Entergy

Entergy Nuclear Northeast
Indian Point Energy Center
450 Broadway, GSB
P.O. Box 249
Buchanan, NY 10511-0249
Tel 914 254 6700

John A Ventosa
Site Vice President
Administration

NL-13-115

September 4, 2013

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

SUBJECT: Response to Request for Additional Information Regarding Proposed License Amendment to Temporarily Connect Seismic to Non-seismic Piping under Administrative Controls (TAC NO. MF1440)
Indian Point Unit Number 2
Docket No. 50-247
License No. DPR-26

REFERENCES:

1. Entergy Letter NL-13-015 to NRC, Proposed License Amendment Regarding Connection of Non Seismic Boric Acid Recovery System to the Refueling Water Storage Tank, dated April 15, 2013
2. NRC Letter to Entergy, Request for Additional Information Regarding Proposed License Amendment to Temporarily Connect Seismic to Non-Seismic Piping under Administrative Controls (TAC NO. MF1440), dated August 7, 2013

Dear Sir or Madam:

Entergy Nuclear Operations, Inc (Entergy) requested a License Amendment, Reference 1, for Indian Point Nuclear Generating Unit No. 2 (IP2). The proposed amendment would revise Technical Specification 3.5.4, to allow connection of the non-seismically qualified piping of the temporary Boric Acid Recovery System to the Refueling Water Storage Tank under administrative controls for a limited period of time. On August 7, 2013, the NRC staff identified the need for additional information to complete their review (Reference 2). Entergy is providing additional information in response to this request in Attachment 1 and Enclosure 1.

A001
NRR

A copy of this response is being submitted to the designated New York State official in accordance with 10 CFR 50.91.

There are no new commitments being made in this submittal. If you have any questions or require additional information, please contact Mr. Robert Walpole, Manager, Licensing at (914) 254-6710.

I declare under penalty of perjury that the foregoing is true and correct. Executed on September 4, 2013.

Sincerely,

JAV/ai

Attachment: 1. Response to Request for Additional Information Regarding Proposed License Amendment to Temporarily Connect Seismic to Non-Seismic Piping under Administrative Controls

Enclosure: 1. Indian Point Calculation IP-CALC-11-00091, AST Analysis of IP2 to address the impact of Containment sump solution back-leakage to the RWST after LOCA

cc: Mr. Douglas Pickett, Senior Project Manager, NRC NRR DORL
Mr. William Dean, Regional Administrator, NRC Region 1
NRC Resident Inspector Office
Mr. Francis J. Murray, Jr., President and CEO, NYSERDA
Ms. Bridget Frymire, New York State Dept. of Public Service

ATTACHMENT 1 TO NL-13-115

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING PROPOSED LICENSE AMENDMENT TO TEMPORARILY CONNECT SEISMIC TO NON-SEISMIC PIPING UNDER ADMINISTRATIVE CONTROLS

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
DOCKET NO. 50-247

Response To Request For Additional Information

Accident Dose Branch Questions and Responses

Question 1

Final Safety Analysis Report (FSAR) Section 14.3.6.6, "External Recirculation," provides a description of the analyses used to justify the proposed change (2.0 gallon per hour limit for Emergency Core Cooling System (ECCS) leakage).

FSAR Section 14.3.6.6 states:

> *Since the leakage is initiated at 6.5 hours after the LOCA* [loss of coolant accident], *it does not contribute to the 2 hour site boundary dose* [exclusion area boundary dose or EAB].

Standard Review Plan (SRP) 15.0.1, "Radiological Consequence Analyses Using Alternative Source Terms," states:

> *The methodology and assumptions for calculating the radiological consequences should reflect the regulatory positions of RG-1.183* [Regulatory Guide 1.183].

Regulatory Guide (RG) 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," Regulatory Position 4.1.5, states:

> *The TEDE should be determined for the most limiting person at the EAB. The maximum EAB TEDE for any two-hour period following the start of the radioactivity release should be determined and used in determining compliance with the dose criteria in 10 CFR50.67.[14] The maximum two-hour TEDE should be determined by calculating the postulated dose for a series of small time increments and performing a "sliding" sum over the increments for successive two-hour periods. The maximum TEDE obtained is submitted. The time increments should appropriately reflect the progression of the accident to capture the peak dose interval between the start of the event and the end of radioactivity release (see also Table 6).*

This is consistent with Title 10 of the *Code of Federal Regulations* [10 CFR], Section 50.67, "Accident Source Term," that states:

> *An individual located at any point on the boundary of the exclusion area for* ***any*** [emphasis added] *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)[2] total effective dose equivalent (TEDE).*

a) Please confirm whether the dose due to ECCS leakage is excluded from the FSAR Section 14.3.6.6 EAB dose calculation.

b) If so, please explain how this is consistent with 10 CFR 50.67. SRP 15.0.1 and 10 CFR 50.67 both state that the worst dose for any 2 hour period is to be used to determine the EAB dose. This would typically mean the ECCS dose should be added to the time dependent EAB dose and the worst 2 hour dose should be determined from this time dependent dose profile. Please justify why the ECCS leakage is not considered in the determination of the EAB dose, or include the ECCS leakage in the EAB dose calculation.

Response to Question 1

a) Any ECCS leakage for the first 6.5 hours following a LOCA is internal to the containment and inherently accounted for in the offsite dose contribution for containment leakage. In order to identify the worst two hour period, the computer runs included time steps to provide EAB 2-hour doses at 0.2 hour intervals. As shown below, the worst two-hour dose is 16.91 rem over the 0.6 to 2.6 hour interval (this dose was increased by a factor of 1.05 for conservatism and rounded to 17.8 rem as reported in FSAR Section 14.3.6.8). The dose gets reduced to16.47 rem in the 0.8 to 2.8 hour period, and further reduced in the 1.0 to 3.0 hour period. After 6.5 hours, when ECCS leakage begins outside of containment, the EAB dose rate from containment airborne leakage is so low that the added radiological contribution from the ECCS leakage pathway is not sufficient to change the maximum 2-hour dose from the peak value set earlier in the accident.

Exclusion Area Boundary Dose (rem TEDE)

0.4 – 2.4 hr	0.6 – 2.6 hr	0.8 – 2.8 hr	1.0 – 3.0 hr
16.59	16.91	16.47	15.36

b) See response to a) above.

Question 2

UFSAR Section 14.3.6.6 states:

> The releases would be subject to filtration by the filtered ventilation system *provided for the primary auxiliary building which houses the portions of the ECCS located outside containment. However, filtration of the releases is not credited in the analysis.*

a) Are releases from non-seismic piping (postulated to fail) subject to the filtered ventilation system in the primary auxiliary building?

Response to Question 2

a) Any break in non-seismic piping in the primary auxiliary building would be subject to the filtered ventilation system.

Question 3

The Nuclear Regulatory Commission's safety evaluation, which reviewed the conversion to 10 CFR 50.67, reviewed an analysis which appears to have different assumptions than those provided in FSAR Section 14.3.6.6.

a) Has the NRC staff reviewed the analysis provided in FSAR Section 14.3.6.6 or were these changes made using 10 CFR 50.59, "Changes, tests and experiments"? If a staff evaluation of this analysis has not been performed, please provide the inputs, assumptions, methodology and results of the analysis that is to be used to support the proposed change.
b) FSAR Section 14.3.6.6 provides design basis dose values for two different assumptions (assuming a boundary layer effect and assuming no boundary layer effect). Which assumption is used for the licensing basis calculation?

Response to Question 3

a) FSAR Section 14.3.6.6 was revised using 10 CFR 50.59, "Changes, tests and experiments", to include potential ECCS back-leakage to the RWST. A copy of the calculation used to support the change is provided in Enclosure 1 as requested.

b) The licensing basis calculation is based on no boundary layer effect resulting in a Control Room Dose of 4.9 rem. This was reviewed and approved by the NRC in the Safety Evaluation for SPU (NRC Letter to Entergy, Indian Point Nuclear Generating Unit No. 2- Issuance of Amendment Re: 3.26 Percent Power Uprate (TAC NO. MC1865), October 27, 2004).

Question 4

Page 3 of 8 of the submittal states:

> *The RWPP [Refueling Water Purification Pump] will take suction through manual isolation valve 855 on line ...*

a) Please confirm whether this sentence should state valve 845 or whether valve 855 is correct.

Response to Question 4

a) The sentence on page 3 of 8 of the submittal contains a typographical error and should state:

> *The RWPP [Refueling Water Purification Pump] will take suction through manual isolation valve **845** on line ...*

Question 5

RG 1.183, Regulatory Position 5.1.2 states:

> *5.1.2 Credit for Engineered Safeguard Features*
>
> *Credit may be taken for accident mitigation features that are classified as safety related, are required to be operable by technical specifications, are powered by emergency power sources, and are either automatically actuated or, in limited cases, have actuation requirements explicitly addressed in emergency operating procedures. The single active component failure that results in the most limiting radiological consequences should be assumed. Assumptions regarding the occurrence and timing of a loss of offsite power should be selected with the objective of maximizing the postulated radiological consequences.*

a) Please describe how the valves credited to isolate the non-seismic pathways after a design basis accident meet the above regulatory position. For those valves that do not meet the regulatory position please explain the differences between the design features, analytical techniques and procedural methods proposed and the regulatory position and justify how the proposed alternatives to the regulatory position proved an acceptable method for complying with the NRC regulations (10 CFR 50.67).

Response to Question 5

a) As noted in the submittal, a dedicated operator would isolate suction from the RWST to BARS by closing valves 845 and 727A. This pair of valves is seismic 1 and in series and the single failure of one of the valves would be mitigated by the other valve. The dedicated operator would also isolate the return line from the BARS to the RWST by closing valve 350. Any leakage through valve 350 would be limited to leakage past MOV 842/843. This pair of valves is in series and tested with a leakage limit of 0.5 gph, which is accounted for in the radiological analysis.

Question 6

Page 4 of 8 of the submittal states:

> *Another potential for sump fluid leakage to impact BARS would be leakage through the 2 inch SI mini-flow line back to the RWST that is connected to valve 350. However, this would be limited to leakage through MOV 842/843, which are tested by 2-PT-R048 and have an acceptance criterion of 0.5 gallons per hour (gph).*

a) Are MOV 842/843 always closed when the potential for this leakage pathway exists? If not, explain the timing involved for closing MOV 842/843 and valve 350. Can the timing of the closure of these valves cause the 0.5 gph leakage limit to the non-seismic piping to be exceeded for any time period after the start of the postulated accident.

