2
	Inerted	Deinerted		Deinerted	Inerted
Proposed S5	I_P^1	D_P^1	SHUTDN	D_P^2	I_P^2
	Inerted	Deinerted		Deinerted	Inerted

Case 6

Case 6 was described in the original RAI response.

The Technical Specification for deinerted time is requested to allow for contingencies and greater flexibility. There is no intent to use the entire 72 hours prior to completing the shutdown nor the entire 72 hours for the startup time. The intent is to maximize the owners' flexibility and avoid requiring exigent technical specification changes.

3.0 SENSITIVITY CASE CALCULATIONS

The following calculations develop the risk metrics for the sensitivity cases.

Case 6 – Base Case for Discussion

Use the average CDF values determined for each of the hazard contributors to assess the integrated impact. The differences in accident sequence character (i.e., Accident Class) are also considered in this case to reflect their influence on LERF.

Total CDF:

$$CDF_{BASE}^{FIRE} = 2.42E\text{-}5/yr$$

$$CDF_{BASE}^{SEISMIC} = 6.58E\text{-}6/yr$$

$$CDF_{BASE}^{INTERNAL} = 9.57E\text{-}6/yr$$

In addition to the total CDF, it is also critical to the assessment of ΔLERF to assess the character of the contributing accident sequences to each of these contributors. This is because, there are portions of each of the hazard spectra that:

- Preclude their assignment to LERF because of sufficient warning time for effective evacuation

  OR

- Preclude their impact on ΔLERF because they already cause a LERF and changes in the deinerted time would not alter this conclusion, i.e., would not affect ΔLERF.

The factors that influence the assessment include the following:

Fire Sequence Effects on LERF

- Fire induced CDF events tend to be dominated by events that adversely impact the ability to remove heat from containment or events that cause long term station blackout. These sequences are not LERF contributors because they allow significant time for evacuation.

  In other words, the fire induced CDF is generally attributed to loss of DHR or long term SBO events with long duration before core damage occurs. This analytic result is attributed to the following:

  - Because BOP cables are generally not mapped, the fire is "assumed" to fail the BOP system and defeat the main condenser as a heat sink.
  - The containment vent generally does not have a unique capability to cope with a fire and therefore many fires that adversely affect RHR also result in failing the containment vent.
  - There are generally two divisions of RHR and RHRSW that remain and are capable of removing decay heat; however, there are a number of potential challenges to one of the divisions and some challenges to both divisions.

- The NRC sponsored assessment of fire induced risk to support NUREG-1150 is provided for a Mark I in NUREG/CR-4550, Vol. 4, Rev. 1, Part 3. The results of the NRC calculation indicates that 65% of the fire CDF is not a potential LERF contributor because the associated core damage sequences occur well after effective evacuation would have occurred.

Seismic Sequence Effects on LERF

- Seismic events have a large percentage of contributors that may be both CDF and LERF contributors, therefore these events do not have that portion of the risk spectrum that is already a LERF affected by deinerted operation. In addition, the ANS Standard for External Events states the following with regard to the treatment of LERF and the assessment of "early" and "late":

  "There are some accident sequences, leading to core damage but not to large early releases in the internal-events PRA model, that need to be designated as potential LERF sequences when the initiator is an external event. These are

> *sequences in which off-site protective action (specifically, the evacuation of nearby populations) is impeded due to the external event. The same sequence that might not be a LERF sequence due to any internal initiator may perhaps affect nearby populations that cannot evacuate as effectively.*
>
> *These sequences would fall into the LERF category because the word "early" in the definition of LERF does not refer to a specific point in time but rather to the issue of whether a large release might occur before effective protective (e.g., evacuation and sheltering) can be implemented to protect surrounding populations.*
>
> *For example, suppose that an earthquake or tornado that initiates an accident sequence at the nuclear plant were to damage the only road available to evacuate close-in populations. … Therefore, in analyzing external events that have the potential to impede effective emergency evacuation, the analysis must examine whether any accident sequences that are not in the LERF category in the internal-events PRA model need to be included in that category for the particular external event being evaluated."*

The internal events PRA assumptions regarding surrounding population evacuation will be severely impacted by seismic scenarios. It is not reasonable to assume that the same time frame for "Early" applies to seismic scenarios. Although it may be justified to assume some other time in the 4 hr to 24 hr time frame to define "Early" for seismic scenarios, the enclosed analysis takes the reasonable approach of reclassifying all corresponding seismic Level 2 PRA "Late" release sequences as "Early" sequences.

