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SUBJECT: Provides 90-day response to GL 97-04, "Assurance of Sufficient Net Positive Suction Head for ECC & Containment Heat Removal Pumps."

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January 5, 1998

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

10 CFR 50.54(f)

Ladies/Gentlemen:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
Wisconsin Public Service Corporation's (WPSC's) 90-Day Response to Generic Letter 97-04

References: 1) Generic Letter 97-04: "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," dated October 7, 1997
2) WPSC's 30-Day Response to Generic Letter 97-04, dated November 4, 1997

In Reference 1, the Nuclear Regulatory Commission (NRC) identified several examples where the net positive suction head (NPSH) available to emergency core cooling and containment heat removal pumps may not be adequate under all design basis operating conditions. The Generic Letter requests licensees review their post-LOCA recirculation cooling NPSH analyses and provide the NRC with plant design basis information, outlined in Reference 1, within 90 days.

This letter provides WPSC's 90-Day Response requested by the NRC. The attachment to this letter provides a summary of Wisconsin Public Service Corporation's (WPSC's) assessment of the issues outlined in the Generic Letter.

As required by the Generic Letter, this response is being submitted under oath and affirmation.

A076

Sincerely,

C. R. Steinhardt
Senior Vice President-Nuclear Power

WKB
Attach.
cc - US NRC, Region III
US NRC Senior Resident Inspector

Subscribed and Sworn to
Before Me This 5th Day
of January 1998

Jeanne M. Ferris
Notary Public, State of Wisconsin

My Commission Expires:
June 13, 1999

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ATTACHMENT 1

Letter from C.R. Steinhardt (WPSC)

To

Document Control Desk (NRC)

Dated

January 5, 1998

Re:

Generic Letter 97-04

Item 1: Specify the general methodology nsed to calculate the head loss associated with the ECCS suction strainers.

WPSC Response:

The containment sump design at the Kewaunee plant incorporates two fine mesh (1/8" x 1"), conical style Johnson Screens. Original manufacturer design information states each screen is designed for 1.5 feet of head loss. The manufacturer design head loss of 1.5 feet incorporates a significant margin for screen blockage. A recently obtained manufacturer calculation for Kewaunee's sump screens supports the head loss assumption made in the original sump screen documentation. The manufacturer's calculation assumes significant screen blockage with the screens fully submerged. The calculation states the screen head loss model is based on a derivation of the Darcy equation for calculating pressure drop through sharp edged orifices. The exact coefficients used in the head loss formula are empirical and are based on the manufacturer's flow testing. Graphs provided with the calculation show the head loss through the screens converges at approximately 1.5 feet for a series of flow rates.

As requested by the NRC, the following is a discussion of the methodology used to calculate the available NPSH to the RHR pumps.

Suction piping from the containment sump to the Residual Heat Removal (RHR) pump suction

Kewaunee's recirculation sump lines consist of two independent lines that take a suction from the common containment sump and run to the suction of each of the RHR pumps.

A calculation exists for available NPSH to the RHR pumps in the post loss of coolant accident (LOCA) recirculation mode. The calculation was performed by the plant's Architect/Engineer (A/E) during the construction phase of the plant. The plant's Nuclear Steam System Supplier (NSSS) may also have performed a NPSH calculation. WPSC is working with the plant's NSSS to obtain any available ECCS NPSH information.

The general methodology used to calculate the available NPSH to the RHR pumps in the recirculation mode is based on the following:

The basic equation used for calculating available NPSH is:

$$NPSH_A = h_s - h_{vp}$$

where: h_{vp} = vapor pressure of the liquid being pumped (expressed as feet of liquid absolute).
h_s = total suction head (expressed as feet of liquid absolute) determined at the pump suction.

h_s can further be defined as:

$$h_s = h_a + h_{st} - h_f$$

where:

h_a = head corresponding to the pressure on the surface of the liquid supply level (expressed as feet absolute).
h_{st} = static elevation head corresponding to the height of the liquid supply level above the pump centerline (expressed as feet).
h_f = suction line friction losses, including entrance losses (expressed as feet).

Further detail on the terms defined above, as each applies to the Kewaunee plant's A/E NPSH calculation, is provided below:

- h_a = head corresponding to the pressure on the surface of the liquid supply level (expressed as feet absolute).

  This term describes the internal containment pressure assumed in the calculation. The Kewaunee plant's NPSH calculation conservatively assumes the containment pressure equals the vapor pressure of the sump liquid. For a further discussion of containment pressure assumptions as they apply to available NPSH to the RHR pumps, see Item 4.