Response to Question 6

a) MOV 842/843 would always be closed when the potential for this leakage pathway exists. For hot leg recirculation, Procedure 2-ES-1.4, "Transfer to Hot Leg Recirculation", requires SI pump mini-flow valves MOV-842/843 to be closed. Similarly, for cold leg recirculation with the SI pumps taking suction from the recirculation pumps, 2-ES-1.3, "Transfer to Cold leg Recirculation", requires verifying MOV-842/843 are closed.

Question 7

Page 4 of 8 of the submittal states:

> *Following the injection phase of a large break LOCA (about 20 minutes) the* ***preferred*** [emphasis added] *means of cold leg recirculation is to use the internal recirculation pumps. This results in the fluid being kept inside containment until hot leg recirculation* [at 6.5 hours].
>
> RG 1.183, Regulatory Position 5.1.3 states:
>
> *The numeric values that are chosen as inputs to the analyses required by 10 CFR 50.67 should be selected with the objective of determining a conservative postulated dose.*

a) Confirm that plant procedures do not allow the recirculation of sump fluids outside containment prior to 6.5 hours.
b) If plant procedures do allow the recirculation of sump fluids outside of containment prior to 6.5 hours why aren't these methods of recirculation considered in the determination of the ECCS leakage dose calculation?
c) RG 1.183, Regulatory Position 1.3 defines the scope of required analyses which include post accident access shielding (NUREG-0737, "Clarification of TMI Action Plan Requirements," Action Item II.B.2, "Post-Accident Access Shielding"). If plant procedures do allow the recirculation of sump fluids outside of containment prior to 6.5 hours please state whether vital area access (Action Item II.B.2) necessary to close valves 845, 727A and 350 and trip the refueling water storage tank (RWST) purification pump is maintained.

Response to Question 7

a) Plant procedure 2-ES-1.3, "Transfer to Cold leg Recirculation", provides instructions for transferring the safety injection system and containment spray system to the recirculation mode. The Procedure requires manually starting one internal recirculation pump, and if it cannot be started then manually starting the other internal recirculation pump. If neither internal recirculation pump can be started then the procedure requires establishing cold leg recirculation using RHR pumps which results in sump fluid going outside containment. It should be noted that Emergency Operating Procedures address all potential contingencies to mitigate an accident.

b) The IP2 design is fairly unique in having two internal recirculation pumps as well as two RHR pumps. There is no single active failure that would require using RHR pumps. Further, IP2 licensing basis does not postulate a passive failure to occur for 24 hours. Consequently, recirculation of sump fluid outside containment would only occur at 6.5 hours for hot leg recirculation. RG 1.183 guidance does not impose postulating a passive failure and consequently ECCS leakage dose is not calculated prior to 6.5 hours.

c) Not Applicable - see response to b) above.

Response To Request For Additional Information

Component Performance, NDE, and Testing Branch

RAI 1

In the referenced letter it is indicated that valves 845, 727A and 350 will be part of the Inservice Test Program with a test frequency of two years. Will these valves be classified as manual, active valves and, therefore, be subject to ASME OM Code exercise testing requirements? Will these valves be further classified as Category A and, therefore, be subject to ASME OM Code leakage testing requirements? (The discussion of post-accident dose consequences indicates that these valves could be exposed to sump fluid.)

Response to RAI 1

Valves 845, 727A and 350 will be classified as manual active valves with open and close ASME OM Code exercise stroke requirements on a two year frequency. Valves 845 and 727A will be classified as Category A, therefore requiring leak testing every two years. Valve 350 will not require leak testing. The potential for sump fluid leakage to impact BARS through valve 350 would be leakage through the 2 inch SI mini-flow line back to the RWST that is connected to valve 350. However, this would be limited to leakage through MOV 842/843, which are in series and tested by Procedure 2-PT-R048, "Leak Test of 842 and 843", and have an acceptance criterion of 0.5 gallons per hour, and accounted for in the radiological analysis.

Response To Request For Additional Information

Health Physics and Human Performance Branch

Question 1

1.0 INTRODUCTION

By letter dated April 15, 2013 (ADAMS Accession Number ML13116A007), Entergy Nuclear Northeast (Entergy), licensee for Indian Point Nuclear Generating Unit 2 (IP2), submitted a license amendment request (LAR) to revise Technical Specification (TS) 3.5.4, "Refueling Water Storage Tank (RWST)". The proposed change would revise the TS to allow the non-seismically qualified piping of the temporary Boric Acid Recovery System (BARS) to be connected to, and isolated from, the RWST's seismically qualified piping by manual operation of RWST seismically qualified boundary valves. This would be done under administrative controls and only for limited periods of time. These limited periods are specified as up to 30 days per fuel cycle for filtration for removal of suspended solids from the RWST water. This change will only be applicable until Refueling Outage R22 (Spring 2016) ends. Manual connection of the RWST seismically qualified piping to non-seismically qualified piping shall not be allowed after the end of R22. The Health Physics and Human Performance Branch (AHPB) has done a preliminary review of the LAR regarding the operator performance aspects and finds that the following additional information is required to complete the review.

1. As described in Section 2 of the licensee's submittal, the change requested for TS 3.5.4 is a proposed Note, that states," The RWST isolation valves 350, 727A and 845 connected to non-safety related piping may be opened under administrative controls for up to 30 days per fuel cycle for filtration until the end of refuel outage 22." Later in Section 3, it is stated that, "Prior to refueling outage (RO) 2R20 the RWST was recirculated for a duration of 13 days. After recirculation the total concentration of silica was less than 1.1 ppm. Prior to RO 2R19 the RWST was recirculated for a duration of 11 days. A sample taken after recirculation had total concentration of silica of 1.3 ppm." Based on this statement the NRC staff assumes that clarity was sufficient after, at most, 13 days, and at a silica concentration of 1.3 ppm.

    a. What concentration of silica/clarity is acceptable for operators to perform their required tasks during shutdown? Why isn't this criterion included in the proposed TS? How will operators know when it is okay to disengage the BARS?
    b. If prior to the previous two refueling outages, it only took 11 days and 13 days to achieve acceptable clarity, why is the licensee requesting allowance for up to 30 days? In order to minimize the time spent in a seismically vulnerable configuration, why wouldn't a duration of 15 days be sufficient?

Response to Question 1

a. The fuel vendor has specified guidelines for implementing zinc addition. For IP2, Chemistry Procedures specify a silica concentration of ≤ 2 ppm to reduce zinc silicate precipitation on fuel surfaces. This is a fuel vendor guidance value, and not a limiting condition for operation. Exceeding this limit would result in fuel exams. Chemistry monitors silica and boron every six hours during the clean up, and is able to predict completion time a day or two ahead of reaching the target value.

b. The 11 days and 13 days in the prior two outages was BARS system operation time. Time is also required for setup and removal of the BARS skid, which is typically one or two days each. Plus there is a period when the BARS unit is secured but still connected to allow the vendor some time off. The 30 days request provides margin in consideration of any delays or equipment issues that might arise with the vendor skid. Since the BARS skid is rented, typically for 21 days, it is only used for the amount of time it is needed.

Question 2

Does IP2 have a Time-critical Action Program to protect high-risk, time-limited actions from inadvertent change? If yes, is the proposed task sequence included in that program? If no, what controls are used to prevent inadvertent changes to the proposed operator actions or the time available to perform them? Does the licensee's configuration control system have a way to identify Tech-Spec-related actions in procedures?

Response to Question 2

IPEC has a Time-critical Action Program, OAP-115,"Operations Commitments and Policy Details". Specific IP2 actions are listed in Attachment 4, however, the proposed task sequence is currently not included in that program. Licensing Request LR-LAR-2013-00113 CA#12 has been initiated to update OAP-115 prior to implementing BARS to include an action to isolate BARS in 31 minutes in the event of a seismic occurrence or an accident requiring injection from the RWST. Further, a CAUTION in 2-OSP-10.1.1, "Support Procedure – Safety Injection Accumulators and Refueling Water Storage Tank Operations", specifies the time available to the dedicated operator to isolate the RWST Silica Cleanup System in the event of a failure such that RWST level will be maintained above the Technical Specification limit. Revisions to Procedures require a Process Applicability Determination be performed which would evaluate the affect or potential affect of the change.

Question 3

In the general discussion of the ingress/egress paths taken by the operators to accomplish the isolation of seismic from non-seismic systems, the licensee states that a card reader is in the intended path.

a. Does this card reader require a different card than an operator would have for plant access? If yes, will the dedicated operator routinely keep this other card on his person? If no, where will it be stored?
b. Did the simulation that was performed to ascertain required time vs. available time include accessing the card reader?
c. Is the card reader designed to work under seismic conditions? SBO? How much additional time would be involved if the operator had to deal with a non-operational card reader?

Response to Question 3

a. No. The card reader uses the employee ID card (security badge), which is the same card as an operator would have for plant access. When at work, company policy requires all employees to wear their ID card on the outside clothing, between the neck and waist.

b. Yes. The simulation included accessing the card reader.

c. No. The security access card reader system is not seismic and will not work under SBO. Operators have keys in their possession to provide manual override in the event of a non-functional card reader and would result in minimal additional time to open the door. As noted in the submittal, a simulation performed by Operations demonstrated substantial margin in the time available to shutdown the BARS and maintain RWST level within the TS value.

Question 4

What method(s) will be used to monitor the continuing effectiveness and safety of the current method of purification of reactor water until the final resolution is implemented in 2016? Will the Corrective Action Program be used to track the status and effectiveness of current process?

Response to Question 4

The continuing effectiveness and safety of the current method of purification of reactor water is monitored by the work control and temporary alteration processes. The Corrective Action Program is used to document and resolve issues that may arise during the campaign.

