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RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING PROPOSED RESOLUTION APPROACH - NRC BULLETIN 96-03
POTENTIAL PLUGGING OF ECCS SUCTION STRAINERS BY DEBRIS
HOPE CREEK GENERATING STATION
FACILITY OPERATING LICENSE NPF-57
DOCKET NO. 50-354

Gentlemen:

By letters dated November 4, 1996, and May 20, 1997, Public Service Electric & Gas Company (PSE&G) responded to Nuclear Regulatory Commission (NRC) Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling Water Reactors." PSE&G requested NRC review and approval of the proposed resolution approach for Hope Creek by July 1, 1997.

The NRC staff requested additional information pertaining to the Hope Creek proposed resolution approach by e-mail on June 17, 1997, and during a telephone call on June 19, 1997.

Attachment 1 to this letter provides a restatement of the NRC's questions and PSE&G's response.

Should there be any questions concerning this submittal, please do not hesitate to contact us.

Sincerely,

Gary J. Ornbach
for E. C. Simpson

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Attachment (1)

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ATTACHMENT

HOPE CREEK GENERATING STATION
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
REGARDING PROPOSED RESOLUTION APPROACH -
NRC BULLETIN 96-03

1. **NRC Question**

Did the licensee ensure that all the welds located in the drywell area containing the highest density of NUKON insulation were included in the 120 break locations analyzed? Per RG 1.82, Rev. 2, the licensee should maximize head loss, which in this case means maximizing NUKON debris generated.

PSE&G Response

The locations evaluated are the postulated pipe break locations identified in the current Hope Creek licensing basis. They include the postulated breaks on the main steam, feedwater and recirculation lines with the largest amounts of potential debris within the zones of influence. Break locations considered non-credible under the current Hope Creek licensing basis were excluded from the evaluation. PSE&G will evaluate the current break locations to determine if other non-credible locations could be expected to produce significantly larger quantities of debris. This evaluation will be completed by the end of the Hope Creek seventh refueling outage (RFO7), currently scheduled to begin in September 1997.

2.a **NRC Question**

Please identify the vendor supplied head loss correlation used to estimate strainer head loss and provide detailed information regarding strainer design and the application of the correlation. The information should clearly show how the correlation was benchmarked with experimental data and the scaling rationale for applying this correlation to the newly designed plant strainer.

Note that substantial uncertainty exists regarding the application of head loss strainer correlations to stacked disk strainers; in particular, scaling from experimental results to full sized strainers. The NUREG/CR-6224 correlation was developed and validated for strainers with uniform debris deposition such as truncated cone strainers and has been found unreliable when applied to stacked disk strainers. The use of the correlation for stacked disk strainers requires a modified input scheme that has not been validated by the NRC; therefore sufficient information is needed to determine the acceptability of the modified input scheme. It is essential that head loss predictions be anchored in applicable experimental results.

PSE&G Response

The new ECCS suction strainers will be of a stacked disk design. One or more strainer modules will be installed for each core spray (CS) and residual heat removal (RHR) system suction line. Each module will be approximately 45 inches in diameter with an active length of about 8 feet. The currently planned configuration is shown in the table below with the approximate increase in surface area compared to the existing strainers.

System	Planned Number of Modules (per suction line)	Approximate Replacement Strainer Surface Area	Approximate Increase in Surface Area
RHR	3	660 ft^2	4,334%
Core Spray	1	220 ft^2	3,928%

The head loss across these new strainers consists of two components, the head loss associated with flow through the clean strainer and the head loss associated with flow through the insulation debris on the strainer surface.

Clean Strainer Head Loss Correlation: Clean strainer head loss is estimated using a correlation developed by the strainer manufacturer (PCI) based on the results of a series of measurements of clean strainer head loss for a PCI prototype stacked-disk strainer. This correlation conservatively predicts the clean strainer head loss as actually measured in those tests.

Testing to confirm the clean head loss correlation was conducted by PCI in April 1997. Test data was plotted for Head Loss vs. Entrance Velocity and Head Loss vs. Flow Rate. Graphs were generated from the plotted points using regression analysis. Additional conservatism was added to the graphs to compensate for uncertainties and measurement error. The Hope Creek specific head loss analysis has not yet been provided by the strainer manufacturer.

Debris Head Loss Correlation: Head loss due to fibrous insulation debris on the strainer surface is estimated using the basic NUREG/CR-6224 fiber head loss correlation, which predicts the head loss given the fibrous and particulate debris properties, debris thickness, and fluid velocity through the debris. Because of the stacked disk strainer geometry and the relatively large quantity of NUKON insulation debris, a modified NUREG/CR-6224 head loss model will be used for calculating debris thickness and fluid velocity.

The modified head loss model accounts for the three dimensional buildup of fibrous debris on a stacked disk strainer. Initially, the entire stacked disk surface area accumulates debris. For heavy fiber loads, once the gaps between disks are filled, fiber accumulates on the outside of a cylindrical shape.

