FPL

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April 22, 2009

L-2009-084
10 CFR 50.54(f)

U. S. Nuclear Regulatory Commission
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Florida Power & Light Company
St. Lucie Unit 1
Docket No. 50-335

Subject: Response to the NRC's Request for Additional Information

References:

(1) Letter from S. P. Lingam (U. S. Nuclear Regulatory Commission) to M. Nazar (FPL), "St. Lucie Unit 1 – Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," Request for Additional Information" January 22, 2009 (TAC NO. MC4710)

(2) Letter L-2008-030 from G. L. Johnston, (FPL) to U. S. Nuclear Regulatory Commission, "Supplemental Response to NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated February 27, 2008 (ML083658978)

(3) Letter L-2008-137 from G. L. Johnston, (FPL) to U. S. Nuclear Regulatory Commission, "Supplemental Response to NRC Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated June 30, 2008 (ML081840513)

(4) Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004

This submittal provides the Florida Power and Light Company (FPL) responses to the U. S. Nuclear Regulatory Commission's (NRC) request for additional information (RAI) (Reference 1) regarding our Supplemental Information provided previously (References 2 and 3) on the subject of the NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (Reference 4).

Attachment 1 provides the responses for St. Lucie Unit 1 to the request for additional information. This information is being provided in accordance with 10 CFR 50.54(f).

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During the development of these RAI responses, FPL discovered a discrepancy with the containment water level calculation with respect to the amount of water vapor suspended in the post LOCA containment atmosphere. The potential impact on the containment pool level is on the order of 1.6 inches and does not significantly impact sump strainer performance. This issue has been entered into the St. Lucie corrective action program.

Please contact Mr. Ken Frehafer, at (772) 467-7748, if you have any questions regarding this response.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on April 22, 2009.

Sincerely yours,

Gordon L. Johnston
Site Vice President
St. Lucie Plant

Attachment: (1)

Attachment 1

St. Lucie Unit 1

Individual Responses to the NRC's RAIs for FPL Generic Letter 2004-02 Supplemental Responses, Dated 02/27/2008 and 06/30/2008

Introduction

Overview of St. Lucie Unit 1 Conservatisms:

In Florida Power & Light Company's (FPL's) St. Lucie Unit 1 Supplemental response of June 30, 2008, FPL summarized some of the actions and analyses that provided conservatism and margin to St. Lucie Unit 1 compliance with Generic Letter 2004-02. These included:

- The surface area for the recirculation sump screens was increased from approximately 24 ft^2 to 8275 ft^2. The replacement strainers have been manufactured by General Electric and have a nominal hole size of 0.0625 inch compared to the previous screens' openings of ¼ inch mesh size. These strainers are distributed around 260 degrees of containment which effectively lowers the approach velocities to the replacement strainers.

- In the debris generation analysis, the zone of influence (ZOI) used for Nukon Insulation is 17.0D. WCAP-16710-P testing confirmed that the ZOI could be reduced to 5D. As such, the strainer system was qualified utilizing a quantity of fiber that is significantly greater than is expected to be generated.

- A uniform factor of 1.1 has been applied to the ZOI radius to ensure the calculation was conservative.

- 100% of the Calcium Silicate (Cal-Sil) generated is assumed to transport to the strainers.

- Irrespective of the conservatively high quantity of fiber considered, debris head loss testing iterations at various bed thicknesses determined the highest head loss fiber quantity for the ultimate strainer design and hydraulic analysis.

- In the transport analysis, 100% of unqualified coatings, regardless of types and location inside containment, were assumed to fail as particulates and transport to the screen. Electric Power Research Institute (EPRI) and industry testing indicates some unqualified coatings do not fail and some coatings fail as chips and may not transport to the sump.

- The near-field effect was not credited in the debris head loss testing or for the debris transport analysis. The steps taken to minimize near-field effects in the head loss tests included placing the flow return near the bottom of the test tank to help suspend debris and using motor driven agitators to ensure that debris remained suspended. This maximized the amount of debris on the screen and provided very conservative head loss results.

- The St. Lucie Unit 1 strainer design does not credit debris transport holdup within containment due to residue on walls or floors, hold-up to due to curb effects or due to trapped volumes or pools. With the exception of fiber, 100% of the debris is assumed to transport to the strainers. For the case of fiber, St. Lucie Unit 1 head loss testing demonstrated that a reduced fiber debris load provided the highest head loss case.

- For the downstream effects wear analysis, the total debris load was determined for a bounding large break loss-of-coolant accident (LBLOCA) in accordance with Nuclear Energy Institute (NEI) 04-07. A minimum sump water volume for recirculation was determined for a small break loss-of-coolant accident (SBLOCA) to maximize the debris concentration in containment. All debris was assumed to be in the sump pool and eroded (to the extent it would be after 30 days) at the start of recirculation.

- A design flow rate of 8530 gpm is conservatively assumed to apply for the entire duration of the event. However, this flow rate includes an operating low pressure safety injection (LPSI) pump and is based on the simultaneous hot and cold leg recirculation mode, which is not initiated until 4 to 6 hours into the event by the supply of LPSI flow. Additionally, it is expected that one train would be secured at some time in the event when decay heat and pool temperature is reduced. This reduction in flow would be expected to reduce the head loss across the strainer and, together with reduced pool temperature, vastly increase the net positive suction head (NPSH) margin.

The following responses to the NRC's RAIs provide another opportunity to discuss, in more detail, St. Lucie Unit 1 analyses, test results, and conservatisms. This is intended to facilitate NRC's review and conclusion that the St. Lucie Unit 1 design and analyses are conservative, and demonstrate that there is sufficient emergency core cooling system (ECCS) NPSH margin available as required by Generic Letter 2004-02.

Responses to the NRC's RAIs Contained in the NRC's January 22, 2009 Letter.

RAI–1: Identify the size jet used in the testing documented in WCAP-16851-P and describe the comparability of the demonstrated destruction zone of influence with what would be expected with the large diameter jets that could occur with a large break loss-of-coolant accident (LOCA). At issue, in part, is that the radial decay of pressure for a small size nozzle will occur much more rapidly (particularly at close range) than for a ruptured reactor coolant system pipe.

RAI–1 RESPONSE: FPL is a participant in the Westinghouse pressurized water reactor (PWR) Owner's Group Initiative that is authorized to address this industry generic RAI. Upon completion of the Westinghouse analyses, FPL shall submit the results to the NRC when they become available.

RAI-2: Page 13 of the supplemental response dated June 30, 2008, states that the fiberglass debris used for head loss testing was assumed to be divided into a two category size distribution: (1) large pieces sized 6"x3"x1" and (2) small pieces sized 1"x1"x1". Page 16 of this same submittal indicates that 40% of the fiberglass is considered to be large pieces, and 60% is considered to be small pieces. However, the staff's review could not identify information as to the quantity of individual fibrous fines assumed to be generated during a LOCA. Provide this information to the staff and also provide a technical basis for any debris characteristics assumptions that were made but that are not consistent with approved guidance in the Nuclear Regulatory Commission (NRC) staff's approved safety evaluation on Nuclear Energy Institute document (NEI) 04-07.

RAI-2 RESPONSE:

For testing conducted for St. Lucie Unit 1 strainers described in the supplemental response, Topic 3.f: Head Loss and Vortexing, Transco thermal wrap, purchased from Transco with an as-manufactured density of 2.4 lbm/ft^3, was used to simulate Nukon fibrous insulation, thermal wrap insulation, and latent fiber. It was shredded by the manufacturer following procedures based on NEDO-32686-A. This was to achieve small fiber. All testing utilized only this shredded fiber.

The size distribution assumed for St. Lucie Unit 1 is provided in Table 2-1.

Table 2-1: Size Distribution of Debris from Inside the ZOI

Debris Source Material (Type)	Debris Size Distribution – Inside the ZOI	
	Small Pieces	**Large Pieces**
Thermal Wrap / Nukon Insulation (Fiber Blankets) (Fibrous)	60%	40%
Thermal Wrap/Nukon 1366.6 ft^3	819.96	546.64

Note that the above information is provided for the original head loss testing. As previously stated, FPL is performing additional testing and will provide the results as committed.

Therefore, the technical basis for debris characteristics assumptions is consistent with approved guidance in the NRC staff's approved safety evaluation of NEI 04-07, Table 3-3 for 60% small fines and 40% large pieces.

