FPL Energy Point Beach, LLC, 6610 Nuclear Road, Two Rivers, WI 54241

FPL Energy
Point Beach Nuclear Plant

February 29, 2008

NRC 2008-0013
GL 2004-02
10 CFR 50.54(f)

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Point Beach Nuclear Plant, Units 1 and 2
Dockets 50-266 and 50-301
Renewed License Nos. DPR-24 and DPR-27

Supplemental Response to Generic Letter 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors

The NRC issued Generic Letter (GL) 2004-02 on September 13, 2004, to request pressurized water reactor (PWR) licensees to perform an evaluation of the emergency core cooling system (ECCS) and containment spray system (CSS) recirculation functions in light of the information provided in the GL and, if appropriate, take additional actions to ensure system function. Additionally, the GL requested PWR licensees provide the NRC with a written response in accordance with 10 CFR 50.54(f). The request was based upon identified potential susceptibility of the PWR recirculation sump to debris blockage during design basis accidents (DBAs) requiring recirculation operation of ECCS or CSS and on the potential for additional adverse effects for flow paths necessary for ECCS and CSS recirculation and containment drainage.

The Nuclear Management Company, LLC (NMC, the former license holder) responded to the GL in letters identified in the attachment to this letter as References 3, 5 and 7. NMC also responded to a related generic communication, Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized Water Reactors," via Reference 1.

FPL Energy Point Beach, LLC, requested an extension of the completion date for the actions required by the GL via Reference 8.

The information in this letter and its enclosures supersedes the information previously provided in References 1, 3, 5, and 7. Enclosure 1 provides the supplemental response to GL 2004-02 for Point Beach Nuclear Plant, Units 1 and 2 (PBNP) detailing the information to support NRC staff verification that the corrective actions are adequate and methodologies used by FPL Energy Point Beach resolve the issues identified in the GL.

The response was prepared using guidance contained in the NRC November 21, 2007, letter (Reference 9), "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses" (ML073110278). This response also used the guidance in the NRC November 30, 2007, letter (ML073320176, Reference 10).

Enclosures 2 and 3 provide the schematic diagrams that support modifications made at PBNP to address the concerns of the GL. Enclosures 4 through 6 provide the component evaluations. Enclosure 7 provides a matrix listing the RAI's and FPL Energy Point Beach responses. Enclosure 8 provides the response to requests for additional information (RAIs) listed as References 4 and 6 in the attachment to this letter.

Regulatory Commitments

Reference 8 contains the following Regulatory Commitment:

> "The final submittal of the testing and analyses demonstrating acceptable long-term ECCS performance in the areas of downstream and chemical effects will be made by June 30, 2008."

FPL Energy Point Beach is scheduled to conduct testing with PCI from June 9, through June 21. The test schedule was discussed with the assigned PBNP NRR Senior Project Manager and the NRR Safety Issue Resolution Branch Chief on February 26, 2008.

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

Executed on February 29, 2008.

Very truly yours,

FPL ENERGY POINT BEACH, LLC

James H. McCarthy
Site Vice President

Attachment / Enclosures

cc: Administrator, Region III, USNRC
Project Manager, Point Beach Nuclear Plant, USNRC
Resident Inspector, Point Beach Nuclear Plant, USNRC
PSCW

ATTTACHMENT

FPL ENERGY POINT BEACH, LLC
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02
POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS

