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PY-CEI/OIE-0404 L

U. S. Nuclear Regulatory Commission
Document Control Desk
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Perry Nuclear Power Plant
Docket No. 50-440
Response to Confirmatory Action Letter

Gentlemen:

This letter is submitted as the second partial response to Confirmatory Action Letter (CAL) RIII-93-07, dated April 16, 1993, which detailed actions requested by the NRC regarding the performance of ECCS Suction Strainers at the Perry Plant.

Your Confirmatory Action Letter specifically identified the following five actions which the Perry Plant had committed to perform in response to the strainer issue:

1. Conduct an investigation to determine the cause of the reduced capability of the RHR pump strainers located in the suppression pool. Include in the evaluation consideration of design adequacy, reasons for fouling, and reasons for any deformation.

2. Maintain documentary evidence of the investigation effort and make this available to the NRC.

3. Prior to startup, provide Region III with the basis for considering the ECCS suppression pool strainers to be capable of performing their required design function.

4. Prior to startup, provide Region III with plans and a commitment to ensure that the suppression pool is maintained at an acceptable level of cleanliness, including any surveillances planned to be performed.

5. Provide within 30 days to Region III a documented evaluation of the above issues including any additional corrective actions taken or planned. In the report, describe the basis for considering the RHR system to be capable of performing its safety function during past operation, particularly in light of the problems identified in RF03.

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On May 9, 1993 letter PY-CEI/OIE-0402 L was submitted to specifically address items three and four identified above. With respect to item two, all documentary evidence associated with the investigation and analysis of this event is being maintained by the site Incident Response Team, in accordance with procedures for Corrective Action programs. Upon request, the Perry Plant staff has provided and will continue to provide to the NRC any available information regarding this effort.

Test data obtained, using RHR "B" and a new strainer, has necessitated a reassessment of using strainer differential pressure to establish "action," "alert," and "differential" levels (reference CAL Item 4) to initiate corrective actions. Further development of methods for monitoring suppression pool cleanliness/strainer condition will be communicated to the NRC prior to startup.

Attachment 1 to this letter provides responses to the remaining items identified in the CAL. Regarding item five, evaluation of past operability of the RHR system with respect to strainer fouling is provided; however, the ongoing efforts to evaluate system design include an assessment of strainer loading during a design basis accident. If any further compromise to the operability of the RHR strainers is identified during this evaluation, a supplement to this response will be submitted within 30 days.

Following NRC receipt of the initial response to the CAL, a telephone conference call between Perry staff and NRC personnel at both Region III and NRR was held on May 11, 1993. During that call, the NRC requested additional clarification in the form of written response to six specific questions regarding future RHR operability. Attachment 2 to this letter provides the necessary response.

With the submittal of this letter, the requirements of the Confirmatory Action Letter and subsequent information requests have been satisfied. Within the next several days, all necessary modifications to the ECCS strainers, all improvements to Containment, Drywell, and Suppression Pool conditions, and all program and procedure modifications for the sustained enhancement of those conditions will have been completed, in preparation for restart from the current maintenance outage. The Incident Response Team dedicated toward the investigation of these events will continue to pursue resolution of all related issues in accordance with site Corrective Action programs.

Your attention to this matter is greatly appreciated.

Sincerely,

Frank R Stead for

Robert A. Stratman

RAS:HLH:ss

Attachments

cc: NRC Project Manager
NRC Resident Inspector Office
USNRC Region III

Description of Event

On May 22, 1992, during Refueling Outage 3 (RFO3), an inspection of the containment side of the suppression pool was performed using a remotely controlled submarine equipped with a video camera. The inspection identified various foreign objects on the pool floor, as well as accumulations of dirt and debris on the suction strainers for Residual Heat Removal (RHR) System loops A and B. Other ECCS strainers were also inspected and determined to be clean. A number of foreign objects were removed from the pool floor. Inspecting personnel recognized the fouling of the RHR strainers, but did not question the operability of the systems, based on the successful completion of all required surveillances. The decision was made to schedule the strainers for cleaning at a later date.

