Attachment 8

Suppression Pool pH Analysis
XC-Q1111-98013, Revision 0

DESIGN ENGINEERING

ENGINEERING CALCULATION

TITLE: Suppression Pool pH Analysis

CALCULATION NUMBER: XC-Q1111-98013

REVISION: 0

THIS CALCULATION SUPERSEDES CALCULATION NUMBERS N/A

AFFECTED SYSTEM(S): N/A

GRAND GULF NUCLEAR STATION, UNIT ONE

[X] SAFETY RELATED

[ ] NON-SAFETY RELATED

PRELIMINARY CALCULATION [ ] FINAL CALCULATION [X]

PREPARED BY: H. E. Broadbent (RESPONSIBLE ENGINEER) DATE: 2/19/99

CHECKED BY: [signature] DATE: 2/19/99

REVIEWED BY: M. D. Withrow (SUPERVISOR) DATE: 2/24/99

APPROVED BY: M. D. Withrow (RESPONSIBLE MANAGER) DATE: 2/24/99

REVISION STATUS SHEET

ENGINEERING CALCULATION REVISION SUMMARY

REVISION	DATE	DESCRIPTION
0	2/24/99	Issue for use

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SHEET REVISION STATUS

SHEET NO.	REVISION	SHEET NO.	REVISION	SHEET NO.	REVISION
i	0	5	0	13	0
ii	0	6	0	14	0
iii	0	7	0	15	0
1	0	8	0	16	0
2	0	9	0	17	0
3	0	10	0	18	0
4	0	11	0	19	0
		12	0		

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APPENDIX/ATTACHMENT REVISION STATUS

APPENDIX NO.	REVISION	ATTACHMENT NO.	REVISION
		1	0
		2	0
		3	0

CONTENTS

1.0 PURPOSE

The purpose of this calculation is to develop the GGNS post-LOCA suppression pool pH transient based on the methodology reported in Engineering Report GGNS-98-0039 [1].

2.0 BACKGROUND

BWR suppression pools are credited in minimizing containment pressurization by condensing steam resulting from a loss of coolant accident (LOCA). At GGNS, the suppression pool is also credited for the long-term retention of iodine, which is washed into the pool by containment spray and by the scrubbing of airborne source term flows through the pool.

Standard Review Plan, NUREG-0800, Section 6.5.2 [15] addresses sump pH considerations for PWRs in Section II.C.1(g) stating:

> The pH of the aqueous solution collected in the containment sump after completion of injection of containment spray and ECCS water, and all additives for reactivity control, fission product removal, or other purposes, should be maintained at a level sufficiently high to provide assurance that significant long-term iodine re-evolution does not occur. Long-term iodine retention is calculated on the basis of the expected long-term partition coefficient. Long-term iodine retention may be assumed only when the equilibrium sump solution pH, after mixing and dilution with the primary coolant and ECCS injection, is above 7 (Ref. 5). This pH value should be achieved by the onset of the spray recirculation mode.

Section 5.2 of NUREG-1465 [2] applies these considerations to BWRs reporting that, although there is no current requirement for pH control of BWR suppression pools, there is a potential for these pools to scrub substantial amounts of iodine in the early phases of an accident only to re-evolve it later as elemental iodine. This NUREG also notes that the cesium hydroxide in the pool may well counteract any acid generation to ensure the pH is maintained sufficiently high that iodine re-evolution is precluded.

This calculation determines the GGNS post-accident pH transient based on the methodology reported in Engineering Report GGNS-98-0039 which was developed from NRC research reported in NUREG/CR-5950 [3]. These results may then be applied in the LOCA airborne dose calculation in the event iodine re-evolution is predicted.

3.0 GIVEN

3.1 Initial pH Values

The allowable suppression pool pH range is 5.3 to 8.6 consistent with the reactor water chemistry guidelines and SAR Section 9.3.6.1.2 and is confirmed quarterly per 08-S-03-10 [4]. This analysis will conservatively assume an initial suppression pool pH value of 5.3. Per SAR Table 5.2-6, the minimum allowable 24-hour reactor coolant chemistry during operation is 5.6 with a minimum pH of 5.3 when depressurized. As such, the reactor coolant pH will conservatively be modeled as 5.3 such that no suppression pool pH elevation need be considered due to the released reactor coolant mixing with the suppression pool inventory.

3.2 Pool Water Volume

This analysis will consider pool inventories that bound the actual GGNS operating range.

3.2.1 Minimum Pool Inventory

The minimum suppression pool volume is 135,291 ft^3 based on Table 1 of ABD-4 [5] and Technical Specification Bases B3.6.2.2. Consistent with Calculation MC-Q1E30-90112 [6], a volume of 500 ft^3 is subtracted from this value for the new ECCS suction strainer installed in RFO9. The total suppression pool volume is therefore 134,791 ft^3.

In the event of a LOCA, the suppression pool makeup (SPMU) system is automatically initiated after a 30-minute timer starts on a LOCA signal (high drywell pressure or low-low reactor water level)[1]. The volume added to the suppression pool based on low water level in the upper pools is 36,163 ft^3 [6]. This volume will be added to the original suppression pool volume after 30 minutes for a total water volume of 170,954 ft^3 or 4.841E6 liters (based on 28.317 liters/ft^3).

The reactor vessel will discharge a large quantity of reactor coolant to the suppression pool in the event of a DBA. A significant fraction of this inventory (~60%) will be discharged as a liquid while most of the resulting steam is quenched in the suppression pool. This reactor coolant inventory is reported as 6.815E5 lbs [5]. Also, some of the suppression pool inventory will vaporize to become humidity in the drywell and containment. Based on the total volume of both drywell and containment of 1.67E6 ft^3 [5] and bounding conditions of atmospheric pressure and 70° F, the total mass of air in the drywell and containment can be calculated to be 1.25E5lbs (ρ=0.075 lbs/ft^3 [7]). At 100% humidity, a bounding low atmospheric pressure, and 185° F, the moisture content is 0.836 pounds of water vapor per pound of dry air [8]. Consequently, the 1.25E5 lbs of dry air will carry 1.045E5 lbs of water vapor, or significantly less than the 6.815E5 lbs released. Since the additional pool inventory from the reactor coolant release bounds the inventory loss due to evaporation, both of these components will be conservatively neglected in

1 An alternate SPMU initiation signal is low-low suppression pool level in association with a LOCA signal. Since, in the proposed core melt scenario, the ECCS pumps are not assumed to be injecting into the reactor vessel for approximately 2 hours, the potential immediate SPMU actuation on low-low suppression pool level (which is caused by the ECCS actuation) is not considered in this analysis.

this analysis. The impact of ESF leakage is insignificant compared to the large suppression pool volume and is consequently ignored.

3.2.2 Maximum Pool Volume

The maximum suppression pool volume is 138,701 ft^3 based on the maximum water level in Technical Specification 3.6.2.2 [17]. The maximum SPMU volume is 37,115 ft^3 [6]. If the entire reactor coolant mass of 6.815E5 lbs is released to the pool, the additional volume is 10,921 ft^3 (based on 62.4 lbs/ft^3). As such, a bounding high suppression pool volume would be 186,737 ft^3. This calculation will apply a value of 10% more than the minimum volume or 188,049 ft^3.

3.3 Chloride-Bearing Cable Inventory

GGNS SAR Table 6.1-2 reports the containment and drywell weights of Hypalon, EPR or cross-linked polyethylene as 176,400 and 9835 lbs, respectively. These values are also reported in Table 2.2 of NUREG/CR-5950 and have been confirmed in EAR X-002-96 [9] to be bounding values based on the GGNS cable database.

A more detailed review of the GGNS chloride-bearing cable inventory in the containment and drywell was performed in EAR X-003-98 [10] based on the methodology reported in Engineering Report GGNS-98-0039. This review concluded that approximately 90% of the cable inventories in the GGNS containment and drywell are routed in conduit or totally enclosed raceways. Consistent with the methodology in Engineering Report GGNS-98-0039, these cable inventories are not included in the HCl generation calculation. The following exposed cable inventories were developed with significant conservatisms that would bound any additional cable lengths that may be added to the GGNS containment or drywell in future design changes.

Table 3-1 Total Combined Pounds of Exposed Cable Jacketing and Insulation

Drywell		Containment	
Free Air Drop	Routed in Trays	Free Air Drop	Routed in Trays
873.65	873.65	1,561.03	14,049.27

In addition to Hypalon, a limited number of cables in the GGNS containment are jacketed with neoprene with a chemical formula of $(C_4H_5Cl)_n$. Based on this formula, neoprene is 35 weight percent (w/o) chlorine relative to the 27 w/o value reported for Hypalon in Section 2.2.5.1 of NUREG/CR-5950. Based on the similar chemical composition of this material relative to Hypalon and the very small inventories in the plant, this material is treated identically to Hypalon in this calculation and is included in the above table.

3.4 Radiation Dose Profiles

Consistent with the methodology reported in Engineering Report GGNS-98-0039, the EQ dose profiles developed with the TID source terms are used to bound the 30-day airborne profiles expected with the NUREG-1465 source terms. The following doses are considered:

- Drywell Airborne Beta
- Drywell Airborne Gamma
- Containment Airborne Beta
- Containment Airborne Gamma

The drywell and containment airborne doses are reported in Bechtel Calculation 5.8.3, Rev. 5 [11]. For the suppression pool dose, a shielding calculation considering the GGNS LOCA source terms and the NUREG-1465 release timing has been performed in Calculation XC-Q1111-98012 [14] based on the suppression pool minimum volume. These airborne and pool integrated doses are either larger than or in agreement with those calculated by the NRC in Figures 4 and 5 of SECY-98-154 [16].

3.5 Source Term Inventories

The cesium and iodine inventories are considered in the suppression pool pH methodology in Engineering Report GGNS-98-0039. These inventories have been calculated for the GGNS core in Calculation XC-Q1J11-98010 [12] as 2400 and 325 g-atoms for cesium and iodine, respectively. These inventories are based on EOC core conditions and include the stable Cs^{133} and I^{127} species. The cesium inventory is a conservatively low estimate for the EOC conditions while the iodine inventory is a conservatively high estimate.

4.0 ASSUMPTIONS

4.1 Pool Mixing

After 2 hours, at least three ECCS pumps will be available to take suction from the pool. At approximately 7000 gpm per pump, at least 21,000 gpm will be circulating from the suppression pool to the reactor vessel or containment spray system. Based on the maximum pool inventory (including the upper containment pool) of 4.841E6 liters, this ECCS flow represents approximately one complete exchange of the pool volume per hour. On this basis, the suppression pool is assumed to be well-mixed such that a single pool pH value can be applied.

