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50-413	Catawba Nuclear Station, Unit 1, Duke Power Co.	05000413
50-414	Catawba Nuclear Station, Unit 2, Duke Power Co.	05000414

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SUBJECT: Forwards 90-day response to GL 97-04, "Assurance of Sufficient NPSH for ECC & Containment Heat Removal Pumps," 971007.

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January 5, 1998

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Subject: Catawba Nuclear Station Units 1 & 2
Docket Nos. 50 -413, 414
TAC Nos. M99973, M99974
McGuire Nuclear Station Units 1 & 2
Docket Nos. 50 -369, 370
TAC Nos. MA0005, MA0006
Oconee Nuclear Station Units 1, 2, & 3
Docket Nos. 50 -269, 270, 287
TAC Nos. MA0017, MA0018, MA0019
Response to Generic letter 97-04: Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps

Generic Letter (GL) 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," dated October 7, 1997, requested licensees to submit information necessary to confirm the adequacy of the net positive suction head (NPSH) available for emergency core cooling (including core spray and decay heat removal) and containment heat removal pumps.

Additionally, the GL required that two written responses be submitted. First, within 30 days, licensees were to submit a written response indicating whether or not the requested actions will be completed and submitted within the requested time period and include a discussion of any alternative actions. Second, within 90 days, licensees

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were to provide the information as outlined in the GL for each of their facilities. New NPSH analyses were neither requested nor required.

A written response was submitted by Duke on November 4, 1997 indicating that we would complete the requested actions and submit the requested information within the requested time period.

Duke has completed their review of the current design-basis analyses used to determine the available NPSH for the emergency core cooling (including core spray and decay heat removal) and containment heat removal pumps that meet the criteria outlined in the GL and have concluded that the available NPSH for these pumps is adequate under all design-basis accident scenarios. The results of this review are provided in Attachment 1 for McGuire Nuclear Station, Attachment 2 for Catawba Nuclear Station and Attachment 3 for Oconee Nuclear Station.

I declare under penalty of perjury that these statements are true and correct to the best of my knowledge.

Should you have questions or need additional information, please contact Allison Jones-Young at (704) 382-3154.

Very truly yours,

M. S. Tuckman

M.S. Tuckman
Executive Vice President
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ATTACHMENT 1
McGUIRE NUCLEAR STATION's RESPONSE TO GL 97-04

McGuire Nuclear Station Response to NRC Generic Letter 97-04

Per the above referenced generic letter, licensees were requested to provide information on five issues relating to net positive suction head for Emergency Core Cooling System (ECCS) pumps. The exact requests, and the specific McGuire responses, are included in the following:

1. Specify the general methodology used to calculate the head loss associated with the ECCS suction strainers.

In order to determine various flow and design issues relating to ECCS sump performance, McGuire contracted Alden Research Laboratory (ARL) to construct a 1:3 scale model of the containment sump and to conduct extensive hydraulic testing. The general methodology used in calculating suction strainer and vortex suppressor head loss was the gathering of empirical data during test runs with various flow and screen blockage conditions, and compiling this data to determine a loss coefficient. The complete report is provided by the ARL Report 29-78, "Assessment of Flow Characteristics within a Reactor Containment Recirculation Sump using a Scale Model".

The bounding case for suction screen head loss is given by maximum flow for the Residual Heat Removal (RHR) and Containment Spray pumps. Using the loss coefficient determined by the above report for 50% strainer blockage, this maximum head loss was calculated to be 1.88 feet. Since the location of the sump screens is 2.5 feet above the sump floor, the suction pressure added by the elevation head would more than compensate for the maximum head loss across the suction strainers.

The calculation for the limiting-case available net positive suction head for the ECCS and Containment Spray pumps assumed a sump level of 0, and therefore no suction screen head loss was included. This is one of several conservatisms contained in the minimum NPSH calculations.

The following discussion on general NPSH calculation methodology is extracted from the McGuire FSAR, Section 6.3.2.14.