On January 16, 1993, during a maintenance outage, the strainers were cleaned and inspected. RHR A and B suppression pool suction strainers were found to be deformed, with the area of the strainer surface between internal stiffeners partially collapsed inward, in the direction of system flow. It was determined that the strainers had been deformed by excessive differential pressure caused by strainer fouling during normal pump operation. Although the duration of the strainer fouling problem could not be conclusively determined, review of the video tape previously taken in RFO3 revealed evidence of the deformation which had not been noticed at the time of the taping. The containment side of the suppression pool was inspected, videotaped, and cleaned in February, 1993, and debris samples were obtained for analysis. Following evaluation of the non-conformance, the deformed strainers were replaced. Condition Report 93-022 was initiated to investigate the circumstances surrounding the strainer fouling and subsequent deformation.

Following an unexpected shutdown on March 26, 1993, safety relief valves were utilized for reactor pressure control, and RHR A and B pumps were operated simultaneously in the suppression pool cooling mode for two hours. Following the shift of the RHR A loop to the Shutdown Cooling mode, RHR B was operated with suppression pool suction for an additional five hours. On April 14, 1993, all ECCS strainers were inspected using a high powered light and a video camera. The RHR B strainer was fouled and deformed in a manner similar to that observed during the January inspection; however, the remaining strainers showed no signs of fouling. Without disturbing the debris on the strainer, a test run of the RHR B pump was performed with suction pressure monitored. With a static suction pressure of 9.25 psig, pump running suction pressure decreased to an indicated 0 psig after approximately 8 hours of operation, and although the pump flow remained adequate, the pump was secured. Condition Report 93-085 was initiated and an Incident Response Team (IRT) was formed. On April 16, 1993, Confirmatory Action Letter (CAL) RIII-93-007 was issued.

CAL RIII-93-007, Action 1

Conduct an investigation to determine the cause of the reduced capability of the RHR pump strainers located in the suppression pool. Include in the evaluation consideration of design adequacy, reasons for fouling, and reasons for any deformation.

Response

The cause of the reduced capability of the RHR pump strainers is considered to be the inadequate maintenance of cleanliness conditions in the suppression pool. The root causes include inadequate program requirements and inadequate personnel sensitivity to the effects of cleanliness on ECCS operability. The design of the strainers was not considered to be a factor. A detailed discussion of these considerations is provided below.

Analysis of Suppression Pool Debris

Video tapes of the RHR A and B strainers taken in May 1992, February 1993, and April 1993 all clearly show debris and corrosion products entangled in or attached to fibrous material.

On February 11 and 14, 1993, samples were taken from the floor of the suppression pool to identify the foreign material. The February 11 sample consisted of fibrous material, two small pieces of metal and corrosion products. The fibers had different lengths, diameters, colors, and physical properties (fibers were twisted, multi-directional, straight, etc.). The two small pieces of soft metal appeared to be aluminum, and would be expected to remain on the pool floor and not contribute to ECCS suction strainer fouling. The source of this metal is unknown. The February 14 sample, taken from a different location on the pool floor, contained only corrosion products.

In April and May, five debris samples were taken directly from the RHR B suction strainer. All of these samples contained fibrous material, corrosion products, and miscellaneous debris such as pieces of griffolyn and herculite. The predominant fibrous material in all of these samples was glass fiber from roughing filter material used in the Drywell Air Cooler System.

Fibers from Containment Vessel Cooling System roughing filter media, industrial filters used in maintenance applications, and other sources were also identified. In addition to a six square inch piece of griffolyn in one of the samples, many small pieces of griffolyn and a uniform coating of corrosion products were entrapped in the fiber mat. X-ray fluorescence identified a predominance of iron oxide (Fe_2O_3) in the corrosion product material. Essentially, the strainer provided a structural framework for a uniform covering of the fibrous material, which acted as an effective filter for suspended solids that otherwise would have passed through the strainer.