- The NRC sponsored assessment of seismic induced risk to support NUREG-1150 is provided for a Mark I in NUREG/CR-4550, Vol. 4, Rev. 1, Part 3. The seismic contributors involve station blackout for 62.5% of the sequences and LOCAs for 34% of the sequences. Using this insight from NUREG-1150, 62.5% of the seismic CDF is assumed to result in LERF all of the time. Therefore, whether the containment is inerted or deinerted, these seismic sequences will lead directly to LERF.

<u>Internal Events Sequence Effects on LERF</u>

- Similar to the above discussions, the example plant has 66% of the internal events risk spectrum composed of late SBO events and long term loss of Decay Heat Removal (DHR). These sequences are found not to be potential contributors to LERF.

Assumptions

- For the fire sequences, use the NUREG-1150 assessment that the relative contribution of sequence contributors is such that 65% are loss of DHR or long term SBO sequences, therefore 35% of the fire sequences represent sequences that could be affected by deinerted conditions and result in ΔLERF contributors.

- For the seismic sequences, use the NUREG-1150 assessment that the relative contribution of sequence contributors is such that 62.5% are already LERF sequences (e.g., SBO, ATWS, containment failure, loss of DHR), therefore 37.5% of the scram sequences represent sequences that could be affected by deinerted conditions and result in LERF contributors.

- For the internal events, use the example plant results that 66% are loss of DHR or long term SBO sequences, therefore 33% of the internal event sequences represent sequences that could be affected by deinerted conditions and result in ΔLERF contributors.

- No combustible gas mitigation is applied for deinerted conditions.

This case applies the deinerted time allowed prior to shutdown and following startup as occurring once during the year. This results in the following:

Current Tech Specs	48 hours deinerted
Proposed Tech Specs	144 hours deinerted

Assumption:

- Assume that the deinerted time equals twice the Technical Specification allowable for both the Base Case and Proposed Case, 48 hours and 144 hours, respectively.
- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains the same for the Base Analysis and the proposed modified inerting times.
- No combustible gas mitigation for deinerted condition.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)

– <u>Base Sensitivity Case 6</u>

$D_B^1 + D_B^2 = 48$ hrs/yr

$I_B^1 + I_B^2 = 7992$ hrs/yr

– <u>Proposed Sensitivity Case 6</u>

$D_P^1 + D_P^2 = 144$ hrs/yr

$I_P^1 + I_P^2 = 7896$ hrs/yr

Using Equation 1:

$$\Delta LERF = CDF_{BASE} * LERF_{BASE}^{COND} \left(\frac{7896-7992}{8760}\right) + CDF_{BASE} * LERF_{DEINERT}^{COND} \left(\frac{144-48}{8760}\right)$$

$$= CDF_{BASE} * \left[LERF_{BASE}^{COND}\left(\frac{-96}{8760}\right) + LERF_{DEINERT}^{COND}\left(\frac{+96}{8760}\right)\right]$$

$$= CDF_{BASE} * \left[\frac{96}{8760}\left(LERF_{DEINERT}^{COND} - LERF_{BASE}^{COND}\right)\right]$$

This leads to the following sensitivity for CDF that could potentially lead to LERF:

$$CDF_{BASE}^{L} = 0.35\, CDF_{BASE}^{FIRE} + 0.375\, CDF_{BASE}^{SEISMIC} + 0.33\, CDF_{BASE}^{INTERNAL}$$

$$CDF_{BASE}^{L} = 8.47E\text{-}6/yr + 2.47E\text{-}6/yr + 3.2E\text{-}6/yr$$

$$CDF_{BASE}^{L} = 1.41E\text{-}5/yr$$

$$\Delta LERF = CDF_{BASE} * \left[\frac{96}{8760}\left(LERF_{DEINERT}^{COND} - LERF_{INERT}^{COND}\right)\right]$$

$$\Delta LERF = 1.41E\text{-}5/yr * 1.096E\text{-}2\ (1.0\text{-}0.1)$$

$$\Delta LERF = 1.4E\text{-}7/yr$$

In addition to the ΔLERF, an estimate of the baseline LERF is developed to allow a comparison with the RG 1.174 Acceptance Guidelines:

Approximate $LERF_{BASE}$ = $LERF_{BASE}^{FIRE} + LERF_{BASE}^{SEISMIC} + LERF_{BASE}^{INTERNAL}$

= 8.47E-7/yr + (4.1E-6/yr + 2.5E-7/yr)+ 3.2E-7/yr

= 5.5E-6/yr

where 62.5% of the seismic CDF always contributes to LERF

Case S1

Same as Case 6, except this case applies the deinerted time allowed prior to shutdown and following startup as occurring twice during the year. This results in the following:

Current Tech Specs	96 hours deinerted
Proposed Tech Specs	288 hours deinerted

Assumption:

- Assume that the deinerted time equals twice the Technical Specification allowable for both the Base Case and Proposed Case, 48 hours and 144 hours, respectively for each outage.
- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains the same for the Base Analysis and the proposed modified inerting times.
- No combustible gas mitigation for deinerted condition.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Sensitivity Case S1

    $D_B^1 + D_B^2 =$ 96 hrs/yr

    $I_B^1 + I_B^2 =$ 7944 hrs/yr

– <u>Proposed Sensitivity Case S1</u>

$D_P^1 + D_P^2 = 288$ hrs/yr

$I_P^1 + I_P^2 = 7752$ hrs/yr

Using Equation 1:

$$\Delta LERF = CDF_{BASE} * LERF_{BASE}^{COND} \left(\frac{7752-7944}{8760}\right) + CDF_{BASE} * LERF_{DEINERT}^{COND} \left(\frac{288-96}{8760}\right)$$

$$= CDF_{BASE} * \left[LERF_{BASE}^{COND}\left(\frac{-192}{8760}\right) + LERF_{DEINERT}^{COND}\left(\frac{+192}{8760}\right)\right]$$

$$= CDF_{BASE} * \left[\frac{192}{8760}\left(LERF_{DEINERT}^{COND} - LERF_{BASE}^{COND}\right)\right]$$

This leads to the following sensitivity for CDF that could potentially lead to LERF:

$$CDF_{BASE}^{L} = 0.35\, CDF_{BASE}^{FIRE} + 0.375\, CDF_{BASE}^{SEISMIC} + 0.33\, CDF_{BASE}^{INTERNAL}$$

$$CDF_{BASE}^{L} = 8.47E\text{-}6/yr + 2.47E\text{-}6/yr + 3.2E\text{-}6/yr$$

$$CDF_{BASE}^{L} = 1.41E\text{-}5/yr$$

$$\Delta LERF = CDF_{BASE} * \left[\frac{192}{8760}\left(LERF_{DEINERT}^{COND} - LERF_{INERT}^{COND}\right)\right]$$

$$\Delta LERF = 1.41E\text{-}5/yr * 2.19E\text{-}2\ (1.0\text{-}0.1)$$

$$\Delta LERF = 2.8E\text{-}7/yr$$

In addition to the ΔLERF, an estimate of the baseline LERF is developed to allow a comparison with the RG 1.174 Acceptance Guidelines:

$$\text{Approximate } LERF_{BASE} = LERF_{BASE}^{FIRE} + LERF_{BASE}^{SEISMIC} + LERF_{BASE}^{INTERNAL}$$

$$= 8.47E\text{-}7/yr + (4.1E\text{-}6/yr + 2.5E\text{-}7/yr) + 3.2E\text{-}7/yr$$

$$= 5.5E\text{-}6/yr$$

where 62.5% of the seismic CDF always contributes to LERF

Case S2

Same as Case 6, except this case applies the deinerted time allowed prior to shutdown and following startup as occurring once during the year. This results in the following:

Current Tech Specs	72 hours deinerted
Proposed Tech Specs	216 hours deinerted

Assumption:

- Assume that the deinerted time equals twice the Technical Specification allowable for both the Base Case and Proposed Case, 48 hours and 144 hours, respectively except for the trip case no deinerted time prior to shutdown is included.
- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains the same for the Base Analysis and the proposed modified inerting times.
- No combustible gas mitigation for deinerted condition.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Sensitivity Case S2