4.2 Pool Inventory Assumptions

In order to aggravate any potential adverse pH transient, this calculation will apply the minimum pool inventory as determined from the minimum suppression pool and upper containment pool water level requirements. Crediting a larger pool inventory will result in additional dilution and a pH value closer to the initial pool pH of 5.3. For cases resulting in pH values above 5.3, an additional calculation considering an additional 10% of the pool volume (as reported in Section 3.2.2) will be performed to demonstrate the extent of the impact of this larger volume. This calculation will consider the dilution impact on the CsOH, HI, and HCl concentrations. The HNO_3 impact is evaluated assuming the pool integrated dose is inversely proportional to pool volume.

As a simplification, the maximum pool inventory (including the upper containment pool) will be applied at all times in the calculation. As discussed in Section 3.2, the suppression pool makeup system will be automatically actuated after 30 minutes in this scenario. Prior to this time, the suppression pool will be undergoing an elevated pH transient and the reduced volume would serve increase the CsOH concentration and elevate the pool pH.

5.0 CALCULATION

5.1 Radiation Doses

In the event the pool pH drops below 7, the entire pH transient must be quantified to determine the timing and magnitude of the adverse pH trend. As such, the transient nature of the EQ curves has been captured by fitting points on the curves to equations. This data is taken from the NUREG-0588 analyses documented in Bechtel Calculation 5.8.3 [11]. An additional 5% conservatism is then added to these fits to consider uncertainties in reading the figures and to ensure most points are bounded by the proposed fit. The following resulting equations reported as a function of time, t, in hours, adequately reflect the GGNS EQ curves. Attachment 1 documents the EQ points applied in this analysis. For the suppression pool dose, the results of Calculation XC-Q1111-98012 [14] are applied.

Drywell Airborne Beta Dose

Integrated Dose (t) = 1.05*(114.77*0.676^(1/t)*t^0.3741) — $t < 96$ hours
Integrated Dose (t) = 1.05*(1284-90786/t+2692641/t^2) — $t \geq 96$ hours

Drywell Airborne Gamma Dose

The EQ gamma doses for the drywell are broken down by region with Region D-5, which represents most of the drywell volume, having the highest doses. This worst-case gamma profile will be conservatively applied to all the drywell cables.

Integrated Dose (t) = 1.05*(5.02*0.9633^t*t^0.5376) — $t \leq 5$ hours
Integrated Dose (t) = 1.05*(8.22*0.9999^t*t^0.1267) — $t > 5$ hours

Containment Airborne Beta Dose

Integrated Dose (t) = 1.05*(14.92*0.6954^(1/t)*t^0.4519) — $t \leq 48$ hours
Integrated Dose (t) = 1.05*(248.2-16676.57/t+426559/t^2) — $t > 48$ hours

Containment Airborne Gamma Dose

The EQ gamma doses for the containment are broken down by region with Region C-5, which represents a large portion of the containment volume, having the highest doses. This worst-case gamma profile will be conservatively applied to all the containment cables.

Integrated Dose (t) = 1.05*(1.95*0.5738^(1/t)*t^0.2779) — $t \leq 480$ hours
Integrated Dose (t) = Integrated Dose (t=480) — $t > 480$ hours

Suppression Pool Gamma Dose

Integrated Dose (t) = 1.05*(0.131*0.1874^(1/t)*t^0.5697) — $t \geq 2$ hours

5.2 Cable Model Calculations

There are many different types of cables in application at GGNS including single and multiple conductor. Some of these cables include interior Hypalon jackets on each individual conductor and some multiple-conductor cables have outer interstices filled with extruded Hypalon. The cable jacket/insulation inventories reported in Section 3.3 include all of these cable types. Some of these GGNS cable types are illustrated below.

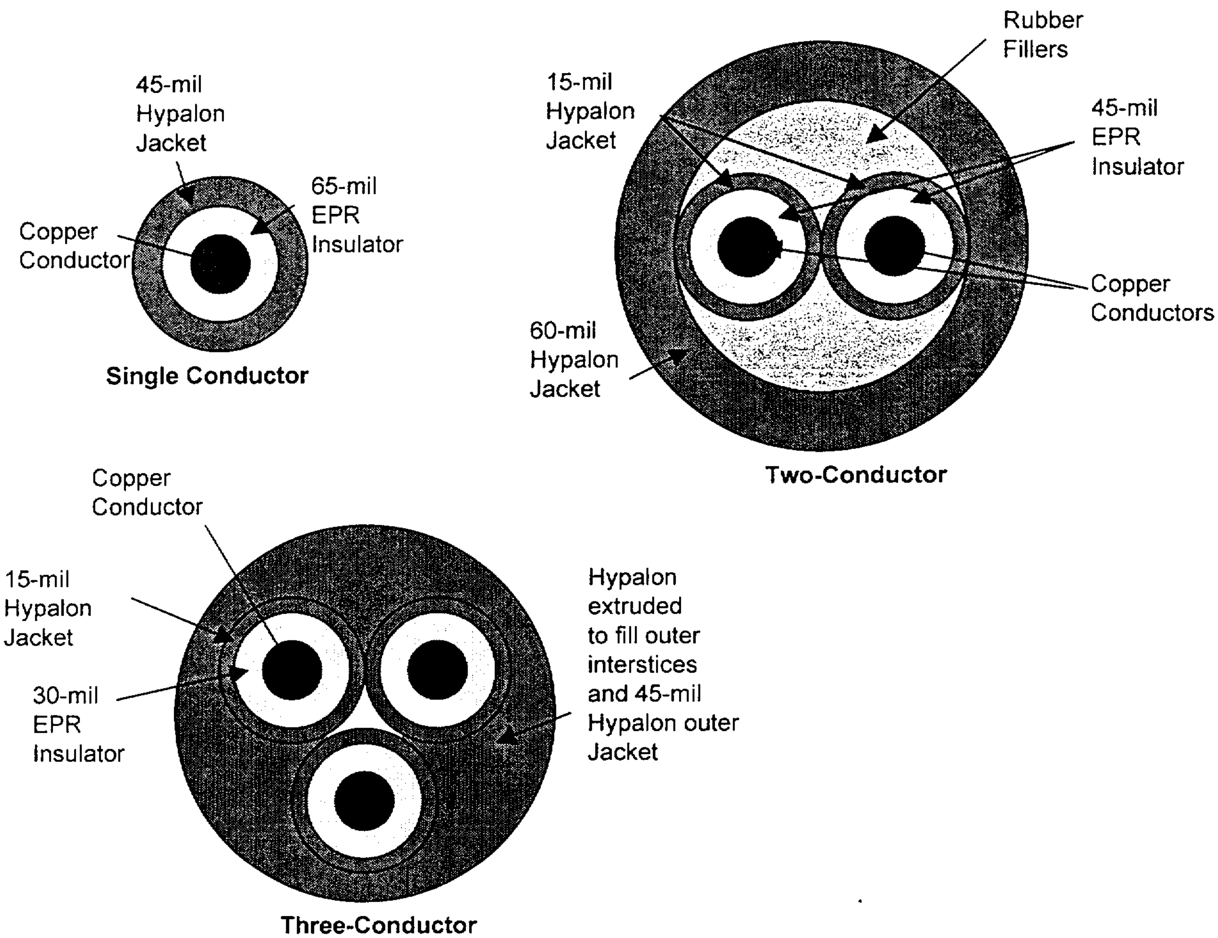


Figure 5-1 Sample GGNS Cable Types

The methodology in Engineering Report GGNS-98-0039, however, is based on simple single-conductor, single-jacketed cables like the NRC model cable in NUREG/CR-1237 [13]. Therefore, to simplify this analysis, the beta and gamma exposures are addressed separately as discussed in detail below.

5.2.1 Beta Radiation

Applying the linear absorption coefficient for beta radiation in Hypalon of 52.08 cm^{-1} from Section 4.2 of NUREG-1081, the beta flux profile in the Hypalon jacket can be seen to be essentially zero at a depth of only 30 mils (0.0762 cm) as shown in Figure 5-2. As such, the HCl generation from beta radiation is driven primarily by absorption in the Hypalon jacket and the internals of the cable construction may be ignored.

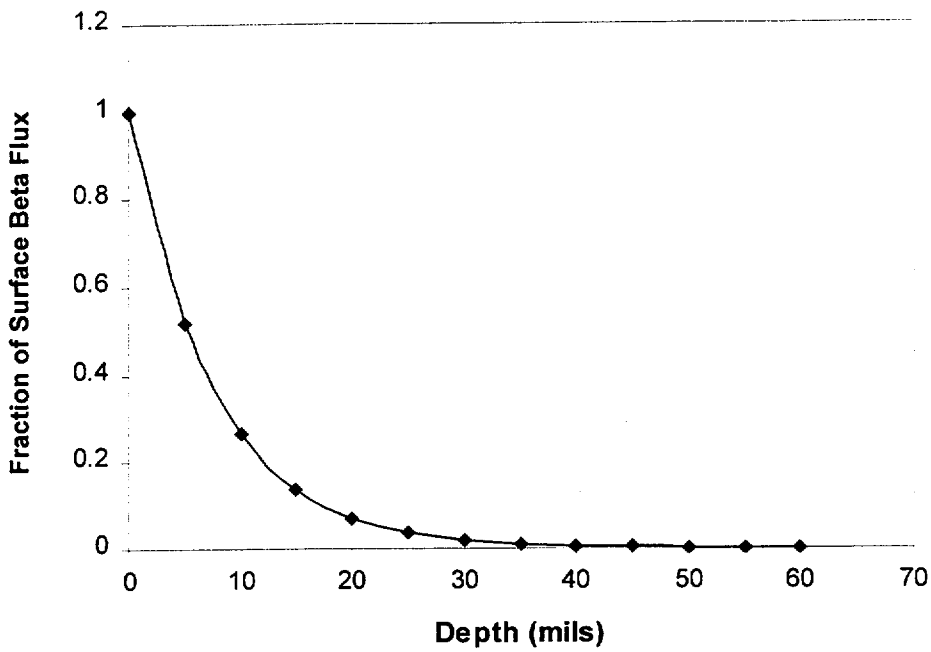


Figure 5-2 Beta Dose Profile in Hypalon

Based on the data in Attachment 1 to EAR X-003-98, six cable types (B*6, B*7, C*2, C*4, C*7, and C*9) make up over 85% of the exposed cables in the drywell and containment. To obtain a comparison of these cable types in terms of their potential for HCl generation, the cable-specific terms in Equation 3-3a of Engineering Report GGNS-98-0039 were identified and a comparative HCl generation term was developed. This HCl term is composed of the product of the mass of Hypalon in the cable jacket, the average-to-incident beta radiation flux ratio, f, and the radiation absorption fraction, $\left(1-e^{-\mu \cdot th}\right)$. Since the cable inventories in Table 3-1 are reported in terms of combined mass of jacket and insulation, the Hypalon mass relative to the combined mass of jacket and insulation is the important comparative parameter in the HCl term.