ENCLOSURE 1 TO NL-13-115

INDIAN POINT CALCULATION IP-CALC-11-00091

AST ANALYSIS OF IP2 TO ADDRESS THE IMPACT OF CONTAINMENT SUMP SOLUTION BACK-LEAKAGE TO THE RWST AFTER LOCA

ENTERGY NUCLEAR OPERATIONS, INC.
INDIAN POINT NUCLEAR GENERATING UNIT NO. 2
DOCKET NO. 50-247

ATTACHMENT 9.2 ENGINEERING CALCULATION COVER PAGE

Sheet 1 of 1

☐ ANO-1	☐ ANO-2	☐ GGNS	■ IP-2	☐ IP-3
☐ JAF	☐ PNPS	☐ RBS	☐ VY	☐ W3

CALCULATION COVER PAGE	(1) EC # 32007 (2) Page 1 Of 33
(3) Design Basis Calc. ■ YES ☐ NO	(4) ■ CALCULATION ☐ EC Markup
(5) **Calculation No: IP-CALC-11-00091**	(6) **Revision: 0**
(7) **Title: AST Analysis of IP2 to Address the Impact of Containment Sump Solution Back-Leakage to the RWST after LOCA**	(8) **Editorial** ☐ YES ■ NO
(9) **System(s): RWST**	(10) **Review Org (Department): FNA**
(11) **Safety Class:** ■ **Safety / Quality Related** ☐ **Augmented Quality Program** ☐ **Non-Safety Related**	(12) **Component/Equipment/Structure Type/Number:**
(13) **Document Type:** **CALCULATION**	
(14) **Keywords (Description/Topical Codes): RADTRAD 3.03**	

REVIEWS

(15) Name/Signature/Date	(16) Name/Signature/Date	(17) Name/Signature/Date
M. Golshani [signature] 11/16/11	Jong E. Chang [signature] 11/16/11	A. Irani [signature] 11/16/11
Responsible Engineer	■ **Design Verifier** ☐ **Reviewer** ☒ Comments Attached	**Supervisor/Approval** ☐ Comments Attached

CALCULATION REFERENCE SHEET	**CALCULATION NO: IP-CALC-11-00091** REVISION: **0**

I. EC Markups Incorporated

1. None.

II. Relationships:	Sht	Rev	Input Doc	Output Doc	Impact Y/N	Tracking No.
CN-CRA-03-55	-	0	■	☐	N	N/A
PU2-E-03-20	-	-	■	☐	N	N/A
CN-CRA-11-25	-	0	■	☐	N	N/A
PU2-E-03-20	-	-	■	☐	N	N/A
CN-REA-03-4	-	-	■	☐	N	N/A
IP-RPT-11-00025	-	0	■	☐	N	N/A
NEA-00023	-	0	■	☐	N	N/A
IP-CALC-11-00063	-	0	■	☐	N	N/A

III. CROSS REFERENCES:

1. RG 1.183
2. NUREG/CR-5950
3. MUREG/CR-6604

IV. SOFTWARE USED: Yes, See Method of Analysis

Title: RADTRAD Version/Release: 3.03 Disk/CD No.______

V. DISK/CDS INCLUDED: None

Title:______ Version/Release______ Disk/CD No.______

VI. OTHER CHANGES: None

ATTACHMENT 9.4 RECORD OF REVISION

Sheet 1 of 1

Revision	Record of Revision
0	Initial issue.

TABLE OF CONTENTS

1.0 Purpose and Background

The radiological dose consequences of a large break Loss-Of-Coolant Accident (LOCA) provided by Westinghouse in Reference 1 for Indian Point Unit 2 (IP2) did not include the dose contribution resulting from the postulated back-leakage of containment sump water to the Refueling Water Storage Tank (RWST). The dose from this back-leakage was considered to be negligible.

This calculation is being performed to quantify the allowable sump back-leakage to the RWST and evaluate the doses at IP2 Control Room (CR) and offsite in the event of a design basis LOCA.

Two allowable back-leakage flow rates were considered:

1) An allowable back-leakage which does not result in an increase in the dose specified in the FSAR (Sec. 14.3.6.8). This is able to be accomplished by using up the additional conservatism that was included in the FSAR values.
2) An allowable back-leakage which does not result in an increase in the dose acceptance limit of 10 CFR50.67 (e.g., 5 rem CR TEDE).

The analysis is performed based on the Alternative Source Term (AST) methodology described in Reg. Guide 1.183 (Ref. 2) and using the RADTRAD 3.03 computer code (Ref. 3).

2.0 Summary of Results & Conclusion

The IP2 doses resulting from the back-leakage to the RWST in the IP2 Control Room (CR), Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) were calculated in the event of a design basis LOCA. The CR doses were calculated for allowable back-leakage to remain below the CR dose reported in the FSAR and to calculate allowable back-leakage value for less than the 10CFR50.67 limit of 5 rem CR TEDE.

Tables 2.1 and 2.2 show the summary of results. The results of analysis in Table 2.1 indicate that the EAB, LPZ and CR doses are less than reported in the FSAR for the back-leakage flow rate of 20 gph. The results of the analysis in Table 2.2 for 29 gph flow rate are also indicated that doses are below the 10 CFR 50.67 limit of 5 rem CR TEDE.

Table 2.1

IP2 LOCA TEDE Doses (rem) [20 gph Back-Leakage]

Case	CR	EAB	LPZ
Back-Leakage To RWST	0.1701	---	0.09263
Calculated Containment & ECCS leakage (Ref. 1) *	4.7263	16.91	12.93
Total	4.896	16.91	13.02
Reported Dose (Refs. 1 & FSAR)	4.9	17.8	13.6
TEDE Limit	**5.0**	**25.0**	**25.0**

* An additional external dose to the CR is also included.

Table 2.2

IP2 LOCA TEDE Doses (rem) [29 gph Back-Leakage]

Case	CR	EAB	LPZ
Back-Leakage To RWST	0.2655	---	0.1481
Calculated Containment & ECCS leakage (Ref. 1)*	4.7263	16.91	12.93
Total	4.99	16.91	13.08
TEDE Limit	**5.0**	**25.0**	**25.0**

* An additional external dose to the CR is also included.

3. Design Inputs

Design Input Data

Parameter	**Value**
Plant Power	3,280.3* MWt
Core Inventories	Table 6.1
Release Fraction & Timing	Table 6.2 (R.G. 1.189)
Chemical Form Release to Containment	Sec. 6.1 (R.G. 1.189)

See Attachment C for all other design input data.

* Core power of 3216 MWt with a reactor power uncertainty of 2%

4. Acceptance Criteria

The radiological criteria for the CR, EAB and LPZ are in 10 CFR 50.67 and Reg. Guide 1.183.

CR Dose Acceptance Criterion:	5.0 rem TEDE
EAB Dose Acceptance Criterion:	25.0 rem TEDE
LPZ Dose Acceptance Criterion:	25.0 rem TEDE

5. Method of Analysis

Post-accident LOCA radiation exposures from the postulated back-leakage of containment sump water to the RWST in the IP2 CR, EAB and LPZ were computed using the following:

(a) The methodology and assumptions in Regulatory Guide 1.183 (Ref. 2),

(b) Appropriate source terms, release pathways, and other assumptions, as described in the section which follows,

(c) Post-accident atmospheric dispersion factors, and

(d) The following Computer Code:

RADTRAD 3.03 (Ref. 3)	The NRC sponsored code RADTRAD, Version 3.03 was used to model the DB LOCA and estimate the dose consequences. The CR, EAB and LPZ doses in terms of TEDE were calculated for the LOCA.

Section 6 and Attachment C present details of the assumptions, data and results associated with the accident analyzed.

6. Calculation/Analysis

Release pathways and contributing radiation sources, which should be analyzed in the design-basis LOCA, are the followings:

(1) Containment leakage,
(2) ECCS recirculation leakage,
(3) External dose cloud, and
(4) Back-leakage of sump water to the RWST.

Doses resulting from activity released through the first three pathways were calculated in Reference 1. The last release pathway was not addressed in previous dose analyses for IP2 (Reference 1). Therefore, this calculation is being performed to evaluate the doses at IP2 Control Room (CR) and offsite from the back-leakage to the RWST in the event of a design basis LOCA.

The source term and basic assumptions for evaluating the TEDE dose associated with a postulated back-leakage to the RWST during the design-basis LOCA were selected to be consistent with Regulatory Guide 1.183 (Ref. 2).

6.1 Fission Product Inventory

The fission product inventory in the core is based on full power operation (3216 MWt + 2% uncertainty, i.e., 3280.3 MWt).
The core inventory of radionuclides of interest is shown in Table 6.1 from Ref. 5. The reactor core inventory release fractions, for each radionuclide group and for the gap release and early in-vessel

damage phases for the DBA LOCA are shown in Table 6.2 (Ref. 2). The chemical form of the radionuclide released to the containment should be assumed to be 95% cesium iodine, 4.85% elemental iodine and 0.15% organic iodine (Reg. Guide 1.183). Since the 0.15% of the iodine released from the core is assumed to be in the organic form and thus is not subject to removal by sprays or deposition and would remain the containment air space. Therefore, the corrected fraction of 0.05 and 0.35 for halogens from Table 2 of Reg. Guide 1.183 should be adjusted to 0.05 x (1-0.0015) = 0.049925 and 0.35 x (1-0.0015) = 0.349475 in RADTRAD input file. The iodine release fraction is also specified as 97% elemental and 3% organic from Reg. Guide 1.183 when iodine is released from liquid. The release fractions for all other nuclide groups are set at zero since they are not subject to release by the containment sump back-leakage pathway to the RWST.

Table 6.1

Core Inventories of Nuclides for use in Radiological Design-Basis Applications

Nuclide Halogens	Activity (Ci)
I 130	3.80E+06
I 131	9.16E+07
I 132	1.33E+08
I 133	1.88E+08
I 134	2.06E+08
I 135	1.75E+08
Noble Gases	
Kr 83m	2.93E+03
Kr 85m	2.43E+07
Kr 85	1.10E+06
Kr 87	4.66E+07
Kr 88	6.56E+07
Xe 131m	1.01E+06
Xe 133m	5.87E+06
Xe 133	1.80E+08
Xe 135m	3.68E+07
Xe 135	4.77E+07
Xe 138	1.55E+08

Nuclide Alkali	Activity (Ci/MWt)
Cs134	2.06E+07
Cs136	6.01E+06
Cs 137	1.19E+07
Cs138	1.71E+08
Rb86	2.38E+05
Tellurium	
Te 127	9.84E+06
Te 127m	1.29E+06
Te 129	2.92E+07
Te 129m	4.30E+06
Te 131m	1.33E+07
Te 132	1.31E+08
Sb 127	9.95E+06
Sb 129	2.97E+07
Ba, Sr	
Ba 139	1.67E+08
Ba 140	1.61E+08
Sr 89	8.83E+07
Sr 90	8.75E+06
Sr 91	1.11E+08
Sr 92	1.20E+08

Table 6.1 (continued)

Core Inventories of Nuclides for use in Radiological Design-Basis Applications

Nuclide Noble Metals	Activity (Ci/MWt)
Ru 103	1.40E+08
Ru 105	9.62E+07
Ru 106	4.89E+07
Rh 105	8.86E+07
Mo 99	1.75E+08
Tc 99m	1.53E+08

Lanthanides	
La 140	1.73E+08
La 141	1.53E+08
La 142	1.48E+08
Zr 95	1.54E+08
Zr 97	1.55E+08
Nd 147	6.11E+07
Nb 95	1.56E+08
Y 90	9.11E+06
Y 91	1.14E+08
Y 92	1.20E+08
Y 93	1.39E+08
Cm 242	3.52E+06
Cm 244	3.82E+05
Pr 143	1.37E+08
Am 241	1.41E+04