- h_{vp} = vapor pressure of the liquid being pumped (expressed as feet of liquid absolute).

  The vapor pressure of the sump liquid is the saturation pressure of the liquid at the corresponding sump temperature. The Kewaunee plant's A/E NPSH calculation assumes the containment sump liquid/atmosphere is at saturated conditions. For a further discussion of containment pressure/vapor pressure assumptions as they apply to available NPSH to the RHR pumps, see Item 4.

- h_{st} = static elevation head corresponding to the height of the liquid supply level above the pump centerline (expressed as feet).

  The static elevation head assumed in the NPSH calculation is the height of the water column between the RHR pump suction and the containment floor. This is a conservative assumption since water level will be above the elevation of the contaiument floor during post LOCA recirculation.

- h_f = suction line friction losses, including entrance losses (expressed as feet).

The calculation methodology used to calculate the head losses associated with the suction piping to the RHR pumps is based on single pump design flow and information provided by Crane. The calculation accounts for losses through the following types of components including the quantities of each:

- Piping length and its associated size and schedule
- Valves
- Fittings, i.e., elbows, reducers, etc.
- Piping entrance losses
- Sump screens

Item 2: Identify the required NPSH and the available NPSH.

WPSC Response

RHR Pump Required NPSH and Available NPSH

The A/E calculation referenced in Item 1 determined the RHR pump available NPSH to be 18.6 feet absolute at 2000 gpm, (assumed post accident single train ECCS recirculation flow). According to the vendor's certified pump curve, the required NPSH is 8 feet absolute at 2000 gpm, (pump design flow).

Based on gnidance provided by the Nuclear Energy Institute (NEI), WPSC understands that the NRC desires the following information not specifically requested by the generic letter.

1. The original design basis for post-accident containment conditions and how the conditions affect available NPSH to the ECCS pumps.
2. Has the basis for the above changed?

As stated in Item 1, the A/E calculation conservatively based the available NPSH to the RHR pumps on the assumptions that the water level in containment would be at the elevation of the contaiument floor and the containment atmosphere/sump would be at saturated conditions.

A review of the Kewaunee USAR, Table 6.2-6, identified a different set of RHR pump available NPSH values. These values were incorporated into Kewaunee's original Final Safety Analysis Report (FSAR) in response to questions raised by the NRC during plant licensing reviews. The values listed in Table 6.2-6 are shown in the following table:

RHR Pnmp NPSH Valnes		
Reqnired NPSH	**Flow**	**Available NPSH (dnring recirculation)**
8 feet (absolute)	2000 gpm (design flow)	31 feet (absolute) minimum
14 feet (absolute)	2600 gpm (runout flow)	

WPSC was unable to establish a basis for the USAR values shown in Table 6.2-6. Use of the following assumptions would support the listed USAR RHR pump available NPSH of 31 feet:

- The entire reactor coolant system volume is discharged into containment.
- The entire volume of the RWST is injected into containment.
- Both accumulators and one boric acid tank are injected into containment.
- No water collects in the reactor cavity sump or other non useable areas.
- Saturated conditions are assumed in containment, (i.e., no credit for overpressure).
- No head losses accounted for between sump water level and RHR pump suction.

Based on the information presented in the Kewaunee USAR and the original A/E NPSH calculation, we surmise that the original design basis assumed the following:

- Large break LOCA.
- Single train ECCS operation.
- No credit for containment overpressure.

Subsequent to the development of the USAR, additional calculations have been performed to determine the water level in the containment post-accident. The calculations were performed to support emergency operating procedures (EOPs), the environmental qualification (EQ) program, and design change requests (DCRs). The objectives of each of these calculations varied. Therefore, the assumptions and the resulting calculated contaiument water level also varied. In all cases, the calculated water level was significantly greater than the water level assumed in the A/E NPSH calculation. To the best of WPSC's knowledge, none of the calculations referenced in this letter have been reviewed by the NRC.

In the unlikely event of a LOCA, the current emergency operating procedure, which transfers ECCS operation from the injection phase to the containment sump recirculation phase, is entered when the refueling water storage tank (RWST) level reaches the 37% low level alarm setpoint. When the RWST 37% low level alarm setpoint is reached, an assessment is made of the number of ECCS trains available. If two trains are available, one train is aligned and switched over to the recirculation phase while the other train continues to draw suction from the RWST. In this scenario, the second ECCS train is prepared for containment sump recirculation and then placed in standby when the

RWST 4% lo-lo level alarm is reached. If only one ECCS train is available, preparation and transfer to containment sump recirculation is initiated at a RWST level of 10%.