$$\text{HCl term} = \frac{m_H}{m_{cable\,ins}} \cdot f \cdot \left(1-e^{-\mu \cdot th}\right)$$

where:

$$m_H = \rho_H \cdot \pi \cdot [R_o^2 - (R_o - th)^2],$$

$$f = \frac{\frac{1}{\mu^2}\left[e^{-\mu \cdot th}(\mu \cdot th + 1) - 1\right] - \frac{R_o}{\mu}\left(e^{-\mu \cdot th} - 1\right)}{R_o \cdot th - \frac{th^2}{2}}$$

ρ_H = density of Hypalon (0.671 lb/ft-in^2),
R_o = cable outer radius (in),
th = cable Hypalon jacket thickness (in),

$m_{cable\,ins}$ = mass of combine cable jacket and insulation (lb/ft), and
μ = linear absorption coefficient for beta radiation in Hypalon (132.28 in^{-1}).

This review is documented in Attachment 2 and summarized below. The largestHCl production (per pound of combined cable jacket and insulation) was found from the C*2 cables due to the high (~18%) average-to-incident flux ratio, and high (~100%) beta absorption. This C*2 cable is a two-conductor Okonite cable with a 45-mil Hypalon outer jacket and also happens to be the cable type with the largest exposed inventory per Attachment 1 to EAR X-003-98. This cable type will be used as the representative cable for the HCl calculation by beta radiation and the inventories reported in Section 3.3 will be assumed to be entirely composed of this cable type.

Table 5-1 HCl Generation Terms for Predominant Cable Types

Cable Type	Jacket Mass Fraction $\frac{m_H}{m_{cable\,ins}}$	Ave Beta Dose Fraction of Incident, f	Absorption Fraction $\left(1-e^{-\mu \cdot th}\right)$	HCl Generation Term
B*6	35.35%	13.51%	99.96%	0.048
B*7	35.18%	13.57%	99.96%	0.048
C*2	33.25%	17.81%	99.74%	0.059
C*4	37.69%	13.58%	99.96%	0.051
C*7	34.63%	13.42%	99.96%	0.046
C*9	35.04%	10.10%	100.00%	0.035

The HCl production rate is given by Equation 3-3a of Engineering Report GGNS-98-0039 below.

$$[\mathrm{HCl}](t) = \frac{G \cdot m_H \cdot f}{V_{pool}} \cdot \left(1-e^{-\mu \cdot th}\right) \cdot \int_0^t \dot{X}_\beta(t,R_o)dt$$

$$= \frac{2.192\mathrm{E}-6 \dfrac{\text{mols}}{\text{Megarad}-\text{g}} \cdot 453.59 \dfrac{\text{g}}{\text{lb}} \cdot \left(\dfrac{m_{tray}}{2} + m_{fa}\right) \cdot 0.059}{4.841\mathrm{E}6 \text{ liters}} \cdot \int_0^t \dot{X}_\beta(t,R_o)dt \qquad (5\text{-}1)$$

$$= 1.212\mathrm{E}-11 \frac{\text{mols}}{\text{Megarad}-\text{lb}-\text{liter}} \cdot \left(\frac{m_{tray}}{2} + m_{fa}\right) \cdot \int_0^t \dot{X}_\beta(t,R_o)dt$$

where:

G = the radiation G value for production of HCl from Hypalon (2.192E-6 g-mols HCl/Megarad-g),

m_{tray} = the mass of combined cable jacket and insulation routed in exposed cable trays (lbs),

m_{fa} = the mass of combined cable jacket and insulation in free air drops (lbs), and

$\dot{X}_\beta(t,R_o)$ = the incident beta dose rate (Megarad/hr) at time t (hours).

5.2.2 Gamma Radiation

Unlike beta radiation, gamma radiation can penetrate the cable interior and HCl may be generated from the interior Hypalon jackets or extruded Hypalon fillers in some of the GGNS cable types. As such, this calculation will simply assume that the mass of combined cable jacket and insulation is entirely composed of Hypalon for the calculation of HCl generation due to the gamma dose. Considering a bounding large cable with a 1/2-inch insulation thickness, the absorption fraction, $\left(1-e^{-\mu\cdot th}\right)$, can be calculated with the linear absorption coefficient of 0.099 cm^{-1} from Table A-1 of Engineering Report GGNS-98-0039 to be 0.118. The average-to-incident radiation flux ratio, f, can be conservatively assumed to be 1.0 indicating no reduction in the gamma flux as it passes through the cable.

$$
\begin{aligned}
[\mathrm{HCl}](t) &= \frac{G\cdot m_H\cdot f}{V_{pool}}\cdot\left(1-e^{-\mu\cdot th}\right)\cdot\int_0^t \dot{X}_\gamma(t,R_o)dt \\
&= \frac{2.192\mathrm{E}-6\,\dfrac{\text{mols}}{\text{Megarad}-\text{g}}\cdot 453.59\,\dfrac{\text{g}}{\text{lb}}\cdot\left(m_{tray}+m_{fa}\right)\cdot 1.0}{4.841\mathrm{E}6\ \text{liters}}\cdot 0.118\cdot\int_0^t \dot{X}_\gamma(t,R_o)dt \qquad (5\text{-}2)\\
&= 2.424\mathrm{E}-11\,\frac{\text{mols}}{\text{Megarad}-\text{lb-liter}}\cdot\left(m_{tray}+m_{fa}\right)\cdot\int_0^t \dot{X}_\gamma(t,R_o)dt
\end{aligned}
$$

where:

- m_{tray} = the mass of combined cable jacket and insulation routed in exposed cable trays (lbs),
- m_{fa} = the mass of combined cable jacket and insulation in free air drops (lbs), and
- $\dot{X}_\gamma(t,R_o)$ = the incident gamma dose rate (Megarad/hr) at time t (hours).

5.2.3 Summary

From Equations 5-1 and 5-2, the total HCl production is reported below.

$$
\begin{aligned}
[\mathrm{HCl}](t) = {}& 1.212\mathrm{E}-11\,\frac{\text{mols}}{\text{Megarad}-\text{lb-liter}}\cdot\left(\frac{m_{tray}}{2}+m_{fa}\right)\cdot\int_0^t \dot{X}_\beta(t,R_o)dt \\
&+ 2.424\mathrm{E}-11\,\frac{\text{mols}}{\text{Megarad}-\text{lb-liter}}\cdot\left(m_{tray}+m_{fa}\right)\cdot\int_0^t \dot{X}_\gamma(t,R_o)dt \qquad (5\text{-}3)
\end{aligned}
$$

where:

- m_{tray} = the mass of combined cable jacket and insulation routed in exposed cable trays (lbs),
- m_{fa} = the mass of combined cable jacket and insulation in free air drops (lbs),
- $\dot{X}_\beta(t,R_o)$ = the incident beta dose rate (Megarad/hr) at time t (hours), and
- $\dot{X}_\gamma(t,R_o)$ = the incident gamma dose rate (Megarad/hr) at time t (hours).

5.3 Hydriodic Acid

The hydriodic acid is calculated from the iodine core inventory of 325 g-atoms reported in Section 3.5. From Section 3.1 of Engineering Report GGNS-98-0039, the transient hydriodic acid concentration is given by:

$$[\mathrm{HI}](t) = \frac{m_I}{200 * V_{pool}} * \left(t - t_{gap}\right) \quad \text{(Gap Release Phase)}$$

$$[\mathrm{HI}](t) = \frac{m_I}{120 * V_{pool}} * \left[t - \left(0.5 + t_{gap}\right)\right] + \frac{m_I}{400 * V_{pool}} \quad \text{(Early In-Vessel Release Phase)}$$

where:

m_I = core iodine inventory (gram-mols), and
V_{pool} = volume of the suppression pool (liters).
t = time into accident (hrs), and
t_{gap} = onset of gap release (121/3600 hrs).

The final HI concentration at 7321 seconds is calculated below to be 1.0076E-6 moles per liter.

$$[\mathrm{HI}](t = 7321\mathrm{s}) = \frac{325}{120 \cdot 4.841\mathrm{E}6} * [7321/3600 - (0.5 + 121/3600)] + \frac{325}{400 \cdot 4.841\mathrm{E}6} = 1.0070\mathrm{E}-6$$

The transient HI concentration is illustrated below.

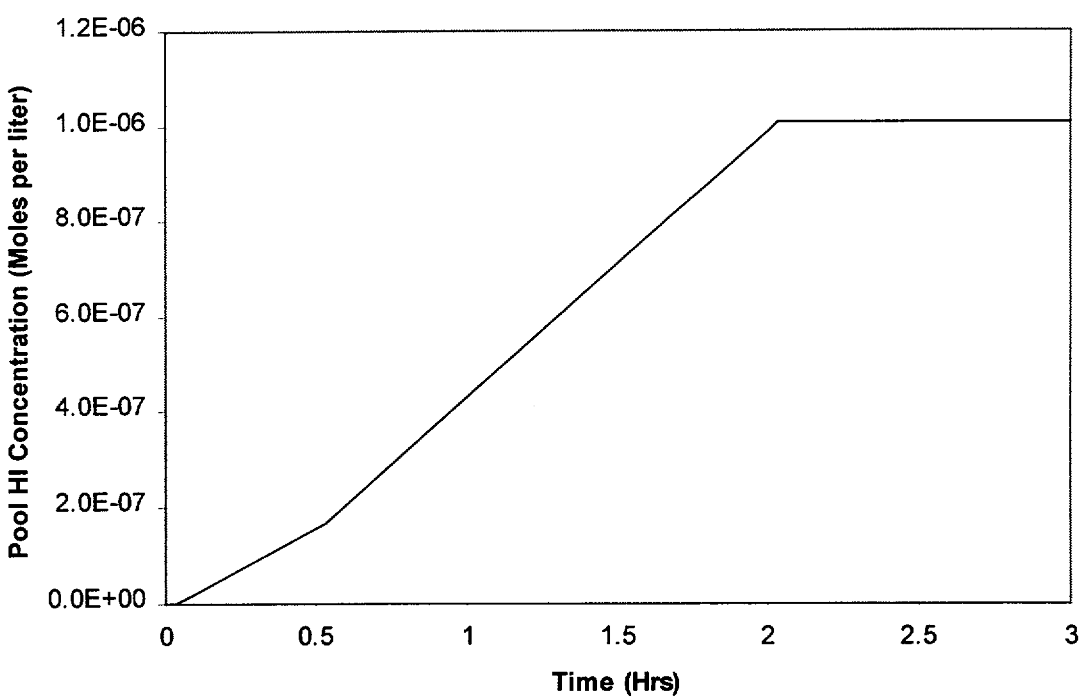


Figure 5-3 Pool HI Transient

5.4 Nitric Acid
The nitric acid is calculated from the integrated pool dose. From Section 3.2 of Engineering Report GGNS-98-0039, the transient nitric acid concentration is given by:

$$[HNO_3](t) = 7.3E-6\int_0^t \dot{X}(t)_{pool}\,dt$$

where:

$\dot{X}(t)_{pool}$ = the time-dependent dose rate in the suppression pool (Megarads/hr)

The transient HNO_3 concentration is illustrated below.