Nuclide Cerium	Activity (Ci/MWt)
Ce 141	1.52E+08
Ce 143	1.42E+08
Ce 144	1.20E+08
Pu 238	4.13E+05
Pu 239	3.50E+04
Pu 240	5.23E+04
Pu 241	1.18E+07
Np 239	1.88E+09

Table 6.2

Core Inventory Fraction Released into Containment Release

(Table 2 of Regulatory Guide 1.183)

Group	Gap Release[1]	Early In-Vessel[2]	Total
Noble Gases	0.05	0.95	1.0
Halogens	0.05	0.35	0.4
Alkali Metals	0.05	0.25	0.3
Tellurium Metals	0.00	0.05	0.05
Ba, Sr	0.00	0.02	0.02
Noble Metals	0.00	0.0025	0.0025
Cerium Group	0.00	0.0005	0.0005
Lanthanides	0.00	0.0002	0.0002

Note: (Ref. 1)
1. Gap release in 30 seconds and 0.5 hr duration
2. Early In-Vessel release in 0.5 hr and 1.3 hr duration

6.2 Iodine Partition Factor in the RWST

Two flow rates (20 and 29 gal/hr) to the RWST were selected: one for an allowable back-leakage which does not result in an increase in the dose specified in the FSAR (Table 12.1) and the second one, an allowable back-leakage which does not result in an increase in the dose acceptance limit of 10 CFR50.67 (5 rem CR TEDE). (In order to find these two flow rates a few flow rates were assumed and run RADTRAD.)

The potential leak path of the sump solution to the RWST is from the Emergency Core Cooling System (ECCS) pump(s) to the RWST water by the way of the piping volume. This is modeled by the transfer of a portion of the flow going to the RWST air and a portion to the RWST water in order to meet the iodine partition factor.

The following Equation from Section 3.3.1 of NUREG/CR-5950 (Ref. 6) was used for equilibrium partition coefficient:

$$\text{Log}_{10}\ PC(I_2) = 6.29 - 0.0149T \quad \text{(Where T = temperature in K)}$$

Using the maximum RWST solution temperature of 114°F (318.71 K) during a 30 day accident period from the input data, the equilibrium partition coefficient was calculated to be 34.77. This factor is defined in terms of concentration, not in terms of activity. Because of the RWST volumes of 13,900 gallons in the liquid space and 38,6000 gallons in the air space, there is a factor of 386000/13900 = 27.77 adjustment that needs taken into account to convert the partition coefficient to a volume basis:

34.77/27.77 = 1.25.

Therefore, if x = gpm to the RWST liquid space and y = gpm to the RWST air space, then

x + y = 0.33333   For 20 gph or 0.16667 gpm
x / y = 1.25

x + y = 0.48334   For 29 gph or 0.33333 gpm
x / y = 1.25

Where y and x are calculated to be:

Y= 0.14815 gpm and x = 0.18518 gpm for flow rate of 20 gph

Y= 0.21482 gpm and x = 0.26852 gpm for flow rate of 29 gph

However, the volume of liquid and air will be changing with time (starting at 6.5 hrs 20 or 29 gallons per hour will be added to the RWST water volume and subtracted from the air volume). As a result, the partition factor will also change with time. Tables 6.3 and 6.4 below from the spread sheet show the results for 20 and 29 gph.

Table 6.3

Flow to the RWST (20 gph)

Flow rate	20		Eq. Par. Coef	34.77				
Time	RWST AIR Volume	RWST water volume	Ratio of air to water	Partition Factor	Flow to air	Flow to water	Flow to air	Flow to water
(hr)	(gal)	(gal)			(gal/min)	(gal/min)	(cfm)	(cfm)
6.5	386000	13900	27.7698	1.25	0.14801	0.18532	0.01979	0.02478
75	384630	15270	25.1886	1.38	0.14003	0.19330	0.01872	0.02584
100	384130	15770	24.3583	1.43	0.13732	0.19601	0.01836	0.02621
150	383130	16770	22.8462	1.52	0.13217	0.20116	0.01767	0.02689
200	382130	17770	21.5042	1.62	0.12738	0.20596	0.01703	0.02754
300	380130	19770	19.2276	1.81	0.11869	0.21464	0.01587	0.02870
400	378130	21770	17.3693	2.00	0.11104	0.22229	0.01485	0.02972
500	376130	23770	15.8237	2.20	0.10425	0.22908	0.01394	0.03063
600	374130	25770	14.5180	2.39	0.09819	0.23515	0.01313	0.03144
720	371730	28170	13.1960	2.63	0.09170	0.24163	0.01226	0.03231

Table 6.4

Flow to the RWST (29 gph)

Flow rate	29		Eq. Par. Coef	34.77				
Time	RWST AIR Volume	RWST water volume	Ratio of air to water	Partition Factor	Flow to air	Flow to water	Flow to air	Flow to water
(hr)	(gal)	(gal)			(gal/min)	(gal/min)	(cfm)	(cfm)
6.5	386000	13900	27.7698	1.25	0.21462	0.26872	0.02869	0.03593
60	384448.5	15451.5	24.8810	1.40	0.20160	0.28173	0.02695	0.03767
75	384448.5	15886.5	24.1997	1.44	0.19835	0.28499	0.02652	0.03810
100	383288.5	16611.5	23.0737	1.51	0.19280	0.29053	0.02578	0.03884
150	381838.5	18061.5	21.1410	1.64	0.18276	0.30058	0.02443	0.04019
200	380388.5	19511.5	19.4956	1.78	0.17364	0.30969	0.02322	0.04141
300	377488.5	22411.5	16.8435	2.06	0.15773	0.32560	0.02109	0.04353
400	374588.5	25311.5	14.7991	2.35	0.14430	0.33903	0.01929	0.04533
500	371688.5	28211.5	13.1751	2.64	0.13282	0.35052	0.01776	0.04686
600	368788.5	31111.5	11.8538	2.93	0.12288	0.36045	0.01643	0.04819
720	365308.5	34591.5	10.5606	3.29	0.11260	0.37073	0.01505	0.04957

There is no transport of activity into the RWST was assumed to occur until 81.5 hours for 20 gph and 66.5 for 29 gph after accident due to delay of 6.5 hours to initiate back-leakage and 75 hours or 60 hours delay imposed by the piping volume from input data [1750 gal (see page 2 of input data)/20 = 87.5 ≈ 75 hours and 1750/29 = 60.3 ≈ 60]. For the 81.5 hrs time step, the flows determined at 75 hours and for the 66.5 hrs time step, the flows determined at 60 hours can be used since the impact of the additional 6.5 hours are not significant.

A transfer from the RWST liquid space to the RWST air space should be used, in order to maintain the partition factors that are calculated above due to the release of activity from the RWST air to the environment. For 20 gph flow rate, the flowing transfers from the RWST water to the RWST air as a function of time were selected:

Time(hr)	Flow(gal/min)
8.15E+01	0.09
3.50E+02	0.2
5.00E+02	0.15
6.50E+02	0.30

These leakages must be shown to be close agreement with the values calculated in the Table 6.3 by running RADTRAD. See Table below from RADTRAD output of IP2RWST20.00

Time (hr)	RWST gas space I-131 inventory (Ci)	RWST liquid I-131 inventory (Ci)	Effective Partition factor (col.3/col.2)	Partition fac. From Table 6.4
100	2.2269E+02	3.1674E+02	1.42	1.43
300	8.4169E+02	1.5220E+03	1.81	1.81
400	7.7482E+02	1.5584E+03	2.01	2.00
500	6.6138E+02	1.4110E+03	2.13	2.20
600	4.7272E+02	1.1368E+03	2.40	2.39
720	2.8779E+02	7.5745E+02	2.63	2.63

For 29 gph flow rate, the flowing transfers from the RWST water to the RWST air as a function of time were selected:

Time(hr)	Flow(gal/min)
8.15E+01	0.09
3.50E+02	0.15

These leakages must be shown to be close agreement with the values calculated in the Table 6.4 by running RADTRAD. See Table below from RADTRAD output of IP2RWST29.O0

Time (hr)	RWST gas space I-131 inventory (Ci)	RWST liquid I-131 inventory (Ci)	Effective Partition factor (col.3/col.2)	Partition fac. From Table 6.4
75	2.4210E+02	3.4459E+02	1.42	1.44
100	5.7103E+02	8.5178E+02	1.49	1.51
300	1.3154E+03	2.5391E+03	1.93	1.81
400	1.1355E+03	2.5524E+03	2.25	2.06
500	9.1766E+02	2.3094E+03	2.52	2.64
600	6.4718E+02	1.8015E+03	2.78	2.93
720	3.6115E+02	1.2190E+03	3.37	3.29

The minimum and maximum Tech Spec temperature range for the RWST is 40°F to 110°F (see the input data), but the tank would not have the potential of seeing this kind of temperature swing on a daily basis. A maximum temperature swing of 40°F is used, which is equivalent to having the tank reach 110°F in the day and then drop to 70°F during the night (using high end of the temperature range (i.e., 70°F to 110°F).

The flow rate would be calculated from the following Equation.

$$P_1V_1/T_1 = P_2V_2/T_2$$

Where, $p_1 = p_2$, v_1 is 386000 gal x 0.1337 = 51600 ft^3 and T_1 and T_2 are 529.67°R and 569.67°R.

Therefore, the volume change can be determined to be:

$V_2 - V_1 = 3897\ ft^3$

If the low end of the temperature range is used (i.e., 40°F to 80°F), the volume change can be determined to be:

$(51600\ ft^3)(539.67°R)/(499.67°R) - 51600 = 4131\ ft^3$

The average flow rate over a full day (higher number is conservative) would be 4131/60x24 = 2.869 cfm. Therefore, 2.9 cfm was used in RADTRAD.

6.3 Determination of Elemental Iodine Fractions based on RWST pH

Both plants IP2 and IP3 have the same rated thermal power and the source inventory of the core is almost the same. Therefore the amount of iodine source in the core for both plants IP2 and IP3 should be almost the same. Therefore, the iodine inventory in the core of 26121g from Reference 7 was used in this calculation. The mass of iodine in the sump water would be 26121 g x 0.40 (40% of iodine released from the core, Reg. Guide 1.183) = 10,448 g

Iodine concentration in the sump water = 10,448/374000 gal = 2.79E-2 g/gal = 7.37E-3 g/L.