RAI-3: The debris characteristics discussion in the supplemental response dated June 30, 2008, provided neither a debris size distribution nor size characteristics for calcium silicate debris, as was requested in the NRC's Revised Content Guide. Provide the assumed debris size distribution and characteristic sizes of the debris pieces for calcium silicate debris generated during a LOCA. Provide a technical basis for any debris characteristics assumptions were made but that are not consistent with approved guidance in the NRC staff's approved safety evaluation on NEI 04-07.

RAI-3 RESPONSE: For testing conducted for St. Lucie Unit 1 strainers described in the supplemental response, Topic 3.f: Head Loss and Vortexing, Thermo 12 Gold Cal-Sil made by Industrial Insulation Group and supplied by Insulation Materials Corporation was used. The Cal-Sil was mechanically pulverized and sifted through a 0.1" by 0.1" screen, following procedures based on NEDO-32686-A. This was to achieve small fine particulate.

Subsequently, additional large flume testing was performed based on similar size characteristics. The size distribution of Cal-Sil was assumed to be 100% small fines.

References to small fines and large pieces correspond to those categories as listed in Table 3-3 of the NRC NEI 04-07 Safety Evaluation.

Debris Source Material (Type)	Debris Size Distribution – Inside the ZOI	
	Small Fines	Large Pieces
Cal-Sil Insulation (Particulates)	100%	--

Table 3-1: Size Distribution of Debris from Inside the ZOI

Cal-Sil powder is used for the entire allocation of scaled transportable Cal-Sil for head loss testing to represent small fine particulate.

The debris loads for St Lucie Unit 1 are provided in the FPL Debris Generation calculation. Break S1 is the bounding break for all debris types. The Cal-Sil load for that break is shown in Table 3-2.

Debris Type	Units	Total	Small	Large
Cal-Sil	ft^3	91.1	91.1	0.0

Table 3-2: Quantity of Debris from Inside the ZOI

Therefore, the technical basis for debris characteristics assumptions is consistent with approved guidance in the NRC staff's approved safety evaluation on NEI 04-07, Table 3-3 for 100% small fines for Cal-Sil.

RAI-4: Describe the statistical methodology used to compute the sample mass used in the estimates of total latent debris mass.

RAI-4 RESPONSE: As described in Topic 3.d, Latent Debris, of the FPL supplementary submittal, the latent debris information is based on walkdowns performed on St. Lucie Unit 2.

The calculation of latent debris derived a conservative estimate of the total mass of latent debris inside the St. Lucie Unit 1 containment based on the postulated events set forth in generic safety issue (GSI)-191. The derivation was based on the observation and measurement of dust and lint inside the St. Lucie Unit 2 containment. A containment walkdown was performed to collect latent debris samples from the plant surfaces listed in Table 4-1 below. As stated within section 3.5.2.2 of the NRC safety evaluation report of NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology", Volume 2, Revision 0, December 6, 2004, a minimum of three (3) samples of each surface type were required. However, to conservatively increase statistical sampling accuracy and to provide redundancy for discrepant samples, a minimum of four (4) samples were collected from each surface type. A total of forty eight (48) samples were collected.

Plant Surface Types
Horizontal concrete surfaces (floors) Vertical concrete surfaces (walls) Grated surfaces at support beams Containment liner (vertical) Cable trays (vertical) Cable trays (horizontal) Horizontal equipment surfaces (heat exchangers, air coolers, etc.) Vertical equipment surfaces (steam generators, air coolers, pressurizer, etc.) Horizontal heating, ventilation, and air conditioning (HVAC) duct surfaces Vertical HVAC duct surfaces Horizontal piping surfaces Vertical piping surfaces (pipes running vertically)

In probability and statistics, the t-distribution or Student's t-distribution is a probability distribution function used for conservatively estimating the mean of a normally distributed population when the sample size is by necessity small compared to the population size. The t-distribution methodology successfully solves the mathematical problems associated with inference based on small samples where the calculated mean (x_m) and calculated standard deviation (s) may by chance deviate from the actual mean and actual standard deviation (i.e., what you would measure if you had many more data items: a larger number of samples). As a result, the t-distribution statistical approach is best suited for conservative derivation of the amount of latent debris that has accumulated in the containment.

An upper tailed t-distribution value of 1.638 for a 90% confidence level was selected and used for statistical evaluation of each containment surface type containing four (4) samples.

Selection of the 90% confidence level upper tailed t-distribution values cited above is technically robust and appropriate for this application based on the walkdown team's inspection and observation that each containment surface type appeared to have a normal distribution of dirt and lint. Additionally, each sample location was randomly selected by the inspection team.

The debris sample data was analyzed to estimate the total latent debris mass. The samples were grouped by surface type (i.e., vertical equipment, horizontal cable tray, etc.). These represent random samples (n) of the total population of areas. The sample mean (x_m) and the sample standard deviation (s) were determined for the debris mass found per unit area.

$$x_m = \sum x_i / n \qquad \text{(Eq. 4-1)}$$

$$s^2 = [\, 1 / (n-1) \,] * [\, \sum x_i^2 - (\, \sum x_i)^2 / n \,] \qquad \text{(Eq. 4-2)}$$

Where: x_m is the mean for a group of samples (gm/ft^2)
x_i is the individual mass per area (gm/ft^2)
n is the number of samples in the group
s is the sample standard deviation

Assuming the latent debris (dust and lint) were normally distributed as indicated by observation, and the number of samples is small relative to the total population, an upper limit on the mean debris loading (u_{ul}) was determined from the t-distribution. Use of the 90% confidence level means there is a 90% probability that the actual mean latent debris loading (u) is less than or equal to u_{ul}.

$$x_m - t_{ul} * s * (n)^{-1/2} < u < x_m + t_{ul} * s * (n)^{-1/2}$$

$$u_{ul} = x_m + t_{ul} * [\, s * (n)^{-1/2} \,] \qquad \text{(Eq. 4-3)}$$

Where: t_{ul} is the upper-tailed t-distribution value at 90% confidence for sample size n
u_{ul} is the upper limit on the mean debris loading at 90% confidence (gm/ft^2)

To estimate the total debris mass for a surface type, u_{ul} is multiplied by the total area for that surface type. The total latent debris mass is then the sum of the derived values for each surface type.

RAI-5: Provide the accuracy of the individual sample mass measurements and the influence of the uncertainty on the total computed mass of latent debris.

RAI-5 RESPONSE: St. Lucie Unit 1 and St. Lucie Unit 2 are of similar design. As described in Topic 3.d, Latent Debris, of the FPL supplementary submittal, the latent debris information is based on walkdowns performed on St. Lucie Unit 2.

Sample Mass Measurement Accuracy

The walkdown plan specified that a scale with an accuracy of at least 0.1 grams was to be used to measure the weight of each latent debris sample. The actual scale accuracy was determined to be 0.0004 grams.

Influence of the Uncertainty in the Samples

Masslin cloths were used to obtain the latent debris samples. Plastic bags were used to store the Masslin cloths with each latent debris sample. Prior to the walkdown, the mass of each plastic bag with the Masslin cloth inside was measured. Following the walkdown, the mass of each sample (plastic bag with Masslin cloth and latent debris) was measured utilizing the same scale that was used for the pre-walkdown measurements. Each latent debris sample mass was obtained by taking the difference between the post-walkdown and pre-walkdown sample masses.

The uncertainty associated with the difference of two values is equal to the sum of the uncertainties associated with each value. The minimum latent debris sample mass was 0.05 grams. Based on a scale accuracy of 0.0004 grams, the maximum data uncertainty is estimated to be less than 1.6%. The average data uncertainty is estimated to be less than 0.2%.

RAI-6: Describe in more detail the methodology used to estimate the total area of tapes, stickers, and miscellaneous debris. Include any assumptions that would reduce the quantity of material transported to the sump screen.

RAI-6 RESPONSE:

Miscellaneous Debris Methodology

As described in Topic 3.d, Latent Debris, of the FPL supplementary submittal, the foreign debris information for St. Lucie Unit 1 is based on walkdowns performed on St. Lucie Unit 2.

St. Lucie Unit 1 and St. Lucie Unit 2 are of similar design. The internal containment horizontal and vertical surfaces are similar. The procedures for containment close out and the organizations who perform these procedures are the same. For foreign debris, the procedures for labeling and lights are similar between St. Lucie Unit 1 and St. Lucie Unit 2. Therefore, the foreign debris for St. Lucie Unit 1 used the St. Lucie Unit 2 total plus 25% to account for any discrepancies.

The containment walkdowns were performed to identify and measure plant labels, stickers, tape, tags, and other debris in accordance with the guidelines in the walkdown plan. Equipment tags located in containment will become debris, unless they are located outside the ZOI of the postulated pipe break and are qualified for the post LBLOCA environment. Therefore, post LBLOCA qualified equipment tags located outside the ZOI (attached by wire, threaded fastener, rivets or qualified tie wraps) are not counted as debris.