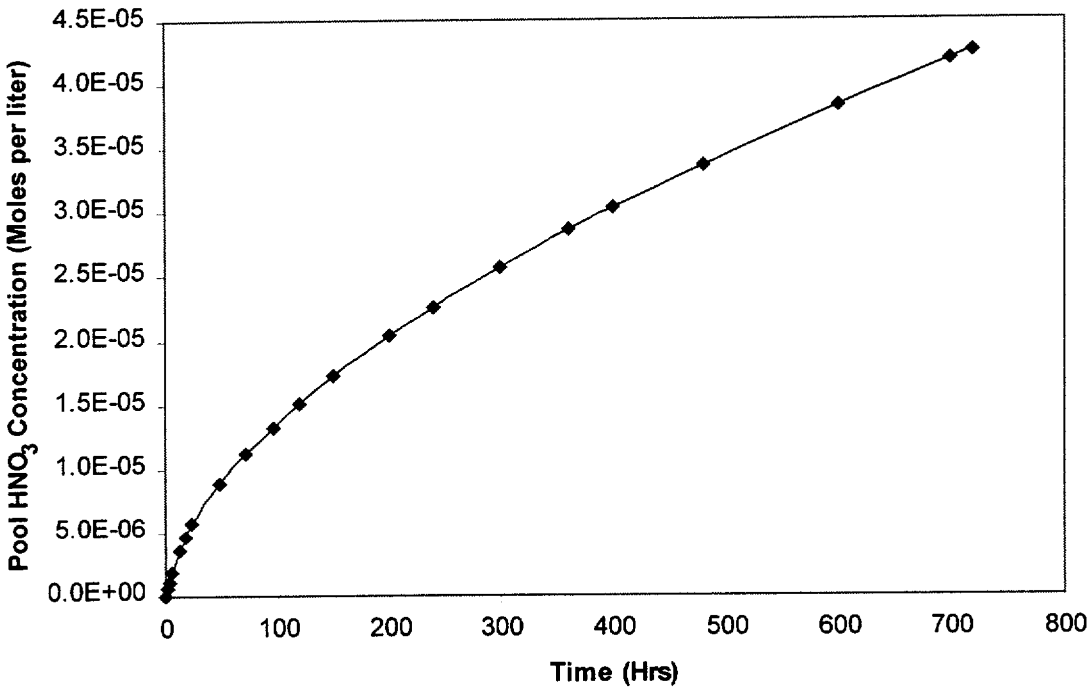


Figure 5-4 Pool Nitric Acid Transient

The final HNO_3 concentration at 30 days is calculated below to be 4.252E-5 moles per liter.

$$[HNO_3](t = 30\text{ days}) = 7.3E-6\cdot 1.05 * \left(0.131 * 0.1874^{\frac{1}{t}} * t^{0.5697}\right)$$

$$= 7.3E-6\cdot 1.05 * \left(0.131 * 0.1874^{\frac{1}{720}} * 720^{0.5697}\right) = 4.2520E-5$$

5.5 Hydrochloric Acid

The hydrochloric acid transient can be calculated from Equation 5-3 above. Since the containment and drywell contain different quantities of cable insulation and have different radiation profiles, the HCl generation in each of these regions is evaluated separately and then summed consistent with the well-mixed pool assumed in Section 4.1. The 30-day HCl concentrations are manually calculated below.

5.5.1 Drywell

The drywell integrated beta and gamma doses at 30 days are calculated with the equations developed in Section 5.1 to be 1221.26 and 18.485 Megarads respectively.

$$\int_0^t \dot{X}_\beta(t,R_o)dt = 1.05*\left(1284 - \frac{90786}{t} + \frac{2692641}{t^2}\right) \quad t \ge 96 \text{ hours}$$

$$\int_0^{30\text{ days}} \dot{X}_\beta(t,R_o)dt = 1.05*\left(1284 - \frac{90786}{720} + \frac{2692641}{720^2}\right) = 1221.26 \text{ Megarads}$$

$$\int_0^t \dot{X}_\gamma(t,R_o)dt = 1.05*\left(8.22*0.9999^t*t^{0.1267}\right) \quad t > 5 \text{ hours}$$

$$\int_0^{30\text{ days}} \dot{X}_\gamma(t,R_o)dt = 1.05*\left(8.22*0.9999^{720}*720^{0.1267}\right) = 18.485 \text{ Megarads}$$

The drywell HCl concentration at 30 days is calculated as 2.0180E-5 moles per liter with Equation 5-3.

$$[\text{HCl}]_{\text{drywell}}(t = 30d) = 1.212E-11\cdot\left(\frac{873.65}{2} + 873.65\right)\cdot 1221.26$$
$$+ 2.424E-11\cdot(873.65 + 873.65)\cdot 18.485 = 2.0180E-5$$

5.5.2 Containment

The containment integrated beta and gamma doses at 30 days are calculated with the equations developed in Section 3.4 to be 237.154 and 11.372 Megarads respectively.

$$\int_0^t \dot{X}_\beta(t,R_o)dt = 1.05*\left(248.2 - \frac{16676.57}{t} + \frac{426559}{t^2}\right) \quad t > 48 \text{ hours}$$

$$\int_0^{30\text{ days}} \dot{X}_\beta(t,R_o)dt = 1.05*\left(248.2 - \frac{16676.57}{720} + \frac{426559}{720^2}\right) = 237.154 \text{ Megarads}$$

$$\int_0^t \dot{X}_\gamma(t,R_o)dt = 1.05 * \left(1.95 * 0.5738^{\frac{1}{t}} * t^{0.2779}\right) \quad t \le 480 \text{ hours}$$

$$\int_0^{30\text{ days}} \dot{X}_\gamma(t,R_o)dt = \int_0^{480\text{ hours}} \dot{X}_\gamma(t,R_o)dt = 1.05 * \left(1.95 * 0.5738^{\frac{1}{480}} * 480^{0.2779}\right) = 11.372 \text{ Megarads}$$

The containment HCl concentration at 30 days is calculated as 2.8981E-5 moles per liter with Equation 5-3.

$$[\mathrm{HCl}]_{containment}(t = 30d) = 1.212E-11 \cdot \left(\frac{14049.27}{2} + 1561.03\right) \cdot 237.154$$
$$+ 2.424E-11 \cdot (14049.27 + 1561.03) \cdot 11.372 = 2.8981E-5$$

5.5.3 Total HCl Production

The total HCl from the radiolysis of cable insulation after 30 days is therefore 4.9161E-5 moles per liter.

$$[\mathrm{HCl}](t = 30d) = [\mathrm{HCl}]_{drywell}(t = 30d) + [\mathrm{HCl}]_{containment}(t = 30d)$$
$$= 2.0180E-5 + 2.8981E-5 = 4.9161E-5$$

The entire suppression pool HCl transient is illustrated below.

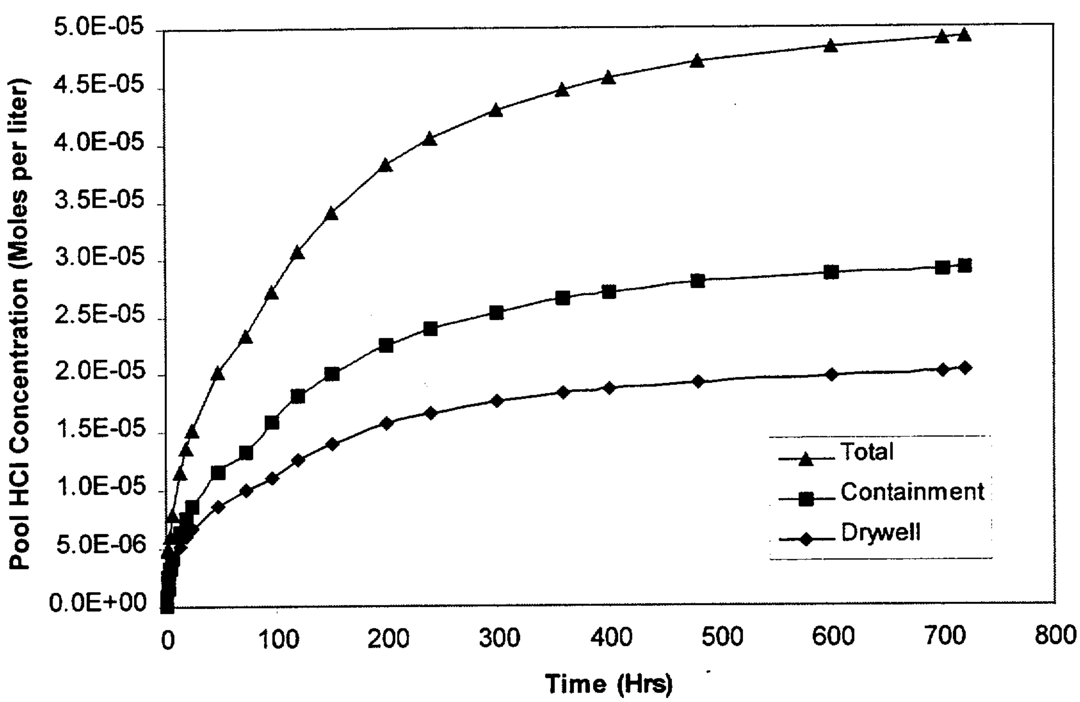


Figure 5-5 Pool HCl Transient

5.6 Cesium Hydroxide

The cesium hydroxide is calculated from the cesium and iodine core inventories reported in Section 3.5 of 2400 and 325 g-atoms for cesium and iodine respectively. From Section 3.4 of Engineering Report GGNS-98-0039, the transient cesium hydroxide concentration is given by:

Gap Release Phase:

$$[CsOH](t) = \frac{0.1m_{Cs} - 0.095m_I}{V_{pool}} * (t - t_{gap})$$

Early In-Vessel Release Phase:

$$[CsOH](t) = \frac{0.4m_{Cs} - 0.475m_I}{3 * V_{pool}} * [t - (0.5 + t_{gap})] + \frac{0.05m_{Cs} - 0.0475m_I}{V_{pool}}$$

The final cesium hydroxide concentration at 7321 seconds is calculated below to be 1.0481E-4 moles per liter.

$$[CsOH](t = 7321s) = \frac{0.4 \cdot 2400 - 0.475 \cdot 325}{3 \cdot 4.841E6} * [7321/3600 - (0.5 + 121/3600)]$$
$$+ \frac{0.05 \cdot 2400 - 0.0475 \cdot 325}{4.841E6} = 1.0481E-4$$

The pool cesium hydroxide transient is illustrated below.