The minimum sodium tetraborate decahydrate ($Na_2B_4O_7$-$10H_2O$) is 8096 lb (TS 3.6.7.1b). Sodium tetraborate in solution reverts to a combination of boric acid and sodium hydroxide (NaOH). The equivalent mass of NaOH is found by taking in the fraction of the mass that would exist as NaOH. The molecular weight of NaOH is 39.998 and the molecular weight for sodium tetraborate decahydrate ($Na_2B_4O_7$-$10H_2O$) is 381.38. Thus, the effective mass of NaOH is:

(8096 lb)x(39.998)/(381.38) = 849.1 lb = 3.85E+05 grams

Taking the mass of NaOH and dividing by the sump volume gives the concentration of NaOH in the sump:

3.85E05 g NaOH /374000 GAL =1.0294 g NaOH/gal

(1.0294 g/gal)/(3.7854 l/gal) = 0.2719 g/l

The Tech Spec limit for the boron concentration in the RWST and the accumulators is 2600 ppm (TS 3.5.4.3). Thus, it is conservative to assume that the containment sump solution would also have a boron concentration of 2600 ppm.

Using the data from Reference 7 for 2500 ppm boron and 3000ppm boron, the initial RWST pH is between 4.57 and 4.62 (Reference 7). Two RADTRAD cases were run for each flow rate (20 and 29 gph). One for iodine concentration and the other for NaOH concentration (The only changes made to the source term input .nif[1] and .rft[2]). Tables below show the iodine concentration (see RADTRAD output conc-iodineip220.o0 for 20 gph and conc-iodineip229.o0 for 29 gph) and

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[1] The .nif files (conc-iodineip2.nif for iodine concentration and conc-naohip2.nif for NaOH concentration) are revised to set the inventory iodine or the mass NaOH.

[2] The .rft files (loca-i.rft for iodine concentration and con-naohip2.rft for NaOH concentration) are revised to set the 40% inventory for iodine and all of the NaOH needs to be modeled as going to the sump.

the NaOH concentration in the RWST water (see RADTRAD output conc-naohip220.o0 for 20 gph and conc-naohip229.o0 for 29 gph).

Table 6.5

Iodine Concentration in RWST

20 gph Flow Rate

	Iodine * (gram)	Water (gal)	Iodine Concentration (g/L)**	Iodine Concentration (g-atoms/L)+
350	1.3878E+02	20770	1.765E-03	1.37E-05
400	1.6602E+02	21770	2.015E-03	1.56E-05
450	1.9329E+02	22770	2.243E-03	1.74E-05
500	2.2054E+02	23770	2.451E-03	1.90E-05
550	2.4776E+02	24770	2.642E-03	2.05E-05
600	2.7493E+02	25770	2.818E-03	2.18E-05
650	3.0204E+02	26770	2.981E-03	2.31E-05
720	3.3988E+02	28170	3.187E-03	2.47E-05

29 gph Flow Rate

Time (hr)	Iodine*++ (gram)	Water (gal)	Iodine Concentration (g/L)**	Iodine Concentration (g-atoms/L)+
350	2.1945E+02	23861.5	2.430E-03	1.88E-05
400	2.6082E+02	25311.5	2.722E-03	2.11E-05
450	3.0104E+02	26761.5	2.972E-03	2.30E-05
500	3.4064E+02	28211.5	3.190E-03	2.47E-05
550	3.7988E+02	29661.5	3.383E-03	2.62E-05
600	4.1886E+02	31111.5	3.557E-03	2.76E-05
650	4.5765E+02	32561.5	3.713E-03	2.88E-05
720	5.1167E+02	34591.5	3.908E-03	3.03E-05

* From RADTRAD computer output: con-iodineip220.o0

** (col.2/col.3)/(3.7854 l/gal)

\+ The concentration is converted to gram-atoms of I-129 (more than 75% of iodine inventory is from I-129) by dividing the concentration (col. 4) by 129 (I-129)

++ From RADTRAD computer output: con-Idineip229.o0

Table 6.6

NaOH Concentration in RWST

20 gph Flow Rate

Time (hr)	NaOH* (gram)	water (gal)	NaOH Concentration (g/L)**
350	5.1214E+03	20770	6.514E-02
400	6.1266E+03	21770	7.435E-02
450	7.1328E+03	22770	8.276E-02
500	8.1387E+03	23770	9.045E-02
550	9.1432E+03	24770	9.752E-02
600	1.0146E+04	25770	1.040E-01
650	1.1146E+04	26770	1.100E-01
720	1.2543E+04	28170	1.176E-01

29 gph Flow Rate

Time (hr)	NaOH+ (gram)	Water(gal)	NaOH Concentration (g/L)**
350	8.0983E+03	23861.5	8.966E-02
400	9.6250E+03	25311.5	1.005E-01
450	1.1109E+04	26761.5	1.097E-01
500	1.2571E+04	28211.5	1.177E-01
550	1.4019E+04	29661.5	1.249E-01
600	1.5457E+04	31111.5	1.313E-01
650	1.6889E+04	32561.5	1.370E-01
720	1.8882E+04	34591.5	1.442E-01

* From RADTRAD computer output: con-naohip220.o0

** (col.2/col.3)/(3.7854 l/gal)

\+ From RADTRAD computer output: con-naohip229.o0

For determining the pH at low NaOH concentration, Reference 7 used the titration curves for trisodium phosphate (TSP) instead. NaOH is a stronger caustic than TSP and the TSP curves thus provides conservatively low estimates of the pH for the NaOH solution. A pH of 7.75 shown for 1.0 g/L of NaOH in 2500 ppm boron solution in Reference 7 vs. of a pH of 7.2 for 1.0 g/L of TSP at the same boron concentration from Reference 8.

A table below from Table 3 of Reference 8 shows the TSP concentration as function of pH base on 3000 ppm boron solution (Table 3 is attached to Ref. 7).

TSP Conc. (g/L)	Solution pH
0	4.57
0.025846852	5.62
0.038731624	5.73
0.051590729	5.83
0.064424244	5.91
0.077232245	5.98
0.082348318	6.00
0.092568274	6.05
0.102772008	6.10
0.115503922	6.16
0.128210624	6.19
0.253907314	6.47

Therefore the pH at a given RWST NaOH concentration is found by linear interpolating between the above values, as appropriate. Tables below show the RWST water pH as a function of time.

Table 6.7

RWST Water pH vs. Time

20 gph Flow Rate

Time (hr)	RWST Water NaOH Conc. (g/L)	pH Interpolation Range	RWST Water pH ≈
350	6.514E-02	5.91 - 5.98	5.92
400	7.4359E-02	5.91 - 5.98	5.96
450	8.276E-02	6.00 - 6.05	6.01
500	9.045E-02	6.00 - 6.05	6.04
550	9.752E-02	6.05 - 6.10	6.08
600	1.040E-01	6.10 - 6.16	6.11
650	1.100E-01	6.10 - 6.16	6.14
720	1.176E-01	6.16 - 6.19	6.17

29 gph Flow Rate

Time (hr)	RWST Water NaOH Conc. (g/L)	pH Interpolation Range	RWST Water pH ≈
350	8.966E-02	6.00 - 6.05	6.03
400	1.005E-01	5.10 - 6.05	6.10
450	1.097E-01	6.10 - 6.16	6.15
500	1.177E-01	6.16 - 6.19	6.17
550	1.249E-01	6.16 - 6.19	6.18
600	1.313E-01	6.19 - 6.47	6.21
650	1.370E-01	6.19 - 6.47	6.23
720	1.442E-01	6.19 - 6.47	6.25

Figure 3.1 of Reference 6 (NUREG/CR-5950) was used to determine the amount of iodine converting to the elemental form based on solution pH and iodine concentration. At a pH of 5.2 and a concentration of 10^{-5}, the fraction of iodine (I_2) as elemental iodine is about 0.02.

As shown in above Table, the RWST pH increases to approximately 6.04 at 500 hours at which point the iodine concentration is ≈1.9E-5 g-atom/L for 20 gph flow rate. For 29 gph flow rate, the RWST pH increases to approximately 6.19 at 500 hours at which point the iodine concentration is 2.5E-5 g-atom/L. Until the pH reaches ≈ 6, the fraction of the iodine converting to the elemental form will be assumed to be based on a pH of 5.2 (a conservative assumption). From Figure 3.1 of NUREG/CR-5950 (Reference 6) and considering the iodine concentration above, this fraction is conservatively selected to be 2% for both flow rates.

After 500 hours, the RWST liquid pH will exceed 5.8 and the indicated conversion to elemental iodine is essentially zero for the iodine concentrations calculated above. The fraction converting to elemental form after 500 hours is conservatively assumed to be 0.5% for both flow rates.

7. Results

The offsite and CR doses were evaluated due to dose contribution resulting from postulated back-leakage of containment sump water to the Refueling Water Storage Tank (RWST). Combining the doses resulting from the activity that calculated in Reference 1 from the containment leakage and the ECCS leakage give total offsite and CR doses. The doses were calculated; 1) An allowable back-leakage which does not result in an increase in the dose specified in the FSAR (Table 12.1). 2) An allowable back-leakage which does not result in an increase in the dose acceptance limit of 10 CFR50.67 (5 rem CR TEDE).

There is no EAB dose indicated for the back-leakage to the RWST because back-leakage would not occur until after the identified worst 2-hour interval.

Tables 2.1 and 2.2 present the TEDE in the CR, EAB and LPZ. Refer to Sec. 2 for a summary of the exposures.

It should be noted that the TSC dose was also calculated for information only and the results are in Attachment B.

8.0 References

1. CN-CRA-03-55, "Indian Point 2 - LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)

2. US NRC Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", (July 2000)

3. NUREG/CR-6604, RADTRAD, "A Simplified Model for Radionuclide Transport and Removal and Dose Estimation," USNRC, Apr. 1998

4. Entergy Letter, PU2-E-03-20, "Entergy Nuclear Northeast - Indian Point2 - Power Uprating Program - Inputs Approved by the Technical Review Committee," 4/15/03

5. CN-REA-03-4, "Core Radiation Sources to Support the Indian Point 2 Power Uprate Project," Rev. 0, 4/3/03

6. NUREG/CR-5950,"Iodine Evolution and PH Control," Dec. 1992

7. CN-CRA-11-25, "Indian Point 3 LOCA Doses including Contribution from Back-Leakage to RWST," IP-CALc-11-00080, (9/23/2011)

8. CN-CDME-00-10, "Boric Acid Trisodium Phosphate Titration Curves," Revision 0, May 23, 2000 (copy of Table 3 is attached in Ref. 7)

9. NEA-00023, "Unit 2 TSC Personnel Doses from RG 1.183/NUREG-1465 Design Basis Loss-OF-Coolant-Accident," Rev. 0, (3/22/05)

10. IP-CALC-11-00063, "IPEC Unit 2 SIS & RHR Selected Internal Piping Volumes," Revision 0, (9/7/11)

ATTACHMENT A

COMPUTER INPUTS & OUTPUTS

Included in the EC 32007 is RADTRAD input and output files pertinent to section 6 of this calculation.