REFERENCES

Ref #	Description
1	Nuclear Management Company, LLC (NMC) Letter to NRC dated August 8, 2003, "Nuclear Regulatory Commission Bulletin 2003-01: Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors - 60-day Response" (ML032310423)
2	Nuclear Regulatory Commission (NRC) Generic Letter (GL) 2004-02 dated September 13, 2004, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactor" (ML042360586)
3	NMC Letter to NRC dated September 1, 2005, "Nuclear Management Company Response to GL 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors." (ML052500302)
4	NRC Letter to NMC dated February 9, 2006, "Point Beach Nuclear Plant, Units 1 and 2: Request For Additional Information Re: Response to GL 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation During Design-Basis Accidents at Pressurized-Water Reactors" (ML060370491)
5	NMC Letter to NRC dated April 28, 2006, "Supplemental Response to GL 98-04 and GL 2004-02 License Event Report 266/301/2005-006-00" (ML061210032)
6	NRC Letter to NMC dated September 18, 2006, "Point Beach Nuclear Power Plant, Units 1 and 2 – Evaluation of Event Notification 42129" (ML060880084)
7	NMC Letter to NRC dated October 3, 2006, "Supplemental Response to GL 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (ML062850105)
8	FPLE-PB Letter to NRC dated November 16, 2007, "Response to GL 2004-02, Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (ML073230345)

9 NRC Letter to NEI, dated November 21, 2007, "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses" (ML073110278)

10 NRC Letter to NEI, dated November 30, 2007, "Supplemental Licensee Responses to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (ML07330176)

11 NEI 02-01, dated April 2002, "Condition Assessment Guidelines: Debris Sources Inside PWR Containments"

12a NEI 04-07 Volume 1, dated December 2004, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Revision 0 (ML043280007)

12b NEI 04-07 Volume 2, dated December 6, 2004, "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02," Revision 0 (ML04320008)

13 WCAP-16530-NP, dated February 2006, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-91," Revision 0

14a WCAP-16406-P, dated June 2005, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," Revision 0

14b WCAP-16406-P, dated August 2007, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," Revision 1

15 WCAP-16793-NP, dated May 2007, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," Revision 0

16 NRC Regulatory Guide 1.82, dated November 2003, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," Revision 3 (ML033140347)

17 LA-UR-04-1227, dated April 2004, "GSI-191: Experimental Studies of Loss-of-Coolant-Accident-Generated Debris Accumulation and Head Loss"

18 Summary of March 1, 2007, "Public Meeting With NEI, Licensees and Sump Strainer Vendors to Discuss Containment Sump Backflushing as a Means of Contributing to the Resolution of Generic Safety Issue-191 (GSI-191)" (ML070720404)

19 NUREG/CR-6224, dated October 1995, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris"

20 Prairie Island Nuclear Generating Plant Corrective Actions for Generic Letter 2004-02, dated May 2, 2005. (ML070750065)

21 Performance Contracting, Inc. Suction Flow Control Device (SFCD) Technology Documents and Reports, dated June 8, 2007. (ML071650462)

22 Regulatory Guide 1.54, dated July 2000, "Service Level I, II, and III Protective Coatings Applied to Nuclear Power Plants"

23 EPRI 1003102, dated November 2001, "Guideline on Nuclear Safety-Related Coatings"

24 EPRI 1014883, dated August 2007, "Plant Support Engineering Adhesion Testing of Nuclear Coating Service Level I Coatings."

25 Point Beach Nuclear Plant, Units 1 and 2, "Issuance of Amendments Re: Leak-Before-Break Evaluation for Primary Loop Piping," dated June 6, 2005

26 "Safety Evaluation of the Request to Apply Leak-Before-Break Status to the Accumulator Line Piping at Point Beach Nuclear Plant, Units 1 and 2," dated November 7, 2000

27 Point Beach Nuclear Plant, Units 1 and 2 - "Supplement to Safety Evaluation on Leak-Before-Break Regarding Correction of Leak Detection Capability," dated February 7, 2005

28 "Safety Evaluation of the Request to Apply Leak-Before-Break Status to the Pressurizer Surge Line Piping at Point Beach Nuclear Power Plant, Units 1 and 2," dated December 5, 2000

29 "Safety Evaluation of the Request to Apply for Leak-Before-Break Status to portions of the Residual Heat Removal System piping at the Point Beach Nuclear Plant, Units 1 and 2," dated December 18, 2005

ENCLOSURE 1

FPL ENERGY POINT BEACH, LLC

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02 "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

SUPPLEMENTAL RESPONSE

GL 2004-02 Requested Information Item 2(a)

Confirmation that the ECCS and CSS recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. This submittal should address the configuration of the plant that will exist once all modifications required for regulatory compliance have been made and this licensing basis has been updated to reflect the results of the analysis described above.

