10 CFR 50.90

A subsidiary of Pinnacle West Capital Corporation

Palo Verde Nuclear Generating Station

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102-06344-DCM/DFS
April 08, 2011

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Sirs:

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2, and 3
Docket Nos. STN 50-528, 50-529, and 50-530
Response to Request for Additional Information Regarding License Amendment Request to Revise an Element of Methodology Used in Evaluating the Radiological Consequences of Design Basis Steam Generator Tube Rupture (SGTR) Accidents (TAC Nos. ME4434, ME4435, and ME4436)

By letter dated July 22, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102150352), Arizona Public Service Company (APS) submitted a license amendment request (LAR) to revise an element of methodology used in evaluating the radiological consequences of design basis Steam Generator Tube Rupture (SGTR) accidents at the Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3. The proposed revision would reduce the iodine spiking factor used for a coincident accident-generated iodine spike (GIS) from a value of 500 to a value of 335. The enclosure to this letter contains responses to an NRC draft request for additional information dated February 10, 2011 (ADAMS Accession Nos. ML110410536 and ML110410543).

No commitments are being made to the NRC by this letter. Should you need further information regarding this response, please contact Russell A. Stroud, Licensing Section Leader, at (623) 393-5111.

A001
NRR

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 4/8/11
(Date)

Sincerely,

D. C. Mims

DCM/RAS/DFS/gat

Enclosure: Response to Request for Additional Information (RAI) Regarding License Amendment Request (LAR) to Revise an Element of Methodology Used in Evaluating the Radiological Consequences of Design Basis Steam Generator Tube Rupture (SGTR) Accidents

cc:

E. E. Collins Jr.	NRC Region IV Regional Administrator
L. K. Gibson	NRC NRR Project Manager for PVNGS
J. R. Hall	NRC NRR Senior Project Manager
M. A. Brown	NRC Senior Resident Inspector for PVNGS
A. V. Godwin	Arizona Radiation Regulatory Agency (ARRA)
T. Morales	Arizona Radiation Regulatory Agency (ARRA)

ENCLOSURE

Response to Request for Additional Information (RAI) Regarding License Amendment Request (LAR) to Revise an Element of Methodology Used in Evaluating the Radiological Consequences of Design Basis Steam Generator Tube Rupture (SGTR) Accidents

NRC Draft Request For Additional Information

By letter dated July 22, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102150352), Arizona Public Service Company (the licensee), submitted a license amendment request (LAR) to revise an element of the methodology used in evaluating the radiological consequences of design basis Steam Generator Tube Rupture (SGTR) accidents at the Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3, as described in the Updated Final Safety Analysis Report (UFSAR). The revision would revise the iodine spiking factor used for a coincident event-generated iodine spike (GIS) from a value of 500 to a value of 335.

The U.S. Nuclear Regulatory Commission (NRC) staff has reviewed the information provided by the licensee and determined that the following additional information is needed to complete the review:

1. In Enclosure 1, page 2, the LAR proposes to change an element of methodology (assumption) used in evaluating the radiological consequences of design basis SGTR accidents. Specifically, this proposed change would revise the iodine spiking factor used for a coincident event-Generated Iodine Spike (GIS) from a value of 500 to 335. For the GIS spiking factor of 500 currently used in the dose analysis of record (AOR), a 2-hour thyroid dose value of 182 rem at the exclusion area boundary (EAB), and an 8-hour thyroid dose value of 125 rem at the low population zone (LPZ) were determined as presented in Table 15.6.3-5 of the PVNGS UFSAR. The LAR asserts that use of the newly proposed GIS spiking factor of 335 would result in the 2-hour thyroid dose at the EAB to be reduced to approximately 124 rem. The LAR also asserts that the 8-hour thyroid dose at the LPZ would be reduced to approximately 84 rem.