The following computer runs were considered in these analyses:

RADTRAD 3.03

Run # 1

Calculate of mass of iodine in the RWST (20 gph)

Input	Output	Inventory
Conc-iodineip220.psf	Conc-iodineip220.o0	conc-iodineip2.nif

Release	Conv. Fac.
Loca-i.rft	dcfs.inp

Run # 2

Calculate of mass of iodine in the RWST (29 gph)

Input	Output	Inventory
Conc-iodineip229.psf	Conc-iodineip229.o0	conc-iodineip2.nif

Release	Conv. Fac.
Loca-i.rft	dcfs.inp

Run # 3

Calculate of mass of NaOH in the RWST (20 gph)

Input	Output	Inventory
Conc-naohip220.psf	Conc-naohip220.o0	con-naohip2.nif

Release	Conv. Fac.
Con-naohip2.rft	dcfs.inp

Run # 4

Calculate of mass of NaOH in the RWST (29 gph)

Input	Output	Inventory
Conc-naohip229.psf	Conc-naohip229.o0	con-naohip2.nif

Release	Conv. Fac.
Con-naohip2.rft	dcfs.inp

Run # 5

Calculate CR & offsite doses from RWST back-leakage (20 gph)

Input	Output	Inventory	Release	Conv.Fac
Ip2rwst20.psf	ip2rwst20.o0	ip2-core.nif	eccsr.rft	dcfs.inp

Run # 6

Calculate CR & offsite doses from RWST back-leakage (29 gph)

Input	Output	Inventory	Release	Conv. Fac
Ip2rwst29.psf	ip2rwst29.o0	ip2-core.nif	eccsr.rft	dcfs.inp

Run # 7

Calculate TSC doses from RWST back-leakage (20 gph)

Input	Output	Inventory	Release	conv. Fac
Ip2tscrwst20.psf	ip2tscrwst20.o0	ip2-core.nif	eccsr.rft	cfs.inp

Run # 8

Calculate TSC doses from RWST back-leakage (29 gph)

Input	Output	Inventory	Release	Conv. Fac
Ip2tscrwst29.psf	ip2tscrwst29.o0	ip2-core.nif	eccsr.rft	cfs.inp

ATTACHMENT B

TSC Doses

IP2 LOCA TSC TEDE Doses (rem) for 20 & 29 gph Flow Rate

Case	20 gph	29 gph
Back-Leakage To RWST	0.0407	0.0635
Calculated Containment & ECCS leakage (Ref. 9)	2.482	2.482
Total	2.52	2.55
TEDE Limit	**5.0**	**5.0**

See RADTRAD output ip2tscrwst20.o0 and ip2tscrwst29.o0

ATTACHMENT C

Supporting Documentation: Design Inputs (Total 9 Pages)

ATTACHMENT 9.1 **DESIGN INPUT RECORD**

Sheet 1 of 1

Design Input Revision: 0 | Page 1 of 9

DESIGN INPUT RECORD

Document Type: Calculation

Document Number: IP-CALC-11-00091 MG Document Revision: 0

Problem Summary: (Attach additional sheets as required)

The high head safety injection (HHSI) system and the low head injection/residual heat removal (RHR) system are connected to the refueling water storage tank (RWST) through multiple valves. The potential doses resulting from leakage of the emergency core cooling system (ECCS) back to the RWST through these valves need to be quantified based on alternate source term (AST) analyses for a large break loss-of-coolant accident (LOCA).

Design Objective: (Attach additional sheets as required)

This analysis will calculate the Indian Point Unit 2 (IP2) Control Room (CR), offsite and the Technical Support Center (TSC) doses resulting from the identified emergency core cooling system (ECCS) back leakage to the IP2 Refueling Water Storage Tank (RWST) during a large break Loss-Of-Coolant Accident (LOCA). The calculated dose due to the ECCS back leakage to the RWST will be combined with the calculated dose resulting from releases via the containment leakage and the ECCS recirculation leakage pathways.

Discipline Review:
Contributing Disciplines:

	Prepared By	Reviewed By:		Prepared By	Reviewed By:
☐ Mechanical			☐ Electrical		
☐ I & C			☐ Civil/Structural		
■ Other (Nuclear)	M. Golshani [signature]	J.E. Chang [signature]	☐ Engineering Programs		

Outside Design Agency ______ ODA Responsible Engineer (Print/Sign/Date) ______

The contributing discipline engineer shall provide his/her name beside the appropriate block.

Lead Discipline Fuels & Nuclear Analysis

RE: (Print/Sign) Mehdi Golshani [signature] 10/31/11 Date

Engineering Supervisor: Ardesar Irani [signature] Date 10/31/11

Input	Value	Input Source (Source Document)
ECCS Back Leakage to the RWST – start of leakage	6.5 hours	Reference: CN-LIS-03-8, Rev. 0, "Indian Point Unit 2 (IPP) Uprate Post-LOCA Calculations."
Sump Water Volume	374,000 gallons	From Page 56 of Reference , CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
Density of RWST water	61.86 lb/ft^3	Density of water at maximum temperature of 110 °F, from Reference CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03), Page 56
Flow Rate of ECCS Back Leakage to the RWST – below the water level	20 & 29 gallons per hour (gph)	Calculate allowable back leakage to remain below the FSAR CR TEDE dose limit. Also calculate value which does not result the dose acceptance limit.
Flow Rate of ECCS Back Leakage to the RWST – above the water level	Not Applicable	The ECCS back leakage to the RWST above the water level will be considered as part of the ECCS leakage in the Primary Auxiliary Building via the containment vent in CN-CRA-03-55, Revision 0. Note that the RWST releases are bounded by the Primary Auxiliary Building releases since the atmospheric dispersion factors of the PAB releases (via containment vent) are greater than those of the RWST releases. [See inputs for atmospheric dispersion factors (χ/Q's)]
Volume of Water Associated with ECCS Back Leakage to the RWST	1,880 gallons	Reference: IP-CALC-11-00063, Table 2. The minimum water volume is estimated to be 2,094 (1943 + 151) gallons between the high head safety injection pump suction and the valve 846 to the RWST 2094 gallons × 0.9 (10% margin) = 1,884.6 gallons ≈ 1,880 gallons
Mass of iodine in sump	26,121 g	Reference: CN-CRA-11-25, "Indian Point 3 LOCA Doses including Contribution from Back-Leakage to RWST," IP-CALC-11-00080, (9/23/2011) Both plants IP2 and IP3 have the same rated thermal power and the source inventory of the core is almost the same. Therefore the amount of iodine source in the core for both plants IP2 and IP3 should be almost the same.

Input	Value	Input Source (Source Document)
ECCS Back Leakage to the RWST – time delay of the sump water reaching the RWST. Based on 20 and 29 gph assumption	75 hours 60 hours	Reference: IP-CALC-11-00063, Table 2. The horizontal section volume of the piping associated with the ECCS back leakage to the RWST is estimated to be 1,931 gallons between the high head safety injection pump suction and the valve 846 to the RWST. Since the sump water temperature is higher than the RWST and its associated piping temperatures, and the sump water is located at lower elevation, the vertical sections of piping are neglected due to the buoyancy-driven thermal mixing. Therefore, the time delay of the ECCS back leakage of 20 or 29 gallons per hour (gph) to reach the RWST is conservatively estimated to be 75 or 60 hours after the start of ECCS external recirculation. Horizontal Sections of 1A and 1B: 429 + 51 + 1304 + 78 + 3 +3 + 40 + 25 + 30 + 19 + 10 gallons = 1992 gallons Horizontal Sections of 2A and 2B: 429 + 51 + 1304 + 78 + 36 + 283 + 47 + 217 + 17 gallons = 2462 gallons 1992 gallons × 0.9 (10% margin) = 1,792.8 gallons ≈ 1,750 gallons 1,750 gallons / 20 gph (assume)= 87.5 hours ≈ 75 hours 1,750 gallons / 29 gph (assume)= 60.3 hours ≈ 60 hours
Iodine species in containment sump water Elemental: Organic: Particulate:	 0 0 100	All iodine is assumed to have converted to stable form in the sump water.

Input	Value	Input Source (Source Document)
Volume of Water Remaining in the RWST after Recirculation Switchover	13900 gallons	Lowest RWST Water Level = 1.49 ft Reference: CR-IP2-2002-04498 Per IP-PRT-09-00014, Rev. 1, page 45 shows the actual lowest RWST water level is 1.74 and page 42 of this reference says "if RWST level decreases to less than 1.5 ft then stop all pumps taking suction from the RWST." Therefore, using 1.49 is conservative. RWST volume: H= 41'-3" Dia.= 40.0' Drawing No: F.P. No. 9321-01-20339-4 Thickness = 0.227" =0.018917' Volume= $\pi R^2 h = 3.14 \times (20 - 0.018917)^2 \times 41.25$ = 51738.27 ft3 = 387054.0 gal RWST Water Volume per Foot = 387054.0 / 41.25 = 9383 gal/ft Remaining Water Volume = 1.49 ft × 9383 gal/ft = 13980 gallons ≈ 13,900 gallons
RWST Minimum Temperature	40°F	SR 3.5.4.1 Section 3.5.4 "Refueling Water Storage Tank (RWST)" of Indian Point Unit 2, Improved Technical Specifications (ITS).
RWST Maximum Temperature	110 °F	SR 3.5.4.1 Section 3.5.4 "Refueling Water Storage Tank (RWST)" of Indian Point Unit 2, Improved Technical Specifications (ITS).
Post-LOCA RWST Maximum Temperature due to the ECCS Back Leakage to the RWST	114 °F	Reference: CN-CRA-11-25, "Indian Point 3 LOCA Doses including Contribution from Back-Leakage to RWST," IP-CALC-11-00080, (9/23/2011) The post-LOCA maximum RWST temperature was estimated in Appendix B (pages 79 and 80) of CN-CRA-11-25 for IP3. A review of the IP2 containment sump temperature and the estimated ECCS back-leakage rate concluded that 114 °F is still bounding.

