Southern Nuclear Operating Company, Inc.
Plant Edwin I. Hatch
11028 Hatch Parkway North
Baxley, Georgia 31513

Tel 912.366.2000
912.537.5900

SOUTHERN COMPANY
Energy to Serve Your World℠

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

Edwin I. Hatch Nuclear Plant
Request to Implement an Alternative Source Term
Response to Request for Additional Information Regarding the
Suppression Pool pH Control Analysis

Ladies and Gentlemen:

On August 29, 2006, Southern Nuclear Operating Company (SNC) submitted a request to revise the Edwin I. Hatch Nuclear Plant (HNP) licensing/design basis with a full scope implementation of an alternative source term (AST). By letters dated November 6, 2006 and November 27, 2006, SNC has submitted further information to support the NRC review of the HNP AST submittal. By letter dated November 14, 2006, the NRC requested additional information concerning the suppression pool pH control analysis.

The enclosure to this letter contains the SNC response to the referenced NRC request for additional information (RAI).

The 10 CFR 50.92 evaluation and the justification for the categorical exclusion from performing an environmental assessment that were included in the August 29, 2006 submittal continue to remain valid.

(Affirmation and signature are on the following page.)

Mr. D. R. Madison states he is a Vice President of Southern Nuclear Operating Company, is authorized to execute this oath on behalf of Southern Nuclear Operating Company and to the best of his knowledge and belief, the facts set forth in this letter are true.

This letter contains no NRC commitments. If you have any questions, please advise.

Respectfully submitted,

SOUTHERN NUCLEAR OPERATING COMPANY

Dennis R. Madison

D. R. Madison
Vice President – Hatch
Edwin I. Hatch Nuclear Plant
11028 Hatch Parkway North
Baxley, GA 31513

Sworn to and subscribed before me this 30th *day of* January, *2007.*

Donna W. Carter
Notary Public

My commission expires: ______

DONNA W. CARTER NOTARY Comm. Exp. 2/27/10 PUBLIC APPLING COUNTY, GA.

DRM/CLT/daj

Enclosure: Response to Request for Additional Information Regarding the Suppression Pool pH Control Analysis

cc: Southern Nuclear Operating Company
Mr. J. T. Gasser, Executive Vice President
RType: CHA02.004

U. S. Nuclear Regulatory Commission
Dr. W. D. Travers, Regional Administrator
Mr. R. E. Martin, NRR Project Manager – Hatch
Mr. D. S. Simpkins, Senior Resident Inspector – Hatch

State of Georgia
Mr. L. C. Barrett, Commissioner – Department of Natural Resources

Enclosure

Edwin I. Hatch Nuclear Plant
Request to Implement an Alternative Source Term

Response to Request for Additional Information
Regarding the Suppression Pool pH Control Analysis

Enclosure

Edwin I. Hatch Nuclear Plant
Request to Implement an Alternative Source Term

Response to Request for Additional Information
Regarding the Suppression Pool pH Control Analysis

NRC QUESTION 1

In the submittal from Southern Nuclear Operating Company, Inc. (SNC), dated August 29, 2006, it is stated that the calculation methodology for suppression pool pH control is based on the approach outlined in NUREG-1465, "Accident Source Terms for Light-Water Nuclear Power Plants," and NUREG/CR-5950, "Iodine Evolution and pH Control." Because pH values lower than 7 cause formation of elemental iodine (I_2) in irradiated water pools, pH has to be maintained above that value. Describe how the procedures, described in NUREG/CR-5950, are applied for controlling the pH of the suppression pool water.

SNC RESPONSE

Information from NUREG/CR-5950 and various other technical reports (NUREG/CR-5732 and other information assembled by Polestar) has been applied to assure control of the Hatch suppression pool water pH. This is accomplished by using the above information in the Polestar STARpH QA software to calculate the post-radiological design basis accident (DBA) loss-of-coolant accident (LOCA) strong acid production for the Hatch suppression pool and to confirm that the buffer action of the sodium pentaborate from the standby liquid control (SLC) system will neutralize this acid, thereby maintaining pool pH above 7 for at least 30 days.