The exact method of introduction of the fibrous materials into the suppression pool has not been conclusively determined; however, several possible explanations were evaluated. The roughing filters in the Containment and Drywell cooling units are normally replaced prior to startup from refueling outages, and remain installed in the systems throughout power operations. The thorough inspection and cleaning of the pool in April 1993 resulted in the removal of several intact pieces of Drywell Cooler roughing filter material from the suppression pool. At least one piece of filter material was removed intact from the B RHR strainer. A review of the repetitive tasks for filter replacement, and discussions with personnel who performed those tasks provided no indication that any roughing filter material was missing or blown out due to normal operation of the drywell air coolers.

Following the identification of the fibers on the RHR suction strainers, and in the effort to establish acceptable levels of cleanliness in the Containment and Drywell, thorough inspection and cleaning of these areas were performed. Individual fibers were not found in the Drywell or Containment during the pre-cleaning area inspections by Incident Response Team members, who were aware of the significance of the fibers and were specifically looking for their presence. Additionally, an insignificant amount of fibrous material was identified in the debris obtained by vacuum cleaning of the containment and drywell. These observations indicate that there is no chronic or acute degradation of properly installed filter media which would introduce discrete fibers into the suppression pool.

The above evidence leads to the conclusion that the material entered the suppression pool as intact pieces rather than individual fibers. Exposure to suppression pool conditions is believed to have broken down some pieces into individual fibers which were then collected as a mat on the strainer surfaces. It is believed that the roughing filter material was introduced to the suppression pool as a result of installation or maintenance activities.

The fouling of the strainers occurred over a period of several months, punctuated by limited cleaning efforts, discussed later in this report. The actual time the material entered the suppression pool cannot be determined. However, because suppression pool cooling operation causes significant turbulence in the pool, it has been postulated that roughing filter material may have been transported from the drywell side of the suppression pool to the containment side during the operation of suppression pool cooling associated with the March 26, 1993 reactor shutdown.

Suppression Pool Cleanliness and Maintenance Practices

Although repetitive tasks were in place for the periodic inspection of the suppression pool, corrective actions had been directed at the removal of discrete, bulky items, which had settled to the pool floor. Maintenance practices called for the immediate removal of items with positive or neutral buoyancy, which could potentially cause gross strainer fouling. Additionally, the RHR strainers were cleaned in 1989, during the first refueling outage. Corrosion products and other sedimentary deposits were not considered to be a threat to ECCS operability, based on the assumption that they would pass through the strainers unimpeded. The presence of fibrous material, which could act as a fine filtration media for suspended particulates, was not identified or postulated prior to the recent events. As a result, thorough cleaning of the suppression pool had not been completed since the plant entered initial operation in 1986.

Inspection and cleaning of the suppression pool is controlled by periodic maintenance specified in the repetitive task program. The specific task identifies the cleanliness standard for the pool as ANSI N45.2 Cleanliness Class C. Such cleanliness standards are intended to be applied to piping and components, and are not easily adaptable to a large body such as the suppression pool. Although specific criteria identify both acceptable and unacceptable conditions, particle sizes which are acceptable under Class C (0.125 inches long) exceed the size of the strainer openings. Additionally, application of such criteria is subject to diverse interpretation. The problem is further compounded when inspection is done through a significant amount of water, or with remote video equipment (subject to distortion and magnification effects, when viewed on a two-dimensional display). Based on the above considerations, more effective measures are necessary for inspection and cleaning.

Until the complete inspection and cleaning of the suppression pool in April 1993, inspection and cleanup efforts were limited to easily visible and accessible pool areas. Because inspections were done from above the surface of the pool, the 120 horizontal vents between the drywell and containment were not inspected. Additionally, the area between the drywell wall and the suppression pool weir were not routinely inspected. The repetitive tasks neither specifically included nor excluded these areas from the inspection and cleaning requirements. However, the discovery of filter material and other debris in these areas indicates these areas were not inspected in the documented inspection activity. The disproportionate amount of debris found in these areas in April, after the pool was thought to have been cleaned in February, highlights the significance of these omissions.