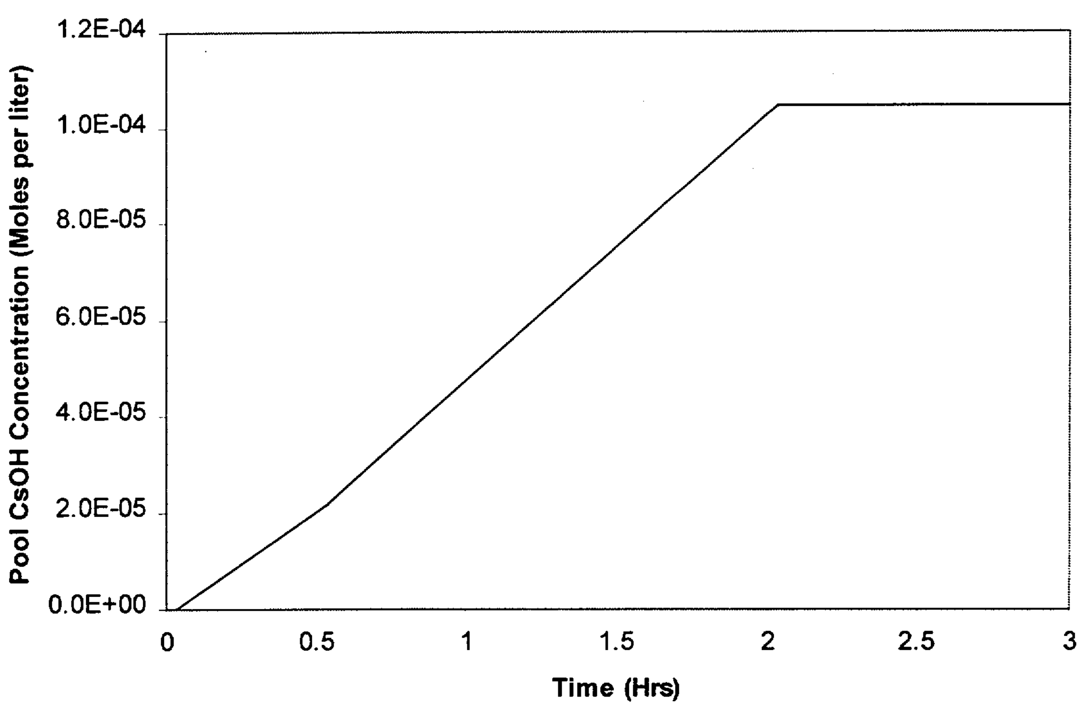


Figure 5-6 Pool CsOH Transient

5.7 Final Pool pH Calculation

From the results of Sections 5.3-5.7, the pool pH at 30 days may be calculated with the methodology in Section 3.5 of Engineering Report GGNS-98-0039 where pH_0 is the initial pool pH value.

$$[\mathrm{H}^+](t) = 10^{-pH_0} + \int_0^t \frac{d}{dt}[\mathrm{HI}](t)dt + \int_0^t \frac{d}{dt}[\mathrm{HNO_3}](t)dt + \int_0^t \frac{d}{dt}[\mathrm{HCl}](t)dt$$

$$[\mathrm{H}^+](t = 30\ \text{days}) = 10^{-5.3} + 1.0070\mathrm{E}-6 + 4.2520\mathrm{E}-5 + 4.9161\mathrm{E}-5 = 9.7700\mathrm{E}-5$$

$$[OH^-](t) = \frac{10^{-14}}{10^{-pH_0}} + \int_0^t \frac{d}{dt}[\mathrm{CsOH}](t)dt$$

$$[OH^-](t = 30\ \text{days}) = \frac{10^{-14}}{10^{-5.3}} + 1.0481\mathrm{E}-4 = 1.0481\mathrm{E}-4$$

The neutralized ions can be calculated as 9.769859E-5 mols per liter.

$$x = \frac{[OH^-]+[H^+]-\sqrt{([OH^-]+[H^+])^2 - 4\cdot([OH^-]\cdot[H^+]-10^{-14})}}{2}$$

$$= \frac{1.0481\mathrm{E}-4 + 9.7700\mathrm{E}-5 - \sqrt{(1.0481\mathrm{E}-4 + 9.7700\mathrm{E}-5)^2 - 4\cdot(1.0481\mathrm{E}-4\cdot 9.7700\mathrm{E}-5 - 10^{-14})}}{2}$$

$$= 9.769859\mathrm{E}-5$$

The final H^+ concentration can then be determined as 1.41E-9 mols per liter.

$$[H^+]_{final} = [H^+] - x = 1.41\mathrm{E}-9$$

The final pool pH can then be calculated as 8.852.

$$pH = -\log([H^+]_{final}) = -\log(1.41\mathrm{E}-9) = 8.852$$

The pool pH at intermediate points is calculated in Attachment 3.

6.0 RESULTS

The GGNS post-accident suppression pool pH profile is calculated in Attachment 3 and illustrated in Figure 6-1 below. The pH rises steadily during the gap and in-vessel release due to the introduction of CsOH into the pool. The pH then begins to decrease after the vessel release terminates due to the continued formation of nitric acid in the suppression pool and hydrochloric acid from radiolysis of the Hypalon cable jacketing. As the pH approaches a value of 7, the slope becomes more negative due to the approaching complete neutralization and the logarithmic function of pH. However, for the 30-day duration of the accident, the GGNS pool pH is shown to never drop below a value of 7.[2] An analysis considering the maximum pool volume is also included in Attachment 3 and demonstrates no significant impact on the final pool pH.

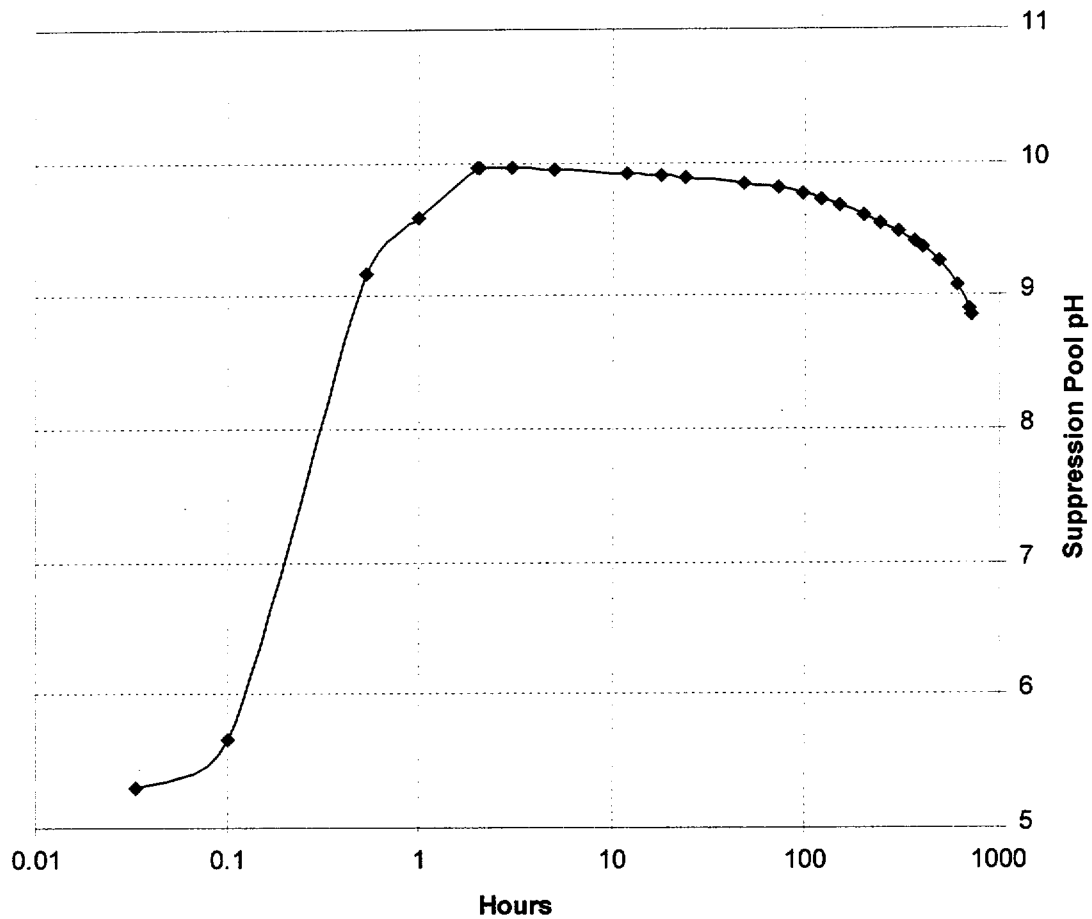


Figure 6-1 GGNS Pool pH Transient

2 As discussed in Section 3.1, the pool pH actually begins the accident at a value of 5.3. However, the pool pH rises quickly above 7.0 after the source term release begins. Considering the very short duration that the pool pH is below 7.0 and the very low iodine concentrations in the pool at this early stage, iodine evolution from the pool during this period may be ignored.

