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	Document Control Branch (Document Control Desk)

SUBJECT: Forwards 90-day response to GL 97-04, "Assurance of Sufficient NPSH for ECC & Containment Heat Removal Pumps," per requirements of Section 182a of AEA of 1954,as amended & 10CFR50.54(f).

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JAN 5 1998
L-97-321
10 CFR 50.54(f)

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

Re: Turkey Point Units 3 and 4
Docket Nos. 50-250 and 50-251
Response to Generic Letter 97-04,
Assurance of Sufficient Net Positive Suction Head for
Emergency Core Cooling and Containment Heat Removal Pumps

By letter dated October 7, 1997, the NRC issued Generic Letter (GL) 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," requesting licensees to (1) review the current design-basis analyses used to determine the available NPSH of the (subject) pumps, and (2) to provide information outlined in items 1 through 5 of the GL.

By FPL letter L-97-272, we replied that we would submit our response to GL 97-04 within the requested 90 days. Attached please find Turkey Point's 90-day response to GL 97-04.

The information is provided pursuant to the requirements of Section 182a of the Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). Should there be any questions concerning this response, please contact us.

Very truly yours,

Robert J. Hovey
Vice President
Turkey Point Plant

CLM

Attachment

cc: Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point Plant

STATE OF FLORIDA)
) ss.
COUNTY OF DADE)

Robert J. Hovey being first duly sworn, deposes and says:

That he is Vice President, Turkey Point Plant, of Florida Power and Light Company, the Licensee herein;

That he has executed the foregoing document; that the statements made in this document are true and correct to the best of his knowledge, information and belief, and that he is authorized to execute the document on behalf of said Licensee.

Robert J. Hovey

Subscribed and sworn to before me this 5th day of Jan, 1998.

Cheryl A. Stevenson
Name of Notary Public (Type or Print)
NOTARY PUBLIC, in and for the County of Dade, State of Florida

CHERYL A. STEVENSON
MY COMMISSION # CC 584017
EXPIRES: June 19, 2000
Bonded Thru Notary Public Underwriters

My Commission expires_________
Commission No.____________

Robert J. Hovey is personally known to me.

INTRODUCTION

As a result of recent activities, the NRC has identified a safety significant issue concerning NPSH available to emergency core cooling and containment heat removal pumps under design basis accident scenarios. GL 97-04 applies to pumps that take suction from containment recirculation sumps and pumps used in "piggyback" operation that are necessary for recirculation cooling of the reactor core and containment.

The scope of GL 97-04 applies to the Turkey Point Residual Heat Removal (RHR) pumps, which take suction from the containment recirculation sumps, and to the Containment Spray (CS) pumps and the High Head Safety Injection (HHSI) pumps, both of which are supplied by the RHR pumps (piggyback) during recirculation. These pumps comprise the Turkey Point Unit 3 and 4 emergency core cooling and the containment heat removal system pumps. The safety concerns identified by GL 97-04 apply to the recirculation cooling phase of the Turkey Point emergency core cooling and containment cooling systems.

The Emergency Core Cooling System (ECCS) provides borated cooling water from the Refueling Water Storage Tank (RWST) to the reactor core immediately following design basis accidents. In the case of a Loss of Coolant Accident (LOCA), the system also recirculates water from the recirculation sump that is first cooled before being returned to the core. The RHR System, which is normally used for decay heat removal following plant shutdown, also serves as the low head safety injection system to deliver injection flow at low Reactor Coolant System (RCS) pressures, and provides the required cooling of the recirculated coolant from the containment recirculation sump. Operation of the ECCS in the recirculation mode is not required following a Main Steam Line Break (MSLB) accident, since loss of primary system water inventory does not occur in that event. Further details of the HHSI, RHR, and CS System configurations are provided within the Turkey Point Updated Final Safety Analysis Report (UFSAR).