FPL Energy Point Beach Response

FPL Energy Point Beach confirms that, with the exceptions pertaining to chemical effects and downstream effects previously described in Reference 8, the emergency core cooling system (ECCS) and containment spray system (CSS) recirculation functions are in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of GL 2004-02.

The exceptions in the areas of chemical effects and downstream effects are limited to providing the conclusive testing and/or analytical bases for resolving the concerns identified in GL 2004-02. There are no known material deficiencies in the installed systems, structures, or components. These exceptions will be resolved as committed to in Reference 8.

The remainder of this enclosure describes the bases for the conclusion that Point Beach Nuclear Plant Units 1 and 2 (PBNP) are in compliance with the Applicable Regulatory Requirements of GL 2004-02, excluding the noted exceptions.

GL 2004-02 Requested Information Item 2(b)

A general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this generic letter. Efforts to implement the identified actions should be initiated no later than the first refueling outage starting after April 1, 2006. All actions should be completed by December 31, 2007. Provide justification for not implementing the identified actions during the first refueling outage starting after April 1, 2006. If all corrective actions will not be completed by December 31, 2007, describe how the regulatory requirements discussed in the Applicable Regulatory Requirements section will be met until the corrective actions are completed.

FPL Energy Point Beach Response

Containment Walkdowns to Quantify Potential Debris Sources

Containment walkdowns to identify and quantify the types and locations of insulation were completed during the fall 2003 (Unit 2) and spring 2004 (Unit 1) refueling outages (U2R26 and U1R28, respectively). The initial inventory of the Unit 1 insulation had been performed during the fall 2002 refueling outage (U1R27), prior to the guidance of NEI 02-01 (Reference 11) had been issued.

The final walkdowns were conducted in accordance with the guidance in NEI 02-01, "Condition Assessment Guidelines: Debris Sources Inside PWR Containment" (Reference 11).

Specifically, the walkdowns focused on obtaining specific data necessary to proceed with the analyses described in NEI 04-07, Volumes1 and 2, "Pressurized Water Reactor Sump Performance Evaluation Methodology" "Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02". (References 12a and 12b)

Three types of walkdowns were performed:

- Piping walkdowns, including in-line valves and components
- Major equipment walkdowns, and
- General area (zone) surveys

Piping walkdowns were performed to confirm, to the extent practical, that the data obtained from controlled source documents was correct. The types and quantities of insulation installed on piping in containment had been previously determined using plant as-built drawings and specifications. The walkdowns were normally conducted on a line-by-line basis. Insulation on piping without associated isometric drawings (typically small bore) was also quantified.

Walkdowns of major pieces of insulated equipment (steam generators, reactor coolant pumps, reactor, and pressurizer) were performed to confirm information obtained using as-built drawings and specifications.

General areas of the containment, including the reactor coolant loop compartments, were surveyed to collect information regarding miscellaneous debris sources that could potentially restrict flow of water through the containment sump screens. In each area (or zone), the surveys quantified items that could potentially become debris following a loss-of-coolant-accident (LOCA), such as fire resistant barrier materials, tape, tags, labels, dirt, dust, lint, paper, pipe banding, tie-wraps, maintenance materials, tygon tubing, gates, and filters. Significant transport paths between cubicles were also noted during the walkdowns.

At the beginning of the spring 2005 (Unit 2) and fall 2005 (Unit 1) refueling outages, sampling of latent dirt and dust was performed and evaluated in accordance with the guidance of NEI 04-07.

Debris Generation Analysis

The debris generation analyses were completed in March 2005 for both units following the guidance of NEI 04-07. These analyses were most recently revised in June of 2006 in response to the NRC Safety Evaluation to NEI 04-07, Volume 2. The results of these analyses are summarized in the following sections of this submittal.