Accessible containment areas were examined during the walkdown. Stickers, labels and other debris were quantified, measured and recorded on the foreign material record sheets. All miscellaneous or non-recurring items were captured individually. Several types of labels and stickers were found consistently on certain plant structures and equipment throughout containment and were measured. The total number of light bulbs in containment lighting was established by drawings, specifications or equipment lists as applicable.

It was observed that many items, such as junction boxes, conduits, and cable trays were marked with paint rather than a label or sticker and therefore will not create any foreign debris. Other items such as post LBLOCA qualified conduit labels (metal tags attached by metal wire or rivets) will not become debris following a GSI-191 pipe break unless they are located in the ZOI. The specific items that could potentially become foreign debris are discussed below.

Light Bulbs

Lighting is located throughout containment and primarily consists of a metal fixture that is a hemisphere opening toward the floor containing a light bulb enclosed by a protective heavy glass cylinder. The light bulbs are standard industrial size and were modeled as a 4" diameter sphere. The protective glass covering was conservatively modeled as an open-end cylinder that is 8" long with a 4.5" diameter hemisphere. The metal fixtures will not be affected by containment spray or elevated containment pressure during a GSI-191 event and will not become transportable debris due to a pipe break. Light bulbs can potentially break and become debris during post LBLOCA conditions due to the increased pressure inside containment.

However, the protective glass cylinder enclosures will not break due to elevated containment pressure because they are not air tight (elevated containment pressure will equalize across the inner and outer glass surfaces). As a result, the protective light bulb glass enclosures will capture and contain any broken or shattered light bulb glass. However, containment lighting located in the ZOI will break and potentially contribute debris loading to the containment sump. Conservative evaluation of plant lighting in the ZOI at the 18 ft elevation of containment (including platforms in this location) determined that 34 plant lights could become debris during a GSI-191 event.

Adhesive

Adhesive residue was found at numerous locations throughout the plant. Based on walkdown observations and discussion with plant personnel, a significant number of various signs have been removed inside containment with adhesive residue remaining behind in many areas. The adhesive is usually very thin and 1/32" was used as the adhesive thickness to determine the total volume of adhesive (except for ten (10) 10" x 0.75" patches of adhesive found on containment walls at elevation 62 ft - 0"). It was conservatively assumed that all adhesive will become debris during LBLOCA conditions.

Equipment Tags

Equipment inside St. Lucie Unit 2 containment is labeled with a 4" x 2.25" hard plastic tag. The tag is attached to equipment by metal wire. Equipment tags attached by metal wire will not become debris outside the ZOI. Equipment tags that are within the ZOI will become debris during a LBLOCA. As a result, equipment tags were counted in the ZOI of one loop (Loop B) to determine the total number of equipment tags that would become debris during a LBLOCA. A total of approximately thirty five (35) tags were counted in the ZOI. For conservatism, fifty (50) was used as the total number of equipment tags that will become debris inside the ZOI during a LBLOCA.

Miscellaneous

Tape and stickers are located throughout containment and were individually counted during the walkdown.

Results

Containment foreign material debris totals were tabulated. These materials are assumed to become available for transport to the containment sump during a postulated LBLOCA. A 10% margin was added to the label, sticker, tape, placards, etc. total to account for areas of containment that were inaccessible during the walkdown due to high dose rate or ongoing work activities. An additional 25% of miscellaneous debris was added to the St. Lucie Unit 2 values in order to account for differences between St. Lucie Unit 2 and St. Lucie Unit 1.

Material Transport Assumptions

No assumptions were made that would reduce the quantity of foreign debris material transported to the sump screen. However, this may change. On October 29, 2008, FPL requested an extension of the completion date of the St. Lucie Unit 1 NRC Generic Letter 2004-

02 actions until July 30, 2009. In this extension request, FPL indicated that the following new activities would be performed:

- Conservatisms in input parameters and the base analysis would be reviewed,
- Methods to reduce debris loads (e.g., insulation replacement) would be identified in order to develop scenarios for "test for success,"
- Perform testing. This testing will include contingency debris and chemical load tests to achieve acceptable results (test for success), and
- Revise calculations and analyses.

These new activities include performing a debris transport analysis, which could potentially change the miscellaneous debris transport assumptions. The results of this transport analysis will be provided in the July 30, 2009 supplemental submittal.

RAI-7: The staff considers the technical basis supporting the transport fraction of 0.3417 calculated for Nukon and Thermal Wrap fibrous debris to lack an adequate supporting technical basis. The method used by the licensee appears to be a simplified hand calculation that is a variation on the nodal network approach that was considered reasonable by the safety evaluation (SE) on NEI 04-07 only if supported by experimental data. The transport methodology used for St. Lucie Unit 1 is not consistent with the approved guidance on debris transport in the SE on NEI 04-07, and the technical basis provided in the supplemental response is not adequate to justify the alternate approach (hand calculation) chosen. Address the following staff concerns:

a. It is unclear how blowdown, washdown, and pool-fill transport were analyzed.

b. The supplemental response identifies only three distinct velocities in the entire containment pool: 0.113 ft/s inside the bioshield, 0.14 ft/s for 26.4% of the area outside the bioshield and 0.07 ft/s for the other 73.6% of the area outside the bioshield. The resolution (number of nodes in the licensee's calculation) does not appear sufficiently fine to provide a prototypical or conservative representation of actual flows in the containment pool.

c. Based on the information provided, it is unclear how 20.6% of the sump pool was calculated to be a "turbulent zone" for large pieces and 30.6% was calculated to be a "turbulent zone" for small pieces. Furthermore, it is not clear that turbulence is the controlling parameter for the tumbling of small and large pieces of debris across the containment floor (e.g., versus velocity), or how a hand calculation can provide a reasonable estimate of the turbulence in the containment pool.

d. It is unclear how the kinetic energy of the break flow and containment sprays was modeled. This flow splashing down into the containment pool can have a significant impact on the velocity and turbulence distributions in the containment pool. For St. Lucie Unit 1 the licensee assumed uniform containment spray drainage. However, the drainage from containment sprays frequently is not at the containment pool elevation due to non-uniformities in the structures at higher elevations that can result in concentrated drainage (e.g., refueling canal drains, hatch openings, gaps in curbs, etc.).

e. The calculation appears to assume that all flow enters the physically nearest strainer module. This assumption is not likely to be valid for modules nearest the bioshield exits carrying the majority of the break flow (note that many licensees have seen significant tangential velocity components or swirling flow patterns near such modules). Neglecting tangential or swirling flow patterns leads to an under-prediction of the velocities throughout the containment pool and local to the strainer modules. Furthermore, without internal strainer flow control, it is not clear that modules nearest the sump suction pipes would not preferentially draw flow, particularly in light of the potential for the clean strainer head losses to result in non-uniform flow.

f. No experimental data was provided to support the simplified analytical hand calculations.

RAI-7 RESPONSE: This RAI is based on information provided to the NRC on June 30, 2008 by FPL in the supplemental response to NRC Generic Letter 2004-02, Potential Impact of Debris

Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors. Subsequently, on October 29, 2008, FPL requested an extension of the completion date of the St. Lucie Unit 1 NRC Generic Letter 2004-02 actions until July 30, 2009. In this extension request, FPL indicated that the following new activities would be performed:

- Conservatisms in input parameters and the base analysis would be reviewed,
- Methods to reduce debris loads (e.g., insulation replacement) would be identified in order to develop scenarios for "test for success,"
- Perform testing. This testing will include contingency debris and chemical load tests to achieve acceptable results (test for success), and
- Revise calculations and analyses.

Providing a response to this RAI at this time would not be pertinent or informative because of these new activities. The information requested in this RAI will be provided in the July 30, 2009 supplemental submittal. Completion of these new activities will provide the technical basis for the transport of fibrous debris.

RAI-8: Provide the following additional information needed to support the assumption of 10% erosion of fibrous debris in the containment pool:

a. Demonstrate the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fiberglass material present in the erosion tests to the corresponding conditions applicable to St. Lucie Unit 1.

RAI-8a RESPONSE: Fiber erosion testing was performed by and documented in a final test report. This test conservatively determined a 10% erosion of fibrous debris in the containment pool over thirty days. The "St. Lucie Low Density Fiberglass (LDFG) Debris Erosion Testing Report," compared the testing performed to specific St. Lucie Unit 1 fiberglass insulation materials, and flow conditions and concluded that the testing conservatively bounded the St. Lucie Unit 1 design parameters.

