

# CATEGORY 1

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

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FPL

Florida Power & Light Company, 6351 S. Ocean Drive, Jensen Beach, FL 34957

February 4, 1998

L-98-33  
10 CFR 50.4  
10 CFR 50.54 (f)

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

RE: St. Lucie Units 1 and 2  
Docket Nos. 50-335 and 50-389  
Generic Letter 97-04 - Response

The Florida Power & Light Company (FPL) response to Generic Letter (GL) 97-04, *Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps*, for St. Lucie Units 1 and 2 is attached.

By letter (L-97-277) dated November 4, 1997, FPL proposed to provide the requested information by March 31, 1998. This date was based on the scheduled completion of the Unit 1 steam generator replacement outage. During a conference call on December 12, 1997, the NRC requested FPL to expedite the response schedule. By letter dated December 18, 1997, the NRC agreed that February 6, 1998, was an acceptable schedule for the response.

The attached 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).

Please contact us if there are any questions about this submittal.

11

Very truly yours,

A076

J. A. Stall  
Vice President  
St. Lucie Plant

JAS/GRM

Attachment 110033

cc: Regional Administrator, Region II, USNRC  
Senior Resident Inspector, USNRC, St. Lucie Plant

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STATE OF FLORIDA     )  
                                  )  
COUNTY OF ST. LUCIE )     ss.

J. A. Stall being first duly sworn, deposes and says:


That he is Vice President, St. Lucie Plant, for the Nuclear Division of Florida Power & 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.

  
\_\_\_\_\_  
J. A. Stall

STATE OF FLORIDA  
COUNTY OF ST. LUCIE

Sworn to and subscribed before me  
this 4th day of February, 1998  
by J. A. Stall, who is personally known to me.

  
\_\_\_\_\_  
Name of Notary Public - State of Florida

 Leslie J. Whitwell  
MY COMMISSION # CC646183 EXPIRES  
May 12, 2001  
BONDED THRU TROY FAIR INSURANCE, INC.

\_\_\_\_\_  
(Print, type or stamp Commissioned Name of Notary Public)

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## Background

The emergency core cooling system (ECCS) and containment spray system (CSS) inject borated water from the refueling water tank (RWT) to the reactor core and the containment (i.e., injection mode) following design basis accidents. In the case of loss-of-coolant-accidents (LOCA), the ECCS and CSS could also be aligned to take suction from the containment recirculation sump (i.e., recirculation mode) for long term core and containment cooling. Two independent recirculation flow paths from the containment sump are provided, each supplying one high pressure safety injection (HPSI) pump, one containment spray (CS) pump, and one low pressure safety injection (LPSI) pump. Although Unit 1 was originally equipped with three HPSI pumps, the third pump has been removed from service. Operation of the ECCS and CSS in the recirculation mode is not required following a main steam line break (MSLB) accident as a loss of primary system water inventory does not occur. As St. Lucie Unit 1 and Unit 2 vary in system alignments during recirculation, separate discussions are provided below. Further details on ECCS and CSS configurations are provided within the St. Lucie Updated Final Safety Analysis Reports (UFSAR).

### Unit 1 System Configuration:

In the injection mode, all HPSI, LPSI, and CS pumps may be operating. Just prior to the recirculation actuation signal (RAS), the operators open the isolation valves from the outlet of the shutdown cooling heat exchanger to the suction piping for the HPSI pumps. This redirects some CS flow to the suction of the corresponding HPSI pumps per plant emergency operating procedures (EOP). This allows the HPSI pumps to take suction from both the RWT and CS pump discharge. Upon receipt of the RAS, switch over from the injection mode to recirculation mode is automatically initiated. This switch over consists of the opening of the containment sump isolation valves, closing of the RWT suction valves to isolate the RWT, and securing of both LPSI pumps. Upon RAS, the ECCS and CS pumps' minimum flow isolation valves are also closed. Six to ten hours following the initiation of the accident if shutdown cooling cannot be established, one LPSI pump is aligned to enable simultaneous hot leg and cold leg injection.