Chemical Effects Evaluation

An analysis of the potential chemical precipitants that may be formed was completed prior to the issuance of WCAP-16530-NP (Reference 13). The results were used to support integrated head loss testing performed in May 2006. After issuance of WCAP-16530-NP, the conclusions of the May 2006 analysis were found to be overly conservative. The May 2006 analysis was superseded by a new analysis that conformed to the WCAP guidance. The new analysis was completed in September 2007, and shows that under credible conditions, the maximum concentration of aluminum in the containment sump is less than 20 ppm.

Head Loss Testing

Head loss testing of a prototype screen was performed at Alden Laboratories in May 2006 using an open flume. Tests of both the full design basis loading and the thin bed regime were conducted to bound the full range of concern. A powdered chemical effects surrogate was used for the testing.

Additional integrated testing to demonstrate acceptable strainer performance that incorporates a generated precipitant will be performed in June 2008. Based upon the results of plant-specific testing completed to date, FPL Energy Point Beach is confident that the final confirmatory testing will demonstrate that the replacement ECCS suction screens will function acceptably under worst-case conditions.

Design and Installation of Replacement ECCS Suction Screens

Enlarged screens designed to accommodate the worst-case mix of debris predicted by the debris generation analyses were installed during the fall 2006 (Unit 2) and spring 2007 (Unit 1) refueling outages. The replacement screens are designed to be fully submerged and have approximately 1500 ft^2 of active surface area on each train. They are designed to accommodate flow of 2200 gpm per train, which is more than the maximum tested net positive suction head (NPSH) flow for the pumps drawing from the sump. The design approach velocity for the screens is 0.0033 fps, which is two orders of magnitude less than the velocity used in tests that have shown a thin bed effect. The replacement screens have predominantly vertical screen surfaces, and are situated on the open floor of the lowest full elevation of containment; not in a pit or depressed sump. The screens incorporate flow control features to ensure that the flow through them is distributed evenly across the entire strainer surface to preclude uneven loading and localized accumulations of debris. Each strainer train has been sized to accommodate more than 100% of the maximum debris postulated to be created as a result of a LOCA. The screens are separate and redundant to provide additional reliability.

Procedures to Address Sump Screen Blockage

Emergency Contingency Action ECA 1.3, "Containment Sump Blockage," was developed and issued for each unit in July 2005.

Downstream Effects Evaluation

An analysis of potential downstream effects on ex-vessel components (pumps, valves, piping, etc.) following the guidance of WCAP-16406-P (Reference 14a) Revision 0 was completed in July 2006. As discussed in Reference 8, that analysis is being revised to incorporate the changes in Revision 1 (Reference 14b) of WCAP 16406-P.

WCAP-16793-NP Revision 0 (Reference 15) contains bounding analyses that demonstrate acceptable in-vessel downstream effects for all but potential chemical plate out. Chemical plate out calculation results will be submitted in the FPL Energy Point Beach final submittal to GL 2004-02.

Configuration Controls

Configuration controls have been established to prevent the introduction or creation of unanalyzed debris sources inside of containment. These administrative controls included the development of a containment debris control program, establishment of the containment as a special foreign material exclusion zone above MODE 5, enhancements to the existing coatings inspection and maintenance program, periodic sampling for latent dirt and debris, and revision of the specification for insulation installation and removal inside of containment. The response to Item 3.p contains details of these configuration controls.

Configuration Changes

No modifications were made to change the existing insulation or chemical buffer. There are no modifications planned in the future.

***GL 2004-02 Requested Information Item 3*. Specific Information Regarding Methodology for Demonstrating Compliance:**

***GL 2004-02 Requested Information Item 3a*. Break Selection**

The objective of the break selection process is to identify the break size and location that presents the greatest challenge to post-accident sump performance.

1. *Describe and provide basis for break selection criteria used in evaluation.*
2. *State whether secondary line breaks were considered in the evaluation (e.g., main steam and feedwater lines.)*
3. *Discuss the basis for reaching the conclusion that the break size(s) and locations chosen present the greatest challenge to post-accident sump performance.*

FPL Energy Point Beach Response

For small breaks, only piping that is 2" in diameter and larger was considered. This is consistent with the Section 3.3.4.1 of the NRC Staff's Safety Evaluation for NEI 04-07 (Reference 12b), which states that breaks less than 2" in diameter need not be considered.