   The LAR further asserts that the current Pre-Accident Iodine Spike (PIS) values would not be affected by the proposed methodology change. The LAR also states,

   > *"The NRC acceptance criterion previously specified on the PVNGS licensing docket for both GIS and PIS cases is 100% of the 10 CFR Part 100 guideline values which allowed a maximum thyroid dose of 300 rem. The results of this proposed change still remain within these acceptance criteria."*

   Title 10 of the *Code of Federal Regulations* (10 CFR), Section 100.11 sets the regulatory limits for offsite radiological dose consequences at both the EAB and LPZ at 25 rem whole body and/or 300 rem thyroid. Further, acceptance criteria provided in Revision 2 of the Standard Review Plan (NUREG-0800), Section

15.6.3, "Radiological Consequences of Steam Generator Tube Failure (PWR)," provides applicable guidelines which state,

> *"...for the postulated accident with the equilibrium iodine concentration for continued full power operation in combination with an assumed accident initiated iodine spike, the calculated doses should not exceed a small fraction of the above [10 CFR Part 100] guideline values, i.e., 10 percent or 2.5 rem and 30 rem, respectively, for the whole-body and thyroid doses."*

Therefore, Revision 2 of NUREG-0800 has effectively established guidance that offsite radiological dose consequences are limited to a small fraction, or 10% of the 10 CFR Section 100.11 guideline values.

In regard to the offsite radiological dose consequences for the SGTR with an assumed accident-initiated iodine spike, please provide justification as to why the proposed 2-hour thyroid dose value of 124 rem at the EAB, and 8-hour thyroid dose value of 84 rem at the LPZ are appropriate, considering that each exceeds the current NRC staff review criterion of 30 rem to the thyroid for offsite dose. Please also provide all pertinent analyses and/or radiological dose calculations that support the justification to allow the staff to conduct an independent evaluation.

Please also verify that the proposed change would not result in a control room (CR) dose above the 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," Criterion 19 limit of 5 rem. Please provide all pertinent radiological analyses, calculations, or documentation needed in order for the NRC staff to conduct an independent evaluation. As it pertains to the PVNGS's current AOR, please also specify where the current CR radiological dose consequence values for the SGTR accident are located.

APS Response

PVNGS SGTR analyses address several design basis event combinations where the acceptance criteria vary depending on their likelihood of occurrence and analytical assumptions. Each event combination includes an initiating occurrence of a guillotine break of a steam generator tube and may also include one or more coincident occurrences (e.g., most reactive Control Element Assembly (CEA) remains withdrawn from the reactor core after reactor trip, Loss of Offsite Power (LOP), Pre-accident Iodine Spike (PIS), accident-Generated Iodine Spike (GIS)) as well as a worst case single failure. With the exception of the SGTR analysis described below, the acceptance criteria for offsite radiological dose consequences are those provided in Revision 2 of

NUREG-0800, Section 15.6.3, "Radiological Consequences of Steam Generator Tube Failure (PWR)" (Reference 8). This revision of NUREG-0800 was published in 1981 and predates NRC approval of full power operating licenses for PVNGS Units 1, 2, and 3 in 1985, 1986, and 1987, respectively (References 9, 10, and 11).

The plant-specific exception to the acceptance criteria of NUREG-0800 involves a SGTR in combination with a LOP, a GIS, and a single failure that results in an Atmospheric Dump Valve (ADV) on the affected steam generator failing to the full open position two minutes after reactor trip. The failed open ADV creates an excess steam demand event coincident with the SGTR. Because no credit is taken for subsequent closure of the ADV or its associated manual block valve, the ADV is assumed to remain full open for the duration of the event analysis, thereby maximizing the potential for offsite dose consequences.

This analysis for the GIS spiking factor of 500 currently used in the dose analysis of record (AOR), results in a 2-hour thyroid dose value of 182 rem at the exclusion area boundary (EAB), and an 8-hour thyroid dose value of 125 rem at the low population zone (LPZ) as presented in Table 15.6.3-5 of the PVNGS UFSAR. This is the limiting fault "SGTRLOPSF" scenario for which APS proposes to modify PVNGS UFSAR Table 15.6.3-5 to reflect a 2-hour EAB thyroid dose of 124 rem and an 8-hour LPZ thyroid dose of 84 rem (contingent upon NRC approval of a GIS spiking factor of 335).