The system configuration during simultaneous hot leg and cold leg injection is limiting with respect to net positive suction head available (NPSHa) as this would allow a CS pump and a LPSI pump to draw from one of the recirculation flowpaths from the sump. The HPSI pump can take suction from both the sump and the CS pump discharge in the piggyback mode. FPL has examined this configuration for calculating the NPSHa assuming that the HPSI pumps take suction directly from the sump or from the CS pumps. This calculation bounds the recirculation configurations described above. The NPSHa for each pump was calculated and compared to the net positive suction head required (NPSHr) by the pump. The results are summarized in the table that follows.

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PUMP	FLOW	NPSHa	NPSHr
CS Pump	3425-gpm	25.26-ft	10-ft
LPSI Pump	3500-gpm	21.67-ft	14-ft
HPSI Pump	640-gpm	22.1-ft	20-ft
CS Pump (with HPSI Piggybacked)	4165-gpm	24.47-ft	12-ft
LPSI Pump	3500-gpm	21.49-ft	14-ft
HPSI Pump Piggybacked	640-gpm	N/A	N/A

Unit 1 utilizes two wire mesh screens and a trash rack to protect the containment sump. In the containment recirculation sump, an inner box screen consisting of ¼-inch by ¼-inch opening interwoven wire mesh encases each of the recirculation pipe inlet openings. A ½-inch by ½-inch outer screen and horizontal trash racks provide prefiltration and protection for the sump. The pressure loss across the inner screen was recalculated using the higher assumed LPSI flowrates during hot leg injection (3500-gpm vs. 250-gpm specified in the UFSAR), which resulted in increased velocities at the inner screens. Likewise, the pressure loss across the screen also increased and exceeded the 1-ft pressure loss discussed in the Unit 1 UFSAR. Consideration for the higher pressure loss across the sump screen was included in the NPSH calculation.

Although the Unit 1 UFSAR currently does not discuss the above maximum LPSI hot leg injection configuration, a safety evaluation has been prepared which addresses updating the Unit 1 UFSAR. This safety evaluation examined the differences between the UFSAR and the calculated NPSHa and NPSHr values and determined that the NPSHa still exceeds NPSHr for ECCS and CS pumps during recirculation from the sumps. Therefore, the differences in NPSH values reported in the UFSAR from those calculated do not constitute an unreviewed safety question.

**Unit 2 System Configuration:**

As with Unit 1, all Unit 2 HPSI, LPSI and CS pumps may be operating in the injection mode. On RAS, the switch over from the injection mode to recirculation mode is automatically initiated. This switch over consists of opening of the containment sump isolation valves, closing of the RWT suction valves to isolate the RWT, and securing of both LPSI pumps. On RAS, the minimum recirculation flow for the ECCS and CS pumps is automatically isolated. Two to six

hours following the initiation of the accident, both HPSI pumps are aligned to enable simultaneous hot leg and cold leg injection. The LPSI pumps are not restarted during recirculation on Unit 2.

The limiting system configuration for Unit 2 is to have a CS pump and a HPSI pump aligned to take suction from a common recirculation flow path from the sump. FPL has reviewed the applicable design calculations and has determined that adequate NPSH is available to the HPSI pumps. In addition, FPL has determined that adequate NPSH was available from the containment sump to the CS pump at runout. These results are summarized below:

PUMP	FLOW	NPSHa	NPSHr
CS Pump	3600-gpm	23.43-ft	18-ft
LPSI Pump	0-gpm	N/A	N/A
HPSI Pump	685-gpm	24.57-ft	23.5-ft

Unit 2 utilizes a fine mesh screen and a trash rack to protect the containment sump. The 0.090-inch fine mesh screen encases the entire sump. A 0.090-inch divider screen is used to provide separation between the two recirculation pipe inlets. A horizontal trash rack provides prefiltration and protection for the sump. The Unit 2 containment sump was designed to meet Regulatory Guide 1.82<sup>1</sup>. The maximum velocity across the fine mesh screen was calculated to be 0.196-ft/sec which meets the 0.2-ft/sec maximum velocity specified by Regulatory Guide 1.82.