The following is an excerpt from the full text of the debris generation analysis for PBNP Unit 2. It details how the limiting break locations were selected, and how the selection methodology conforms to the guidance provided in NRC Regulatory Guide (RG) 1.82 Revision 3 (Reference 16) and NEI 04-07 Volumes 1 and 2 (References 12a and b, respectively). The same methodology was used in determining the Unit 1 break locations.

> To assure that the ECCS systems can perform their required safety function, the magnitude of the debris load introduced to containment for various LOCA breaks must be quantified.

NRC Regulatory Guide 1.82 Revision 3 requires the following:

1.3.2.3 A sufficient number of breaks in each high-pressure system that relies on recirculation should be considered to reasonably bound variations in debris generation by the size, quantity, and type of debris. As a minimum, the following postulated break locations should be considered.

- Breaks in the reactor coolant system (e.g., hot leg, cold leg, pressurizer surge line) and, depending on the plant licensing basis, main Steam and main feedwater lines with the largest amount of potential debris within the postulated [zone of influence], ZOI,
- Large breaks with two or more different types of debris, including the breaks with the most variety of debris, within the expected ZOI,
- Breaks in areas with the most direct path to the sump,
- Medium and large breaks with the largest potential particulate debris to fibrous insulation ratio by weight, and
- Breaks that generate an amount of fibrous debris that, after its transport to the sump screen, could form a uniform thin bed that could subsequently filter sufficient particulate debris to create a relatively high head loss referred to as the 'thin-bed effect.' The minimum thickness of fibrous debris needed to form a thin bed has typically been estimated at 1/8 inch thick based on the nominal insulation density (NUREG/CR-6224).

These requirements can be met by examining breaks in the [reactor coolant system] RCS piping proximate to major equipment such as the Steam Generators [SG]. Because the RCS lines are the largest-bore lines in containment, they tend to result in the largest Zones of Influence (see Section 4.3.2), and therefore encompass the greatest quantities of potential debris. They also tend to maximize the number of different types of thermal insulation (and other debris sources) that are affected. Break locations centered at connections to the SG nozzles tend to have ZOIs located such that they envelope nearly the entire Steam Generator as well as the Reactor Coolant Pump(s) [RCPs]. Break locations further from the SG nozzles tend to result in lesser quantities of debris because their ZOIs envelope smaller portions of the Steam Generators.

It is theoretically possible for smaller lines that are physically closer to the ECCS recirculation sumps to generate a greater quantity of debris that will actually be transported to the sump, so attention is given to the Pressurizer Surge Line. Additionally, auxiliary lines inside the outer Reactor Coolant Pressure Boundary (RCPB) isolation valves are identified and examined to determine whether any are routed in the immediate vicinity of the ECCS recirculation sump. Breaks at locations outside the second RCPB valve are not considered, since they are isolable from the reactor and RCS. Break locations at RCS connections to the Reactor Vessel [RV] nozzles are also examined, but due to the location inside the primary bioshield and the flow path from this point through containment to the ECCS recirculation sump suctions, breaks at the RV nozzles typically do not present the same degree of debris accumulation on the ECCS suction screens that is credited for breaks in RCS piping outside the primary bioshield.

Main Steam and Feedwater lines need only be analyzed as potential break locations in plants where ECCS recirculation is required to mitigate the effects of breaks in these lines. The ECCS recirculation is not required for breaks in Main Steam and Feedwater lines at Point Beach Unit 2.