Although the SGTRLOPSF offsite dose values exceed the current standard review plan (SRP) criterion of 30 rem, they were deemed acceptable by the NRC because, as discussed below, APS was specifically required to reanalyze the SGTR event assuming a loss of offsite power and the worst single active failure. This reanalysis requirement went beyond the guidance of NUREG-0800, Section 15.6.3 which states that NRC staff review of SGTR accidents at the operating license stage shall include the following:

> ". . . Review of the applicant's description of the tube failure accident, with and without offsite power. This includes a review of the sequence of events, the bases for the occurrence, and assurance of an adequate degree of conservatism. . . ."

NUREG-0800, Section 15.6.3 does not, however, include the phrase "single failure" or explicitly address how single failures are to be accounted for in the sequences of events for SGTR analyses.

The PVNGS plant-specific reanalysis requirement comes from an NRC Division of Licensing letter to Combustion Engineering dated April 26, 1983 (Reference 12), that established guidance for the treatment of the single failure criterion at PVNGS by stating the following:

> ". . . Please reanalyze the SGTR event assuming a loss of offsite power and the worst single active failure. Failures should be assumed in any equipment that is relied upon or will be used to mitigate a SGTR event.

> No credit for non-safety-related equipment should be taken unless justification is provided why such equipment can be relied upon to function properly during a SGTR event.
>
> In particular, if the emergency operating procedures instruct the operator to operate a piece of equipment during a SGTR, then the effects of failure of that equipment should be analyzed. The secondary side atmospheric relief valves fall into this category. Credit for operator action to correct any failures will be allowed if actions are suitably justified.
>
> The results of your reanalysis of the SGTR accident with a most limiting single active failure should demonstrate that the radiological consequences of this event combination are within 10 CFR 100 dose guidelines. . . ."

In December 1984, the NRC staff accepted APS's SGTRLOPSF reanalysis for PVNGS that utilized the 10 CFR 100 dose limit guidelines and calculated a 2-hour EAB thyroid dose that exceeded 30 rem for a GIS. The NRC staff conclusion, documented in Supplement 7 to the PVNGS Safety Evaluation Report (SER), NUREG-0857 (Reference 13), stated that:

> ". . . The staff has also performed an independent evaluation of the offsite radiological consequences of the postulated event at the exclusion area boundary. Using assumptions consistent with [Standard Review Plan] SRP Section 15.6.3, the staff estimated the potential radiological consequences at the exclusion area boundary to be 77 rem (thyroid) and 0.4 rem (whole body) which are less than the guideline values of 10 CFR 100. On the basis of the above, the staff concludes that the results of the applicant's reanalysis of the SGTR accident are acceptable..."

Since the initial licensing of PVNGS, there have been five other licensing actions where the NRC staff has reviewed and accepted the SGTRLOPSF reanalyses for which 2-hour EAB and/or 8-hour LPZ thyroid doses exceeded the staff review criterion of 30 rem for a GIS. These reviews and approvals are documented in the following NRC staff Safety Evaluations (SEs):

- May 16, 1994 (Reference 14) – PVNGS operating license amendment Nos. 75 (Unit 1), 61 (Unit 2), and 47 (Unit 3) – These amendments modified the PVNGS Technical Specifications by changing the Pressurizer Safety Valve (PSV) setpoint tolerance from ±1 % to +3 % and -1 %; by changing the Main Steam Safety Valve (MSSV) setpoint tolerance from ±1 % to ±3 %; by reducing the High Pressurizer Pressure Trip (HPPT) setpoint response time from 1.15 seconds to 0.5 second; and by reducing the minimum Auxiliary Feedwater (AFW) pump flow requirement from 750 gallons per minute (gpm) to 650 gpm.