The testing utilized Nukon, a low-density fiberglass insulation material manufactured by Performance Contracting, Inc. (PCI). The insulation was procured in large sheets and cut and/or shredded in order to accommodate any particular use. Two sizes of Nukon LDFG insulation were tested: Large samples measuring 6" x 3" x 1" weighing approximately 10 to 20 grams per sample, and small samples in which each sample was a collection of 8-12 clumps of 1" x 1" x 1" shredded fiberglass weighing approximately 4 to 6 grams total per sample. These small clumps that formed the sample were arranged such that each clump would be exposed to the same flow rate.

After the formation of each sample, they were boiled in tap water for over 10 minutes in order to remove the binder. Such boiling envelopes the conditions that the fiber would undergo during the blow down and recirculation phases of post-LBLOCA responses at St. Lucie Unit 1. The erosion tests were conducted at room temperature, and this temperature was recorded with each data point. The increased post-LBLOCA water temperature at St. Lucie Unit 1 would have little effect on the flow erosion of fiberglass with respect to water density and viscosity differences. The lack of containment recirculation chemicals and neutral pH of the tap water would also have little effect on the flow erosion mechanism. Chemicals such as aluminum that would be present in containment would actually coagulate on the fibers and increase the weight of the fiber pieces as opposed to aiding its erosion.

Erosion tests were performed at a flow velocity that is equal to the incipient tumbling velocity for the specific size of LDFG. These flow velocities were 0.37 ft/s for large sample pieces and 0.12 ft/s for the small sample pieces. Since the incipient tumbling velocity is the velocity at which the debris would start moving, this velocity bounds the greatest velocity that a piece of insulation lying in the containment pool would experience without being carried to the sump strainer. It also bounds any lesser flows that might be found in the St. Lucie Unit 1 pool. Therefore, it is considered the velocity that would produce the most insulation fines that would travel to the sump strainer while the piece of insulation itself would remain stationary in the pool.

St. Lucie Unit 1 contains Nukon and thermal wrap insulation. The test used Nukon samples of the same density as the St. Lucie Unit 1 Nukon and thermal wrap low LDFG materials. Based on this density similarity, Nukon served as the surrogate for erosion testing for these materials.

Conclusion: The erosion test results based on incipient tumbling velocity are conservative for

St. Lucie Unit 1 because incipient tumbling velocities are greater than actual flow characteristics for significant amounts of fiberglass insulation.

RAI-8: Provide the following additional information needed to support the assumption of 10% erosion of fibrous debris in the containment pool:

b. Identify the length of the erosion tests and how the results were extrapolated to the sump performance mission time.

RAI-8b RESPONSE: The small Nukon samples generally eroded more than the large samples, despite the large samples undergoing a higher flow velocity. The highest large sample erosion value of approximately 6% at 48 hours is approximately the average of the small samples for all erosion durations. The extra large sample (6" x 6" x 1") flow eroded at a velocity of 0.37 ft/s also eroded less than the large and small samples for the corresponding duration—2.35% of initial weight compared to an average of 4.32% and 4.48% for large and small samples at 8 hours, respectively. Small samples erode more weight due to the increased surface area and the preparation by shredding, which produces more fines available for flow erosion. Because the small samples eroded more than the large samples, the analysis of the data only considered the small samples. This method of data analysis yielded the most conservative fiber erosion results and the higher results for the small size samples were conservatively applied to all of the fiber, large and small.

Tests were performed for a variety of durations both in vertical test loop and test flume configurations. Durations included were from 2 to 737 hours. No extrapolations were performed since percent mass changes for longest durations were not necessarily the largest. To be conservative, all of the larger percent mass changes were included in the evaluation, regardless of duration.

Because the erosion of LDFG has yielded scattered results across all erosion time durations, a reasonable supposition was to hypothesize that the erosion is not directly time-dependent, and can be accurately described by averaging all of the erosion values against one another to reach an erosion value. After 737 hours of erosion, all of the fiber pieces or fines that will wash off at the constant 0.12 ft/s flow velocity already have eroded. To find an appropriate erosion value for all small fiber pieces, the average of all small sample erosion data will be applicable to a 30 day mission time.

The average of the weight loss values of the tests is 5.93% ±4.37% of initial weight using root mean square (RMS) error analysis versus the calculated average. This averaging methodology estimates that the fiber erosion rate at 30 days can be conservatively estimated as 5.93% + 4.37% ≈ 10% of initial fiber weight. The attrition/erosion mechanism that strips away the loose pieces of LDFG via flowing water would reduce an initial amount of fiber by 10% over 30 days.

RAI-8: Provide the following additional information needed to support the assumption of 10% erosion of fibrous debris in the containment pool:

c. Clarify how the erosion test results were applied for the different "zones" or computational nodes in the containment pool that were assigned in the transport calculation.

RAI-8c RESPONSE: Erosion tests were performed at a flow velocity that is equal to the incipient tumbling velocity for the specific size. These flow velocities are 0.37 ft/s for large sample pieces and 0.12 ft/s for the small sample pieces. Since the incipient tumbling velocity is the velocity at which the debris would start moving, this velocity bounds the greatest velocity that a piece of insulation lying in the containment pool would experience without being carried to the sump strainer. Therefore, it is considered the velocity that would produce the most insulation fines that would travel to the sump strainer while the piece of insulation itself would remain stationary in the pool. The 10% erosion is conservatively based on this maximum incipient tumbling velocity on a continuous basis for the entire mission time for all of the fiberglass insulation that can erode.

Accordingly, it is not necessary to apply the erosion test results for the different "zones" or computational nodes in the containment pool that are assigned in transport calculations, past or future. Transport calculations arrive at an array of velocities for the containment pool whereas the erosion analysis conservatively assumed a continuous maximum incipient tumbling velocity to exist throughout the mission time for the purposes of bounding calculated flow and the maximum fiber erosion/depletion.

RAI-9: Identify whether the debris transport analysis considers the flow rate from a low pressure safety injection (LPSI) pump that fails to trip following switchover. If it does not, then provide the basis for concluding that a single failure of a LPSI pump to trip can be mitigated immediately after switchover during the high-stress period immediately following a LOCA, and that, therefore, the LPSI pump failure to trip flow regime need not be considered. The staff notes that, although the flow from a LPSI pump was analyzed in hot-leg recirculation mode, the LPSI pump flow rate for the hot-leg configuration appears to be significantly lower than for a single LPSI pump that fails to trip following switchover.

RAI-9 RESPONSE: In the design flow case for head loss and NPSH analysis, additional lower LPSI pump flow in the hot leg recirculation mode is considered for conservatism throughout the mission time. In addition, the increased flow due to an operating LPSI pump (failed to trip) at full flow in the cold leg recirculation mode has been considered in the head loss calculation and NPSH analysis. The full additional flow from a LPSI pump failure to trip will also be incorporated into any further testing and transport analysis.

In the unlikely event of a LPSI pump failure to trip on recirculation actuation signal (RAS), the additional flow would be break flow rather than spray flow which is conservative for debris transport. However, for St. Lucie Unit 1, the amount of break flow did not impact debris transport in the current analyses because all debris except for fiber was assumed to transport to the screens. In the case of fiber, testing demonstrated that an amount of fiber much less than the maximum generated yielded the greatest head losses. The highest test head losses were utilized for the NPSH analysis.

The original St. Lucie Unit 1 strainer testing report contains plots of strainer head loss as a function of time for all of the tests conducted. Tests of limiting conditions for the St. Lucie Unit 1 design demonstrate that significant head loss due to debris was not accumulated during testing for up to 100 minutes after the start of testing.

It is generally accepted that most operator actions can be accomplished within a 30 minute period or less, especially if the action can be recognized in and accomplished from within the control room. Most Combustion Engineering (CE) plants are designed for automatic realignment of the ECCS system for the ECCS recirculation mode. Most non-CE designed PWRs require and credit manual operator action for recognizing the need for and alignment of all recirculation components (i.e., sump, refueling water tank (RWT), and mini-flow recirculation valves – up to eight or more components) within a similar time period, with or without a single failure. These manual actions are required prior to RWT pump down and vortexing whereas the manual LPSI flow stoppage is required prior to debris head loss buildup, a significantly longer period of time. If operator action can be credited for manual alignment of all components for the recirculation mode at non-CE PWRs, it can be concluded that a single failure of a LPSI pump to trip can be mitigated after automatic switchover to RAS, during the high-stress period following a LBLOCA, prior to debris head loss build up. This is based on the following:

St. Lucie Unit 1 debris testing was performed under the most conservative of conditions with debris addition just upstream of the strainer test article. It is reasonable to conclude that manual action, in the low probability likelihood of a single LPSI trip failure, could be accomplished within the same time period (100 minutes), before significant head loss is established due to debris buildup during an actual event.

