VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

August 28, 2000

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 00-123A
NLOS/GDM R0
Docket Nos. 50-280, 281
License Nos. DPR-32, 37

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
REQUEST FOR ADDITIONAL INFORMATION
ALTERNATE SOURCE TERM - PROPOSED TECHNICAL SPECIFICATION CHANGE

In a letter dated April 11, 2000 (Serial No. 00-123), Virginia Electric and Power Company submitted a license amendment request for implementation of the Alternate Source Term (AST) as the plant design and licensing bases for Surry Power Station Units 1 and 2. During the NRC's review of the submittal, the staff identified a need for additional information to facilitate their review. The staff's questions were provided to us on July 25, 2000, and we responded to the questions during a conference call on August 3, 2000. As a result of the conference call, we agreed to provide the following information:

- an example calculation of the particulate spray removal coefficient (λ_{mf}) for a specific time interval
- the elemental iodine spray removal coefficient as determined by the methodology described in the Standard Review Plan, and
- the actual limiting elemental iodine decontamination factor (DF) as determined by the methodology described in the Standard Review Plan.

The first item above is provided in Attachment 1 to this letter. The second and third items were provided verbally to the Surry Project Manager, Mr. Gordon Edison, as agreed to in the conference call and are also provided in Attachment 2 for completeness.

Should you have any questions or require additional information, please contact us.

Very truly yours,

W. R. Matthews
Vice President – Nuclear Operations

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Attachments:

1. Calculation of Containment Particulate Spray Removal Coefficients
2. Calculation of Elemental Iodine Spray Removal Coefficient and Limiting DF

Commitments made in this letter: None.

cc: U.S. Nuclear Regulatory Commission
Region II
Atlanta Federal Center
61 Forsyth Street, SW
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Mr. R. A. Musser
NRC Senior Resident Inspector
Surry Power Station

Attachment 1

Calculation of Containment Particulate Spray Removal Coefficients

Attachment 1
Calculation of Containment Particulate Spray Removal Coefficients (λ_{mf})

Table of
Spray System Characteristics

Containment Spray Dome headers:	Containment Spray Crane Wall Headers:
Elevation - 142'-5" & 143'-9"	Elevation 95' -6"
834 gpm (100 - 700 sec)	956 gpm (100 - 700 sec)
958 gpm (700 - 4100 sec)	1032 gpm (700 - 4100 sec)
Inside Recirculation Spray headers:	Outside Recirculation Spray Headers:
Elevation - 93'-5" & 94'-5"	Elevation - 93' 5" & 94'-5"
2700 gpm (216 sec - 30 days)	3000 gpm (415 sec - 30 days)

NUREG/CR-5966 [Page 173] presents the following equations for the aerosol removal rate for the 10-percentile level:

$$\ln\left(\lambda_{m_f=0.9}\right) = 5.5750 + (0.94362)\ln Q - (7.327\text{E}-7)QH^2 - (6.9821\text{E}-3)Q^2H + (3.555\text{E}-6)Q^2H^2$$

$$\frac{\lambda_{m_f}}{\lambda_{m_f=0.9}} = \left[0.1108 - (0.00201)\log_{10} Q\right]\left[1 - \left(\frac{m_f}{0.9}\right)^{0.8945}\right] + \left(\frac{m_f}{0.9}\right)^{0.8945}$$

where "λ_{mf}" is the removal rate, "m_f" is the mass fraction remaining in the containment, "H" is the spray drop height, and "Q" is the spray water flux, calculated by dividing the spray flow rate by the cross-sectional area of the containment. The first equation above is used to calculate the removal rate corresponding to a mass fraction of 0.9. Plugging this value into the second equation yields the removal for a given value of mass fraction.

Since the removal rate is dependent on drop height and spray rate, each of the 2 spray headers has a different removal rate. For the dome headers, drop height and spray flux are calculated as follows :

H = (142'5") – (47'4") = 95.1 ft = 2.90E3 cm
Q = (834 gal/min)(0.13368 ft^3/gal)/(1.25E4 ft^2) = 8.92E-3 ft/min = 4.53E-3 cm/sec (100 – 700 sec)
Q = (958 gal/min)(0.13368 ft^3/gal)/(1.25E4 ft^2) = 1.02E-2 ft/min = 5.20E-3 cm/sec (700 – 4100 sec)

For the 100 sec to 700 sec time step the value of $\lambda_{mf=0.9}$ was solved using the equation below which is equivalent to the equation in NUREG/CR-5966 on page 173 for $\ln(\lambda_{mf=0.9})$ for the 10th percentile.

$\lambda_{mf=0.9}$ = EXP(5.575 + (0.94362)*LN(4.53E-3) – (0.0000007327)*4.53E-3*2.90E3^2 – (0.0069821)*4.53E-3^2*2.90E3 + 0.000003555*4.53E-3^2*2.90E3^2)

$\lambda_{mf=0.9}$ = 1.575 hr^{-1}

For the 100 sec to 700 sec time step the value of ($\lambda_{mf}/\lambda_{mf=0.9}$) was solved using the equation below which is the equation in NUREG/CR-5966 on page 173 for ($\lambda_{mf}/\lambda_{mf=0.9}$) for the 10th percentile.