"The Emergency Core Cooling System is designed so that adequate net positive suction head is provided to system pumps in accordance with Regulatory Guide 1.1. To

demonstrate that adequate NPSH is provided for the ECCS pumps, it is not necessary to provide a graph of NPSH as a function of time; it is only necessary to demonstrate that the NPSH is adequate under the worst limiting conditions. Adequate net positive suction head is shown to be available for all pumps as follows:

1. Residual Heat Removal Pumps

   The net positive suction head of the residual heat removal pumps is evaluated for normal shutdown operation, and for both the injection and recirculation modes of operation for the design basis accident.

   The recirculation mode of operation gives the limiting NPSH requirement for the residual heat removal pumps, and the NPSH available is determined from the following equation:

   NPSH[actual] = (h)containment pressure - (h)vapor pressure + (h)static head - (h)loss

   To evaluate the adequacy of the available NPSH, several conservatism are applied:

   a. No increase in Containment pressure from that present prior to the accident is assumed.

   b. The Containment sump fluid temperature is assumed to be 190°F even though the maximum temperature reached is approximately 173°F.

   c. The static elevation head is calculated from the floor elevation of the sump (elevation 725' + 0") instead of the available water level. The elevation of the RHR pump is 699' + 6" (Centerline of discharge pipe).

   d. The head loss is evaluated based on all pumps running at the maximum calculated runout flow with conservatively assumed junction factors.

   e. The required NPSH is based on one pump running at a maximum calculated runout flow of 4000 gpm.

2. Safety Injection and Centrifugal Charging Pumps

The net positive suction head for the safety injection pumps and the centrifugal charging pumps is evaluated for both the injection and recirculation modes of operation for the design basis accident. The end of the injection mode gives the limiting NPSH requirement for the safety injection pumps and the centrifugal charging pumps, and the NPSH available is determined from the following equation:

NPSH[actual] = (h)containment pressure - (h)vapor pressure + (h)static head - (h)loss

To evaluate the adequacy of the available NPSH, several conservatisms are applied:

a. The Refueling Water Storage Tank (RWST) fluid temperature is assumed to be 100°F.

b. The static elevation head is calculated taking no credit for water level above the bottom of the RWST (elevation 761' + 2").

c. The head loss is evaluated based on all pumps running at the maximum calculated runout flow with conservatively assumed junction factors.

d. The required NPSH is based on one pump running at its maximum calculated runout flow."

In summary, although head loss across the sump suction screens and vortex suppressor were not incorporated in the calculations for minimum available NPSH, the more limiting assumption of 0 sump level was used. If actual elevation and suction screen head loss were incorporated into the available NPSH calculation, results would be slightly higher than the current conservative values.

2. Identify the required NPSH and the available NPSH.

Required NPSH and available NPSH (for the most limiting flows and operating modes) are given for the ECCS and containment spray pumps by the following table:

Pump	Required NPSH (feet)	Available NPSH (feet)	
		Injection	Cold Leg Recirc.
		Min. RWST Level (760')	Minimum Sump Level (725')
Containment Spray A	24	69.9	32.1
Containment Spray B	24	65.0	25.7
Safety Injection A	28	53.0	191.4
Safety Injection B	28	53.2	193.7
Residual Heat Removal A	19	62.5	34.9
Residual Heat Removal B	19	62.7	34.4
Centrifugal Charging A	23	44.1	183.5
Centrifugal Charging B	23	44.1	183.5

3. **Specify whether the current design-basis NPSH analysis differs from the most recent analysis reviewed and approved by the NRC for which a safety evaluation was issued.**

   Current design-basis NPSH analysis is unchanged, and still accurately reflected by the general methodology discussion in the FSAR, as related in the issue 1 response. This item was last formally reviewed by the NRC in the March 1978 SER.

4. **Specify whether containment overpressure (i.e., containment pressure above the vapor pressure of the sump or suppression pool fluid) was credited in the calculation of available NPSH. Specify the amount of overpressure needed and the minimum overpressure available.**

   No amount of overpressure was used in calculating available NPSH. Additionally, a barometric pressure of 14.4 psia was used.