To validate this modified modeling approach, head loss calculations were performed for a series of tests conducted at EPRI to measure the head loss associated with a prototype PCI strainer subject to a variety of flow and debris loading conditions. The range of parameters investigated in those tests was representative of the conditions that would be expected at Hope Creek. Overall, excellent agreement was shown between measured and predicted head loss over a wide range of conditions. This excellent agreement provided a strong basis for demonstrating the validity of the modified application of the NUREG/CR-6224 head loss correlation to the case of high fiber loads on a stacked disk strainer.

In the tests which most closely approximated expected conditions at Hope Creek, the fibrous debris thickness on the outside of the strainer was within 20% of that predicted for Hope Creek. Measurements were made for a wide range of flow rates through the strainer, with the fluid approach velocity at the strainer within 20% of that expected at Hope Creek. The predicted head loss for the entire range of strainer flow rates was within 10% of the measured values. In all cases, the predicted head loss was higher than the measured value, demonstrating the conservative nature of the head loss correlation.

The prototype strainer was similar in diameter to the Hope Creek replacement strainers. The modified correlation accurately accounts for the increase in length from the prototype strainer to the Hope Creek strainers.

2.b **NRC Question**

Given the relatively small NPSH margin for current strainers (approximately 1 ft of water), please discuss how uncertainty in head loss predictions will be handled. How can you ensure an adequate NPSH margin given the uncertainties in the application of the head loss correlation?

PSE&G Response

Adequate margin will be ensured by the use of head loss correlations based upon experimental results (described above) and by the use of conservative input assumptions. The design of the replacement strainers is based upon a conservative base-case estimate of strainer head loss following a LOCA. This base-case analysis uses conservative values for total fibrous debris, total particulate debris, flow rate through the strainers (worst case pump configuration), debris filtration efficiency (100%), and settling during the high energy phase of the LOCA (none).

The zone of influence for calculating fibrous debris generation is conservatively based upon the volume associated with a double jet, fully offset, unrestrained break at a distance which corresponds to a dynamic pressure of 5.36 psig. Since testing conducted by the Boiling Water Reactor Owners' Group (BWROG) showed that jacketed and unjacketed NUKON was not destroyed at pressures less than 10 psig, the calculated zone of influence will bound the actual zone of influence in the drywell.

Although the break which produces the largest amount of debris in the suppression pool does not result in the most limiting ECCS pump configuration, the strainers are conservatively sized to ensure adequate NPSH for the largest amount of debris simultaneous with the most limiting pump configuration.

2.c **NRC Question**

How sensitive are the head loss predictions to input scheme assumptions?

PSE&G Response

The Hope Creek specific head loss analysis has not yet been completed. As part of the Hope Creek replacement strainer design, individual input parameters suspected to be important in the estimate of head loss will be investigated via sensitivity analysis.

3. **NRC Question**

Does the utility plan to use 50% area plugged for the design of new strainers?

PSE&G Response

The new design will not assume that the strainers are 50% plugged. The new strainers are designed based on debris generation as described in the BWROG Utility Resolution Guidance (URG) and the debris head loss correlation as discussed in the answer to NRC Question number 2.

4. **NRC Question**

Given the assumption of 300 lbm of sludge, does the licensee plan to desludge every outage?

PSE&G Response

PSE&G does not plan to desludge the suppression pool during every refueling outage.

The 300 lbm assumed for the design sludge loading was based upon the conservative sludge generation rate recommended in the URG. This value is more than 1.5 times the median sludge generation rate from an industry survey. We believe that the actual sludge accumulation rates at Hope Creek are significantly lower. Hope Creek has a Torus Water Cleanup system installed to permit processing suppression pool water through a filter demineralizer. Torus inspections performed in RFO5 and RFO6 showed very low levels of debris and sludge. There was no noticeable change in sludge levels between refueling outages.

During RFO7, samples will be taken to characterize the sludge to obtain a better value for density and using several representative locations to determine total torus sludge loading. This information will be used to accurately determine the actual sludge accumulation rate per cycle at Hope Creek and to provide for accurate acceptance criteria for use in torus inspections. The program has been established to inspect the torus every outage, determine the sludge loading, and use the acceptance criteria to decide whether torus cleaning is required. The acceptance criteria in the existing program will be revised, if required, to ensure the total sludge loading could not threaten strainer performance for the subsequent operating cycle.

5. **NRC Question**

What is the outside diameter (O.D.) of the pipe in which break is postulated? What is maximum O.D. of the pipe on which NUKON is installed?

PSE&G Response

The break is postulated on the reactor recirculation suction pipe. The outside diameter is 28 inches. The reactor recirculation suction pipe is also the maximum outside diameter pipe on which NUKON is installed. The insulation thickness for this line is 3.5 inches.