Input	Value	Input Source (Source Document)
Volume of Air in the RWST after Recirculation Switchover	386,000 gallons	Height of the RWST = 41′ – 3″ Drawing No: F.P. No. 9321-01-20339-4 RWST Volume at 41′ – 3″ = 13820 gallons + (41′ – 3″) × 9383 gallons/ft = 400,874 gallons Remaining Air Volume = 400,874 gallons – 13,980 gallons = 386,894 gallons ≈ 386,000 gallons
Maximum Boron Concentration of RWST	2600 parts per million [ppm]	SR 3.5.4.3 Section 3.5.4 "Refueling Water Storage Tank (RWST)" of Indian Point Unit 2, Improved Technical Specifications (ITS).
Minimum Boron Concentration of RWST	2400 parts per million [ppm]	SR 3.5.4.3 Section 3.5.4 "Refueling Water Storage Tank (RWST)" of Indian Point Unit 2, Improved Technical Specifications (ITS).
Maximum Diurnal Temperature Variation	40 °F	A review of the four (4) year Indian Point meteorological data shows the maximum diurnal temperature variation does not exceed 40 °F. [See page 81 of IP-CALC-11-00080, Revision 0, (CN-CRA-11-25, Revision 0), "Indian Point 3 LOCA Doses including Contribution from Back-Leakage to RWST."]
Minimum Sodium Tetraborate Decahydrate for Post-LOCA pH Control	8,096 pounds [lbm]	SR 3.6.7.1.b Section 3.6.7 "Recirculation pH Control System" of Indian Point Unit 2, Improved Technical Specifications (ITS).

Input	Value	Input Source (Source Document)
Atmospheric Dispersion Factors [χ/Q] for the IP2 Control Room (CR) Air Intake Associated with the IP2 RWST Release [sec/m^3] 0 – 2 hours: 2 – 8 hours: 8 – 24 hours: 1 – 4 days: 4 – 30 days:	 5.62E-04 3.72E-04 1.35E-04 1.10E-04 9.02E-05	Table 2.1 of IP-CALC-11-00060, Revision 0, "Analysis of IP2 Control Room and Technical Support Center Atmospheric Dispersion Factors due to Releases from the IP2 FSB & RWST." (9/28/11)
Control Room Volume	102,400 ft^3	Consistent with analysis in Reference , CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
CR Normal Operation flow rates (cfm) Filtered Makeup: Filtered Recirculation: Unfiltered Makeup: Unfiltered inleakage:	 0 0 920 700	Consistent with analysis in Reference , CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
Time to switch CR HVAC to emergency operation mode	60 sec.	Consistent with analysis in Reference, CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
CR HVAC emergency operation flow (cfm) Filtered Makeup: Unfiltered Makeup: Unfiltered inleakage:	 1800 0 700	Consistent with analysis in Reference, CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)

Input	Value	Input Source (Source Document)
CR HVAC Filter efficiencies (%) Elemental iodine: Organic iodine: Particulates:	 95 90 99	Consistent with analysis in Reference, CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
CR Breathing rate (m^3/sec)	3.5E-04	Ref. Reg. Guide 1.183 and also consistence with analysis in Reference, CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
CR Occupancy Factors 0-2 hours: 1-4 days: 4-30 days:	 1.0 0.6 0.4	Ref. Reg. Guide 1.183 and also consistence with analysis in Reference, CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
Offsite Meteorological Dispersion Factors (sec/m^3) EAB 0-2 hours: LPZ 0-8 hours: 8-24 hours: 1-4 days: 4-30 days:	 7.5E-04 3.5E-04 1.2E-04 4.2E-05 9.3E-06	Consistence with analysis in Reference, CN-CRA-03-55, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
Offsite breathing rate (m^3/sec) 0-8 hours: 8-24 hours: 1-30 days:	 3.5E-04 1.8E-04 2.3E-04	Ref. Reg. Guide 1.183 and also consistence with analysis in Reference, "Indian Point 2 – LOCA Doses for Stretch Power Uprate Program," Revision 0, (10/31/03)
Technical Support Center (TSC) Net-free Volume	860.9 m^3	Page 11 of NEA-00023, Revision 0, "Unit 2 TSC Personnel doses from RG 1.183/NUREG-1456 Design Basis Loss-of-Coolant Accident."

Input	Value	Input Source (Source Document)
Atmospheric Dispersion Factors [χ/Q] for the Technical Support Center (TSC) Air Intake Associated with the IP2 RWST Release [sec/m^3] 0 – 2 hours: 2 – 8 hours: 8 – 24 hours: 1 – 4 days: 4 – 30 days:	 3.58E-04 1.24E-04 5.66E-05 4.77E-05 3.94E-05	Table 2.2 of IP-CALC-11-00060, Revision 0, "Analysis of IP2 Control Room and Technical Support Center Atmospheric Dispersion Factors due to Releases from the IP2 FSB & RWST." (9/28/11)
Technical Support Center (TSC) Unfiltered Intake Flow Rate [Normal Operation]	12,870 cfm	8620 cfm + 4250 cfm = 12,870 cfm This value is greater than 11,230 cfm [damper flow rate] and 12,500 cfm [air-handling fan flow rate] for conservatism. A226586, Revision 6, "Technical Support Center HVAC Flow Diagram Elev. 72'-0", Elev. 88'-6" (Unit #2)." A226587, Revision 3, "Technical Support Center HVAC Flow Diagram El. 33'-0", 37'-0" & 53'-0" (Unit #2)."
Technical Support Center (TSC) Ventilation Mode [Incident Operation]	Filtered pressurized intake	Page 11 of NEA-00023, Revision 0, "Unit 2 TSC Personnel doses from RG 1.183/NUREG-1456 Design Basis Loss-of-Coolant Accident."
Technical Support Center (TSC) Filtered Intake Flow Rate [Incident Operation]	3400 standard cubic feet per minute (scfm) [conservatively lowered from 3492 cfm]	3492 to 4268 cfm: 2-PT-EM001, Revision 0, "TSC Filtration System." 3770 scfm: Page 11 of NEA-00023, Revision 0, "Unit 2 TSC Personnel doses from RG 1.183/NUREG-1456 Design Basis Loss-of-Coolant Accident."

Input	Value	Input Source (Source Document)
Technical Support Center (TSC) Recirculation Flow Rate [Both Normal and Incident Operation]	0 scfm [No Recirculation]	Page 11 of NEA-00023, Revision 0, "Unit 2 TSC Personnel doses from RG 1.183/NUREG-1456 Design Basis Loss-of-Coolant Accident."
Technical Support Center (TSC) Ventilation Mode Change from Normal to Incident Operation	60 minutes [maximum delay time for conservatism]	The Technical Support Center (TSC) and the Operations Support Center (OSC) will be staffed within 60 minutes, and the OSC Radiation Protection Coordinator will request the Control Room to align the TSC ventilation system for incident operation. IP-EP-210, Revision 9, "Central Control Room." IP-EP-220, Revision 10, "Technical Support Center." IP-EP-230, Revision 7, "Operations Support Center."
Technical Support Center (TSC) Unfiltered Inleakage Flow Rate [Both Normal and Incident Operation]	500 scfm	Page 11 of NEA-00023, Revision 0, "Unit 2 TSC Personnel doses from RG 1.183/NUREG-1456 Design Basis Loss-of-Coolant Accident."
Technical Support Center (TSC) Exhaust Flow Rate [Incident Operation]	3900 scfm	3400 scfm [filtered intake] + 500 scfm [unfiltered inleakage] = 3900 scfm
Technical Support Center (TSC) Filter Efficiencies [Incident Operation] Particulate: Inorganics (elemental): Organics: Noble gases:	 99% 95% 90% 0%	Page 11 of NEA-00023, Revision 0, "Unit 2 TSC Personnel doses from RG 1.183/NUREG-1456 Design Basis Loss-of-Coolant Accident."

DESIGN VERIFICATION COVER PAGE

☐ ANO-1	☐ ANO-2	☒ IP-2	☐ IP-3	☐ JAF	☐ PLP
☐ PNPS	☐ VY	☐ GGNS	☐ RBS	☐ W3	☐ NP

Document No.: IP-CALC-11-00091	Revision No.: 0	Page 1 of 10

Title: AST Analysis of IP2 to Address the Impact of Containment Sump Solution Back-Leakage to the RWST after LOCA

☒ Quality Related ☐ Augmented Quality Related

DV Method: ☒ Design Review ☐ Alternate Calculation ☐ Qualification Testing

VERIFICATION REQUIRED	DISCIPLINE	VERIFICATION COMPLETE AND COMMENTS RESOLVED (DV print, sign, and date)
☐	Electrical	
☐	Mechanical	
☐	Instrument and Control	
☐	Civil/Structural	
☒	Nuclear	Jong E. Chang / [signature] 11/16/11
☐		
☐		

Originator: Mehdi Golshani / [signature] 11/16/11
Print/Sign/Date After Comments Have Been Resolved

ATTACHMENT 9.6 **DESIGN VERIFICATION CHECKLIST**

Sheet 1 of 3

IDENTIFICATION:				DISCIPLINE:
Document Title: AST Analysis of IP2 to Address the Impact of Containment Sump Solution Back-Leakage to the RWST after LOCA				☐ Civil/Structural ☐ Electrical ☐ I & C ☐ Mechanical ☒ Nuclear ☐ Other
Doc. No.: IP-CALC-11-00091		Rev. 0	QA Cat.	
Verifier:	Jong E. Chang Print	[signature] Sign	11/16/11 Date	
Manager authorization for supervisor performing Verification. ☒ N/A	Print	Sign	Date	

METHOD OF VERIFICATION:

Design Review ☒ Alternate Calculations ☐ Qualification Test ☐

The following basic questions are addressed as applicable, during the performance of any design verification. [ANSI N45.2.11-1974] [NP QAPD, Part II, Section 3] [NP NQA-1-1994, Part I, BR 3, Supplement 3S-1]

NOTE The reviewer can use the "Comments/Continuation sheet" at the end for entering any comment/resolution along with the appropriate question number. Additional items with new question numbers can also be entered.

1. Design Inputs – Were the inputs correctly selected and incorporated into the design?

   (Design inputs include design bases, plant operational conditions, performance requirements, regulatory requirements and commitments, codes, standards, field data, etc. *All information used as design inputs should have been reviewed and approved by the responsible design organization, as applicable.*

   All inputs need to be retrievable or excerpts of documents used should be attached.

   See site specific design input procedures for guidance in identifying inputs.)

