APPENDIX 9A

ANALYSIS FOR NON SEISMIC SPENT FUEL POOL COOLING SYSTEMS

As described in Subsection 9.1.3 the Spent Fuel Pool (SFP) Cooling Systems are designed as non-seismic Category I, Quality Group C systems. Consequently, the radiological consequences of a loss of spent fuel pool cooling due to a seismic event are evaluated. In order to perform this analysis it is necessary to assume the SFP will boil even though Section 9.1.3.3 establishes that the design basis of the plant for this event is to prevent boiling through the use of RHRFPC mode.

Since the cooling systems for both units are cross-connected and in close proximity it was assumed that a seismic event causes the loss of cooling to both spent fuel pools. In addition, in order to maximize both the heat loads and the iodine inventories in the pools, refuelings within 180 days were postulated. (Period of time between outages is nominally 365 days, thus use of 180 days is conservative.) The loss of cooling was assumed during the second refueling, just after isolation of the pools (i.e., refueling and cask pit gates installed). The RHR system is assumed to not be available for cooling the SFP even though it would be able to provide cooling in response to this event. Thus, it is assumed that the pools will boil. The analysis involved an evaluation of the time to pool boiling, the ability to maintain water level if the pool boils, and the dose consequences at the Exclusion Area Boundary (EAB) and the Low Population Zone (LPZ) and the Control Room Habitability Envelope (CRHE) due to releases from the boiling pools.

The assumptions used in this analysis were consistently chosen to be conservative and bounding similar to those in Regulatory Guide 1.183 for design basis accidents. The combination of all of these design basis assumptions occurring at the same time would be extremely unlikely, making this accident as analyzed, one of very low probability.

Both a realistic and conservative analysis of the dose consequences resulting from a boiling spent fuel pool are evaluated. The realistic analysis assumes a conservative value for the number of assemblies in a reload offload batch operated at 4032 MW(t). The conservative analysis assumes a full core offload using the same decay timing characteristics as the smaller reload batch offload. A spiking and steady state release source term is implemented in this analysis. Both the spiking and steady state source term are obtained from Section 11.1.

The following event scenario is assumed for both realistic and conservative analyses of the dose consequences from a spent fuel pool boiling event. Radioactive iodine and noble gases present in the recently off-loaded irradiated fuel resident in the spent fuel pool are assumed to leak into the spent fuel pool water at given leakage rates during conditions when spent fuel pool

cooling is unavailable. The leakage rates are conservatively assumed equivalent to worst case full power operation failed fuel leakage rates. The activity leakage consists of both a spiking and steady state source term. The spiking source term is assumed to exist between the start of the heatup of the spent fuel pool (when cooling is lost due to an assumed seismic event) and initiation of pool boiling, at which time the spiking source term terminates. At the time boiling begins, the steady state source term is assumed to initiate and continue for thirty days. The released iodine and noble gas activity for both spiking and steady state conditions is assumed to uniformly disperse throughout the pool water, and then be released into the air above the spent fuel pool at a rate equal to the boiling evaporation rate of the pool water. The evaporation rate is conservatively assumed to be equal to the maximum makeup rate of the Emergency Service Water (ESW) system of 70 gpm. No credit is taken for holdup of the released activity into the spent fuel pool area, or for iodine plateout on walls and equipment or washout by condensing water vapor in the refueling area. The released activity in the air above the spent fuel pool is assumed to be instantaneously released to the environment through the SGTS system vent. The carryover fraction of iodine from the boiling spent fuel pool water to the spent fuel pool atmosphere is assumed to be the carryover fraction for normal water chemistry conditions. Noble gases are assumed transported to the atmosphere without any partition effects.

The event sequences for the realistic and conservative cases are assumed to occur as follows.

Realistic Scenario:

t = 0 days:
Affected unit shutdown for refueling. Unaffected unit operates at full power with no recently discharged fuel in spent fuel pool, pool activity negligible due to clean up systems operation and normal decay processes. No releases in progress.

t = 24 Hours:
Fuel assemblies begin to be discharged from reactor vessel. Assume batch of 348 assemblies discharged at 7.5 fuel movements per hour. The number of hours to complete a reload offload is 46.4 hrs. No releases in progress.

t = 24 Hours + 46.4 hours = 70.4 hours:
All fuel assemblies in reload batch off-loaded; fuel pool cooling system assumed to fail; fuel pool clean up system fails; conservatively assume isolated fuel pool. Release of spiking activity from fuel to spent fuel pool initiates. Spent fuel pool begins to conservatively evaporate at a rate equal to the maximum ESW make up rate. Release from pool begins. Conservative accident period begins; offsite and control room dose integration begins. The 50% direction independent offsite X/Qs are used to determine the EAB and LPZ doses.

t= 24 hours + 46.4 hours + 25 hours = 95.4 hours = 3.975 days:
Per administrative controls, minimum time to spent fuel pool boiling is 25 hours. Release of spiking activity completes, steady state activity release from fuel into pool begins. Spent fuel pool boiling evaporation rate continues at maximum ESW make up rate. Accident period continues for 30 days after which spent fuel pool cooling is assumed to be restored.