Applying the foregoing ("Process 1") break selection methodology, the following break locations have been evaluated as potential limiting debris load cases:

1. RCS Hot Legs — one break location, piping to Steam Generator B nozzle
2. RCS Cold Legs — one break location, RCP B discharge piping
3. Pressurizer Surge Line — one break location at hot leg connection
4. Pressurizer Surge Line — one break location directly over the Crossover Leg
5. RCS Crossover Leg — one break location at Steam Generator B nozzle
6. Safety Injection Line — one break location which is most direct path to the ECCS sump
7. Greatest Variety of Debris Types—one break location on the Hot Leg where it connects to the Surge Line

Each of these breaks fulfills the objectives of the first four bullets of RG 1.82 Section 1.3.2.3, and together they serve to bound both the largest quantity of transportable debris and the debris load comprising the greatest variety of debris types. These selections are also consistent with the selection of break locations discussed in Section 3.3.4 of NEI 04-07. For primary piping, NEI 04-07 suggests that break locations be evaluated at five-foot intervals along the pipe being considered. This 'Process 2' methodology is intended to determine the limiting break location with respect to:

1. The maximum volume of debris that may be generated and transported to the sump, and
2. The worst combination of debris that may be generated and transported to the sump.

The 'Process 1' break selection methodology discussed above has been validated against the 'Process 2' (step interval) methodology, and has been shown to provide bounding results with respect to maximum debris loads and variety of debris types generated for a typical PWR.

The RG 1.82 Revision 3 (Reference 16) recommendation to postulate a break with a high particulate to fibrous mass debris ratio that produces a thin-bed of fiber debris at the ECCS sump screen was met by analysis and testing, as committed in Reference 8. Additional confirmatory integrated head loss and chemical effects testing remains to be performed. The analysis and testing used an assumed thin fiber bed, and used a maximum loading of particulates. The particulate loading was determined by summing the maximum particulates of each type (e.g. CalSil, asbestos, etc.) from each of the analyzed breaks. This resulted in a conservatively high particulate loading on a presumed thin bed.

The following excerpt from the PBNP Unit 2 debris generation analysis applies the methodology described above, and addresses how the exact break locations for PBNP Unit 2 were determined. Break selection for Unit 1 used the same methods and approach, but as described following this excerpt, resulted in fewer analyzed break locations:

Upon review of the provided information, Framatome ANP concluded that the most critical LOCA breaks from the standpoint of debris generation and transport to the ECCS sump screen are located within the SG B vault room. The rationale for this conclusion includes:

- The B-side of containment is closer in proximity to the ECCS sump and debris generated on the B-side will be more likely to transport to the sump screen because it will have a shorter and less tortuous transport path.

- The B-side of containment contains the Pressurizer and the Pressurizer surge line. These additional elements are potential debris sources and will thus add to the generated debris loads.
- Of the types of thermal insulation present in the PBNP Unit 2 containment, CalSil is the most penalizing in terms of sump screen head loss. Using information contained in the Unit 2 walkdown report it is determined that there is substantially more CalSil present in the Loop B vault than in the Loop A vault.

The goal of break selection is to postulate break locations that are going to result in the most critical debris load at the ECCS sump screen. Since the largest volumes of insulation are located on the Steam Generators, Reactor Coolant Pumps, Pressurizer, and Reactor Coolant System piping, the area within the Steam Generator vaults (i.e., the solid concrete walls surrounding all of the aforementioned components) is the primary focus.

The insulation on the Reactor Vessel, if damaged by a LOCA within the bioshield, is not transportable to the ECCS sump. The upper portion of the vessel is surrounded by concrete walls including the refueling canal and a missile shield above. Insulation coming off the lower portion of the vessel would have to drop down to the floor, move through the Access Tunnel, float up to El 26', and find a way back down to El 8'. The potential for this scenario is unlikely relative to the other breaks and was not considered further.

The closer the break locations are to the major sources of insulation, the greater the volume of insulation debris generated. The larger the areas affected by the break (i.e., the larger the ZOI), the greater potential to generate insulation debris. The areas affected are directly related to the size of the pipe that is broken.

Therefore, using the approach outlined in Section 4.3.1, the desire to have large pipes the source of the LOCA, and to be close to the insulated equipment, the break locations selected for PBNP Unit 2 are given below along with the rationale for choosing each of these break locations.