The final factor in the consideration of suppression pool cleanliness programs is the lack of knowledge of plant staff regarding the effect of pool conditions on ECCS operability. Plant personnel involved in past inspection and cleanup activities for the pool did not recognize the potential compromise to system operability presented by the issues discussed in the preceding paragraphs. Conviction that the pool conditions were acceptable was reinforced by the following standards for operability:

- continued satisfactory results of ECCS system surveillance testing
- continued acceptable water clarity and chemistry conditions
- continued acceptable operation of the Suppression Pool Cleanup System
- procedural requirements for the periodic removal of known objects from the pool floor
- procedural requirements for the immediate removal of items with neutral or positive buoyancy when inadvertently introduced into the pool.

Cleanliness conditions and practices in the general areas of the containment and drywell were also evaluated. These considerations are especially significant for containment designs with an open suppression pool. The effect of containment spray and pool swell in accident scenarios could result in the transfer of debris from the higher elevations of the containment to the suppression pool. All of the analyses discussed above for the suppression pool can be equally applied to the drywell and containment.

In addition, the issue of material accountability was considered. Prior to these events, material accountability requirements were not in place for material introduced into the containment. This policy allowed material to be left in these areas after it was brought in for specific activities, contributing to the general cleanliness problems in containment, and increasing the probability of introducing foreign material into the suppression pool. The lack of an accountability policy also contributed to the lack of sensitivity toward the effects of cleanliness on equipment operability.

Evaluation of Design Adequacy

The original strainer design was evaluated to determine adequacy with respect to design requirements. The primary function of the strainer is to ensure that particles of a size detrimental to ECCS pump operation are restricted from the pump suction, while ensuring that the minimum Net Positive Suction Head requirements are not compromised under the most limiting conditions. The original design specifications required that the strainer provide no more than 1 psid head loss, at rated flow and fifty percent fouled conditions. The design of the strainer was evaluated and identified to satisfy the stated specification, provided that adequate cleanliness conditions were maintained in the suppression pool.

Another requirement of the strainer, although not specifically addressed in the design specifications, is that the design provide adequate structural strength to preclude failure which could introduce gross amounts of debris into the pump suction, adversely affecting operability. As in the previous discussion, assuming design flow and fifty percent fouling on the strainer, the strainer will not be susceptible to failure as long as adequate pool cleanliness is maintained.

Although the design of the original strainers is adequate for the original design assumptions, excessive differential pressures were recorded, and deformation of the strainers was experienced, even though rated flow was able to be maintained. This indicates that although the design could be considered adequate, resistance to fouling, tolerance to fouling, and the margin to failure were minimal.

CAL RIII-93-007, Action 5

Provide within 30 days to Region III a documented evaluation of the above issues including any additional corrective actions taken or planned. In the report, describe the basis for considering the RHR system to be capable of performing its intended safety function during past operation, particularly in light of the problems identified in RFO3.

Response

Evaluation of the issues associated with this Confirmatory Action Letter, as well as corrective actions taken and planned, have been addressed by the responses to CAL RIII-93-007 Actions 1, 3, and 4. In light of problems identified in RFO3 and identified during this investigation, it can not be conclusively determined that the RHR system was capable of performing its intended long term safety function during past operation. A detailed discussion of this consideration is provided below.

Design Basis of RHR Suction Strainers

The design requirements of the RHR suction strainers are provided in the General Electric design specification. This design specification states that the strainer mesh openings shall be capable of effectively screening all foreign particles of sufficient size (>3/32 inch sphere) to clog the pump cyclone separators or containment spray nozzles. The suction strainer shall also be designed such that it does not become more than fifty percent plugged following one hundred days of post-LOCA operation. The differential pressure associated with a fifty percent plugged strainer is used in Net Positive Suction Head (NPSH) calculations to ensure that the NPSH available exceeds the minimum NPSH requirements for the pump.