The STARpH software was developed and is maintained by Polestar under the Polestar 10CFR50 Appendix B QA Program. The purpose of the STARpH code is to calculate the pH of a water pool in the containment of a nuclear reactor power plant following a radiological DBA release of fission products to the containment.

The STARpH code is well-established and widely accepted, having been originally developed in 1997, and subsequently applied to a number of plants as noted in section 2.2.2 of enclosure 1 of the Hatch August 29, 2006 alternative source term (AST) submittal. STARpH has been applied to 14 nuclear plants for post-DBA containment sump pH determinations. Seven of these applications have been approved by NRC, 4 are under review, and 3 are still in preparation. The list of plants to which STARpH has been applied and the status of the application is given below.

- Perry (NRC review completed).
- Hope Creek (NRC review completed)
- Browns Ferry 1, 2, and 3 (NRC review completed)
- Vermont Yankee (NRC review completed)
- Waterford-3 (NRC review completed)
- Columbia (under NRC review)

- Hatch Units 1 and 2 (under NRC review)
- Oyster Creek (under NRC review)
- Salem (submittal in preparation)
- South Texas Project 1 and 2 (submittal in preparation)

STARpH consists of three main models. The STARpH Radiolysis of Water model calculates the generation of HNO_3 due to the radiolysis of air and water and the resulting pH of the water. The STARpH Radiolysis of Cable model calculates the generation of HCl due to the radiolysis of electrical cable insulation in the gas space of the containment. The STARpH Add Acid model calculates the pH of the water pool as a result of the addition of HNO_3 and HCl in the presence of buffers, including sodium pentaborate such as used for Hatch.

The STARpH Radiolysis of Water model is based on information from NUREG/CR-5732, NUREG-1465, Regulatory Guide 1.183, and other technical reports and information assembled by Polestar. This model is discussed in detail as part of the response to NRC question 2 below.

The STARpH Radiolysis of Cable and Add Acid models are based on information from NUREG/CR-5950 and other technical reports and information assembled by Polestar.

The procedures of NUREG/CR-5950 are applied in STARpH in the following manner:

- Appendix B of NUREG/CR-5950 is the basis for calculating the HCl produced in the Radiolysis of Cable model due to radiolysis of chloride-bearing (mainly hypalon) cable insulation in containment. The Appendix B information that is applied in Radiolysis of Cable includes the method for determining the rate of HCl generation as a function of gamma and beta radiolysis.
- Important parameters in the NUREG/CR-5950 methodology that are used in the Radiolysis of Cable model include the G value (molecules per eV of energy deposited in the chloride-bearing material), the radiation energy flux incident on the chloride-bearing insulation surface, the total surface area of the chloride-bearing insulation, and the fraction of the incident radiation energy flux that is absorbed in the chloride-bearing material.
- A model from NUREG-1081 (referred to in NUREG/CR-5950) is used as the basis for determining the radiation energy flux in Radiolysis of Cable.
- Section 2.3.3 of NUREG/CR-5950 is the basis for the STARpH Add Acid model for determining the effect of buffer materials on pH.

A detailed description of the calculation of the Hatch HCl production using Radiolysis of Cable is provided below in the response to NRC question 2. A more detailed description of the buffer action for Hatch using the STARpH Add Acid model is provided below in the response to NRC question 3.

NRC QUESTION 2

Describe your methodology for calculating strong acids (hydrochloric and nitric) generated in the post-LOCA radiation field existing in the containment.

SNC RESPONSE

There are two models for strong acid calculation in STARpH. The first is the Radiolysis of Water model which calculates the mol/L of HNO_3 (nitric acid). The second is the Radiolysis of Cable model which calculates the mol/L of HCl (hydrochloric acid). Each of these models is discussed below.