To evaluate the relative importance of each type of acid, a comparison of the origin of each acid is presented in Figure 6-2. The primary source of acid is from radiolysis of the cable insulation, particularly from the beta dose. The nitric acid generated from radiolysis of the suppression pool water is the second largest source of acid. The hydriodic acid is nearly insignificant in this analysis considering the large quantities of hydrochloric and nitric acids.

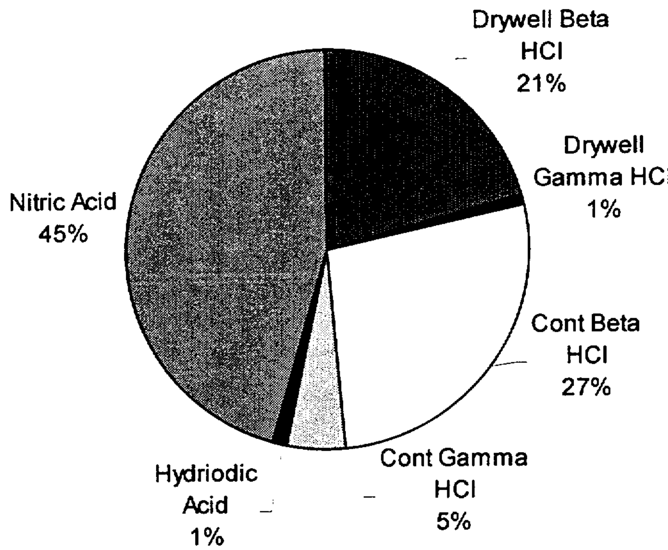
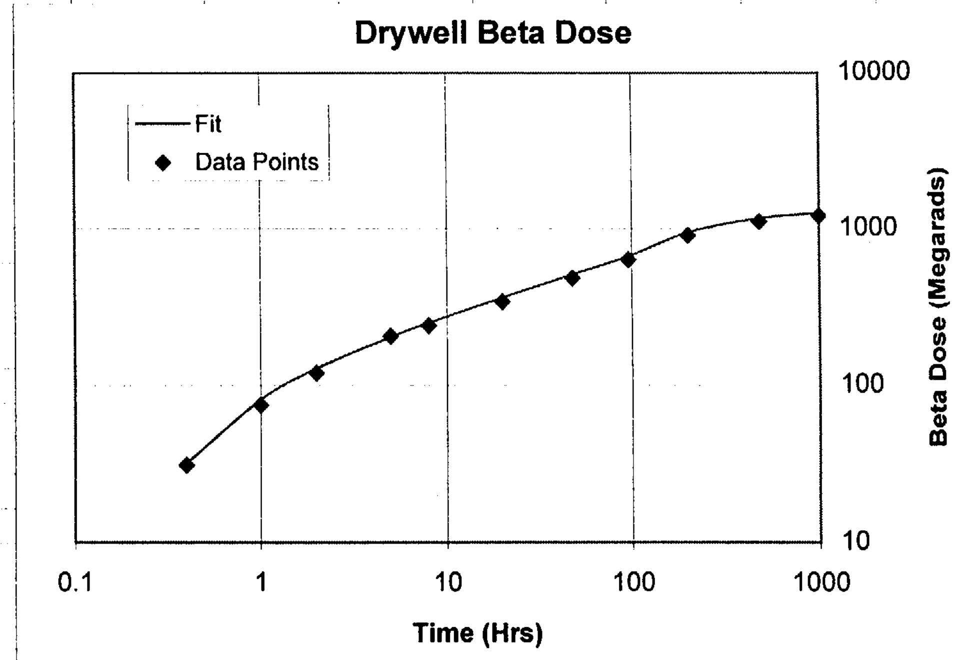


Figure 6-2 Acids by Contribution (after 30 days)

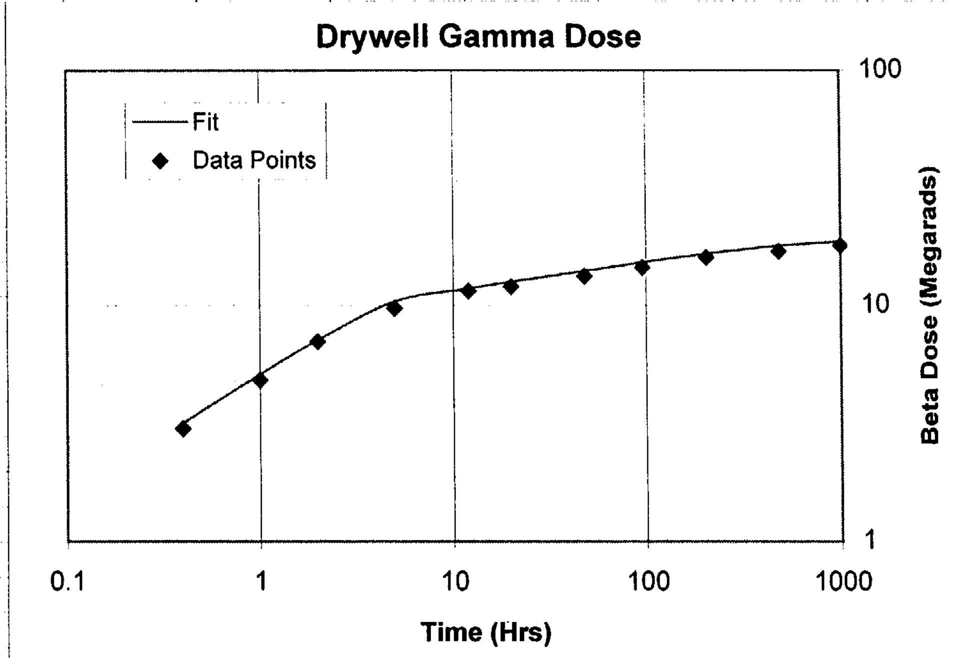
7.0 REFERENCES

1. Engineering Report GGNS-98-0039, Rev. 0, Suppression Pool pH and Iodine Re-evolution Methodology.
2. NUREG-1465, Accident Source Terms for Light-Water Nuclear Power Plants, dated February 1995.
3. NUREG/CR-5950, Iodine Evolution and pH Control, dated December 1992.
4. Chemistry Procedure 08-S-03-10, Rev. 28, Chemistry Sampling Program.
5. Analysis Basis Document (ABD) 4, Rev. 0, Analytical Bases for Containment Performance.
6. Calculation MC-Q1E30-90112, Rev. 1, Calculation in Support of UFSAR Table 6.2-50 "Suppression Pool Geometry – GGNS" Values.
7. Crane Technical Paper 410, Flow of Fluids through Valves, Fittings, and Pipe, 25th Printing, 1991.
8. Cooling Tower Institute Code Tower Standard Specifications, "Acceptance Test Code for Water-Cooling Towers", CTI Code ATC-105, dated February 1990.
9. Engineering Assistance Request X-002-96, dated April 3, 1996.
10. Engineering Assistance Request X-003-98, dated November 30, 1998.
11. Bechtel Calculation 5.8.3, Rev. 5, NUREG-0588 Source Terms & Integrated Doses.
12. Calculation XC-Q1J11-98010, Rev. 0, Cesium and Iodine Inventories for Pool pH Calculation.
13. NUREG/CR-1237, Best-Estimate LOCA Radiation Signature, dated January 1980.
14. Calculation XC-Q1111-98012, Rev. 0, Suppression Pool Radiation Doses.
15. NUREG-0800, Standard Review Plan, Section 6.5.2, "Containment Spray As a Fission Product Cleanup System" Rev. 2, December 1988.
16. SECY-98-154, "Results of the Revised (NUREG-1465) Source Term Rebaselining for Operating Reactors", dated June 30, 1998.
17. GGNS Technical Specifications and Bases, Amendment 136.

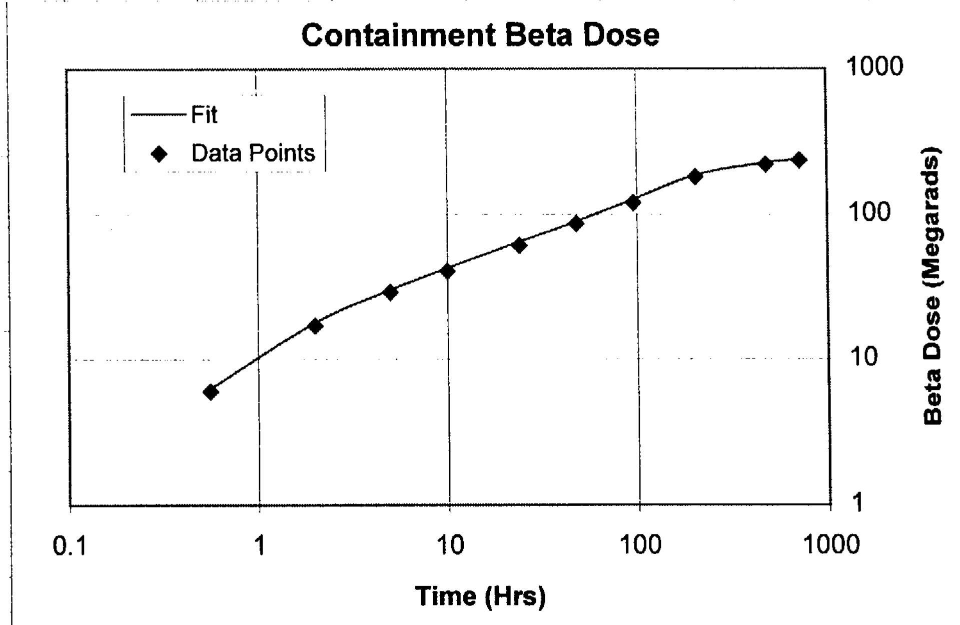
Time (Hrs)	Data Points (Megarad)	Fit (Megarad)
0.4	31	32.13772
1	75	81.46375
2	120	128.4122
5	205	203.4659
8	240	249.8084
20	340	362.4352
48	480	508.6596
96	630	662.0069
200	900	942.2553
480	1100	1161.877
1000	1200	1255.702