At PNPP, a fifty percent plugged strainer of the original design corresponds to 1 psid at design flow (reference USAR 6.2.2.2.). This differential pressure is a design input parameter used in calculating the NPSH available in accordance with Reg Guide 1.1 (reference USAR 5.4.7.2.2.a). The requirements for 1 psid for fifty percent blockage at design flow rate and 3/32 inch strainer mesh openings are also described in the Gilbert procurement specification. No criterion is specified for maximum approach velocity. Similar design requirements exist for the other suppression pool suction strainers.

Past Suppression Pool, Containment, and Drywell Conditions

Until the April 14, 1993 RHR B suction strainer fouling event, an accurate understanding of the cleanliness requirements for the suppression pool, containment, and drywell was not reflected in the standards and programs utilized at PNPP. As a result, cleanings of the suppression pool, containment, and drywell were inadequate, and no material accountability control program was established for materials brought into the containment. Many of these materials were inadvertently introduced to the suppression pool and more could have been introduced to the suppression pool in the event of an accident involving pool swell or containment spray. The introduction of these materials to the suppression pool would have substantially increased the possibility of strainer fouling during or after an accident.

In addition to the items found in the suppression pool, containment, and drywell as a result of inspection and cleaning activities, roughing filter materials and pipe insulation were found installed in areas that could have resulted in those materials also being introduced into the suppression pool as a result of an accident (reference CAL Action 3. Response).

Impact on RHR System Past Operability

Analysis of previous quarterly pump surveillance data revealed that the RHR A and B strainers have been operated with differential pressures in excess of 1 psid numerous times. It is expected that the strainers would have experienced fouling beyond the fifty percent blockage/1 psid design value during the 100 days of continuous operation following a LOCA event. Available data cannot be used to predict either the rate or maximum severity of the fouling, both of which greatly influence the operability of the RHR systems during a sustained event with continued pool circulation activities such as a Reactor Recirculation System line break accident. Because of this lack of predictability, a worst case scenario of inadequate pump NPSH may be possible. Assuming an NPSH inadequacy, the ability of the RHR A and B pumps to continue to operate through this postulated accident, without operator intervention, would eventually be compromised. The conservative conclusion is that the RHR system may not have performed its intended safety function of long-term continuous suction from the suppression pool following a postulated accident. This conservative conclusion encompasses past operations, from initial startup to March 26, 1993, when the plant was last shut down.

NRC Questions Provided in Telephone Conference on May 11, 1993

1. **Question: What were the design assumptions considered with respect to strainer backflush capability?**

   Response: Assuming the strainer condition which would result in a 32 psid differential at 7800 gpm normal flow, and a reverse flowrate of 3200 gpm (Suppression Pool Cleanup Pump runout), a worst-case backflush differential pressure condition was calculated to be 6.6 psid. As an added conservatism, a dp of 7 psid was used for design purposes.

   The maximum realistic strainer dp is 2.6 psid for an expected SPCU backflush flow rate of 2000 gpm. This is considered to be a realistic flow in the backflush operation since one of the valves to be positioned as part of the backflush alignment will be throttled to establish the normal SPCU pump flow prior to initiating the backflush.

   Once the backflush has occurred and the strainer is returned to its clean condition, the reverse flow dp is expected to be less than 0.1 psid at a flowrate of 2000 gpm.

2. **Question: The original design specification includes a 1 psid limit on strainer differential pressure. Explain why the proposed 4 psid limit is acceptable with respect to the design basis.**

   Response: The PNPP design basis for ECCS and RCIC suppression pool strainers is premised on ensuring required NPSH for the ECCS/RCIC pump(s) while maintaining satisfactory water quality. This design basis ensures that the requirements of General Design Criteria 34 through 37, as well as the guidelines in Reg Guide 1.1, are satisfied.