Radiolysis of Water Model

The STARpH Radiolysis of Water model calculates the production of HNO_3 from the radiolysis of air and water. The radiation field in the pool results from the fission products released to the pool from the core during a radiological DBA LOCA.

The radiation field energy deposition in the water pool in the Radiolysis of Water model is based on the nuclide groupings and group-specific energy deposition rates identified in Table 3.4 of NUREG/CR-5732. The data in this table are in terms of MeV/h/kg at 5 hours after reactor scram for each of the eight fission product groups. The group-specific energy deposition rates are time dependent due to decay, and have been adjusted in the Radiolysis of Water model to determine the group-specific energy deposition rates at nine time intervals after reactor scram (0 - 1 hour, 1 – 2 hours, 2 -5 hours, 5 – 12 hours, 12 hours - 1 day, 1 - 3 days, 3 - 10 days, 10 - 20 days, and 20 - 30 days).

For each of these times, HNO_3 production is calculated by multiplying the group-specific energy deposition rates by the fission product group inventory in the water pool (based on NUREG-1465 release fractions for the DBA LOCA) to get the energy deposition rate of each group, and by summing these values to obtain the total energy deposition rate. The total energy deposition rate is then multiplied by the g value for HNO_3 (0.007 molecules/100 eV) and by the time interval in hours, and divided by the pool volume to obtain mol/L of HNO_3 produced during this time interval.

The STARpH Radiolysis of Water calculated energy deposition rates for Hatch as a function of time, along with the HNO_3 produced during the time interval, are given in the following table. The total HNO_3 produced over 30 days is ~2E-4 mol/L (see tables of output in response to NRC question 4).

Time Interval after Scram	Energy Deposition Rate in Pool (MeV/hr)	HNO_3 Produced during Interval (mol/L)
0 – 1 hr	1.65E23	7.1E-6
1 – 2 hr	6.16E22	2.6E-6
2 – 5 hr	4.23E22	5.5E-6
5 – 12 hr	2.97E22	8.9E-6
12 – 1 d	2.31E22	1.2E-5
1 d – 3 d	1.62E22	3.4E-5
3 – 10 d	8.61E21	6.2E-5
10 – 20 d	3.87E21	4.0E-5
20 – 30 d	2.51E21	2.6E-5

Radiolysis of Cable Model

The STARpH Radiolysis of Cable model calculates the production of HCl from the radiolysis of hypalon and PVC in electrical cable insulation. In this calculation, all the fission products released from the core to the containment during the radiological DBA LOCA that are not in the pool are considered to be uniformly suspended in the gas space in the containment. All cables are assumed to be located in the gas space.

The Radiolysis of Cable model is based on the approach in NUREG/CR-5950, Appendix B and NUREG-1081. HCl is generated from both gamma radiolysis and beta radiolysis. The rate of generation of HCl from gamma radiation energy is the product of the following factors: radiation G value (2.1 molecules HCl/100 eV for hypalon which is 3.5E-20 g mol/MeV); the total surface area S (cm^2/lbm) of the cable insulation per unit mass of insulation; the mass N (lbm) of insulation; the fraction of incident energy absorbed $A\gamma$ (dimensionless) in the cable insulation; and the radiation energy flux φ_γ (MeV/cm^2/s) incident on the cable insulation surface. The radiation energy flux φ_γ (MeV/cm^2/s) incident on the cable surface can in turn be expressed as $\varphi_\gamma = (E_\gamma /V)(f_\gamma)$ where E_γ is the total energy release rate (MeV/s) for gamma radiation distributed in the containment gas space, V is the containment gas space volume, and f_γ is a factor that results from integration of the energy release rate and associated attenuation expression over a distance of the containment radius (assuming the cable is on average located roughly midway between the center and the walls of the containment proper). In the STARpH Radiolysis of Cable model utilized for Hatch, the E_γ was obtained from radiation energy signatures in NUREG/CR-2367, adjusted for NUREG-1465 release fractions, for geometry and shielding effects in containment, and for the fraction of fission product release that is suspended in the containment gas space.