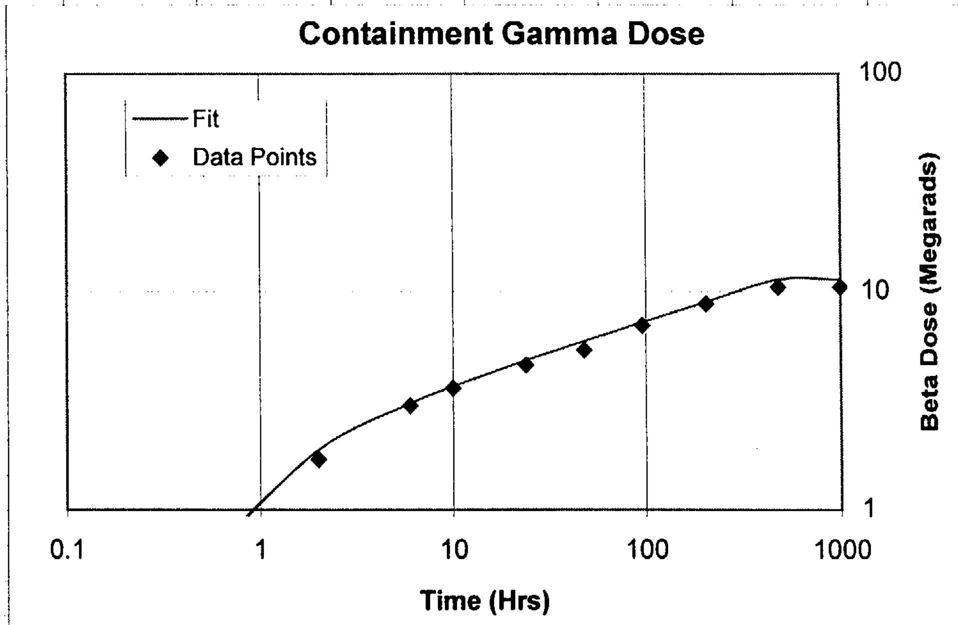
Time (Hrs)	Data Points (Megarad)	Fit (Megarad)
0.4	3	3.172964
1	4.8	5.077554
2	7	7.099861
5	9.7	10.38645
12	11.5	11.81061
20	12	12.59021
48	13.3	14.0278
96	14.5	15.24212
205	16	16.59804
480	17	17.98569
1000	18	18.73827



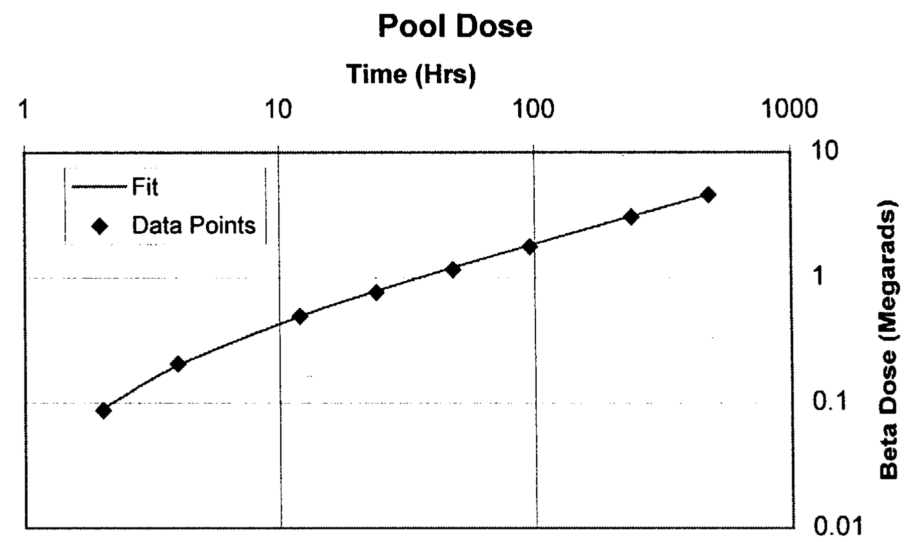
Time (Hrs)	Data Points (Megarad)	Fit (Megarad)
0.56	6	6.30145
2	17	17.86944
5	29	30.14877
10	40.5	42.76432
24	61	64.87868
48	86	89.41786
96	120	126.8089
205	180	185.8511
480	220	226.074
720	235	237.154



Time (Hrs)	Data Points (Megarad)	Fit (Megarad)
0.56	0.62	0.646339
2	1.7	1.880444
6	3	3.070899
10	3.6	3.672823
24	4.6	4.838748
48	5.4	5.934922
96	7	7.237427
205	8.8	8.963622
480	10.5	11.37204
1000	10.5	11.37204



Time (Hrs)	Data Points (Megarad)	Fit (Megarad)
2.033611	0.08719	0.090463914
4	0.2041	0.199363922
12	0.4902	0.492796502
24	0.7598	0.784270125
48	1.161	1.205349783
96	1.761	1.820477012
240	3.039	3.100536244
480	4.577	4.617944023
720	5.812	5.824690795



EAR Att V Page #	Cable Type	Outer Diam (in)	Outer Radius (in)	Jacket Thickness (in)	Jacket Mass (lbs/ft)	Total Ins per EAR Att I Mass (lbs/ft)	Jacket Mass Fraction	Ave Beta Dose Fraction of Incident, f	Absorption Fraction	HCl Generation Term
3	B*6	0.678	0.3390	0.060	0.0781	0.2210	35.35%	13.51%	99.96%	0.048
4	B*7	0.639	0.3195	0.060	0.0732	0.2080	35.18%	13.57%	99.96%	0.048
9	B*7	0.523	0.2615	0.045	0.0453	0.2080	21.79%	17.81%	99.74%	0.039
10	B*6	0.587	0.2935	0.060	0.0666	0.2210	30.14%	13.67%	99.96%	0.041
16	C*2	0.522	0.2610	0.045	0.0452	0.1360	33.25%	17.81%	99.74%	0.059
17	C*4	0.634	0.3170	0.060	0.0726	0.1925	37.69%	13.58%	99.96%	0.051
19	C*7	0.745	0.3725	0.060	0.0866	0.2500	34.63%	13.42%	99.96%	0.046
20	C*9	1.024	0.5120	0.080	0.1591	0.4540	35.04%	10.10%	100.00%	0.035

Transient Pool pH Results

Vol.(l)=	4.8410E+06			DRYWELL			CONTAINMENT								
Time		Pool Int		Int Gamma	Int Beta		Int Gamma	Int Beta							
(Hours)	[HI]	Dose (Mrad)	[HNO3]	Dose (Mrad)	Dose (Mrad)	[HCl]	Dose (Mrad)	Dose (Mrad)	[HCl]	Total [H+]	[CsOH]	Total [OH-]	Root x	Final [H+]	pH
0	0.0000E+00		0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	5.011872E-06	0.0000E+00	1.995262E-09	0.000000E+00	5.011872E-06	5.300
0.03361	0.0000E+00									5.011872E-06	0.0000E+00	1.995262E-09	0.000000E+00	5.011872E-06	5.300
0.1	2.2285E-08									5.034157E-06	2.8679E-06	2.869910E-06	2.865300E-06	2.168858E-06	5.664
0.53361	1.6784E-07			3.6862E+00	4.5739E+01	8.8260E-07	6.0720E-01	5.9708E+00	8.5108E-07	6.913388E-06	2.1599E-05	2.160135E-05	6.912707E-06	6.807978E-10	9.167
1	4.2876E-07			5.0776E+00	8.1464E+01	1.5089E-06	1.1749E+00	1.0894E+01	1.5782E-06	8.527760E-06	4.7471E-05	4.747304E-05	8.527503E-06	2.567688E-10	9.590
2	9.8822E-07	8.8378E-02	6.4516E-07	7.0999E+00	1.2841E+02	2.3403E-06	1.8804E+00	1.7869E+01	2.5710E-06	1.155654E-05	1.0294E-04	1.029454E-04	1.155643E-05	1.094224E-10	9.961
2.03361	1.0070E-06	9.0464E-02	6.6039E-07	7.1548E+00	1.2963E+02	2.3620E-06	1.8979E+00	1.8059E+01	2.5973E-06	1.163859E-05	1.0481E-04	1.048099E-04	1.163848E-05	1.073291E-10	9.969
3	1.0070E-06	1.4719E-01	1.0745E-06	8.5051E+00	1.5952E+02	2.8939E-06	2.3089E+00	2.2802E+01	3.2464E-06	1.323373E-05	1.0481E-04	1.048099E-04	1.323362E-05	1.091986E-10	9.962
5	1.0070E-06	2.4616E-01	1.7970E-06	1.0386E+01	2.0347E+02	3.6716E-06	2.8656E+00	3.0149E+01	4.2216E-06	1.570898E-05	1.0481E-04	1.048099E-04	1.570887E-05	1.122322E-10	9.950
12	1.0070E-06	4.9280E-01	3.5974E-06	1.1811E+01	2.9551E+02	5.1938E-06	3.8996E+00	4.6719E+01	6.3371E-06	2.114717E-05	1.0481E-04	1.048099E-04	2.114705E-05	1.195274E-10	9.923
18	1.0070E-06	6.5041E-01	4.7480E-06	1.2426E+01	3.4767E+02	6.0483E-06	4.4326E+00	5.6683E+01	7.5756E-06	2.439081E-05	1.0481E-04	1.048099E-04	2.439068E-05	1.243484E-10	9.905
24	1.0070E-06	7.8427E-01	5.7252E-06	1.2879E+01	3.8929E+02	6.7285E-06	4.8387E+00	6.4879E+01	8.5821E-06	2.705470E-05	1.0481E-04	1.048099E-04	2.705457E-05	1.286086E-10	9.891
48	1.0070E-06	1.2053E+00	8.7991E-06	1.4028E+01	5.0866E+02	8.6732E-06	5.9349E+00	8.9418E+01	1.1550E-05	3.504151E-05	1.0481E-04	1.048099E-04	3.504137E-05	1.433311E-10	9.844
72	1.0070E-06	1.5363E+00	1.1215E-05	1.4732E+01	5.9359E+02	1.0052E-05	6.6685E+00	1.0381E+02	1.3325E-05	4.061130E-05	1.0481E-04	1.048099E-04	4.061115E-05	1.557663E-10	9.808
96	1.0070E-06	1.8205E+00	1.3289E-05	1.5242E+01	6.6193E+02	1.1159E-05	7.2374E+00	1.2681E+02	1.5934E-05	4.640151E-05	1.0481E-04	1.048099E-04	4.640134E-05	1.712078E-10	9.766
120	1.0070E-06	2.0745E+00	1.5144E-05	1.5642E+01	7.5016E+02	1.2577E-05	7.7094E+00	1.4579E+02	1.8088E-05	5.182805E-05	1.0481E-04	1.048099E-04	5.182787E-05	1.887433E-10	9.724
150	1.0070E-06	2.3623E+00	1.7245E-05	1.6042E+01	8.3835E+02	1.3995E-05	8.2102E+00	1.6378E+02	2.0149E-05	5.740789E-05	1.0481E-04	1.048099E-04	5.740768E-05	2.109606E-10	9.676
200	1.0070E-06	2.7908E+00	2.0372E-05	1.6554E+01	9.4226E+02	1.5667E-05	8.9017E+00	1.8426E+02	2.2542E-05	6.459997E-05	1.0481E-04	1.048099E-04	6.459972E-05	2.486933E-10	9.604
240	1.0070E-06	3.1005E+00	2.2634E-05	1.6874E+01	1.0001E+03	1.6599E-05	9.3687E+00	1.9543E+02	2.3881E-05	6.913270E-05	1.0481E-04	1.048099E-04	6.913242E-05	2.802889E-10	9.552
300	1.0070E-06	3.5258E+00	2.5738E-05	1.7254E+01	1.0619E+03	1.7596E-05	9.9727E+00	2.0722E+02	2.5336E-05	7.468963E-05	1.0481E-04	1.048099E-04	7.468929E-05	3.319988E-10	9.479
360	1.0070E-06	3.9153E+00	2.8582E-05	1.7551E+01	1.1052E+03	1.8298E-05	1.0494E+01	2.1543E+02	2.6388E-05	7.928603E-05	1.0481E-04	1.048099E-04	7.928564E-05	3.917843E-10	9.407
400	1.0070E-06	4.1595E+00	3.0364E-05	1.7716E+01	1.1276E+03	1.8659E-05	1.0808E+01	2.1963E+02	2.6944E-05	8.198642E-05	1.0481E-04	1.048099E-04	8.198598E-05	4.381371E-10	9.358
480	1.0070E-06	4.6179E+00	3.3711E-05	1.7986E+01	1.1619E+03	1.9216E-05	1.1372E+01	2.2607E+02	2.7828E-05	8.677367E-05	1.0481E-04	1.048099E-04	8.677312E-05	5.544230E-10	9.256
600	1.0070E-06	5.2476E+00	3.8308E-05	1.8281E+01	1.1972E+03	1.9789E-05	1.1372E+01	2.3267E+02	2.8514E-05	9.262978E-05	1.0481E-04	1.048099E-04	9.262896E-05	8.209558E-10	9.086
700	1.0070E-06	5.7316E+00	4.1841E-05	1.8456E+01	1.2178E+03	2.0124E-05	1.1372E+01	2.3651E+02	2.8914E-05	9.689705E-05	1.0481E-04	1.048099E-04	9.689579E-05	1.263568E-09	8.898
720	1.0070E-06	5.8247E+00	4.2520E-05	1.8485E+01	1.2213E+03	2.0180E-05	1.1372E+01	2.3715E+02	2.8981E-05	9.770017E-05	1.0481E-04	1.048099E-04	9.769877E-05	1.406248E-09	8.852