The CS system sprays borated water from the RWST into the containment following a LOCA or MSLB to limit the pressure and temperature profile inside containment to within design limits. The CS system also operates in the long term cooling phase following a design basis accident to recirculate cooled borated water from the sump, to restore the containment conditions to near atmospheric pressure and pre-event temperature.

The plant specific information requested by GL 97-04 is presented below in the order specified.

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

1.1 Methodology used to determine the head loss associated with the ECCS suction strainers:

The Turkey Point containment recirculation sump screens are considered the ECCS strainers referenced by GL 97-04. Each containment structure includes redundant sumps which supply redundant RHR pumps. The pumps are aligned to both sumps and each sump is designed to accommodate two pumps. The sump screens consist of structural steel supporting overlapping layers of ½" and ¼" screen mesh.

The design basis for the sump screen head loss conservatively assumes that one screen is 100% clogged and the other is 50% clogged. The "clean" open flow area of the screens has been determined for a worst case projected area due to an overlap of the ½" and ¼" wire meshes less support members and piping. This worst case flow area is then reduced by 50% for the single operating screen for the NPSH analysis. The head loss across the screen is then determined using Darcy's equation with an applied flow resistance coefficient "K" derived specifically for flow through wire meshes:

$$\Delta h = K\frac{V^2}{2g}$$

1.2 General Net Positive Suction Head Methodology:

The following section provides information not specifically requested by GL 97-04. This information is being provided in response to NRC discussions at the NEI/NRC Meeting held in Baltimore, Maryland on December 5, 1997.

1.2.1 Methodology for Determination of Available Net Positive Suction Head ($NPSH_A$):

The following discussion describes the general methodology used to determine the available NPSH at the centerline of the pump's suction nozzle.

$$NPSH_A = \frac{P_{atm}-P_{vap}}{\rho}\left(\frac{g_c}{g}\right)\left(\frac{144in^2}{ft^2}\right) + \Delta h_{static} - \Delta h_{loss}$$

Where:

$NPSH_A$ = Available NPSH (ft, absolute)
P_{atm} = Atmospheric pressure applied to the supply source (psi)
P_{vap} = Saturation pressure corresponding to the pump suction temp. (psi)
ρ = Density of the pumped fluid (lb_m/ft^3)
g = Acceleration of gravity (32.2 ft/sec^2)
g_c = Universal gravitational constant 32.2 (lb_m-ft)/(lb_f-sec^2)
Δh_{static} = Static water column elevation difference (ft)
Δh_{loss} = Frictional head loss to the pump suction (ft)

Since the loss term (Δh_{loss}) is velocity dependent, $NPSH_A$ is calculated for the maximum pump flow rate for each alignment. This approach minimizes the $NPSH_A$ to yield conservative results.

1.2.2 Methodology for Determination of Required Net Positive Suction Head ($NPSH_R$):

Applicable vendor design and test information was used to determine the required NPSH for each of the safeguards pumps which is dependent on flow rate. The required NPSH data for centrifugal pumps is typically based on pumping clear water at a temperature of 85°F or less. However the required NPSH can be reduced for pumping of fluids at elevated temperatures, such as post accident conditions. Although the actual effect of high temperature fluids is to reduce the required NPSH at the rated flow, for conservatism, the "cold water" $NPSH_R$ was used for the Turkey Point analysis. Thus, a "hot fluid factor" as described in GL 97-04 was not credited in any of the Turkey Point NPSH analyses.

1.2.3 Methodology for Determination of Static Head (Δh_{static}):

The Turkey Point UFSAR contains the following statement regarding sump level for initiation of recirculation cooling (Section 6.2.2):

> *Recirculation may start with a water depth of 2.93 feet on the containment floor at elevation 14'-0".*

This sump level is considered the original NPSH design basis. This sump level corresponds to a plant elevation of approximately 17 feet. In comparison, the RHR pumps are located approximately 20 feet lower than this sump level at a plant elevation of -2.75 feet. Thus, this configuration provides an absolute positive static head applied to the RHR pumps of approximately 20 feet.