A St. Lucie Unit 1 emergency operating procedure (EOP), calls for ensuring RAS actuation as a matter of specific procedural requirements and is consistent with CE EOP guidelines. A specific tabular checklist provides directions to MANUALLY ALIGN RAS COMPONENTS. This table requires the specific signoff for verification that both LPSI pumps trip or are manually stopped. It states "ENSURE LPSI Pumps STOPPED".

The following design features support the current license basis that operator action can be credited to recognize and mitigate the failure to trip of a single LPSI pump upon RAS signal:

METHODS AVAILABLE TO MANUALLY STOP LPSI PUMP FLOW:

- Stop pump(s) from RTGB (main control board) control switch
- Stop pump(s) from Local PB (push button) station
- Stop pump(s) from 4160 V switchgear control switch
- Open 1E 4160 SWGR emergency bus feeder breaker/Open emergency diesel generator supply breaker on affected train bus
- Throttle closed LPSI header flow control valves to minimize LPSI flow until such time as pump can be stopped

CONTROL ROOM INDICATION OF OPERATING PUMP

- Control switch lights
- Pump motor running current, on RTGB
- System header pressure
- System header flow

CONTROL ROOM INDICATION OF POTENTIAL PUMP CAVITATION

- Erratic pump motor running current, on RTGB
- Erratic system header pressure
- Erratic system header flow

CONTROL ROOM INDICATION OF POTENTIAL LOSS OF 1E 125 DC CONTROL POWER

- Loss of all control switch indicating lights for the affected LPSI pump motor.

CONTROL ROOM INDICATION OF RAS ACTUATION

- Control room indication

It can be concluded that the existing design and licensing basis and procedural requirements which credit operator action to stop flow from a single LPSI pump after failure to trip on RAS signal continue to apply for the new GSI-191 ECCS/containment spray system (CSS) strainer design for St. Lucie Unit 1.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity, kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

a. Provide the clean strainer head loss (CSHL) calculation methodology.

RAI-10a RESPONSE: As stated in the supplemental response, the CSHL from this system is made up of two components; the strainer disk head loss and the module/piping head loss. The strainer disc head loss is based on the strainer head loss tests.

The module/piping head losses are the hydraulic losses associated with flow from the strainer plenums to the manifold and then through the manifold discharge piping to the ECCS suction. Assumptions, margins and conservatisms used in establishing the head losses are:

- A maximum temperature of 210°F.
- A minimum temperature of 65°F.
- A flow rate of 8530 gpm that is conservatively assumed to apply for the duration of the event. It is based on simultaneous hot and cold leg recirculation, which is not initiated until 4 to 6 hours into the event.
- Pipe connections between the 10-foot sections of pipe are modeled as orifices that restrict the flow, which is conservative.

The flow through the strainer internals is assumed to be turbulent, consistent with the calculation approach of Crane TP 410 used for fittings and piping, due to the abrupt direction changes and abrupt expansions from the strainer disks to the plenum.

Piping head losses are due to the hydraulic losses associated with flow from the strainer plenums to the manifold and then through the manifold discharge piping to the ECCS pump suctions. Predicted plenum losses for the St. Lucie Unit 1 piping are calculated to be a maximum of 5.87 ft. This is conservatively based on evenly distributed flow, 8530 gpm total flow through 21 strainer modules (area adjusted), and 65°F fluid temperature. This CSHL was used for calculating overall total debris laden head loss at all temperatures (i.e., not scaled).

A calculated value of 5.87 ft for clean system head loss was added to the debris head loss to determine total system head loss including debris. Note that the 5.87 ft for clean system head loss is based on even flow through each strainer module based on area. A clean strainer disc head loss of 0.107 ft was determined by testing. If the strainers are clean, the actual head loss through the plenums and piping was calculated to be 1.854 ft. The clean head loss through the plenums and piping is smaller if the calculation accurately accounts for unbalanced flow; i.e., with more flow entering the strainers nearest to the pump. The total clean system head loss is 0.107 ft plus 1.854 ft, or 1.961 ft. Using 5.87 ft for clean system head loss accounts for the balancing effect that will be produced by the accumulation of debris on the strainers. In the subsequent calculation for NPSH 5.87 ft was used for clean strainer head loss.

The assumption of evenly distributed flow for the CSHL results in independence from the amount of debris buildup. This makes the overall debris laden head loss very conservative as noted above.

A LPSI pump failure to stop on RAS was considered in the CSHL calculation.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity, kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

b. In the CSHL area the supplemental response stated that debris head loss is assumed to be directly proportional to bed thickness and flow rate through the bed. The concept of head loss proportional to bed thickness ignores the potential for thin bed formation and other bed morphology issues such as compression. It is unclear how this assumption relates to the CSHL calculation. If the current CSHL methodology is retained, please provide information that explains how the debris bed thickness applies to the CSHL calculation and justifies the assumption that bed thickness is proportional to head loss. Please note that recently the NRC staff has accepted CSHL calculations that assume that each module has an equal amount of in-flow. Alternatively, a licensee could determine how the CSHL value changes as the debris bed forms and provide a value based on such an evaluation.

RAI-10b RESPONSE: The June 30, 2008 FPL St. Lucie Unit 1 supplemental response provided a paragraph containing eight bullets describing assumptions, margins and conservatisms related to establishing strainer head losses, as follows:

The module/piping head losses are the hydraulic losses associated with flow from the strainer plenums to the manifold and then through the manifold discharge piping to the ECCS suction. Assumptions, margins and conservatisms used in establishing the head losses are:

- A maximum temperature of 210°F.
- A minimum temperature of 65°F.
- A flow rate of 8530 gpm that is conservatively assumed to apply for the duration of the event. It is based on simultaneous hot and cold leg recirculation, which is not initiated until 4 to 6 hours into the event.
- A transportable fraction of 36% was assumed for LDFG in the sector tests (i.e., 36% of the LDFG was assumed to erode and reach the strainers). The actual transport fraction was calculated to be 34.17%.
- The quantity of Cal-Sil in the sector test was based on 109.4 ft^3 at the strainer modules. The calculated quantity is 91.9 ft^3.
- Debris accumulation was assumed to be proportional to flow rate.
- Debris head loss is assumed to be directly proportional to the debris bed thickness and flow rate through the debris bed. Debris bed compression is not taken into account.
- Pipe connections between the 10-foot sections of pipe are modeled as orifices that restrict the flow, which is conservative.

Bullets four through seven do not relate to the CSHL calculation, including the reference to debris bed thickness, but relate to debris laden head losses since they discuss debris characteristics.

The current CSHL methodology is retained. However, the debris bed thickness does not apply to the CSHL calculation as described above. See FPL response to RAI 10a for methodology. Conservatively determined CSHL are added to debris laden screen losses to determine the overall strainer system head loss.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

c. It was implied that the debris was added to the sector test prior to starting the recirculation pump. Either verify that the pump was started before debris addition or provide details on the test sequence and justification that adding debris prior to starting the recirculation pump would result in prototypical or conservative head loss values.

d. Provide documentation of the testing methodology including:
   1. debris introduction sequences (debris type and size distribution) including time between additions
   2. description of test facility
   3. general procedure for conducting the tests
   4. debris introduction locations within the test flume
   5. comparison of actual fibrous size distribution added during the test versus fibrous sizes predicted in the transport evaluation
   6. particulate debris size distributions
   7. amounts of each debris type added to each test
   8. test strainer area
   9. test flow rates
   10. description of debris introduction procedures including debris mixes and concentrations showing that fibrous debris agglomeration did not occur
   11. thin bed test debris introduction sequences
   12. incremental amounts of fibrous debris added for thin bed tests

e. Provide documentation of the amount of debris that settled in the agitated and nonagitated areas of the test tank

f. Provide information that shows how test results were extrapolated to emergency core cooling system mission times or provide a discussion of how the test results were determined to bound the head loss during the entire required mission time. If a mission time based net positive suction head (NPSH) margin evaluation was used, provide NPSH margin values for the entire mission time.

g. Provide the test termination criteria and sufficient data to show that the test was run in accordance with the termination criteria.

k. The supplemental response stated that the strainer sector test cases were observed and photographed to ensure that absence of bore holes. However, bore holes cannot be detected visually with assurance. Additionally, some post-test photos indicate that there was clean strainer area following the test. In order to assure that viscosity correction is applicable to test results, flow sweeps should be conducted for conditions on which extrapolations are based (e.g., there should not be open screen area, nor should there be pre-existing bore holes). Provide information that provides additional justification that bore holes did not occur during testing. In addition, provide an evaluation of whether the clean strainer areas would affect the results of the extrapolation to higher temperatures.

l. The supplemental response stated that debris was prevented from settling using stirring. No information was provided to show that the stirring did not drive non-prototypical debris onto the bed or prevent debris from collecting naturally on the strainer. Provide information that verifies that the stirring did not result in non-protypical bed formation.