   The original strainer was designed to have greater than 200% of the flow area of the 24" diameter ECCS pump suction line. At 50% plugged the strainer maintained over 100% flow area of the 24" ECCS pump suction line without impact to pump NPSH, as demonstrated by pre-operational testing. Based on a review of the General Electric design specifications, the 50% strainer fouling limit is based on maintaining 100% pump suction line flow area through the strainer, to ensure satisfaction of pump NPSH requirements. No basis was identified for the 1 psid limitation, except that such a minimum pressure drop would not compromise NPSH.

   The 4 psid design value for the new strainer design is within the margin determined by the ECCS/RCIC pump NPSH calculations, in order to provide a limit regarding strainer fouling before ECCS/RCIC performance is affected. This limiting condition of strainer dp ensures that the NPSH requirements specified in Reg Guide 1.1 will be satisfied.

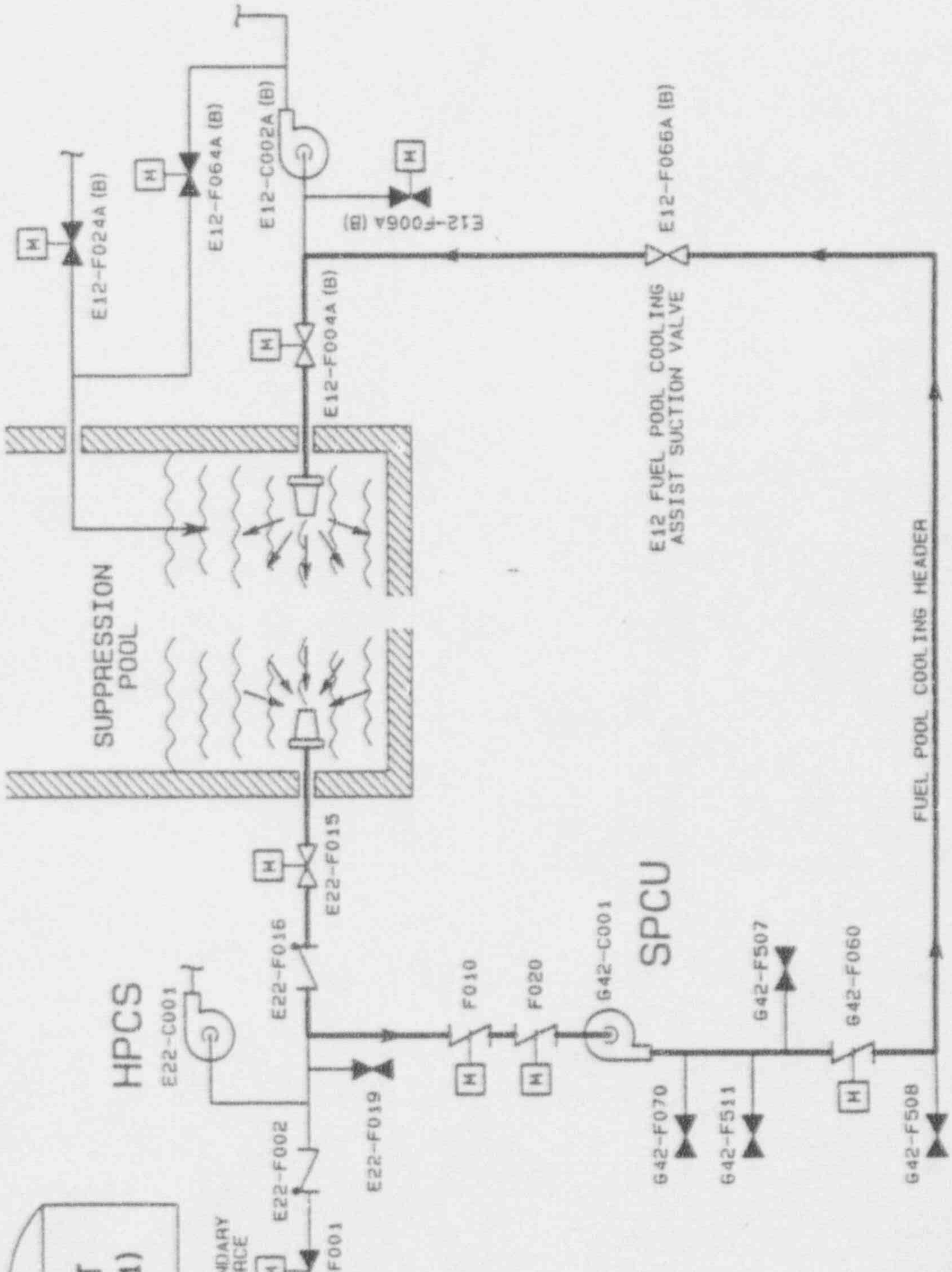
3. **During discussion of the content of Attachment 1, page 3 of 14, on the last sentence of the last paragraph, a question was raised concerning the meaning of the phrase "beyond system design bases".**