- May 23, 1996 (Reference 15) – PVNGS operating license amendment Nos. 108 (Unit 1), 100 (Unit 2), and 80 (Unit 3) – These amendments modified the PVNGS operating licenses and Technical Specifications by authorizing an increase in Rated Thermal Power (RTP) from 3800 megawatts thermal (MWt) to 3876 MWt; by lowering allowable Reactor Coolant System (RCS) cold leg temperature limits; and by lowering PSV setpoints by 25 pounds per square inch (psi).
- October 23, 1996 (Reference 16) – PVNGS operating license amendment Nos. 109 (Unit 1), 101 (Unit 2), and 81 (Unit 3) – These amendments modified the PVNGS Technical Specifications by changing the reference method for calculating Dose Conversion Factors (DCFs) to be used in dose calculations; and by changing the upper and lower limits for pressurizer pressure to account for new instrument uncertainties and to reduce the allowed operating band.
- September 29, 2003 (Reference 17) – PVNGS operating license amendment No. 149 (Unit 2) – This amendment modified the PVNGS Unit 2 operating license and Technical Specifications by authorizing an increase in RTP from 3876 MWt to 3990 MWt; and by making conforming changes to reflect the installation of replacement steam generators.
- November 16, 2005 (Reference 18) – PVNGS operating license amendment Nos. 157 (Units 1, 2, and 3) – These amendments modified the PVNGS Unit 1 and 3 operating licenses and Technical Specifications by authorizing an increase in RTP from 3876 MWt to 3990 MWt; by making conforming changes to reflect the installation of replacement steam generators in Units 1 and 3; and by making administrative changes to the Unit 2 Technical Specifications so that changed pages would apply to all three PVNGS units.

The SGTRLOPSF AOR was initially submitted for NRC staff review on the PVNGS Unit 2 docket by letter dated December 21, 2001 (Reference 19). The offsite dose consequences that are currently reported in PVNGS UFSAR Table 15.6.3-5 appeared in Table 6.4-6 of the "Power Uprate Licensing Report" attached to that letter. Supplemental information regarding the analytical assumptions and models that were used to calculate those dose consequences were also provided for NRC staff review on the Unit 2 docket by letter dated September 4, 2002 (Reference 20). The applicability of this AOR to PVNGS Units 1 and 3 at 3990 MWt power uprate conditions was subsequently affirmed by APS in a letter dated July 9, 2004 (Reference 21).

The NRC staff performed an independent, confirmatory evaluation of PVNGS SGTRLOPSF offsite dose consequences as described in Safety Evaluations dated September 29, 2003 (Unit 2), and November 16, 2005 (Units 1 and 3) (References 17 and 18, respectively). The assumptions used by NRC staff in performing this evaluation are summarized below in Table 1 and include a GIS spiking factor of 500.

PVNGS UFSAR Section 6.4.7, "Bounding System Unfiltered Air Inleakage for Radiological Design," states that:

> ". . . The Palo Verde Nuclear Generating Station (PVNGS) Control Room (CR) is designed to meet [General Design Criterion] GDC 19 of 10 CFR 50, Appendix A during all design basis events. . . ."

This includes the five rem whole body dose limit specified in GDC 19.

Previously in this response, APS letters to the NRC that addressed a power uprate of the PVNGS units to 3990 MWt and associated offsite dose consequences for SGTR accidents (References 19, 20, and 21) were discussed. These letters also addressed CR dose consequences for SGTR accidents. For example, Table 9.9-2 of the "Power Uprate Licensing Report," attached to the December 21, 2001 letter (Reference 19), reported CR dose consequences of 0.363 rem whole body and 26.8 rem thyroid for a SGTRLOPSF event in combination with a PIS. For PVNGS the SGTRLOPSF event in combination with a GIS is less limiting than the PIS case due to differences in the time-dependent release of radioactive isotopes from the primary and secondary systems. APS letter dated September 4, 2002 (Reference 20), answered an NRC RAI and updated the control room dose results by replacing the original Table 9.9-2 with a new Table 9-1.

As documented in the NRC Safety Evaluations dated September 29, 2003 (Unit 2), and November 16, 2005 (Units 1 and 3) (References 17 and 18, respectively), the NRC staff performed an independent, confirmatory evaluation of PVNGS SGTRLOPSF control room dose consequences. The assumptions used by the NRC staff in performing this evaluation are summarized in Table 1.