This design basis sump level ensures that adequate NPSH is provided for the recirculation alignments. Thus, the design basis NPSH calculations reference a sump level at the plant elevation of 17 feet. FPL reviewed the projected sump inventory and corresponding sump elevation to verify this original NPSH design basis sump level. This review concluded that the actual sump level is expected to be greater, providing additional margin. For example, the sump level expected for the maximum hypothetical accident is 4.74 feet (plant elevation 18.74 feet) and more recent analysis performed in consideration of Westinghouse Nuclear Safety Advisory Letter (NSAL) 97-009 determined an absolute worst case minimum level, with no loss of RCS inventory, of 17.1 feet plant elevation. Thus, the use of the design basis sump level of 17 feet for the NPSH design basis calculations is conservative.

1.2.4 Methodology for Determination of Frictional Head Loss (Δh_{loss}):

This term is determined using hydraulic network computer models. Westinghouse developed models of the Turkey Point ECCS and CS systems using the proprietary PEGISYS software. These models determine the network flow rates and respective pressure drops based on the actual piping and equipment hydraulic resistances, elevation changes, and pump curves. The computer code uses Bernoulli's equation combined with Darcy's equation to determine the head loss. Computer runs were made specifically to determine NPSH for alignments of interest applying conservative assumptions as follows:

- Nominal pump curves were used in lieu of degraded pump curves to maximize flow
- Suction losses were maximized while pump discharge losses were minimized to yield conservative results with respect to $NPSH_A$
- Sump screen losses were maximized
- Minimum sump level of 17 feet was assumed

The suction head losses were extracted from the computer runs and applied to the NPSH equation. Thus, the term "Δh_{loss}" is inclusive of all losses associated with the respective pump suction flow path including sump screens, piping, valves, and other equipment.

1.2.5 Methodology for Determination of Containment Pressure (P_{atm}):

This term represents the containment atmospheric pressure applied to the suction source. Under most applications, this term is normally additive to the static head (Δh_{static}). However for the high temperature applications of interest, the atmospheric pressure is necessary to prevent flashing of hot sump fluid (sump fluid temperature, $T_{sump} \geq 212°F$). Therefore, this term cancels with the vapor pressure ($P_{atm} - P_{vap} \equiv 0$) in the $NPSH_A$ equation. Using this approach, the sump water and the containment steam environment are conservatively assumed to be at the same saturated pressure. This methodology is consistent with Regulatory Guide 1.1.

For long term cooling alignments (t ≥ 24 hours) when the sump is sub-cooled (T_{sump} < 212°F), the containment pressure is conservatively considered to be zero gauge (P_{atm} = 0 psig). Thus, even assuming a gross failure of containment during long term cooling (which is beyond the plant's design basis) adequate NPSH is assured.

1.2.6 Methodology for Determination of Fluid Vapor Pressure (P_{vap}):

This term represents the vapor or saturation pressure corresponding to the sump water temperature. As described above, this term cancels with the atmospheric pressure for hot fluid applications. For long term cooling alignments, the vapor pressure is determined based on the time dependent accident analysis for sump temperature. This methodology provides conservative results with regard to the $NPSH_A$ analyses.

2. Identify the required NPSH and the available NPSH

The available and the required NPSH is identified for the post-accident recirculation ECCS operation, as follows:

(1) NPSH evaluation for short term recirculation alignments of the RHR pumps which take suction from the recirculation sumps
(time < 24 hours)

(2) NPSH evaluation for long term recirculation alignments of the RHR pumps which take suction from the recirculation sumps
(time > 24 hours)

(3) NPSH evaluation of the CS and HHSI pumps in piggy-back operation which are placed in series with the RHR pumps (time > 0 hours)

The limiting NPSH cases were determined based on lowest margin between the available and the required NPSH. The calculated values for NPSH are provided for Unit 3 only, but are also applicable to Unit 4. Turkey Point Unit 3 and 4 are assumed to be identical for the purpose of accident analyses, including NPSH evaluations. To verify this assumption, an independent comparison of the Unit 3 and 4 physical piping configurations was performed, and no significant differences were found that could affect the results of NPSH analyses.