$\lambda_{mf}/\lambda_{mf=0.9}$ = (0.1108 - 0.00201 * LOG (4.53E-3)) * (1 - (0.9/0.9) ^ 0.8945) + (0.9/0.9) ^ 0.8945 = 1.0

NUREG/CR-5966 recommends that for a volume with continuing source, the removal constant associated with a mass fraction of 0.9 be used until the time-dependent source terminates [page 170]. Hence, the mass fraction is assumed to remain at 0.9 from the start of the sprays until the end of the early in-vessel release phase at 1.8 hr. The following table shows the removal rates for 100 seconds to 700 seconds for the dome header, assuming the mass fraction remains at 0.9. The last 2 columns indicate the time step during which the removal rate is in effect.

m_f	Q	H	Removal Constant (hr^{-1})			Time (hr)	
	(cm/sec)	(cm)	$\lambda_{mf=0.9}$	$\lambda_{mf}/\lambda_{mf=0.9}$	λ_{mf}	From	To
9.00E-01	4.53E-03	2.90E+03	1.58E+00	1.00E+00	1.58E+00	2.78E-02	1.94E-01

All the other spray headers – the containment crane wall headers and the recirculation spray headers – are at about the same elevation with the following height :

$$H = (93'5") - (47'4") = 46.1 \text{ ft} = 1.40E3 \text{ cm}$$

As with the dome headers above, a time-dependent Q value is calculated for each of these lower headers and used to produce the table below using the same calculational techniques used for the dome headers. Where 2 or more headers are in operation during a time step, the Q values are added. The mass fraction is assumed to remain at 0.9 from the start of the sprays until the end of the early in-vessel release phase at 1.8 hr.

m_f	Q	H	Removal Constant (hr^{-1})			Time (hr)	
	(cm/sec)	(cm)	$\lambda_{mf=0.9}$	$\lambda_{mf}/\lambda_{mf=0.9}$	λ_{mf}	From	To
9.00E-01	5.19E-03	1.40E+03	1.83E+00	1.00E+00	1.83E+00	2.78E-02	6.00E-02
9.00E-01	1.99E-02	1.40E+03	6.34E+00	1.00E+00	6.34E+00	6.00E-02	1.15E-01
9.00E-01	3.62E-02	1.40E+03	1.09E+01	1.00E+00	1.09E+01	1.15E-01	1.94E-01

The removal rates for the dome headers and the lower headers are combined from the tables above to yield the following effective removal rates for all the sprays:

Time (hr)		λ_{mf}
From	To	(hr^{-1})
2.78E-02	6.00E-02	3.40E+00
6.00E-02	1.15E-01	7.92E+00
1.15E-01	1.94E-01	1.25E+01

Attachment 2

Calculation of Elemental Iodine Spray Removal Coefficient and Limiting DF

Attachment 2
Calculation of Elemental Iodine Spray Removal Coefficient and Limiting DF

Elemental Iodine Spray Removal Coefficient

A value for the elemental iodine spray lambda during the containment spray operation was calculated using the Standard Review Plan (SRP) 6.5.2 (Reference 3) equation.

$$\lambda = (6\, K_g\, T\, F) / V\, D$$

Where,

λ = Elemental iodine removal coefficient,

K_g = Gas-phase mass - transfer coefficient, (7.5 cm/sec from Reference 1)

F = Volumetric flow rate of spray pump,

T = Drop fall time [Ratio of height to velocity], (terminal velocity 400 cm/sec from Reference 1)

V = Containment free volume,

D = Mean diameter of spray drop, (1000 μm from Reference 1)

The containment spray system sprays from the dome headers and from the crane wall headers, and the water falls to the operating floor. The dome headers are at an elevation of 143', the crane wall headers are at an elevation of 95.5', and the operating floor is at 47.33'. The containment spray water drops 95.67' (2916 cm) from the dome headers to the operating floor, and 48.17' (1468 cm) from the crane wall headers to the operating floor. The flow from the dome headers is 958 gallons per minute or 60,440 cubic centimeters per second. The flow from the crane wall headers is 1032 gallons per minute or 65,109 cubic centimeters per second.

The containment free volume is 1.863E6 cubic feet. Of this volume only 60% is modeled as being sprayed by the containment spray system. Therefore, the volume input is 1.863E6 x 0.60 or 1.118E6 cubic feet (3.1653E10 cubic centimeters).

The inputs for the containment spray system yield a spray lambda of 35 hr^{-1}.

Maximum Elemental Iodine Decontamination Factor

From SRP Section 6.5.2, Rev. 1, 1981, page C-10, the equation for the maximum elemental iodine decontamination factor is

$$DF = 1 + (Vs / Vc) \times H$$

where "H" is the equilibrium iodine partition coefficient, "Vs" is the volume of liquid in the containment sump and "Vc" is the containment net free volume less "Vs". From Reference 1 and Reference 4 the value of "H" is 5000. From Reference 2 the volume of liquid in the containment sump is 5.83E4 cubic feet. From Reference 2 the volume of the containment net free volume is 1.863E6 cubic feet. However, only 60% of the containment is modeled as being sprayed. The DF cutoff of 200 is only applied to the 60% of the containment that is sprayed. Therefore, the containment net free volume used in this equation is 0.60 x 1.863E6 cubic feet. Substituting these values into the above equation yields

$$DF = 1 + (5.83E4 \text{ cubic feet} / 0.60 \times 1.863E6 \text{ cubic feet}) \times 5000 = 262$$

References

1. Stone and Webster Engineering Calculation 12846.07-ESG-PE-039-0, "To determine the elemental iodine and airborne iodine particulate removal coefficient and decontamination factor," July 10, 1980.

2. Letter from D. A. Christian to USNRC, Serial No. 00-123, "Virginia Electric and Power Company, Surry Power Station Units 1 and 2, Proposed Technical Specifications and Bases Changes, Alternate Source Term Implementation", April 11, 2000.

3. NUREG-0800, Section 6.5.2, Revision 1, July, 1981 and Revision 2, December 1988.

4. WASH-1329, "A Review of Mathematical Models for Predicting Spray Removal of Fission Products in Reactor Containment Vessels", W. F. Pasedag and A. K. Postma, U. S. Atomic Energy Commission, June 14, 1974.