   Yes ☒ No ☐ N/A ☐

2. Assumptions – Are assumptions necessary to perform the design activity adequately described and reasonable? Where necessary, are assumptions identified for subsequent re-verification when the detailed activities are completed? *Are the latest applicable revisions of design documents utilized?*

   Yes ☒ No ☐ N/A ☐

3. Quality Assurance – Are the appropriate quality and quality assurance requirements specified?

   Yes ☒ No ☐ N/A ☐

4. Codes, Standards and Regulatory Requirements – Are the applicable codes, standards and regulatory requirements, including issue and addenda properly identified and are their requirements for design met?
Yes ☒ No ☐ N/A ☐

5. Construction and Operating Experience – Have applicable construction and operating experience been considered?
Yes ☐ No ☐ N/A ☒

6. Interfaces – Have the design interface requirements been satisfied and documented?
Yes ☒ No ☐ N/A ☐

7. Methods – Was an appropriate design or analytical (for calculations) method used?
Yes ☒ No ☐ N/A ☐

8. Design Outputs – Is the output reasonable compared to the inputs?
Yes ☒ No ☐ N/A ☐

9. Parts, Equipment and Processes – Are the specified parts, equipment, and processes suitable for the required application?
Yes ☐ No ☐ N/A ☒

10. Materials Compatibility – Are the specified materials compatible with each other and the design environmental conditions to which the material will be exposed?
Yes ☐ No ☐ N/A ☒

11. Maintenance requirements – Have adequate maintenance features and requirements been specified?
Yes ☐ No ☐ N/A ☒

12. Accessibility for Maintenance – Are accessibility and other design provisions adequate for performance of needed maintenance and repair?
Yes ☐ No ☐ N/A ☒

13. Accessibility for In-service Inspection – Has adequate accessibility been provided to perform the in-service inspection expected to be required during the plant life?
Yes ☐ No ☐ N/A ☒

14. Radiation Exposure – Has the design properly considered radiation exposure to the public and plant personnel?
Yes ☒ No ☐ N/A ☐

15. Acceptance Criteria – Are the acceptance criteria incorporated in the design documents sufficient to allow verification that design requirements have been satisfactorily accomplished?
Yes ☒ No ☐ N/A ☐

16. Test Requirements – Have adequate pre-operational and subsequent periodic test requirements been appropriately specified?
Yes ☐ No ☐ N/A ☒

17. Handling, Storage, Cleaning and Shipping – Are adequate handling, storage, cleaning and shipping requirements specified?
Yes ☐ No ☐ N/A ☒

18. Identification Requirements – Are adequate identification requirements specified?
Yes ☐ No ☐ N/A ☒

19. Records and Documentation – Are requirements for record preparation, review, approval, retention, etc., adequately specified? Are all documents prepared in a clear legible manner suitable for microfilming and/or other documentation storage method? Have all impacted documents been identified for update as necessary?
Yes ☒ No ☐ N/A ☐

20. Software Quality Assurance- ENN sites: For a calculation that utilized software applications (e.g., GOTHIC, SYMCORD), was it properly verified and validated in accordance with EN- IT-104 or previous site SQA Program?
ENS sites: This is an EN-IT-104 task. However, per ENS-DC-126, for exempt software, was it verified in the calculation?
Yes ☒ No ☐ N/A ☐

21. *Has adverse impact on peripheral components and systems, outside the boundary of the document being verified, been considered?*
Yes ☐ No ☐ N/A ☒

Comments / Continuation Sheet

Question #	Comments	Resolution	Initial/Date
1	Various editorial comments were identified and addressed. No response required.	N/A	MG JEL 11/16/11
2	[Section 6.2] The potential ECCS back-leakage flow to the RWST via Valve 846 is below the RWST water level as identified in Attachment C, Design Inputs (page 2 of 9). Hence, the flow to "air" is an artificial flow path to match the iodine partition factor between the RWST water and the RWST air. This is not the potential ECCS leakage to the RWST via MOV-842 and MOV-843, which is above the RWST water level. No response required.	N/A	MG JEL 11/16/11
3	[Section 6.3] The equivalent mole of sodium hydroxide (NaOH) was used to determine the delivered sump water. Then the titration curve of boric acid/trisodium phosphate (TSP) was used to estimate the RWST pH. However, the actual sump solution is based on sodium tetraborate (STB), which is also a weak base. Therefore, it is not obvious that the titration curve using TSP is always conservative to estimate the RWST pH for the elemental iodine fraction. The following post-LOCA sump pH values are found based on TSP and STB: • 12,000 lbm of TSP (trisodium phosphate dodecahydrate, TSP-10H_2O) in the post-accident IP2 containment sump at 2000 ppm boron resulted in pH of 7.61 (page 10 of CN-CRA-96-005, Revision 2). If the mass is adjusted to 10,000 lbm of TSP, the resulting pH is approximately 7.53. • 10,000 lbm of STB (sodium	N/A	MG JEL 11/16/11

Question #	Comments	Resolution	Initial/Date
	tetraborate decahydrate, STB-$12H_2O$) in the post-accident IP2 containment sump at 2000 ppm born resulted in pH of 7.4 (Figure 3 of IP-CALC-07-00129, Revision 2). The molar mass of TSP-$10H_2O$ is 380.1234 g/mol and STB-$12H_2O$ is 381.38 g/mol so they are very comparable in weight. Thanks to the TSP titration curve, the estimated RWST pH could be higher as much as pH = 0.13, which is non-conservative. While determining the elemental iodine fraction in page 31 of the calculation, the elemental iodine fraction in the RWST was selected based on pH of 6.04 instead of 5.2, which gives a margin of pH = 0.84. Therefore, although the TSP titration curve results in slightly non-conservative RWST pH, the elemental iodine fraction was chosen such that the inputs to RADTRAD are still conservative. No response required.		
4	[Design Inputs] The maximum RWST temperature was reviewed not just for the final temperature but for the whole accident duration, i.e., 30 days. As shown in the following Attachment 1, the maximum RWST temperature maintains below 114 °F at 20 gph of the back-leakage flow rate. No response required.	N/A	MG JZL 11/16/11

Attachment 1. Maximum RWST Water Temperature due to the Sump Water Back-Leakage

INPUTS

t_initial = start of ECCS leakage to RWST

6.5	hours	: Section 2.0 of CN-LIS-30-8, Revision 0
23,400	seconds	: Section 3.1 of CN-CRA-03-55, Revision 0

t_final = accident duration

30	days	: Regulatory Guide 1.183
2,592,000	seconds	

V_pipe = piping volume

1880	gallons	: Design Input : RHR Suction Line

V_rwst = RWST water volume

13900	gallons	: Design Input

T_rwst = RWST water temperature

110	deg F	: SR 3.5.4.1 of IP3 Improved Technical Specifications

Q_leakage = ECCS leakage to RWST

20	gallons per hour	: Design Input

Maximum ECCS Temperature
: Minimum ECCS w/ NUREG-1465

: pages 61 - 63, CN-CRA-03-12, Revision 0
: Sump Temperature

Time [sec]	ECCS Temperature [deg F]
23,199	196.31
25,599	191.26
26,799	188.97
29,199	184.86
31,599	191.28
36,399	175.45
41,599	170.68
61,199	160.83
80,799	156.51
85,599	155.78

90,399	155.11
99,999	153.84
101,999	151.64
104,999	148.76
106,999	147.11
109,999	144.94
114,999	142.05
119,999	139.84
128,999	137.05
138,999	135.06
158,999	132.81
199,999	130.53
201,999	129.66
206,999	127.71
216,999	125.11
236,999	122.59
275,999	120.89
314,999	120.09
353,999	119.46
401,999	118.54
411,999	117.4
431,999	116.32
470,999	115.67
548,999	115.21
626,999	114.87
782,999	114.27
1,008,999	111.09
1,094,999	107.04
1,251,999	106.82
1,854,999	106.62
3,750,999	106.09

CALCULATION

ECCS Back Leakage to RWST

[sec]	[deg F]	[gallon-deg F]	[gallon-deg F]	[gallons]	[deg F]
23400	196.31	2398.3	2398.3	12.2	110.1
25599	191.26	1275.1	3673.3	18.9	110.1
26799	188.97	2519.6	6192.9	32.2	110.2
29199	184.86	2464.8	8657.7	45.6	110.2
31599	191.28	5100.8	13758.5	72.2	110.4
36399	175.45	5068.6	18827.1	101.1	110.5
41599	170.68	18585.2	37412.2	210.0	110.9

61199	160.83	17512.6	54924.8	318.9	111.2
80799	156.51	4173.6	59098.4	345.6	111.3
85599	155.78	4154.1	63252.6	372.2	111.4
90399	155.11	8272.5	71525.1	425.6	111.5
99999	153.84	1709.3	73234.4	436.7	111.6
101999	151.64	2527.3	75761.8	453.3	111.6
104999	148.76	1652.9	77414.7	464.4	111.6
106999	147.11	2451.8	79866.5	481.1	111.7
109999	144.94	4026.1	83892.6	508.9	111.7
114999	142.05	3945.8	87838.4	536.7	111.8
119999	139.84	6992.0	94830.4	586.7	111.9
128999	137.05	7613.9	102444.3	642.2	111.9
138999	135.06	15006.7	117451.0	753.3	112.1
158999	132.81	30251.2	147702.2	981.1	112.4
199999	130.53	1450.3	149152.5	992.2	112.4
201999	129.66	3601.7	152754.2	1020.0	112.4
206999	127.71	7095.0	159849.2	1075.6	112.5
216999	125.11	13901.1	173750.3	1186.7	112.5
236999	122.59	26561.2	200311.4	1403.3	112.7
275999	120.89	26192.8	226504.3	1620.0	112.8
314999	120.09	26019.5	252523.8	1836.7	112.9
353999	119.46	31856.0	284379.8	2103.3	113.0
401999	118.54	6585.6	290965.3	2158.9	113.0
411999	117.4	13044.4	304009.8	2270.0	113.0
431999	116.32	25202.7	329212.4	2486.7	113.0
470999	115.67	50123.7	379336.1	2920.0	113.1
548999	115.21	49924.3	429260.4	3353.3	113.2
626999	114.87	99554.0	528814.4	4220.0	113.2
782999	114.27	143472.3	672286.8	5475.6	113.3
1008999	111.09	53076.3	725363.1	5953.3	113.2
1094999	107.04	93362.7	818725.8	6825.6	113.0
1251999	106.82	357847.0	1176572.8	10175.6	112.2
1854999	106.62	436550.3	1613123.0	14270.0	111.4
2592000	106.09				

V_total = total water volume

Back Leakage	14270	gallons	1613123	gallon-deg F
Piping	1880	gallons	206800	gallon-deg F
RWST	13900	gallons	1529000	gallon-deg F
Total =	30050	gallons	3348923	gallon-deg F

T_final = final RWST temperature

111.445 deg F

112 deg F

The final RWST temperature is conservatively increased to 114 °F.