    $D_B^1 + D_B^2 = 72$ hrs/yr

    $I_B^1 + I_B^2 = 7968$ hrs/yr

– <u>Proposed Sensitivity Case S2</u>

$D_P^1 + D_P^2 = 216$ hrs/yr

$I_P^1 + I_P^2 = 7824$ hrs/yr

Using Equation 1:

$$\Delta\text{LERF} = CDF_{BASE} * LERF_{BASE}^{COND} \left(\frac{7824-7968}{8760}\right) + CDF_{BASE} * LERF_{DEINERT}^{COND} \left(\frac{216-72}{8760}\right)$$

$$= CDF_{BASE} * \left[\text{LERF}_{\text{BASE}}^{\text{COND}}\left(\frac{-144}{8760}\right) + \text{LERF}_{\text{DEINERT}}^{\text{COND}}\left(\frac{+144}{8760}\right)\right]$$

$$= CDF_{BASE} * \left[\frac{144}{8760}\left(\text{LERF}_{\text{DEINERT}}^{\text{COND}} - \text{LERF}_{\text{BASE}}^{\text{COND}}\right)\right]$$

This leads to the following sensitivity for CDF that could potentially lead to LERF:

$$CDF_{BASE}^{L} = 0.35\, CDF_{BASE}^{FIRE} + 0.375\, CDF_{BASE}^{SEISMIC} + 0.33\, CDF_{BASE}^{INTERNAL}$$

$$CDF_{BASE}^{L} = 8.47\text{E-6/yr} + 2.47\text{E-6/yr} + 3.2\text{E-6/yr}$$

$$CDF_{BASE}^{L} = 1.41\text{E-5/yr}$$

$$\Delta LERF = \text{CDF}_{\text{BASE}} * \left[\frac{144}{8760}\left(\text{LERF}_{\text{DEINERT}}^{\text{COND}} - \text{LERF}_{\text{INERT}}^{\text{COND}}\right)\right]$$

$$\Delta LERF = 1.41\text{E-5/yr} * 1.64\text{E-2}\ (1.0\text{-}0.1)$$

$$\Delta LERF = 2.1\text{E-7/yr}$$

In addition to the ΔLERF, an estimate of the baseline LERF is developed to allow a comparison with the RG 1.174 Acceptance Guidelines:

Approximate $LERF_{BASE}$ = $LERF_{BASE}^{FIRE} + LERF_{BASE}^{SEISMIC} + LERF_{BASE}^{INTERNAL}$

= 8.47E-7/yr + (4.1E-6/yr + 2.5E-7/yr)+ 3.2E-7/yr

= 5.5E-6/yr

where 62.5% of the seismic CDF always contributes to LERF

Case S3

Same as Case 6, except this case applies the deinerted time allowed prior to shutdown and following startup as occurring once during the year and limits the time prior to shutdown to ~24 hrs. This results in the following:

Current Tech Specs	48 hours deinerted
Proposed Tech Specs	96 hours deinerted

Assumption:

- Assume that the deinerted time equals twice the Technical Specification allowable for the Base Case, 48 hours, and twice the Tech Spec allowable for the proposed status and 24 hrs. for the proposed shutdown.
- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains the same for the Base Analysis and the proposed modified inerting times.
- No combustible gas mitigation for deinerted condition.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Sensitivity Case S3

    $D_B^1 + D_B^2 =$ 48 hrs/yr

    $I_B^1 + I_B^2 =$ 7992 hrs/yr

– <u>Proposed Sensitivity Case S3</u>

$D_P^1 + D_P^2 = 96$ hrs/yr

$I_P^1 + I_P^2 = 7944$ hrs/yr

Using Equation 1:

$$\Delta\text{LERF} = CDF_{BASE} * LERF_{BASE}^{COND} \left(\frac{7944-7992}{8760}\right) + CDF_{BASE} * LERF_{DEINERT}^{COND} \left(\frac{96-48}{8760}\right)$$

$$= CDF_{BASE} * \left[\text{LERF}_{\text{BASE}}^{\text{COND}}\left(\frac{-48}{8760}\right) + \text{LERF}_{\text{DEINERT}}^{\text{COND}}\left(\frac{+48}{8760}\right)\right]$$

$$= CDF_{BASE} * \left[\frac{48}{8760}\left(\text{LERF}_{\text{DEINERT}}^{\text{COND}} - \text{LERF}_{\text{BASE}}^{\text{COND}}\right)\right]$$