RAI-10c, d, e, f, g, k, & l RESPONSE: These RAIs are based on information provided to the NRC on June 30, 2008 by FPL in the supplemental response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors." Subsequently, on October 29, 2008, FPL requested an extension of the completion date of the St. Lucie Unit 1 NRC Generic Letter 2004-02 actions until July 30, 2009. In this extension request, FPL indicated that the following new activities would be performed:

- Conservatisms in input parameters and the base analysis would be reviewed,
- Methods to reduce debris loads (e.g., insulation replacement) would be identified in order to develop scenarios for "test for success,"
- Perform testing. This testing will include contingency debris and chemical load tests to achieve acceptable results (test for success), and
- Revise calculations and analyses.

Providing responses to these RAIs at this time would not be pertinent or informative because of these new activities. Responses for these RAIs will be provided in the July 30, 2009 supplemental submittal. Completion of these new activities will provide the technical basis for the responses to these RAIs.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

h. The flashing evaluation did not provide the margin to flashing through the strainer. The submittal stated that a small amount of air pressure is credited, but the amount of overpressure required was not provided, nor was the available margin. The total head loss, including chemical effects, was listed as 11.42 ft at 210°F with a submergence of less than 1 ft. Provide information that shows that flashing will not occur within the strainer. Include the inputs and assumptions used to make this determination. Provide the margin to flashing at the limiting point during recirculation.

RAI-10h RESPONSE: FPL has performed a flashing analysis which determines the margin to flashing across the sump screens for two different flow cases for St. Lucie Unit 1. The first case is for the LPSI pump failure to trip on RAS case with a clean strainer. St. Lucie EOPs require operators to manually stop the LPSI pump upon failure to automatically stop on RAS. FPL has evaluated this response and concluded that the mandated operator action can be accomplished before significant head loss due to strainer debris buildup materializes during the recirculation mode. The second case is for the design basis flow and debris laden strainer head loss. Debris laden head losses are based on the results of previous tests. FPL plans to conduct additional flume head loss testing. The head loss margins are substantial, and FPL expects these margins to be sufficient to bound future test data.

Tables 10h-1 and 10h-2 summarize the pressure available to preclude the water from flashing because of the pressure drop across the screen face. The column titled Over Pressure is the partial air pressure converted to feet of water plus the elevation pressure of the sump water above the highest point of the screen minus the pressure drop across the screen. This represents the available margin. The point of least margin or limiting point is the minimum temperature condition evaluated.

Table 10h-1 assumes a flow of 11,630 gpm across a clean strainer disk for the LPSI failure to trip case.

Table 10h-1 LPSI Failure to Trip

Temperature (°F)	Over Pressure (ft. of water)
65	26.30
70	26.61
80	27.21
90	27.81
100	28.41
110	29.01
120	29.61
125	29.91
130	30.21
140	30.91
150	31.43
160	32.05
170	32.68
180	33.31
190	33.95
200	34.60
210	35.26
220	35.92
230	36.60
240	37.28

The submergence for a SBLOCA is 0.5 ft less than the LBLOCA. The over pressure in feet of water may be reduced by 0.5 ft for a SBLOCA.

Table 10h-2 summarizes the pressure available to preclude the water from flashing because of the pressure drop across the debris laden screen face. This table assumes the design basis flow of 8530 gpm across a debris laden strainer disk with chemical effects based on the Alion Science and Technology (Alion) chemical effects testing.

Table 10h-2 Debris Laden Margin

Temperature (°F)	Over Pressure (ft. of water)
65	8.98
70	10.49
80	13.05
90	15.23
100	17.16
110	18.81
120	20.34
125	21.00
130	21.70
140	23.08
150	24.19
160	25.32
170	26.39
180	27.44
190	28.40
200	29.41
210	30.25
220	31.10
230	31.97
240	32.84

The submergence for a SBLOCA is 0.5 ft less than the LBLOCA. The over pressure in feet of water may be reduced by 0.5 ft for a SBLOCA.

Assumptions used for the evaluation include:

1. It is assumed that the water in the sump is at saturation. This is a conservative assumption. The temperatures of the water in the containment sump are consistently lower than the temperature of the containment atmosphere. The pressure of the containment atmosphere is created by the steam produced during the LBLOCA and the partial pressure of air in containment. The temperature of the water in the containment sump is produced by the hot water created by the LBLOCA and the water from the RWT pumped into containment during the injection phase. The water from the RWT is at a much lower temperature than the water created by the LBLOCA. Therefore, for the flashing evaluation, it is conservative to assume that the water in the sump and the steam in the containment atmosphere are at saturation.

2. Heating of the air in containment behaves as an ideal gas.

3. Post LBLOCA containment atmosphere water vapor and air are at approximately the same temperature.

4. Containment atmospheric pressure at plant elevation is 14.7 psia.

5. Relative humidity in containment is conservatively considered to be 100%.

6. Post LBLOCA containment pool temperature is conservatively assumed to be equal to containment atmosphere temperature.

7. The minimum partial pressure of air already in containment at the beginning of the postulated LBLOCA can be credited for the purposes of evaluating head loss margin to flashing at the ECCS/CSS sump screen debris bed.

8. Flow rates through the ECCS/CSS suction strainer debris bed are laminar with associated head losses varying with kinematic viscosity. The kinematic viscosity is the dynamic viscosity divided by the density.

As shown in Tables 10h-1 and 10h-2, the partial pressure of air already in containment was credited to prevent flashing. The partial pressure of air was determined using the most conservative assumptions. In accordance with the Technical Specifications (TS) the minimum containment pressure relatively to atmosphere at which the plant may be operated is -0.7 psig. It is conservative to assume that vapor pressure is at a maximum. In accordance with the TS the maximum containment temperature at which the plant may be operated is 120°F. The vapor pressure at this temperature is 1.69 psia. The initial containment pressure was thus determined, 14.7 psia – 0.7 psi – 1.69 psi = 12.31 psia. The partial pressure of air was then adjusted according to temperature over the entire range from 65°F to 240°F. Note that it is not even necessary to credit air heating to achieve significant margins.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

i. The strainer submergence and vortexing evaluation included the volume of the Safety Injection Tanks (SIT) for the small break LOCA. It is possible for some small breaks that this volume would not be available for sump pool inventory. Provide a justification for the crediting of SIT volumes for sump pool level for all required breaks.

RAI-10i RESPONSE: As stated in the supplemental response dated June 30, 2008, the range of SBLOCA breaks includes those that require recirculation from the containment sump as well as those that permit the operators to depressurize the reactor coolant system (RCS) and initiate the shutdown cooling mode of decay heat removal, which does not require suction from the containment sump. Because the SBLOCA produces less debris, the debris load on the sump strainers is less than the design basis debris load. However, for the purpose of evaluating the sump strainer under SBLOCA conditions, it is conservatively assumed that the recirculation flow from the containment sump and the debris load are the same as the LBLOCA, and that the water level is that of the SBLOCA.

For breaks so small that RCS pressure can be maintained above the safety injection tank (SIT) pressure (thus preventing outflow) using high pressure safety injection (HPSI) pumps and/or charging pumps, system flows and debris generation are minimal as compared to the LBLOCA design basis. During the injection mode, this RCS pressure would be above the shutoff head of the LPSI pumps stopping inflow and would reduce flow from the HPSI pumps. Containment pressure would be insufficient to generate containment spray actuation signal (CSAS) or would be mitigated so rapidly as to allow early termination of the CSS pumps. With elevated RCS pressure, RCS cooling can be accomplished with steam generators and/or the shutdown cooling system. Considering such reduced flows from this very small break, the time to actuation of RAS is significantly delayed beyond the LBLOCA design of 20 to 30 minutes. 411,260 gallons is the minimum volume of water available from the RWT. With this volume, and even the equivalent of a 640 gpm (full HPSI pump) flow, it would take 10.7 hours to consume the RWT. This is sufficient time to cool the plant without switching to recirculation mode.