Other breaks were evaluated and were shown to result in less insulation debris transported to the suppression pool. Breaks identified as having the greatest potential for either damaging insulation or transporting insulation to the suppression pool included the following:

System	Location	Nominal Size (inches)
Reactor Recirculation	RPV terminal end	28
RHR	shutdown cooling suction (at inboard isolation valve)	20
Feedwater	distribution header	20
Feedwater	supply line	24
Main Steam	RPV terminal end	26
Main Steam	riser elbow	26

6. **NRC Question**

Please provide additional information and justification for the estimate of 393 ft^3 of insulation debris transported to the suppression pool. Specifically, why does this estimate not consider debris generated below the lowest grating? The estimate of 393 ft^3 of insulation debris transport is equivalent to 28% (above grating transport fraction) of the total 1402 ft^3 generated; therefore, all of the debris must have been assumed to be generated above the lowest grating. Considering that the most limiting large break occurs in the recirculation pump suction, which could happen directly above the lowest grating, why does the ZOI not extend below this grating?

PSE&G Response

Other breaks included volumes below the lowest grating in their zones of influence. However, the reactor recirculation suction pipe break resulted in the largest volume of debris transported to the suppression pool. The debris from this pipe break is generated above the lowest grating.

7. **NRC Question**

It appears that no allowance was made for unqualified or indeterminate coatings in sizing the strainer. Verify that this is true and provide justification for why such an allowance is not necessary.

PSE&G Response

No allowance was made for unqualified or indeterminate coatings in sizing the strainer since the estimated quantity of unqualified coatings is small and the amount of debris loading is expected to be negligible compared to other contributors already postulated.

In the near proximity of the LOCA line break, all coatings are expected to fail, regardless of their qualification status. This is accounted for as a debris source in sizing the replacement strainers.

With the exception of those items described in Hope Creek UFSAR section 6.1.2, qualified coatings were used for equipment and surfaces inside the Hope Creek containment. The estimated total quantity of unqualified or indeterminate coatings in the Hope Creek containment that could produce debris during a LOCA is reported in the UFSAR to be less than 275 lbm. Beyond the jet impingement zone, some unqualified coatings can be expected to fail during a LOCA. However, it is reasonable to assume that most failures of unqualified coatings that are not in the immediate vicinity of the line break would not occur until several hours after the high energy phase of the LOCA event and would not be transported to the suppression pool in significant quantity. In addition, it is reasonable to assume that, if coating debris reaches the suppression pool after the initial blowdown, most would settle out on the bottom before reaching the suction strainers. In NUREG/CR-6224, more than 90% of the volume of paint chips reaching the suppression pool is calculated to ultimately settle on the suppression pool floor.

8. **NRC Question**

It appears that no allowance was made for foreign material in containment (such as clothing, plastic sheeting, etc.) in sizing the strainer. Verify that this is true and provide justification for why such an allowance is not necessary.

PSE&G Response

During work in the drywell or suppression chamber, foreign material control is established in accordance with administrative procedures.

If the drywell or suppression chamber is accessed during an outage, a closeout inspection is performed at the completion of the outage. The inspection is performed utilizing an administrative procedure. The procedure checklist requires verification that no debris, trash or temporary equipment remains in the drywell. Checks for loose or damaged insulation, exposed filter media, and temporary filters are also required. In addition, the same procedure requires verification that the suppression chamber to drywell vacuum breakers are clear, and the suppression pool is free of debris.

The combination of foreign material control during work and closure inspection at outage completion provides assurance that foreign material will not remain in primary containment.

9. **NRC Question**

Were any changes made to the analysis of the hydrodynamic loading of the containment structure as part of the installation of the new strainers? Was any new testing performed in this area?

PSE&G Response

The methodology for estimating the acceleration drag forces on the replacement strainers is consistent with that prescribed by Mark I Containment Program Load Definition Report (LDR) and its supporting documents. A new hydrodynamic mass coefficient (C_m) was developed to account for the replacement strainer geometry.

The large replacement ECCS suction strainers are cylindrical in shape, however, there are three significant factors which distinguish them from the solid cylindrical structures analyzed in the LDR. First, they are not two dimensional structures. They have finite l/d ratios. Therefore, their virtual mass in accelerated flow fields is influenced by flow around the strainer ends. Second, the strainers are not of uniform diameter. They are composed of a geometry of large diameter disks and smaller diameter disks which form the gaps between the large disks. Finally, the strainers are made of perforated material which is up to 40 percent open area. The holes in the plate reduce pressure differentials resulting from the flow field and therefore reduce the virtual mass.

The determination of a conservative hydrodynamic mass coefficient for the replacement strainer geometry used the same methodology as adopted by the Mark I LDR. Since the strainer assemblies are generally cylindrical in shape, the reference point was the C_m value of 2.0 used by the LDR supporting documentation.

Testing was performed to develop empirically based values of coefficients of constant velocity drag and hydrodynamic (inertial) mass. The testing was performed by Digital Structures, Inc., for Duke Engineering and Services, PSE&G's contractor.

A strainer representative of the original strainer(s) discussed in the LDR was tested and the results scaled up to a coefficient of 2.0. A strainer representative of the new Hope Creek strainers was tested and the resultant coefficient was generated utilizing the same scaling factor as the original strainer. In this way the conservatism established in the use of the 2.0 value is maintained.