Following a design-basis LOCA, containment sump liquid level will depend on the size of the break. In the event of a large break LOCA, it is safe to assume the volume of both accumulators and a large portion of the RCS inventory will be available in the contaiument sump. In the event of a small break LOCA, the accumulators may never inject and the RCS inventory will be maintained in the RCS. Therefore, the only liquid available in the containment sump would be the amount injected from the RWST. In the event of a small break LOCA and assuming:

1. Only a single train of ECCS is available, (i.e., transfer to recirculation occurs at 10% RWST level).
2. Liquid inventory lost to fill the reactor cavity is unavailable for recirculation.

The containment sump screens will be fully submerged when recirculation is initiated.

If both ECCS trains are available and assumed to be operating, the transfer of the first ECCS train to containment sump recirculation will be initiated prior to the sump screens being fully submerged. The second train would not be aligned until the sump screens are fully submerged. In either of the scenarios, the A/E NPSH calculation bounds the available NPSH to the RHR pumps.

Piggyback Operation: Safety Injection (SI) pump and Containment Spray (ICS) pump NPSH

In a "piggyback" configuration, one RHR pump can provide suction supply to a SI pump and an ICS pump. The table below shows the required NPSH for the 1CS and SI pumps. The values are taken from USAR Table 6.2-6 and the manufacturers' certified pump curves.

SI and ICS pump NPSH		
	NPSH required	flow
SI pumps	17 feet absolute	700 gpm (design flow)
	21 feet absolute	835 gpm (runout flow)
ICS pumps	18 feet absolute	1300 gpm (design flow)

Kewaunee did not identify an analysis showing the available NPSH to the SI and ICS pumps during piggyback operation. We believe a "piggyback" operation NPSH analysis was never performed for the following reasons:

- The discharge head of the RHR pumps is much greater than the static head provided by the atmospheric RWST.

- The piping run from the RHR pump discharge to the suction of the SI and ICS pumps is not excessive in length.
- RHR flow throttling is accomplished downstream of the branch piping takeoff to the suction of the SI and ICS pumps.

Therefore, providing adequate available NPSH to these pumps during "piggyback" operation should not be a concern.

Item 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.**

WPSC Response

WPSC does not believe that a Kewaunee plant ECCS NPSH analysis has ever been submitted to the NRC for review. The original safety evaluation issued to WPSC from the Atomic Energy Commission did not directly address NPSH calculations. A review of Kewaunee's licensing documentation shows the only NPSH information submitted to the NRC was that listed in USAR Table 6.2-6.

Item 4: **Specify whether containment overpressure (i.e., containment pressnre above the vapor pressnre of the snmp or suppression pool fluid) was credited in the calculation of available NPSH. Specify the amount of over pressure needed and the minimnm over pressure available.**

WPSC Response:

Kewaunee's A/E NPSH calculation does not take credit for containment overpressure. to assure available NPSH to the RHR pumps during post-LOCA recirculation. The A/E NPSH calculation assumes the containment sump liquid is at saturated conditions. This assumption is used to conservatively allow the containment pressure to equal the vapor pressure of the sump liquid. Thus, the available NPSH to the RHR pumps is conservatively based on the static liquid elevation, h_{st}, above the pump centerline. These assumptions are consistent with the definition of containment overpressure discussed in the generic letter.

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

WPSC Response:

Item 5 is not applicable to the Kewaunee plant.

Summary and Conclusions

The Kewaunee plant's original A/E calculation does not take credit for containment overpressure to assure sufficient available NPSH to the RHR pumps during post-LOCA containment sump recirculation. A specific NPSH analysis has not been identified for "piggyback" operation of the ECCS pumps. Though an analysis has not been identified for "piggyback" operation of the ECCS pumps, a review of the system piping design and NPSH requirements of the SI and 1CS pumps shows sufficient available NPSH can be assured during "piggyback" operation. Differences exist among the information concerning the available NPSH to the RHR pumps during post-LOCA contaiument sump recirculation. WPSC will initiate action to reconcile the differences.

WPSC's review of the design information concerning the available and required NPSH to the ECCS pumps during containment sump recirculation and "piggyback" operation concludes that sufficient margin is present to ensure proper pump operation.