Even if it is assumed that SIT volumes do not discharge and spill through this break to the containment pool, and that recirculation mode is for some reason still required, the resultant post SBLOCA containment water level without SIT volume is approximately 23 ft versus 23.36 ft.

The strainer system high point vent on the manifold box is at elevation 22.69 ft which would be still submerged without SIT volume contributions. For these very small break flow rates, strainer approach velocities don't constitute a vortex issue and submersion precludes air ingestion. Therefore, it can be concluded that a SBLOCA with full RCS blowdown and SIT discharge (with higher flows and debris) is the bounding SBLOCA case from a Generic Letter 2004-02 perspective.

RAI-10: The extrapolation of test results to parameters other than tested conditions is discussed in the supplemental response. It states that the strainer sector test head loss was scaled to the full sized strainer system based on velocity kinematic viscosity, and bed thickness differences. State all extrapolations or scaling that was performed for the head loss evaluation. Provide the methodology for all scaling including the inputs and assumptions used.

j. The supplemental response stated that the vortexing evaluation was conducted with flow rates three times the average strainer module flow rate because modules near the pump suctions would have higher flow rates before a debris bed formed on the strainer. The submittal did not provide the actual flow rates through these modules under clean conditions. Provide the maximum flow through the limiting strainer module in the strainer array under clean conditions. Verify that the vortexing evaluation bounds the worst case strainer module flow rate.

RAI-10j RESPONSE: Testing was conducted with the water depth over the strainers similar to the plant configuration. The hydraulic report documents that no vortexing or air entrainment was observed during testing with a flow rate of two times the required headloss test flow rate. The Strainer Air Ingestion Analysis calculates that no vortex shall form for a strainer with a velocity of three times the average strainer velocity. The high velocity is used to account for strainers that are closer to the sump manifold. The "Strainer Manifold Vent Vortexing Calculation" calculates that no vortex shall form over the air vents in the piping manifold.

The actual flow rates through the highest flow modules under clean conditions are associated with modules E1 and E2 which are in closest proximity to the manifold and pump suction piping. The maximum flow through the limiting strainer modules in the strainer array under clean conditions is provided by case 4 of the calculation. The maximum flow through strainer E1 is 1118 gpm and through strainer E2 is 1043 gpm.

The "Strainer Air Ingestion Analysis" utilized 1638 gpm for strainer module flow to analyze the possibility of vortex. Therefore, the maximum flow is bounded by the 1638 gpm.

RAI-11: Provide technical justification in support of the assumption of "no blockage of the refueling pool canal drains." Identify the type, physical characteristics (size, shape, etc.), and amounts of debris which may be blown into the refueling cavity during a LOCA. If it is determined that drainage from the refueling cavity could be blocked, specify the volume of water held up in the cavity and state the effect on minimum containment sump pool level.

RAI-11 RESPONSE: The St. Lucie Unit 1 refueling cavity pool canal drains consist of redundant six inch diameter drains located on the side of the cavity with the centerline of the 6" drains located 6" from the bottom of the refueling canal, approximately 3 feet apart.

FPL has performed containment design reviews and walkdowns to assess flow chokepoints and flow paths from potential high energy break locations to the containment sump suction strainers including upwards from inside the biological shield wall through the floor at elevation 62 ft and into the refueling cavity and outside the biological shield wall. The limiting St. Lucie Unit 1 breaks are within the secondary biological shield wall around the RCS loop level. This review concluded that pathways from the loops up and through the 62 ft level floor were few and torturous to the point of being inconsequential for any type of debris considered. This is due to a large solid floor area at elevation 62 ft, relatively small compartment areas covered with grating, and tight clearances around stairs, curbs and penetrations.

No significant pathway was found to exist through the biological shield wall at the lower wall drain windows which are mostly blocked with strainer modules.

While there is no exact way to quantify the debris type, size and shape, if you assume that significant debris is able to make its way vertically over 40 feet against the forces of gravity and falling containment spray flow and through the aforementioned tortuous path the following design features preclude total blockage of both drain paths:

- Drains are redundant
- Drains are separated
- Drains are horizontal and wall located rather than vertical and floor located to minimize gravity effects on debris transport
- Drains are submerged at post LBLOCA recirculation mode containment level, thereby minimizing wash down/transfer velocity effects of containment spray to the drain. Floating debris is prevented direct access to drain penetrations. The centerline of the drains is at El. 22 ft – 0" which is below minimum pool level,
- Drain diameters are large so that larger debris of conforming size would be required to simultaneously block and perfectly seal both drains without pass through for significant water holdup
- Design drawings indicate no protective screens at the drains to become obstructed with smaller debris that would otherwise pass through the drain or accumulate on the cavity floor.

- Drains are above the cavity floor so that significant debris can be accumulated in the "heel" of the cavity before reaching drain level
- The refueling cavity is large with a lot of area for debris to "hide out"

Therefore, the fuel transfer canal drains do not create a chokepoint at St. Lucie Unit 1.

RAI-12: The NRC staff considers in-vessel downstream effects to not be fully addressed at St. Lucie Unit 1 as well as at other pressurized-water reactors. The St. Lucie Unit 1 supplemental response refers to draft WCAP-16793-NP, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous, and Chemical Debris in the Recirculating Fluid." The NRC staff has not issued a final SE for WCAP-16793-NP. The licensee may demonstrate that in-vessel downstream effects issues are resolved for St. Lucie Unit 1 by showing that the licensee's plant conditions are bounded by the final WCAP-16793-NP and the corresponding final NRC staff SE, and by addressing the conditions and limitations in the final SE. The licensee may alternatively resolve this item by demonstrating, without reference to WCAP-16793 or the staff SE, that in-vessel downstream effects have been addressed at St. Lucie Unit 1. In any event, the licensee should report how it has addressed the in-vessel downstream effects issue within 90 days of issuance of the final NRC staff SE on WCAP-16793. The NRC staff is developing a Regulatory Issue Summary to inform the industry of the staff's expectations and plans regarding resolution of this remaining aspect of Generic Safety Issue-191.

RAI-12 RESPONSE: FPL was at the recent joint NEI/NRC meeting on January 14 and 15, 2009 regarding issues related to the final resolution of GSI-191. This RAI and presentations by the NRC are understood and actions will be taken by FPL to meet the requested NRC schedule. FPL is confident that it will be able to demonstrate that St. Lucie Unit 1 in-vessel downstream effects will be bounded by the final version of WCAP-16793-NP. Also, at this time, FPL believes that St. Lucie Unit 1 will be in compliance with the NRC's safety evaluation of the final WCAP-16793-NP.

In FPL's June 30, 2008 supplemental response on Generic Letter 2004-02, the response to Topic 3.n stated that St. Lucie Unit 1 was bounded by the generic results for in-vessel fuel effects related to fiber and debris bypass contained in WCAP-16793-NP, Rev.0. As further noted in the response to Topic 3.n, St. Lucie Unit 1 performed a unit specific analysis for chemical plate out on the fuel that yielded satisfactory results for fuel temperatures of only 378.7°F. In the June 30, 2008 supplemental response, Attachment 2, Enclosure 2, FPL also provided St. Lucie Unit 1 responses to NRC staff's Limits and Conditions related to the staff's initial review of WCAP 16793-NP.

FPL believes that sufficient evaluation has been conducted for St. Lucie Unit 1 to demonstrate acceptable in-vessel conditions. However, at the recent joint NEI/NRC meeting on January 14 and 15, 2009, NRC requested industry assurance that plants will submit a final in-vessel evaluation within 90 days after NRC issues a SE on the final version of WCAP-16793-NP. FPL will evaluate the NRC SE at the time of issuance to determine if there are additional impacts that require new or different methods for evaluating this issue. FPL fully intends to meet NRC's schedule request.