Although the Unit 2 UFSAR currently does not reflect the above values, a safety evaluation has been prepared which addresses updating the Unit 2 UFSAR. This safety evaluation examined the differences between the UFSAR and calculated NPSHa and NPSHr values and determined that the NPSHa still exceeds NPSHr for ECCS and CS pumps during recirculation from the sumps. Therefore, the differences in NPSH values reported in the UFSAR from those calculated do not constitute an unreviewed safety question.

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<sup>1</sup> NRC Regulatory Guide 1.82, *Sumps for Emergency Core Cooling and Containment Spray Systems*, Rev 0.





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Generic Letter 97-04 Information

NRC Request 1:

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

FPL Response 1:

Unit 1

St. Lucie Unit 1 utilizes a box type strainer at the inlet of each of the two containment sump recirculation lines. The strainers contain a fine mesh screen with ¼-inch openings. The flow area available within each of the box strainers is equivalent to twice the cross sectional area of the recirculation pipe. The head loss associated with these strainers was assumed to be less than 1-ft (Table 6.2-9A of the UFSAR). This assumption was based on operation of similar strainers.

FPL recalculated the NPSH available during hot leg injection during recirculation from the containment sump. This calculation conservatively included considerations for increased LPSI flows of up to 3500-gpm during hot leg injection, as opposed to the 250-gpm presently indicated in Table 6.2-9A in the UFSAR. As part of this calculation, the head loss across the sump strainers was also recalculated. The recalculation of the head loss across the strainer assumed 50% screen blockage, a recirculation flowrate of 7665-gpm, and utilized a square edged orifice approach for modeling the screen openings. The hydraulic radius for the open area in the screen was calculated and used as the equivalent diameter for the orifice<sup>2</sup>. The equation<sup>3</sup> used to determine the head loss through the screen follows.

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<sup>2</sup> Crane Technical Paper 410, *Flow of Fluids Through Valves, Fittings, and Pipe*, 24th Edition, Equation 3-35.

<sup>3</sup> Crane Technical Paper 410, *Flow of Fluids Through Valves, Fittings, and Pipe*, 24th Edition, Equation 3-21.

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$$H_L = \frac{Q^2}{(19.65 * d^2 * C)^2}$$

where:  $H_L$  = head loss across an orifice (screen)  
 $Q$  = flowrate  
 $d$  = equivalent diameter  
 $C$  = flow coefficient for orifice

The results of this calculation indicated a head loss of up to 3-ft at the higher assumed recirculation flowrates.

Unit 2:

St. Lucie Unit 2 utilizes a 0.090-inch fine mesh screen in the containment sump to filter sump fluids prior to recirculation through the CS and ECCS pumps. The Unit 2 sump screen was designed in accordance with Regulatory Guide 1.82<sup>4</sup>. An existing calculation demonstrated that with 50% of the sump screen blocked, the velocity of sump fluids across the screen was less than 0.2-ft/sec. Additionally, full scale testing of the Unit 2 containment sump had been performed to evaluate the hydraulic performance of the sump<sup>5</sup>.

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<sup>4</sup> Regulatory Guide 1.82, *Sumps for Emergency Core Cooling and Containment Spray Systems*, Revision 0.

<sup>5</sup> *Performance Evaluation of a Containment Sump at Full Scale* by William W. Durgin prepared by Ebasco Services, Inc., dated September 1982.

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**NPSH Methodology:**

The following methodology was used to calculate the NPSH available to the ECCS and CS pumps: (Table 6.2-9A of the Unit 1 UFSAR and Table 6.2-42 of the Unit 2 UFSAR)

$$\text{NPSH (available)} = P_t - P_v = P_a + P_s + P_e - P_i - P_v - P_b$$

where:       $P_t$  = pressure at pump suction centerline  
               $P_v$  = vapor pressure of pumped water  
               $P_a$  = air pressure  
               $P_s$  = steam pressure  
               $P_e$  = elevation pressure  
               $P_i$  = head loss due to friction in suction piping  
               $P_b$  = head loss due to sump