The CR dose consequence values from the current PVNGS analyses for the SGTRLOPSF accident and other design basis events are reported in PVNGS UFSAR Table 6.4.7-1. The thyroid dose value reported in the UFSAR table is for a SGTRLOPSF event in combination with a PIS and is based on the event sequence which assumes control room isolation at 300 seconds post-accident initiation.

As discussed above, APS has previously evaluated dose consequences for SGTR events and determined that whole body dose for CR personnel would not exceed five rem. The proposed change in the subject APS LAR (Reference 1) would result in reduced calculated CR thyroid dose following certain SGTR event combinations. The proposed change, however, would have no effect on assumed noble gas releases which are contributors to CR whole body dose. Thus the proposed change would not result in a CR dose above the GDC 19 limit of five rem whole body.

References

1. APS Letter No. 102-06227-DCM/RAB/DFS, "Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2, and 3, Docket Nos. STN 50-528, 50-529, and 50-530, Request for Amendment to Change an Element of Methodology Used in Evaluating the Radiological Consequences of Design Basis Steam Generator Tube Rupture (SGTR) Accidents," D. C. Mims (APS) to Document Control Desk (NRC), July 22, 2010. (NRC ADAMS Accession No. ML102150352)
2. NRC Memorandum No. SECY-98-248, "Proposed Generic Letter 98-XX "Steam Generator Tube Integrity"," W. D. Travers (NRC Executive Director for Operations) to the NRC Commissioners, October 28, 1998. (NRC ADAMS Accession No. ML992920090)
3. NRC Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," July 2000. (NRC ADAMS Accession No. ML003716792)
4. NRC Regulatory Guide 1.195, "Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors," May 2003. (NRC ADAMS Accession No. ML031490640)
5. NRC Memorandum, "Review Standard for Extended Power Uprates," L. B. Marsh (Director, NRC Division of Licensing Project Management) to J. T. Larkins (Executive Director, NRC Advisory Committee on Reactor Safeguards and Advisory Committee on Nuclear Waste), August 1, 2003. (NRC ADAMS Accession No. ML081900513)
6. NRC Memorandum, "Draft Request for Additional Information – Palo Verde Nuclear Generating Station, Units 1, 2, and 3, License Amendment Request to Revise the SGTR Accident Analysis Assumptions (TAC Nos. ME4434, ME4435, and ME4436)," R. Hall (NRC) to R. Stroud (APS), February 10, 2011. (NRC ADAMS Accession No. ML110410536)
7. Attachment to NRC Memorandum, "Draft Request for Additional Information, License Amendment Request to Revise the Steam Generator Tube Rupture Accident Analysis, Palo Verde Nuclear Generating Station, Units 1, 2, and 3, Docket Nos. STN-50-528, STN-50-529, and STN-50-530, Arizona Public Service Company," February 10, 2011. (NRC ADAMS Accession No. ML110410543)
8. NUREG-0800 (formerly issued as NUREG-75/087), "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 15.6.3, "Radiological Consequences of Steam Generator Tube Failure (PWR)," Revision 2, July 1981. (NRC ADAMS Accession No. ML052350149)

9. NRC Letter, "Palo Verde Nuclear Generating Station, Unit 1 – Issuance of Facility Operating License No. NPF-41," H. L. Thompson, Jr. (NRC), to E. E. Van Brunt, Jr. (APS), June 1, 1985. (NRC ADAMS Accession No. ML021680305)

10. NRC Letter, "Palo Verde Nuclear Generating Station, Unit 2 – Issuance of Facility Operating License No. NPF-51," F. J. Miraglia (NRC) to E. E. Van Brunt, Jr. (APS), April 24, 1986. (NRC ADAMS Accession No. ML022350208)

11. NRC Letter, "Palo Verde Nuclear Generating Station, Unit 3 – Issuance of Facility Operating License No. NPF-74," D. M. Crutchfield (NRC) to E. E. Van Brunt, Jr. (APS), November 25, 1987. (NRC ADAMS Accession No. ML022380004)

12. NRC Letter, "CESSAR – Request for Additional Information," Docket No. STN 50-470, C. O. Thomas (Chief, Standardization & Special Projects Branch, NRC Division of Licensing) to A. E. Scherer (Director, Nuclear Licensing, Combustion Engineering, Inc.), April 26, 1983. (See related ADAMS Legacy Accession Nos. 8305130081 and 8307270352)

13. NUREG-0857, "Safety Evaluation Report Related to the Operation of Palo Verde Nuclear Generating Station Units 1, 2, and 3," Supplement No. 7, Section 15.4.5, "Steam Generator Tube Rupture Accident," December 1984.