This leads to the following sensitivity for CDF that could potentially lead to LERF:

$$CDF_{BASE}^{L} = 0.35\, CDF_{BASE}^{FIRE} + 0.375\, CDF_{BASE}^{SEISMIC} + 0.33\, CDF_{BASE}^{INTERNAL}$$

$$CDF_{BASE}^{L} = 8.47\text{E-6/yr} + 2.47\text{E-6/yr} + 3.2\text{E-6/yr}$$

$$CDF_{BASE}^{L} = 1.41\text{E-5/yr}$$

$$\Delta LERF = \text{CDF}_{\text{BASE}} * \left[\frac{48}{8760}\left(\text{LERF}_{\text{DEINERT}}^{\text{COND}} - \text{LERF}_{\text{INERT}}^{\text{COND}}\right)\right]$$

$$\Delta LERF = 1.41\text{E-5/yr} * 5.48\text{E-3}\ (1.0\text{-}0.1)$$

$$\Delta LERF = 6.95\text{E-8/yr}$$

In addition to the ΔLERF, an estimate of the baseline LERF is developed to allow a comparison with the RG 1.174 Acceptance Guidelines:

Approximate $LERF_{BASE}$ = $LERF_{BASE}^{FIRE} + LERF_{BASE}^{SEISMIC} + LERF_{BASE}^{INTERNAL}$

= 8.47E-7/yr + (4.1E-6/yr + 2.5E-7/yr)+ 3.2E-7/yr

= 5.5E-6/yr

where 62.5% of the seismic CDF always contributes to LERF

Case S4

Same as Case 6, except this case applies the deinerted time allowed prior to shutdown and following startup as occurring once during the year. This results in the following:

Current Tech Specs	48 hours deinerted
Proposed Tech Specs	144 hours deinerted

Assumption:

- Assume that the deinerted time equals twice the Technical Specification allowable for both the Base Case and Proposed Case, 48 hours and 144 hours, respectively.
- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains the same for the Base Analysis and the proposed modified inerting times.
- No combustible gas mitigation for deinerted condition.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Sensitivity Case 6

    $D_B^1 + D_B^2 =$ 48 hrs/yr

    $I_B^1 + I_B^2 =$ 7992 hrs/yr

– <u>Proposed Sensitivity Case 6</u>

$D_P^1 + D_P^2 =$ 144 hrs/yr

$I_P^1 + I_P^2 =$ 7896 hrs/yr

Using Equation 1:

$$\Delta LERF = CDF_{BASE} * LERF_{BASE}^{COND} \left(\frac{7896-7992}{8760}\right) + CDF_{BASE} * LERF_{DEINERT}^{COND} \left(\frac{144-48}{8760}\right)$$

$$= CDF_{BASE} * \left[LERF_{BASE}^{COND}\left(\frac{-96}{8760}\right) + LERF_{DEINERT}^{COND}\left(\frac{+96}{8760}\right)\right]$$

$$= CDF_{BASE} * \left[\frac{96}{8760}\left(LERF_{DEINERT}^{COND} - LERF_{BASE}^{COND}\right)\right]$$

This leads to the following sensitivity for CDF that could potentially lead to LERF:

$$CDF_{BASE}^{L} = 0.35\, CDF_{BASE}^{FIRE} + 0.375\, CDF_{BASE}^{SEISMIC} + 0.33\, CDF_{BASE}^{INTERNAL}$$

$$CDF_{BASE}^{L} = 8.47E\text{-}6/yr + 2.47E\text{-}6/yr + 3.2E\text{-}6/yr$$

$$CDF_{BASE}^{L} = 1.41E\text{-}5/yr$$

$$\Delta LERF = CDF_{BASE} * \left[\frac{96}{8760}\left(LERF_{DEINERT}^{COND} - LERF_{INERT}^{COND}\right)\right]$$

$$\Delta LERF = 1.41E\text{-}5/yr * 1.096E\text{-}2\ (1.0\text{-}0.1)$$

$$\Delta LERF = 1.4E\text{-}7/yr$$

In addition to the ΔLERF, an estimate of the baseline LERF is developed to allow a comparison with the RG 1.174 Acceptance Guidelines:

Approximate $LERF_{BASE}$ = $LERF_{BASE}^{FIRE} + LERF_{BASE}^{SEISMIC} + LERF_{BASE}^{INTERNAL}$

= 8.47E-7/yr + (4.1E-6/yr + 2.5E-7/yr)+ 3.2E-7/yr

= 5.5E-6/yr

where 62.5% of the seismic CDF always contributes to LERF

Case S5

Same as Case 6, except this case applies the deinerted time allowed prior to shutdown and following startup as occurring 1.5 times during the year. This results in the following:

Current Tech Specs	48 hours deinerted/shutdown
Proposed Tech Specs	144 hours deinerted/shutdown

Assumption:

- Assume that the deinerted time equals twice the Technical Specification allowable for both the Base Case and Proposed Case, 72 hours and 144 hours, respectively.
- CDF remains the same for conditions inerted or deinerted.
- Transition risk occurs over a period of approximately 24 hours and remains the same for the Base Analysis and the proposed modified inerting times.
- No combustible gas mitigation for deinerted condition.
- Risk calculation performed for the following plant schedules:
  - Shtdn = 30 days/yr (720 hrs/yr)
  - Base Sensitivity Case 6

    $D_B^1 + D_B^2 =$ 72 hrs/yr

    $I_B^1 + I_B^2 =$ 7968 hrs/yr

– <u>Proposed Sensitivity Case 6</u>

$D_P^1 + D_P^2 = 144$ hrs/yr

$I_P^1 + I_P^2 = 7896$ hrs/yr

Using Equation 1:

$$\Delta\text{LERF} = CDF_{BASE} * LERF_{BASE}^{COND} \left(\frac{7896-7968}{8760}\right) + CDF_{BASE} * LERF_{DEINERT}^{COND} \left(\frac{144-72}{8760}\right)$$

$$= CDF_{BASE} * \left[\text{LERF}_{\text{BASE}}^{\text{COND}}\left(\frac{-72}{8760}\right) + \text{LERF}_{\text{DEINERT}}^{\text{COND}}\left(\frac{+72}{8760}\right)\right]$$

$$= CDF_{BASE} * \left[\frac{72}{8760}\left(\text{LERF}_{\text{DEINERT}}^{\text{COND}} - \text{LERF}_{\text{BASE}}^{\text{COND}}\right)\right]$$

This leads to the following sensitivity for CDF that could potentially lead to LERF:

$$CDF_{BASE}^{L} = 0.35\, CDF_{BASE}^{FIRE} + 0.375\, CDF_{BASE}^{SEISMIC} + 0.33\, CDF_{BASE}^{INTERNAL}$$

$$CDF_{BASE}^{L} = 8.47\text{E-6/yr} + 2.47\text{E-6/yr} + 3.2\text{E-6/yr}$$

$$CDF_{BASE}^{L} = 1.41\text{E-5/yr}$$

$$\Delta LERF = \text{CDF}_{\text{BASE}} * \left[\frac{72}{8760}\left(\text{LERF}_{\text{DEINERT}}^{\text{COND}} - \text{LERF}_{\text{INERT}}^{\text{COND}}\right)\right]$$

$$\Delta LERF = 1.41\text{E-5/yr} * 8.22\text{E-3}\ (1.0\text{-}0.1)$$

$$\Delta LERF = 1.04\text{E-7/yr}$$

In addition to the ΔLERF, an estimate of the baseline LERF is developed to allow a comparison with the RG 1.174 Acceptance Guidelines:

Approximate $LERF_{BASE}$ = $LERF_{BASE}^{FIRE} + LERF_{BASE}^{SEISMIC} + LERF_{BASE}^{INTERNAL}$

= 8.47E-7/yr + (4.1E-6/yr + 2.5E-7/yr) + 3.2E-7/yr

= 5.5E-6/yr

where 62.5% of the seismic CDF always contributes to LERF

4.0 RESULTS

The results of the sensitivity cases show the following:

Case	No. of Refuel/yr	No. of Forced Outages/yr	No. of Trips/yr	Deinerted (Hours/yr)			ΔLERF
				Base	Sensitivity	Δ	
S1	1	1	0	96	288	192	2.8E-7
S2	1	0	1	72	216	144	2.1E-7
S3	1	0	0	48	96	48	6.95E-8
S4	0.5	0	1	48	144	96	1.4E-7
S5	0.5	1	0	72	144	72	1.04E-7
6	1	0	0	48	144	96	1.4E-7