**NOTE:**      In accordance with NRC Standard Review Plan Section 6.2.2 the containment pressure is assumed equal to the fluid vapor pressure (i.e.,  $P_a + P_s = P_v$ )

Therefore, the equation simplifies to:

$$\text{NPSHa} = P_e - P_i - P_b$$

The elevation pressure is based on the difference in elevation between the minimum height of water in the recirculation sump and the centerline of the respective pumps. The minimum elevation of water in the recirculation sump is 23.49-ft for Unit 1 and 21.42-ft for Unit 2. The suction centerline for the Unit 1 HPSI, LPSI, and CS pumps are at elevations -8.2-ft, -6.91-ft, and -8.44-ft, respectively. The centerline for the Unit 2 HPSI, LPSI, and CS pumps are at elevations -6.63-ft, -6.63-ft, and -6.43-ft, respectively. The head loss due to friction in the suction piping is determined as part of the NPSH calculation. The head loss due to the sump screens was discussed above.

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NRC Request 2:

Identify the required NPSH and the available NPSH.

FPL Response 2:

Unit 1:

PUMP	FLOW		NPSHa		NPSHr	
	UFSAR <sup>1</sup>	Calc/ Anal	UFSAR <sup>1</sup>	Calc/ Anal	UFSAR <sup>1</sup>	Calc/ Anal
CS Pump	3425-gpm	3425-gpm	28.73-ft	25.26-ft	10.0-ft	10-ft
LPSI Pump	250-gpm	3500-gpm	30.7-ft	21.67-ft	20.0-ft	14-ft
HPSI Pump	640-gpm	640-gpm	24.0-ft	22.1-ft	20.0-ft	20-ft
CS Pump (with HPSI Piggybacked)	N/A	4165-gpm	N/A	24.47-ft	N/A	12-ft
LPSI Pump	N/A	3500-gpm	N/A	21.49-ft	N/A	14-ft
HPSI Pump Piggybacked	N/A	640-gpm	N/A	N/A	N/A	N/A

<sup>1</sup> Unit 1 UFSAR Table 6.2-9A

Note: Although the NPSHa and NPSHr values determined by calculation/analysis differ from those in the UFSAR, the results still indicate that  $NPSHa \geq NPSHr$ . Therefore, there is adequate NPSH available to accommodate the ECCS and CS pumps during recirculation from the sump and no unreviewed safety question exists.

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Unit 2:

PUMP	FLOW		NPSHa		NPSHr	
	UFSAR	Calc/ Anal	UFSAR	Calc/ Anal	UFSAR	Calc/ Anal
CS Pump	3560 <sup>2</sup> -gpm	3600-gpm	25.35 <sup>3</sup> -ft	23.43-ft	21.0 <sup>3</sup> -ft	18-ft
LPSI Pump <sup>o</sup>	0-gpm	0-gpm	N/A	N/A <sup>2</sup>	N/A	N/A
HPSI Pump	685 <sup>4</sup> -gpm	685-gpm	23.5 <sup>5</sup> -ft	24.57-ft	19.9 <sup>6</sup> -ft	23.5-ft

<sup>2</sup> Unit 2 UFSAR Section 6.2.2.3.1

<sup>3</sup> Unit 2 UFSAR Table 6.2-42

<sup>4</sup> Unit 2 UFSAR Table 6.3-1

<sup>5</sup> Unit 2 UFSAR Section 6.3.2.2.3

<sup>6</sup> Unit 2 UFSAR Table 6.3-23

Note: Although the NPSHa and NPSHr values determined by calculation/analysis differ from those in the UFSAR, the results still indicate that NPSHa ≥ NPSHr. Therefore, there is adequate NPSH available to accommodate the ECCS and CS pumps during recirculation from the sump and no unreviewed safety question exists.