14. NRC Letter, "Issuance of Amendments for the Palo Verde Nuclear Generating Station, Unit No. 1 (TAC No. M79226), Unit No. 2 (TAC No. M79227), and Unit No. 3 (TAC No. M79228)," B. E. Holian (NRC) to W. F. Conway (APS), May 16, 1994. (NRC ADAMS Accession No. ML021700681)

15. NRC Letter, "Issuance of Amendments for the Palo Verde Nuclear Generating Station, Unit No. 1 (TAC No. M94541), Unit No. 2 (TAC No. M94542), and Unit No. 3 (TAC No. M94543)," C. R. Thomas (NRC) to W. L. Stewart (APS), May 23, 1996. (NRC ADAMS Accession No. ML021710572)

16. NRC Letter, "Issuance of Amendments for the Palo Verde Nuclear Generating Station, Unit No. 1 (TAC No. M95880), Unit No. 2 (TAC No. M95881), and Unit No. 3 (TAC No. M95882)," J. W. Clifford (NRC) to J. M. Levine (APS), October 23, 1996. (NRC ADAMS Accession No. ML021710525)

17. NRC Letter, "Palo Verde Nuclear Generating Station, Unit 2 (PVNGS-2) – Issuance of Amendment on Replacement of Steam Generators and Uprated Power Operations (TAC No. MB3696)," B. M. Pham (NRC) to G. R. Overbeck (APS), September 29, 2003. (NRC ADAMS Accession No. ML032720538)

18. NRC Letter, "Palo Verde Nuclear Generating Station, Units 1, 2, and 3 – Issuance of Amendments RE: Replacement of Steam Generators and Uprated Power Operations and Associated Administrative Changes (TAC Nos. MC3777, MC3778, and MC3779)," M. B. Fields (NRC) to J. M. Levine (APS), November 16, 2005. (NRC ADAMS Accession No. ML053130275)

19. APS Letter No. 102-04641-CDM/RAB, "Palo Verde Nuclear Generating Station (PVNGS), Unit 2, Docket No. STN 50-529, Request for a License Amendment to Support Replacement of Steam Generators and Uprated Power Operations," C. D. Mauldin (APS) to Document Control Desk (NRC), December 21, 2001. (NRC ADAMS Accession No. ML013650419)

20. APS Letter No. 102-04835-CDM/TNW/RAB, "Palo Verde Nuclear Generating Station (PVNGS), Unit 2, Docket No. STN 50-529, Response to Request for Additional Information Regarding Steam Generator Replacement and Power Uprate License Amendment Request," C. D. Mauldin (APS) to Document Control Desk (NRC), September 4, 2002. (NRC ADAMS Accession No. ML022530373)

21. APS Letter No. 102-05116-CDM/TNW/RAB, "Palo Verde Nuclear Generating Station (PVNGS), Units 1, 2 and 3, Docket Nos. STN 50-528, 50-529, and 50-530, Request for a License Amendment to Support Replacement of Steam Generators and Uprated Power Operations in Units 1 and 3, and Associated Administrative Changes for Unit 2," C. D. Mauldin (APS) to Document Control Desk (NRC), July 9, 2004. (NRC ADAMS Accession No. ML042010289)

Table 1

Assumptions Used in NRC Staff Confirmatory Accident Dose Calculations for the Limiting Fault SGTRLOPSF Event Combination**