2.1 NPSH evaluation for short term recirculation alignments of the RHR pumps which take suction from the recirculation sumps (time < 24 hours)

The short term cooling alignments occur during the first 24 hours post-accident. During this initial recovery stage, the operation of the ECCS is procedurally restricted to one RHR pump and one RHR heat exchanger. This restricted mode of operation ensures that

adequate NPSH is available during the critical "hot" sump temperature operations (T_{sump} > 212°F). While the sump fluid is at elevated saturation conditions, containment pressure is relied upon to prevent flashing of the sump fluid. Therefore within the NPSH equation, the sump's saturation pressure (P_{vap}) is canceled with the containment pressure (P_{atm}). Note that the containment pressure is conservatively assumed to be at the same temperature and saturation pressure as the sump fluid. The actual containment pressure would exceed the sump saturation pressure due to partial pressure of the compressed containment air. For conservatism these terms are canceled, which is consistent with the methodology prescribed in Regulatory Guide 1.1. Thus, no credit is taken for containment "over-pressure" as referenced in GL 97-04.

The limiting NPSH case for the RHR pumps during the short term recirculation alignments was determined to be the High-Head/Cold-Leg Recirculation with Containment Spray alignment. The alignment for this case consists of the following:

- One sump screen is 100% blocked and the other is 50% blocked
- One RHR Pump takes suction from one 50% blocked sump screen
- The RHR pump discharges to one HHSI pump and one CS pump in piggyback operation

The result of the limiting case for the short term recirculation alignments is presented below:

SHORT TERM RECIRCULATION ALIGNMENTS LIMITING NPSH ANALYSIS (t < 24 hours)		
Pump	$NPSH_A$	$NPSH_R$
RHR 3A	18.2'	< 10'

2.2 NPSH evaluation for long term recirculation alignments of the RHR pumps which take suction from the recirculation sumps (time > 24 hours)

For long term cooling alignments (after the first 24 hours) the sump has been sufficiently cooled to allow operation of an additional RHR pump and an additional RHR heat exchanger. Since the sump is now subcooled, containment pressure is <u>not</u> relied upon to prevent sump flashing. Therefore, containment pressure is considered to be zero gauge (P_{atm} = 0 psig) in the NPSH analysis.

The limiting NPSH case for the RHR pumps during the long term recirculation alignments was determined to be the Concurrent High-Head/Hot-Leg Recirculation and Low-Head/Cold-Leg Recirculation with Containment Spray alignment. The alignment for this case is based on the following:

- One sump screen is 100% blocked and the other is 50% blocked
- Two RHR pumps take suction from one 50% blocked sump screen
- The RHR pumps discharge to three cold legs, one HHSI pump, and one CS pump in piggyback operation

The result of the limiting case for the long term recirculation alignments is presented below:

LONG TERM RECIRCULATION ALIGNMENTS LIMITING NPSH ANALYSIS (t > 24 hours)		
Pump	$NPSH_A$	$NPSH_R$
RHR 3A	25.1'	12.7'

2.3 NPSH evaluation of the CS and HHSI pumps in piggy-back operation which are placed in series with the RHR pumps (time > 0 hours)

During piggyback operation the HHSI and CS pumps are placed in series with the RHR pumps. The piggyback mode of operation is limited to one CS pump and one HHSI pump. However, two RHR pumps may be operated to provide low head injection and the supply pressure for the secondary pumps. Thus, the suction pressure supplied to the secondary pumps is equal to the discharge pressure of the RHR pumps less line losses and elevation changes. For this reason, $NPSH_A$ is not a concern for the secondary pumps. Specifically, the minimum margin between the $NPSH_A$ and $NPSH_R$ for the pumps in piggyback is 60 feet.