Vol.(l)=	5.3251E+06			DRYWELL			CONTAINMENT								
Time (Hours)	[HI]	Pool Int Dose (Mrad)	[HNO3]	Int Gamma Dose (Mrad)	Int Beta Dose (Mrad)	[HCl]	Int Gamma Dose (Mrad)	Int Beta Dose (Mrad)	[HCl]	Total [H+]	[CsOH]	Total [OH-]	Root x	Final [H+]	pH
0	0.0000E+00		0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	5.011872E-06	0.0000E+00	1.995262E-09	0.000000E+00	5.011872E-06	5.300
0.03361	0.0000E+00									5.011872E-06	0.0000E+00	1.995262E-09	0.000000E+00	5.011872E-06	5.300
0.1	2.0259E-08									5.032131E-06	2.6072E-06	2.609191E-06	2.605070E-06	2.427061E-06	5.615
0.53361	1.5258E-07			3.6862E+00	4.5739E+01	8.0237E-07	6.0720E-01	5.9708E+00	7.7370E-07	6.740522E-06	1.9636E-05	1.963778E-05	6.739747E-06	7.753122E-10	9.111
1	3.8978E-07			5.0776E+00	8.1464E+01	1.3718E-06	1.1749E+00	1.0894E+01	1.4347E-06	8.208134E-06	4.3155E-05	4.315749E-05	8.207848E-06	2.861259E-10	9.543
2	8.9838E-07	8.0343E-02	5.8651E-07	7.0999E+00	1.2841E+02	2.1275E-06	1.8804E+00	1.7869E+01	2.3373E-06	1.096157E-05	9.3585E-05	9.358691E-05	1.096145E-05	1.210281E-10	9.917
2.03361	9.1548E-07	8.2240E-02	6.0035E-07	7.1548E+00	1.2963E+02	2.1473E-06	1.8979E+00	1.8059E+01	2.3612E-06	1.103616E-05	9.5280E-05	9.528190E-05	1.103604E-05	1.187002E-10	9.926
3	9.1548E-07	1.3381E-01	9.7678E-07	8.5051E+00	1.5952E+02	2.6308E-06	2.3089E+00	2.2802E+01	2.9513E-06	1.248629E-05	9.5280E-05	9.528190E-05	1.248617E-05	1.207792E-10	9.918
5	9.1548E-07	2.2378E-01	1.6336E-06	1.0386E+01	2.0347E+02	3.3378E-06	2.8656E+00	3.0149E+01	3.8378E-06	1.473652E-05	9.5280E-05	9.528190E-05	1.473639E-05	1.241534E-10	9.906
12	9.1548E-07	4.4800E-01	3.2704E-06	1.1811E+01	2.9551E+02	4.7216E-06	3.8996E+00	4.6719E+01	5.7610E-06	1.968032E-05	9.5280E-05	9.528190E-05	1.968019E-05	1.322721E-10	9.879
18	9.1548E-07	5.9128E-01	4.3164E-06	1.2426E+01	3.4767E+02	5.4985E-06	4.4326E+00	5.6683E+01	6.8869E-06	2.262908E-05	9.5280E-05	9.528190E-05	2.262895E-05	1.376407E-10	9.861
24	9.1548E-07	7.1297E-01	5.2047E-06	1.2879E+01	3.8929E+02	6.1168E-06	4.8387E+00	6.4879E+01	7.8019E-06	2.505080E-05	9.5280E-05	9.528190E-05	2.505066E-05	1.423868E-10	9.847
48	9.1548E-07	1.0958E+00	7.9991E-06	1.4028E+01	5.0866E+02	7.8847E-06	5.9349E+00	8.9418E+01	1.0500E-05	3.231155E-05	9.5280E-05	9.528190E-05	3.231139E-05	1.588045E-10	9.799
72	9.1548E-07	1.3967E+00	1.0196E-05	1.4732E+01	5.9359E+02	9.1381E-06	6.6685E+00	1.0381E+02	1.2114E-05	3.737499E-05	9.5280E-05	9.528190E-05	3.737482E-05	1.726905E-10	9.763
96	9.1548E-07	1.6550E+00	1.2081E-05	1.5242E+01	6.6193E+02	1.0145E-05	7.2374E+00	1.2681E+02	1.4486E-05	4.263881E-05	9.5280E-05	9.528190E-05	4.263862E-05	1.899578E-10	9.721
120	9.1548E-07	1.8859E+00	1.3767E-05	1.5642E+01	7.5016E+02	1.1434E-05	7.7094E+00	1.4579E+02	1.6444E-05	4.757204E-05	9.5280E-05	9.528190E-05	4.757183E-05	2.095994E-10	9.679
150	9.1548E-07	2.1475E+00	1.5677E-05	1.6042E+01	8.3835E+02	1.2723E-05	8.2102E+00	1.6378E+02	1.8318E-05	5.264462E-05	9.5280E-05	9.528190E-05	5.264438E-05	2.345352E-10	9.630
200	9.1548E-07	2.5370E+00	1.8520E-05	1.6554E+01	9.4226E+02	1.4243E-05	8.9017E+00	1.8426E+02	2.0492E-05	5.918287E-05	9.5280E-05	9.528190E-05	5.918259E-05	2.770137E-10	9.557
240	9.1548E-07	2.8187E+00	2.0576E-05	1.6874E+01	1.0001E+03	1.5090E-05	9.3687E+00	1.9543E+02	2.1710E-05	6.330353E-05	9.5280E-05	9.528190E-05	6.330322E-05	3.127084E-10	9.505
300	9.1548E-07	3.2052E+00	2.3398E-05	1.7254E+01	1.0619E+03	1.5997E-05	9.9727E+00	2.0722E+02	2.3033E-05	6.835528E-05	9.5280E-05	9.528190E-05	6.835491E-05	3.713747E-10	9.430
360	9.1548E-07	3.5594E+00	2.5983E-05	1.7551E+01	1.1052E+03	1.6634E-05	1.0494E+01	2.1543E+02	2.3989E-05	7.253383E-05	9.5280E-05	9.528190E-05	7.253339E-05	4.395894E-10	9.357
400	9.1548E-07	3.7813E+00	2.7604E-05	1.7716E+01	1.1276E+03	1.6963E-05	1.0808E+01	2.1963E+02	2.4495E-05	7.498873E-05	9.5280E-05	9.528190E-05	7.498824E-05	4.927649E-10	9.307
480	9.1548E-07	4.1981E+00	3.0646E-05	1.7986E+01	1.1619E+03	1.7469E-05	1.1372E+01	2.2607E+02	2.5298E-05	7.934078E-05	9.5280E-05	9.528190E-05	7.934015E-05	6.272840E-10	9.203
600	9.1548E-07	4.7706E+00	3.4825E-05	1.8281E+01	1.1972E+03	1.7990E-05	1.1372E+01	2.3267E+02	2.5922E-05	8.466452E-05	9.5280E-05	9.528190E-05	8.466358E-05	9.417687E-10	9.026
700	9.1548E-07	5.2105E+00	3.8037E-05	1.8456E+01	1.2178E+03	1.8294E-05	1.1372E+01	2.3651E+02	2.6285E-05	8.854385E-05	9.5280E-05	9.528190E-05	8.854237E-05	1.483784E-09	8.829
720	9.1548E-07	5.2952E+00	3.8655E-05	1.8485E+01	1.2213E+03	1.8346E-05	1.1372E+01	2.3715E+02	2.6346E-05	8.927396E-05	9.5280E-05	9.528190E-05	8.927230E-05	1.664005E-09	8.779