5. **When containment overpressure is credited in the calculation of available NPSH, confirm that an appropriate containment pressure analysis was done to establish the minimum containment pressure.**

   N/A; containment overpressure is specifically NOT credited in McGuire's NPSH calculations for ECCS pumps.

ATTACHMENT 2

CATAWBA NUCLEAR STATION'S RESPONSE TO GL 97-04

Catawba Nuclear Station Response to NRC Generic Letter 97-04

Per the above referenced generic letter, licensees were requested to provide information on five issues relating to net positive suction head for Emergency Core Cooling System (ECCS) pumps. The exact requests, and the specific Catawba responses, are included in the following:

1. **Specify the general methodology used to calculate the head loss associated with the ECCS suction strainers.**

   In order to determine various flow and design issues relating to ECCS sump performance, Catawba contracted Alden Research Laboratory (ARL) to compare their sump design to the 1:3 scale model of the McGuire containment sump which had been the subject of extensive hydraulic testing, as described above. The purpose of this study, in addition to reviewing the McGuire study results and recommending changes to the Catawba sump design, was to assess the need for a separate model study for the Catawba sump. Alden Research Labs issued CNS/Review-ARL-208N, which concluded that a separate study was unnecessary.

   Just as for McGuire, the bounding case for suction screen head loss is given by maximum calculated flow for the Residual Heat Removal (RHR) and Containment Spray pumps. Since the Catawba sump screen design results in considerably larger screen area than the McGuire design, the approach velocity is lower and the head loss was estimated to be less than 1 foot at maximum flow for 50% strainer blockage. Since the location of the sump screens is 2.5 feet above the floor, the suction pressure added by the elevation head would more than compensate for the maximum head loss across the suction strainers.

   The calculation for the limiting-case available net positive suction head for the ECCS and Containment Spray pumps assumed a sump level of 0, and therefore no suction screen head loss was included. This is one of several conservatisms contained in the minimum NPSH calculations.

   The following discussion on general NPSH calculation methodology for the Containment Spray Pump is extracted from UFSAR section 6.2.2.3, Design Evaluation: "In accordance with Regulatory Guide 1.1, the plant and

piping layout of the Containment Spray System ensures that the pump net positive suction head (NPSH) requirements are met at maximum runout conditions with the Containment Spray Pumps taking suction from either the refueling water storage tank (RWST) or the containment sump. The NPSH available from the containment sump is calculated using the maximum credible sump water temperature (190°F) with no credit taken for containment overpressure or height of water in the containment sump."

The following discussion on general NPSH calculation methodology for the RHR pump is extracted from the Catawba UFSAR, Section 6.3.2.2, NPSH: "The Emergency Core Cooling System is designed so that adequate net positive suction head is provided to system pumps in accordance with Regulatory Guide 1.1. To demonstrate that adequate NPSH is provided for the ECCS pumps, the most limiting conditions are considered.

Pump vendors have verified that the required NPSH for the ECCS pumps is less than the maximum specified [available] NPSH through testing in accordance with the criteria established by the Hydraulic Institute Standards. Further, from the pump head/flow and NPSH required characteristics curves that are derived from the testing, Westinghouse subsequently confirmed that adequate NPSH is available based on the actual system piping layouts, and conservatively calculated maximum pump runout verified by preoperational testing.

Adequate net positive suction head is shown to be available for all pumps as follows:

Residual Heat Removal Pumps

The net positive suction head of the residual heat removal pumps is evaluated for normal shutdown operation, and for both the injection and recirculation modes of operation for the design basis accident. The recirculation mode of operation gives the limiting NPSH requirement for the residual heat removal pumps, and the NPSH available is determined from the following equation:

$$NPSH_{actual} = (h)_{\text{containment pressure}} - (h)_{\text{vapor pressure}} + (h)_{\text{static}} - (h)_{\text{loss head}}$$

To evaluate the adequacy of the available NPSH, several conservatisms are applied:

1. No increase in Containment pressure from that present prior to the accident is assumed.

2. The Containment sump fluid temperature is assumed to be 190°F even though the maximum temperature reached following the switchover to cold leg recirculation is approximately 170°F.