As an example, the STARpH Radiolysis of Cable calculated energy release rates for the Hatch Unit 1 containment gas space as a function of time, along with the HCl produced during the time interval from gamma and beta radiolysis, are given in the following table. The total Hatch Unit 1 HCl produced over 30 days is ~1500 mol which, when divided by the Hatch Unit 1 pool volume of 2.7E6 L, gives 5.6E-4mol/L. This matches the Hatch Unit 1 STARpH HCl output for 30 days in the table presented in the response to NRC question 4.

Time Interval after Scram	Calculated Gamma Energy Release Rate in Gas Space (MeV/s/w)	Calculated Beta Energy Release Rate in Gas Space (MeV/s/w)	Total HCl Produced during Time Interval (mol)
0 – 1 hr	2.3E8	1.7E9	29
1 – 2 hr	2.0E8	1.5E9	26
2 – 5 hr	1.7E8	1.2E9	62
5 – 12 hr	1.2E8	8.9E8	103
12 – 1 d	9.0E7	6.6E8	130
1 d – 3 d	5.6E7	4.4E8	361
3 – 10 d	1.9E7	1.9E8	534
10 – 20 d	3.9E6	5.1E7	198
20 – 30 d	1.1E6	1.6E7	60

NRC QUESTION 3

Describe how the methodology in NUREG/CR-5950 is applied for determining buffering action of sodium pentaborate.

SNC RESPONSE

The buffering action of sodium pentaborate is calculated in STARpH with the Add Acid submodel. This model calculates the concentration of strong acid required to change the pH of the buffered solution by 0.1 pH unit, according to Equation 7 presented in NUREG/CR-5950. The Add Acid submodel keeps track of the pH changes resulting from strong acid additions to determine the pH as a function of time. The strong acid additions as a function of time are the HNO_3 and HCl calculated by the Radiolysis of Water and Radiolysis of Cable submodels, respectively.

Keys to obtaining the correct results with the Add Acid submodel are (a) the use of the appropriate boron concentration corresponding to the amount of sodium pentaborate specified, including the isotopic content of the boron; (b) the use of the appropriate dissociation constant for the sodium borate depending on the temperature of the solution; and (c) the use of the appropriate starting pH of the buffered solution prior the addition of strong acids. The calculation of the concentration of boron (item a) gives 5.7E-3 mol B/L. The determination of the dissociation constant for the sodium borate at a sump temperature estimated to be an average over ~30 days for BWR suppression pools (155°F) (item b) is made using a Polestar analysis of literature data on the variation of the dissociation constant of a borate buffer with temperature. The determination of the starting pH of the buffer solution (item c) is accomplished using the dissociation constant (item b) and a Polestar analysis of the pH of sodium oxy-borates available in the literature.

NRC QUESTION 4

It is stated in Section 2.2.2 of the August 29, 2006, submittal that the pH of the suppression pool water is calculated using the STARpH code. Please provide the input and output data to the STARpH code, which will allow us to verify that the pH is at or above 7 for the 30-day post-accident period.

SNC RESPONSE

The design input for Hatch from which the STARpH input derives is provided below in the tables entitled "Hatch pH Design Inputs" and "Hatch Units 1 & 2 Containment Cable Characteristics." The design inputs and the cable characteristics are based upon Hatch licensing/design basis information. The strong acid output is provided in the tables entitled "Calculation of [H^+] Added to Pool, Hatch Unit 1" and "Calculation of [H^+] Added to Pool, Hatch Unit 2." The pH output is provided in section 2.6 of enclosure 1 of the Hatch August 29, 2006 AST submittal.