Conservative Scenario:

Timing same as realistic case, except a full core offload (764) assemblies is assumed. This increases the spiking source term. The time period for the offload (46.4 hours) is conservatively maintained as that of the reload batch to minimize decay time. The 0.5% direction dependent offsite X/Qs are used to determine the LPZ dose.

As shown in Table 9A-1, the dose consequences of the boiling pool, without operation of the Standby Gas Treatment System, are well below the guideline values of 10CFR50.67 and Regulatory Guide 1.29. The doses were determined using the RADTRAD computer code (Reference 9A-1).

The following assumptions were used to calculate the EAB, LPZ and CRHE doses for the loss of cooling to the spent fuel pools.

1.   Iodine in fuel from past refuelings (over 60 days) will be negligible due to the long decay times.

2.   It is assumed that all of the defective fuel rods in the core are transferred to the SFP.

3.   The iodine activity in the SFP water when cooling/cleanup is lost is assumed to be negligible compared to the activity released from the fuel during pool boiling. Activity in the core coolant or from a shutdown spike would have been cleaned up to acceptably low levels by the RWCU and SFP Cleanup Systems before fuel transfer began.

4.   The activity released from the fuel is assumed to be uniformly mixed in the 48,690 ft^3 (3.00×10^6 1bm mass) of water in one SFP.

5.   It is assumed that makeup water is available prior to boiling, thus the mass of water is constant.

6.   Iodine carryover fractions of 0.02 (design basis iodine carryover from reactor coolant to steam) and

7.   0.1 at the pool surface were used.

8.   No credit was taken for iodine plateout on walls and equipment or washout by condensing water vapor in the refueling area.

9.   No credit is taken for holdup of the activity in the SFP area or removal of iodine by the ventilation system; thus, the release to the air above the SFP is assumed to be instantaneously released to the environment.

9.   The steady state release source term was conservatively based on full power design basis iodine and noble gas fuel leakage release rates. The design basis off gas release rate for noble gases is 100,000 µCi/sec after 30 minutes delay. For this analysis, noble gas release rates were back corrected to the full power t = 0 release rates. The design basis release rate for iodines corresponds to an I-131 leakage from the fuel of 700 µci/sec. These release rates are the basis for reactor coolant sources given in FSAR section 11.1.

10.   A spiking release is assumed to occur during the heat up period after the spent fuel pool cooling system fails until full pool boiling occurs at 25 hours after the loss of spent fuel pool cooling. The spiking release is based on the full power depressurization spiking activities listed in Table 11.1-6.

11.   Radiological consequences for the EAB and LPZ were evaluated using the 50% direction independent meteorology for the realistic case and 0.5% direction dependent meteorology for the conservative case. The control room X/Q values were for a release through the SGTS vent.

Conservative Case Offsite X/Q (0.5% Direction Dependent)
Exclusion Area Boundary:
0-2 hr 8.3×10^{-4} sec/m^3
Low Population Zone:
0-8 hr 4.9×10^{-5} sec/m^3
8-24 hr 3.5×10^{-5} sec/m^3
24-96 hr 1.7×10^{-5} sec/m^3
96-720 hr 6.1×10^{-6} sec/m^3

Realistic Case Offsite X/Q(50% Direction Independent)
Exclusion Area Boundary:
0-2 hr 1.3×10^{-4} sec/m^3
Low Population Zone:
0-8 hr 4.8×10^{-6} sec/m^3
8-24 hr 3.8×10^{-6} sec/m^3
24-96 hr 2.3×10^{-6} sec/m^3
96-720 hr 1.1×10^{-6} sec/m^3

Control Room Habitability Envelope X/Q - SGTS Exhaust Vent:
0-2 hr $1.16 \times 10{-3}$ sec/m^3
2-8 hr 8.64×10^{-4} sec/m^3
8-24 hr 3.09×10^{-4} sec/m^3
24-96 hr 1.87×10^{-4} sec/m^3
96-720 hr 1.60×10^{-4} sec/m^3

12.   The CRHE's nominal inlet air flow rate is 5810 cfm $\pm$ 10%. The analysis was performed using an inlet makeup flow of 6391 cfm, the maximum value for which the system is in compliance with the plant Technical Specifications. In addition, unidentified unfiltered inleakage of 500 cfm and unfiltered ingress/egress leakage through doors of 10 cfm was used.

13.   The volume for the CRHE is 518,000 ft^3.

REFERENCES

9A-1   USNRC NUREG/CR-6604, "RADTRAD A Simplified Model for RADionuclide Transport and Removal And Dose Estimation", December 1997. Supplement 1, June 1999. Supplement 2, October 2002. Version 3.03.

Dose Location	Dose (1) (Rem TEDE)	
	Conservative Analysis	Realistic Analysis
2 Hour Exclusion Area Boundary	6.77E-03	2.34E-03
30 Day Low Population Zone	2.01E-02	6.64E-04
30 Day Control Room Habitability Envelope	3.02E-01	6.06E-02
(1) 6.77E-03 means 6.77X10^{-3}		

TABLE 9A-1

RESULTS OF BOILING SPENT FUEL POOL ANALYSIS