3. The static elevation head is calculated from the floor elevation of the sump instead of the available water level. The assumption of zero water level in the containment recirculation sump is conservative and also decouples the NPSH calculations from the Refueling Water Storage Tank level considerations.

4. The head loss to pump suction is evaluated based on all pumps running at the maximum calculated runout flow with conservatively assumed junction factors.

Safety Injection and Centrifugal Charging Pumps

The net positive suction head for the safety injection pumps and the centrifugal charging pumps is evaluated for both the injection and recirculation modes of operation for the design basis accident. The end of the injection mode gives the limiting NPSH requirement for the safety injection pumps and the centrifugal charging pumps, and the NPSH available is determined from the following equation:

$$NPSH_{actual} = (h)_{atmospheric\ pressure} - (h)_{vapor\ pressure} + (h)_{static} - (h)_{loss\ head}$$

To evaluate the adequacy of the available NPSH, several conservatisms are applied:

1. The RWST fluid temperature is assumed to be 114°F.

2. The static elevation head is calculated taking no credit for water level above the outlet nozzle on the RWST.

3. The head loss to pump suction is evaluated based on all pumps running at the maximum calculated runout flow with conservatively assumed junction factors.

4. The required NPSH for a pump is based on the pump running at its maximum calculated runout flow.

Elevations of the ECCS components are given in Section "General Station Description." Available and required NPSH for ECCS pumps are provided in Table 6-87. The actual available NPSH will always be greater than the calculated value.

2. Identify the required NPSH and the available NPSH.

Required NPSH and available NPSH (for the most limiting flows and operating modes) are given for the ECCS and containment spray pumps by the following table:

Pump	Required NPSH (feet)	Available NPSH (feet)	
		Injection	Cold Leg Recirc.
		Min. RWST Level (5%')	Minimum Sump Level (552')
Containment Spray A	20	91	31
Containment Spray B	20	94	33
Safety Injection A	29	76	RHR pump boost
Safety Injection B	29	77	RHR pump boost
Residual Heat Removal A	22.75	99	28 *
Residual Heat Removal B	22.75	96	30 *
Centrifugal Charging A	18.5	74	RHR pump boost
Centrifugal Charging B	18.5	74	RHR pump boost

* In UFSAR section 6.3.2.2, a case is described in which residual heat removal pumps operate at maximum runout flow of 5300 gpm. For this case, credit is taken for approximately 2 feet of water (100,000 gallons) on the containment floor which is roughly half the minimum injected volume from RWST. This is a conservative assumption. This

has been shown to be a non-mechanistic flow rate considering actual system flow restrictions and actual Emergency Procedure alignments. However, this is not an accident alignment case with suction aligned to the containment sump, so this case is not presented here. The case presented here is for maximum calculated runout flow. Per UFSAR section 6.3.2.2, higher runout values of the flow are observed during preoperational testing or refueling conditions when [the RWST is full, suction pressure is high, and] the discharge head is significantly reduced due to lower back pressure resulting from removal of the reactor vessel head.

3. Specify whether the current design-basis NPSH analysis differs from the most recent analysis reviewed and approved by the NRC for which a safety evaluation was issued.

Current design-basis NPSH analysis is unchanged, and still accurately reflected by the general methodology discussion in the UFSAR, as related in the issue 1 response. This item was last formally reviewed by the NRC in the Catawba SER Supplement 5, dated February, 1986.

4 Specify whether containment overpressure (i.e., containment pressure above the vapor pressure of the sump or suppression pool fluid) was credited in the calculation of available NPSH. Specify the amount of overpressure needed and the minimum overpressure available.

No amount of overpressure was used in calculating available NPSH. Additionally, a barometric pressure of 14.38 psia was used.

5. When containment overpressure is credited in the calculation of available NPSH, confirm that an appropriate containment pressure analysis was done to establish the minimum containment pressure.

N/A; containment overpressure is specifically NOT credited in Catawba's NPSH calculations for ECCS and Containment Heat Removal pumps.