Hatch pH Design Inputs

1. Reactor power = 2818 MWth
2. Suppression pool volume = 85,110 ft^3 (min) and 89,670 ft^3 (max)
3. RCS inventory = 9,965 ft^3 liquid (volume in vessel and recirculation loops), 18,000 lbm steam
4. Pool initial pH = 7.2
5. Fission product mass inventory – based on values of BWRs of similar thermal power, including a multiplication factor of 1.1 for conservatism
6. Electrical cable insulation mass, see Containment Cable table
7. Electrical cable OD, see Containment Cable table
8. Electrical cable insulation jacket thickness, see Containment Cable table
9. Electrical cable insulation average density, see Containment Cable table
10. Fraction of cable with chloride-bearing insulation that is in conduit = 10%
11. Average conduit wall thickness = 0.1402 in
12. Unit 1 drywell free volume = 146,010 ft^3
13. Unit 1 minimum pressure suppression chamber free volume = 112,900 ft^3
14. Unit 2 drywell free volume = 146,266 ft^3
15. Unit 2 minimum pressure suppression chamber free volume = 109,800 ft^3
16. Mass of sodium pentaborate in SLC system available for injection = 1,975 lbm
17. Chemical formula for sodium pentaborate = $Na_2B_{10}O_{16} \bullet 10H_2O$
18. Boron enrichment is 60% B_{10}

Hatch Units 1 & 2 Containment Cable Characteristics

Hatch Unit	Jacket Type	Mass (lbm)	Ave. Jacket Thickness (cm)	Ave. Jacket Density (g/cm)	Ave. Cable OD (cm)	Ave. Insulation ID (cm)
1	Hypalon	6,859	0.163	1.51	1.76	1.43
2	Hypalon	4,215	0.137	1.52	1.75	1.48

Calculation of [H+] added to pool, Hatch Unit 1

Time	[HNO_3]	Net [OH^-]	[HCl]	[H^+] Added	Net [H^+] Added
1h	7.10E-6	1.50E-4	1.06E-5	1.77E-5	(1.39E-4)
2h	9.75E-6	1.47E-4	2.00E-5	2.98E-5	(1.27E-4)
5h	1.52E-5	1.42E-4	4.27E-5	5.79E-5	(9.93E-5)
12h	2.41E-5	1.33E-4	8.07E-5	1.05E-4	(5.23E-5)
1d	3.60E-5	1.21E-4	1.29E-4	1.65E-4	8.00E-6
3d	6.95E-5	8.73E-5	2.63E-4	3.33E-4	1.76E-4
10d	1.32E-4	2.51E-5	4.61E-4	5.93E-4	4.36E-4
20d	1.72E-4	(1.5E-5)	5.35E-4	7.07E-4	5.50E-4
30d	1.97E-4	(4.1E-5)	5.57E-4	7.54E-4	5.98E-4

Calculation of [H+] added to pool, Hatch Unit 2

Time	[HNO_3]	Net [OH^-]	[HCl]	[H^+] Added	Net [H^+] Added
1h	7.10E-6	1.50E-4	7.79E-6	1.49E-5	(1.42E-4)
2h	9.75E-6	1.47E-4	1.47E-5	2.45E-5	(1.32E-4)
5h	1.52E-5	1.42E-4	3.12E-5	4.64E-5	(1.11E-4)
12h	2.41E-5	1.33E-4	5.90E-5	8.31E-5	(7.40E-5)
1d	3.60E-5	1.21E-4	9.43E-5	1.30E-4	(2.67E-5)
3d	6.95E-5	8.73E-5	1.92E-4	2.62E-4	1.05E-4
10d	1.32E-4	2.51E-5	3.38E-4	4.70E-4	3.13E-4
20d	1.72E-4	(1.5E-5)	3.92E-4	5.64E-4	4.07E-4
30d	1.97E-4	(4.1E-5)	4.09E-4	6.06E-4	4.50E-4