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.

In response to this request, FPL reviewed the design basis for the ECCS pumps NPSH analysis and the documented communications with the NRC regarding this issue. Based on this review, no NRC Safety Evaluation was identified documenting review of NPSH issues regarding the ECCS or CS pumps. The most recent design basis information regarding the NPSH that was reviewed and approved by the NRC is considered to be the UFSAR.

Section 6.2.3 of the Turkey Point UFSAR contains the following statement regarding the NPSH requirements of the RHR pumps during recirculation:

> *The NPSH of the residual heat removal pumps is evaluated for normal shutdown operation, and both the injection and recirculation phase operation of the design basis accident. Recirculation operations gives the limiting NPSH requirement, and sufficient NPSH to initiate recirculation is determined by the water level switches. During recirculation an adequate margin exists between the available and required NPSH.*

As previously discussed, the UFSAR also contains the following statement regarding sump level for recirculation initiation:

> *Recirculation may start with a water depth of 2.93 feet on the containment floor at elevation 14'-0".*

Review of the design basis NPSH analyses confirm that a depth of 2.93 feet (plant elevation is approximately 17 feet) is adequate for all ECCS recirculation alignments. There has been no subsequent change to this design basis value. The actual containment depth will exceed this value providing additional margin.

Thus, the original design basis of 2.93 feet sump level providing adequate $NPSH_A$ is considered the most recent design basis which was reviewed and approved by the NRC.

Note that NPSH calculations have been performed since the issuance of the Turkey Point operating licenses in connection with initiatives such as design basis reconstitution. The results of the more recent calculations have not affected the design basis as described in the UFSAR.

Based on this review, it is concluded that the most recent design bases analysis for Turkey Point does not differ from the most recent analysis reviewed and approved by the NRC.

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 not credited in any NPSH analysis performed for Turkey Point. Specifically, the NRC provided the following clarification during the NEI/NRC Meeting held in Baltimore, Maryland on December 5, 1997, regarding containment overpressure:

> *Containment overpressure refers to pressure above the initial pressure, rather than pressure above vapor pressure. If you have a cool fluid source ($T < 212°F$), where the vapor pressure is less than the initial containment pressure, applying initial containment pressure in the NPSH analyses should not be considered "overpressure."*

The containment pressure is canceled by the vapor pressure for all hot water cases ($T_{sump} \geq 212°F$). Under conditions where the sump fluid is at elevated saturation, containment pressure is relied upon to prevent flashing of the sump fluid. Therefore within the NPSH equation, the sump's saturation pressure (P_{vp}) is canceled with the containment pressure (P_{atm}). Note that the containment pressure is conservatively assumed to be at the same temperature and saturation pressure as the hot sump fluid. However, the actual containment pressure would exceed the sump saturation pressure due to partial pressure of the compressed containment air. That is, the post accident containment environment is a mixture of air and steam. Therefore, the containment sump remains subcooled under the additional pressure of the air. For conservatism, however, these terms are canceled in accordance with the methodology prescribed in Regulatory Guide 1.1.

For long term cooling alignments ($t \geq 24$ hours) when the sump is sub-cooled ($T_{sump} < 212°F$), the containment pressure is considered to be zero gauge ($P_{atm} = 0$ psig). Thus, even assuming a gross failure of containment during long term cooling (which is beyond the plant's design basis) adequate $NPSH_A$ is assured. The corresponding sump vapor pressure is determined based on the time dependent accident analysis for sump temperature.

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.**

This question is not applicable to Turkey Point.

CONCLUSION

In response to GL 97-04, Turkey Point has performed an extensive review of the NPSH analysis for the emergency core cooling systems. Based on the review, FPL concludes that the Turkey Point emergency core cooling systems have been appropriately designed with regard to NPSH. The design basis information as described in the original operating license safety evaluation remains valid.