Response: The last sentence of the last paragraph of Attachment 1 to the initial CAL response (PY-CEI/OIE-0402L), page 3 of 14 states, "Furthermore, strainer's designed capability to be backflushed adds another option beyond system design bases to ensure that suppression pool and RHR "A" and "B" availability is maximized."

The phrase "beyond system design bases" is inappropriate for use in this context. The paragraph was intended to indicate that the provisions for backflushing the ECCS strainers in an accident scenario provide added measures of conservatism not previously considered. Thus, the sentence should have read, "Furthermore, strainer's designed capability to be backflushed adds another option to ensure that suppression pool and RHR A and B availability is maximized."

4. Question: Please provide a one-line diagram of a suction path for backflushing RHR suppression pool suction strainers.

Response: See Figure below.



BACK FLUSH OF RHR "A" (B) STRAINER

5. **Question: What were the jet impingement considerations given to the insulation material housed in the Drywell Air Cooler Air Handling Unit cabinets?**

Response: There are three Drywell Air Cooler Air Handling Units installed in the drywell. Two of these units are mounted on grating on Elevation 630' and the third unit is on the drywell floor at Elevation 583'.

A lateral jet from Feedwater System piping at Elevation 625' can impose some wetting on the units at Elevation 630'. However, the jet must pass through grating at 630' to impact the units. The closest point of the units to the jet source is approximately nine feet above the grating, with the furthest point approximately 14.5 feet. At approximately 5 feet, the jet force decreases to 4 psi and is further dissipated as it impacts the grating. Thus, the lateral jet postulated from the feedwater piping is shown to dissipate due to the distance and the grating and will cause only minor wetting.

The other unit sits on the drywell floor and is not subject to any jets from a high energy line break or pool swell. It will be submerged in water once the drywell cavity fills up from the water leaking out of the break. Thus it is not subject to any severe water turbulence to affect the internal insulation.

6. **Question: Why is only the RHR B pump suction strainer being tested for 12 hours and not the other strainers?**

Response: An additional twelve (12) hour test will be performed using the RHR B suction strainer only. This additional run is not to determine the operability status of the B RHR pump or strainer. It is intended to provide information as to the cleanliness conditions in the suppression pool. As such, the 12-hour test could have been performed using either RHR A or B pump. This test will be performed in the Test Return or Suppression Pool Cooling mode and will determine if any dp or strainer fouling occurs. As discussed in the May 11, 1993 conference call with the NRC, there will also be additional testing for backflushing purposes using the RHR A strainer .

All suppression pool suction strainers are being tested prior to declaring the associated system operable. The operability test for the system consists of the normal Pump and Valve Operability test. During the test, each strainer will be placed in operation in accordance with the applicable pump operability Surveillance Instruction. Baseline clean strainer dp data will be obtained with the pump at rated ECCS flow, to establish the strainer and suction line condition for comparison with future data.