ATTACHMENT 3

OCONEE NUCLEAR STATION'S RESPONSE TO GL 97-04

GL 97-04 RESPONSE FOR OCONEE NUCLEAR STATION UNITS 1, 2, & 3

The following requirements are stated in the subject Generic Letter. ONS responses are provided accordingly:

1. **Specify the general methodology used to calculate the head loss associated with the ECCS suction strainers.**

Each Unit at Oconee Nuclear Station is designed with an emergency sump which is provided with vertical screens around a rectangular frame. The screen area is approximately 100 sq. ft. with 0.12″ square mesh openings. There is a heavy grating behind the screen for structural support. There is also a heavy grating around the sump perimeter above the screens. The grating has openings which measure 1″ by 3.75″, and the approximate area of the grating is 40 sq. ft. The head loss through the sump screens is calculated by determining a resistance coefficient, K, and then applying the Darcy Weisbach relationship, $Hl = KV^2/2g$. The resistance coefficient, K, is found from methodologies presented in the Handbook of Hydraulic Resistance, Third Edition, by I. E. Idelchik, copyright 1994 by CRC Press. The velocity of flow is determined from the post-accident flow rates called for in the station Emergency Operating Procedures with adjustment for worst case instrument error to maximize flows. A 50 percent blockage of the sump screen and grating is assumed, thus reducing the available flow areas through the screen and grating, and increasing the velocities and resultant head losses. The resultant head loss was determined to be less than 0.03 ft.

2. **Identify the required NPSH and the available NPSH.**

NPSH requirements for the Reactor Building Spray (BS) System and Low Pressure Injection System (LPI) are as follows:

	Required NPSH	Available NPSH
BS	18.9 ft.	20.4 ft.
LPI	11.9 ft.	19.1 ft.

These values are based upon analysis of the "B" (Bravo) train of Oconee Unit 3 at a sump temperature of 230F, which is bounding for all trains of all three units. It should be noted that the above numbers do not represent the NPSH margin at maximum sump temperature conditions. However, analyses show that the NPSH margin increases at both higher

and lower sump temperatures for the worst-case break location. Therefore, the above values represent the minimum analyzed margin for NPSH.

3. **Specify whether the current design-basis NPSH analysis differs from the most recent analysis reviewed and approved by the NRC for which a safety evaluation was issued.**

The current design-basis NPSH analysis is different from that reviewed and approved by the NRC. The previously reviewed analysis was based upon a worst-case cold leg break, which produces more favorable (lower) sump temperatures and (higher) building pressures to support NPSH available. The former analysis also did not account for uncertainty in flow rates due to instrument error, and a higher post-accident water level in the reactor building was credited . The NPSH (available) values approved by the NRC in SER dated July 6, 1973 are slightly lower than the current analysis reflects. The NPSH required for the BS system was also slightly lower, while the requirement for LPI was slightly higher. The original SER does acknowledge the crediting of overpressure, although the current analysis credits somewhat higher building pressure.

4. **Specify whether containment overpressure (i.e., containment pressure above the vapor pressure of the sump or suppression pool fluid) was credited in the calculation of available NPSH. Specify the amount of overpressure needed and the minimum overpressure available.**

Containment overpressure was credited in the calculation of available NPSH. The analysis shows that overpressure (building pressure - vapor pressure) requirements for the two systems are as follows:

	Pressure Required	Pressure Available
BS	2.28 psi	2.90 psi
LPI	0 psi	2.90 psi

5. **When containment overpressure is credited in the calculation of available NPSH, confirm that an appropriate containment pressure analysis was done to establish the minimum containment pressure.**

A thorough analysis of the reactor building pressure and temperature response for the worst-case hot leg break assumption was performed and is documented in calculation OSC-6521, titled "Containment Response With 30-Minute Delay in LPSW Flow". This analysis evaluates a break of the Reactor Coolant System hot leg with single failure of 4160V switchgear, which disables one train of BS, LPI, and RBCU's. The analysis shows that the combinations of sump temperature and containment pressure are bounding for all other break assumptions.