RAI-13: *On page 32 of the supplemental response dated June 30, 2008, the licensee made the statement that "the original St. Lucie Unit 1 strainer did not utilize redundant sump strainers." However, this statement does not appear fully consistent with Figure 6.2-40 in the Updated Final Safety Analysis Report (UFSAR) and the discussion on page 6.2-47, which explains that, while there is a common outer mesh with 1/2-inch openings, each suction line is encased by an individual screen capable of filtering down to 1/4 inch. Based upon the UFSAR description, it appears that the fine mesh layer of the former screen design actually did provide a measure of independence between the sump suction inlets, which is not present in the new single-barrier common strainer design. Since the new strainer traverses approximately 270 degrees of the containment, potential concerns associated with inadvertent damage to the strainer (e.g., during maintenance activities) or gaps due to improper installation appear to have increased compared to the previous smaller assembly with independent inner screens. Address the reduction in strainer redundancy that has occurred with the installation of the replacement strainer design and provide a technical basis to conclude that the potential for inadvertent damage and installation issues has been adequately addressed for the replacement strainer.*

RAI-13 RESPONSE:

Strainer Redundancy

As described in the supplemental response dated June 30, 2008, the original St. Lucie Unit 1 strainer design did not utilize redundant sump strainers. For the original design, the common containment sump was protected by an outer screen that would exclude large debris (greater than 1/2-inch) from the sump. The suction end of each recirculation line was encased with a finer mesh screen that would exclude smaller debris (greater than 1/4-inch) from the inlets to the ECCS/CSS during recirculation. The purpose of these screens was to prevent debris greater than 1/4 inch in size from reaching the recirculation inlets of the ECCS/CSS. The recirculation suction inlets are located 15 feet apart to provide separation of the redundant ECCS/CSS recirculation intakes. There was a total of approximately 290 square feet of flow area into the sump.

For the new design, twenty one (21) strainer modules have been installed inside containment. The strainers use an arrangement of parallel, rectangular strainer disks that have exterior debris capturing surfaces of perforated plate covered with woven wire mesh. The strainer perforations are 1/16"diameter holes (nominal diameter of 0.062"). The strainer modules are grouped together into four (4) groups. Each group is piped separately by a pipe run to the suction manifold where the total strainer flow is combined. The suction manifold discharges through two (2) outlet pipes which are routed to the existing ECCS/CSS recirculation suction inlets. The strainer surface area is approximately 8,275 ft^2.

For the original design, the post accident fluid would pass through a common outer screen and into the common sump. From the common sump, the fluid would be directed toward two separate ECCS/CSS recirculation suction inlets. The fluid would pass through a finer mesh screen prior to entering each ECCS/CSS recirculation suction inlet. Objects greater than 1/4 inch in size would be prevented from entering the ECCS/CSS recirculation suction inlets. For the new design, the post accident fluid would pass through four (4) separate independent groups of strainers (twenty one (21) strainers total). The fluid would be directed from the strainers through four (4) separate independent piping systems (one piping system for each group of strainers) to the common strainer/suction manifold where the total strainer flow is combined. From the common suction manifold, the fluid would pass through two separate pipes. Each pipe would route the fluid to an individual ECCS/CSS recirculation suction inlet. Objects greater than 1/16 inch in size would be prevented from entering the ECCS/CSS recirculation suction inlets.

Although for the original sump strainer design there were separate inner screens associated with each ECCS/CSS recirculation suction inlet, these inner screens were credited only for their finer debris retention and not as redundant screens. Failure of an inner sump screen was not considered to be a credible passive failure because of its design.

The single failure analysis for the recirculation mode of operation considered both active and passive failures. The active failures considered were pump, valve, and indicator failures. The passive failures considered were check valve failures and fluid line ruptures.

In keeping with the existing methodology, the new sump strainer configuration has been designed to preclude any source of credible passive failure, and as such is not redundant. The strainer modules and all associated equipment are designed as seismic Class I equipment. All required load combinations have been shown to be acceptable, including crush pressure. In addition, environmental conditions and dynamic effects associated with a LBLOCA have been considered and will not result in the failure of the strainer system. Finally, using the mechanistically determined, conservative maximum hypothetical debris loading, the strainer system has been demonstrated by testing that adequate NPSH will be available to the ECCS/CSS pumps during all phases of recirculation.

The system has been designed such that there is no credible passive failure mechanism that could render both ECCS/CSS trains inoperable.

Therefore, the strainer system has been designed to preclude credible sources of passive failure, and is not designed as a redundant or single-failure proof system. This is consistent with the existing design basis of the system. Note that St. Lucie Unit 1 is not committed to Regulatory Guide (RG) 1.82 (which specifies independent suction strainers), and Generic Letter 2004-02 does not impose requirements with regards to redundancy. In summary, there are no technical or applicable regulatory requirements, or regulatory commitments for St. Lucie Unit 1 for the sump strainer to be redundant.

UFSAR Figure 6.2-40 is being revised to portray the current new design sump strainer configuration.

Installation issues

Post installation inspections were performed to verify that the sump strainer will function as intended. Identified deficiencies or discrepancies were evaluated and, if required corrected prior to system operability.

The installation inspections included verifying that:

- separation between the joints of any two adjacent surfaces (i.e., gaps or fit-ups) in the strainer system fluid boundaries (e.g., strainer plates, plenums, piping, couplings, manifold, interface assembly, etc.) do not exceed the tolerances specified by the installation drawings,

- anchor bolts were torqued in accordance with the installation specification, and

- assembly field bolting was torqued in accordance with the installation specification.

Dimensional verification of installed equipment was performed against installation drawings and work packages.

These post installation inspections provided the technical basis to conclude that the potential for installation issues has been adequately addressed for the replacement sump strainer system.

Potential for inadvertent damage

One new procedure has been written for inspection of the new strainer system, and the containment close-out procedure has been updated.

The new procedure requires that there are no holes, gaps or tears greater than 1/16" (0.0625") in any component of the strainer system (e.g., including connections). The new procedure assures that the strainers are properly inspected and have no visible damage. Additionally, during the preparation for outage activities, in order to protect the containment sump strainers and piping from potential damage during the outage, the procedure requires the installation of signage to prevent outage personnel from storing material on the containment sump strainers and piping.

The procedure also calls for the removal of any temporary covers prior to restart.

The containment closeout procedure was updated to include all of the strainer system components in the final containment closeout inspection.

The effect of these changes is to ensure that all components (strainer modules, piping, and pipe connections) are inspected, and that there are no holes, gaps or tears greater than 1/16 inch in any strainer system component.

RAI-14: On page 35 of the supplemental response, the licensee stated that the original St. Lucie Unit 1 design did not have separate trash racks (although a two-layered screen assembly was in place prior to the installation of the replacement strainers). However, existing Technical Specification (TS) 4.5.2.d.2 refers to trash racks being present. The replacement strainer design clearly does not have trash racks. Submit an appropriate change to the St. Lucie Unit 1 TSs to be consistent with the new St. Lucie Unit 1 sump strainer configuration and analysis.

RAI-14 RESPONSE: The existing St. Lucie Unit 1 TS Surveillance Requirement (SR) 4.5.2.d.2 reads as follows:

> "[Each ECCS subsystem shall be demonstrated OPERABLE: ...At least once per 18 months by:] A visual inspection of the containment sump and verifying that the subsystem suction inlets are not restricted by debris and that the sump components (trash racks, screens, etc.) show no evidence of structural distress or corrosion."

The SR specifically refers to "sump components" and parenthetically refers to trash racks, screens, etc., as examples of sump components.

During FPL's preparation, review, and verification of the Generic Letter 2004-02 Supplemental Responses for St. Lucie Unit 1, this TS SR and the corresponding Bases were reviewed to determine whether any changes were required or warranted. The FPL review determined: 1) no change was required to the SR, which requires the sump components to be inspected to show no evidence of structural distress or corrosion, and 2) the parenthetical phrase "(trash racks, screens, etc.)" was intended to represent examples of "sump components" to be inspected. FPL also determined that a formal License Amendment Request was not required, but an explanation should be provided in the Bases to clarify this issue.

Therefore, in order to clarify the scope and intent of the SR, the applicable Unit 1 TS Bases were modified to read as follows:

> "TS Surveillance Requirement 4.5.2.d.2 requires that each ECCS subsystem be demonstrated OPERABLE at least every 18 months by visual inspection of the containment sump and verifying that the suction inlets are not restricted by debris and that the sump components (trash racks, screens, etc.) show no evidence of structural distress or corrosion.
>
> There are no trash racks or screens associated with the sump components, but the current Technical Specification of "sump components (trash racks, screens, etc.)" sufficiently encompasses the strainer modules. Therefore, the surveillance requirements are satisfied when visual inspection verifies that loose debris is not present which could be transported to the strainers, and by visual inspection of the strainer modules and associated equipment for structural distress or corrosion."

The revised Bases thus make it clear that the St. Lucie Unit 1 design does not include trash racks or screens.

Based on the above discussion, FPL does not plan to revise TS SR 4.5.2.d.2.

RAI-15: The NRC staff understands that the licensee has changed its test approach to evaluate chemical effects. Please submit the revised chemical effects test results and analyses to the NRC when they become available.

RAI–15 RESPONSE: FPL shall comply with this request and shall submit the revised chemical effects test results and analyses to the NRC when the test results have been verified and approved.