NRC Request 3:

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

FPL Response 3:

In response to this request FPL reviewed the design basis NPSH analyses for the ECCS and CS pumps and the documented communications with the NRC regarding this issue. Based on this review, no additional NRC Safety Evaluations were identified documenting the specific review of NPSH analyses for ECCS or CS pumps after initial licensing. The most recent design basis information regarding NPSH that was reviewed and approved by the NRC is considered to be that from the original licensing of each St. Lucie unit. The basis for these NPSH analyses and changes follow:

Unit 1:

The original NPSH analysis for ECCS and CS pumps was based on a plant configuration of three HPSI pumps, two LPSI pumps, and two CS pumps on two recirculation trains. The "B" and "C" HPSI pumps were assumed to be on the same recirculation train. The data presented in the UFSAR Table 6.2-9A are from NPSH calculations which assumed both of these HPSI pumps operating on the same train in conjunction with a CS pump and a LPSI pump. The NRC Safety Evaluation for Unit 1 stated the following:

Section 6.2.2:

"The applicant's analysis indicates that sufficient water will have been delivered to the containment at that time [RAS] to provide the required NPSH to the spray pumps. We have examined the information provided by the applicant concerning the available NPSH for the pumps. The system is designed to provide adequate net positive suction head to the system pumps considering the water temperatures and containment pressure calculated being present during the accident. On this basis we conclude that the design is acceptable relative to the intent of Regulatory Guide 1.1."

Section 6.3:

"We have examined the information presented by the applicant concerning the available NPSH for the ECCS pumps. The system is designed to provide adequate net positive suction head to the system pumps considering the water temperatures and containment pressure calculated being present during the accident. On this basis we conclude that the design is acceptable relative to the intent of Regulatory Guide 1.1."

Subsequent to this, the "C" HPSI pump was removed from service. Although NPSH calculations were performed evaluating this change, the NPSH summary presented in Table 6.2-9A was not revised since the reduction in the number of pumps actually increased the NPSH margin and was, therefore, conservative. A notation was added to Table 6.2-9A to reflect this change.

During review of procedures implementing post-LOCA recirculation and hot leg injection, it was noted that LPSI flowrates procedurally allowed range from 250-gpm up to an assumed 3500-gpm. Based on this, a NPSH calculation was performed which demonstrated that adequate NPSH was available to satisfy the NPSH required for the CS,





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HPSI, and LPSI pumps. A safety evaluation was prepared to update the Unit 1 UFSAR to reflect the results of this calculation.

**Unit 2:**

The original NPSH analysis for ECCS and CS pumps was based on a plant configuration of two HPSI pumps and two CS pumps on two recirculation trains. The data presented in the Unit 2 UFSAR are consistent with the NPSH calculations performed. The NRC Safety Evaluation Report (SER) for Unit 2 stated the following:

**Section 6.2.2:**

“Sufficient net positive suction head (NPSH) will be available to the spray pumps for both the injection and recirculation mode of operation. The applicant’s evaluation of the available NPSH is consistent with the guidelines of Regulatory Guide 1.1, *Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps*, and is acceptable.”

**Section 6.3.2:**

“The applicant has compared the required ECCS pump NPSH as supplied by the manufacturer with the calculated available NPSH and determined that the available NPSH for the LPSI pumps exceeds the required NPSH.”

The adequacy of the NPSH available for the HPSI pumps was not specifically addressed within this NRC SER.

Other than the correction of minor discrepancies, there has been no change in the NPSH analyses for the Unit 2 ECCS and CS pumps.

**NRC request 4:**

Specify whether containment overpressure was credited in the calculation of available NPSH. Specify the amount of overpressure needed and the minimum overpressure available.

**FPL Response 4:**

Containment overpressure was not credited for either St. Lucie Unit 1 or Unit 2. The containment pressure is assumed to be equal to the saturation pressure of the containment

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sump water. As such, the containment pressure term and sump saturation pressure term would cancel as prescribed in Regulatory Guide 1.1<sup>6</sup>.

NRC Request :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.

FPL Response 5:

Containment overpressure was not credited for either Unit 1 or Unit 2. Therefore, this question is not applicable to St. Lucie Units 1 and 2.

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<sup>6</sup>

Regulatory Guide 1.1, *Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps.*