** Note: From References 17 and 18.

Reactor power (including 2% uncertainty), MWt	4,070
Source term (4,070 MWt core), Ci	
Kr-83m	1.69E+07
Kr-85m	5.28E+07
Kr-85	1.79E+06
Kr-87	8.77E+07
Kr-88	1.30E+07
Kr-89	1.69E+08
Xe-131m	1.06E+06
Xe-133m	5.63E+06
Xe-133	2.29E+08
Xe-135m	7.39E+07
Xe-135	2.18E+08
Xe-137	2.17E+08
Xe-138	2.02E+08
I-131	1.02E+08
I-132	1.55E+08
I-133	2.29E+08
I-134	2.68E+08
I-135	2.08E+08
RCS mass, lbm	560,000
Initial RCS specific activity, µCi/gm dose equivalent I-131	1.0
Initial secondary system specific activity, µCi/gm dose equivalent I-131	0.1
Pre-accident iodine spike (PIS) activity, µCi/gm dose equivalent I-131	60
Accident-generated iodine spike (GIS) multiplier	500
Iodine spike duration, hrs	8

Iodine spike appearance rate parameters	
Filtration efficiency fraction	1.0
Letdown flow, gpm	150
RCS initial activity, μCi/gm dose equivalent I-131	1.0
RCS leakage, gpm	1.0
Iodine appearance rates, Ci/hr	
I-131	13,624
I-132	12,005
I-133	24,341
I-134	16,000
I-135	19,790
Dose conversion factors	ICRP-30
Offsite breathing rate, m^3/sec	
0 – 8 hrs	3.47E-04
8 – 24 hrs	1.75E-04
24 – 720 hrs	2.32E-04
Control room volume, ft^3	1.61E+05
Normal ventilation makeup flow, cfm	1,200
Essential HVAC system	
Filtered air makeup, cfm	1,000
Filtered recirculation, cfm	25,740
Unfiltered inleakage, cfm	63
Filter efficiency, elemental, %	95
Filter efficiency, organic, %	95
Filter efficiency, particulate, %	95
Control room breathing rate, m^3/sec	3.47E-04
Control room occupancy factors	
0 – 24 hrs	1.0
1 – 4 days	0.6
4 – 30 days	0.4
Limiting control room χ/Q (includes occupancy factors), sec/m^3	
0 – 8 hrs	1.56E-03
8 – 24 hrs	1.08E-03
1 – 4 days	4.15E-04
4 – 30 days	1.03E-04

Offsite χ/Q, sec/m^3		
EAB:	0 – 2 hrs	2.3E-04
LPZ:	0 – 8 hrs	6.4E-05
	8 – 24 hrs	4.8E-05
	24 – 96 hrs	2.6E-05
	96 – 720 hrs	1.1E-05
SGTRLOPSF event timing, sec		
Reactor trip		100
LOP		103
Safety Injection Actuation Signal (SIAS)		245
Control room switchover from normal to emergency mode (after SIAS), sec		50
Break flow flashing fraction		
0 – 2,400 sec		1.0
2,400 sec – 8 hrs		0.05
Break flow to affected steam generator, lbm/sec		
0 – 60 sec		60
60 – 360 sec		46.5
360 – 1,080 sec		53.5
1,080 – 3,000 sec		63
3,000 – 4,200 sec		57
4,200 – 5,760 sec		48
5,760 – 7,200 sec		40.5
7,200 – 12,000 sec		36
12,000 – 26,400 sec		31.5
26,400 – 28,800 sec		30
Primary-to-secondary leakage to unaffected steam generator, gpm		1.0

Steam generator mass, lbm	Affected SG	Unaffected SG
0 – 60 sec	100,000	100,000
60 – 360 sec	70,000	100,000
360 – 1,080 sec	55,000	128,000
1,080 – 3,000 sec	170,000	185,000
3,000 – 4,200 sec	300,000	262,000
4,200 – 28,800 sec	300,000	303,000

Steam release from affected steam generator, lbm	
0 – 2 hrs	550,000
2 – 8 hrs	775,000

Steam release from unaffected steam generator, lbm	
0 – 2 hrs	25,000
2 – 8 hrs	50,000
Steam partition coefficient	0.01
Main condenser decontamination factor (prior to LOP)	100