<u>Case 1</u>: RCS Loop B Hot Leg at the connection to Steam Generator B Nozzle - This break satisfies the NRC RG 1.82 Rev 3 suggestion to postulate a hot leg break. It is chosen because the Steam Generator is a significant potential source of debris and this location is in fact the closest point on the hot leg to the Steam Generator.

<u>Case 2</u>: RCS Loop B Cold Leg at the connection to Reactor Coolant Pump B Nozzle - This break satisfies the NRC RG 1.82 Rev 3 suggestion to postulate a cold leg break.

<u>Case 3</u>: Pressurizer Surge Line at the Hot Leg connection - This break satisfies the NRC RG 1.82 Rev 3 suggestion to postulate a surge line break. This break is thought to have the potential to produce a significant amount of debris because of its proximity to the Hot Leg and Steam Generator.

<u>Case 4</u>: Pressurizer Surge Line directly over the Crossover Leg - This break satisfies the NRC RG 1.82 Rev 3 suggestion to postulate a surge line break and is chosen as a supplement to Case 3 because it is not initially evident as to whether Case 3 or Case 4 would be most critical. This break is thought to have the potential to produce a significant amount of debris because of its proximity to the Crossover Leg.

<u>Case 5</u>: Crossover Leg at Steam Generator B Nozzle - This break is chosen in order to analyze at least one break in each of the three legs in the RCS loop. This break is thought to

have the potential to produce a significant amount of debris because it is a large bore break in close proximity to both the Steam Generator and the Reactor Coolant Pump.

Case 6: Safety Injection System Most Direct Path to the ECCS Sump - This break is the closest to the ECCS Sump of all possible LOCA breaks.

Case 7: Hot Leg connection to the Pressurizer Surge Line - This break satisfies the [NRC] RG 1.82, Revision. 3 which suggests postulating a break that generates the greatest variety of debris. This case generates all seven types of thermal insulation (RMI, Asbestos, CalSil, Fiberglass, Temp-Mat/Insulbatte®, Mineral Wool, and NUKON®)."

Differences in Break Selection Locations Between the Two PBNP Units

Unit 2 was the first unit at PBNP to be evaluated. All seven (7) cases were evaluated for Unit 2. Lessons learned from performing the Unit 2 analysis led to the elimination of one break case. Differences between the units in insulation types and configuration led to the elimination of a second break case. Therefore, Cases 1 through 5 were evaluated for Unit 1.

In Unit 1, the high energy lines closest to the ECCS sump screens are the RCS pipes located inside the adjacent RCS loop compartment. There is an asymmetry between the two units such that there is no safety injection line in the immediate vicinity of the ECCS sump on Unit 1. Therefore, evaluation of the RCS breaks satisfied the requirement for a break closest to the sump screens and the break evaluated as Case 6 for Unit 2 was not applicable.

The Case 1 break in Unit 1 (RCS Loop B hot leg connection to the steam generator nozzle) satisfied the requirement to consider a break that generates the greatest variety of debris. Therefore, it was not necessary to perform a comparable Unit 2, Case 7 analysis.

GL 2004-02 Requested Information Item 3b. Debris Generation/Zone of Influence (ZOI) (excluding coatings)

The objective of the debris generation/ZOI process is to determine, for each postulated break location; (1) the zone within which the break jet forces would be sufficient to damage materials and create debris; and (2) the amount of debris generated by the break jet forces.

1. *Describe the methodology used to determine the ZOIs for generating debris.*
2. *Provide destruction ZOIs and basis for each applicable debris constituent.*
3. *Identify which debris analyses used approved methodology default values.*
4. *For debris with ZOIs not defined in GR/SE, or if using other than default values, discuss method(s) used to determine ZOI.*
5. *Identify if destruction testing was conducted to determine ZOIs. If such testing has not been previously submitted to the NRC for review or information, describe the test procedure and results with reference to the test report(s).*
6. *Provide the quantity of each debris type generated for each break location evaluated. If more than four break locations were evaluated, provide data only for the four most limiting locations.*
7. *Provide total surface area of all signs, placards, tags, tape, etc.*

FPL Energy Point Beach Response

3.b.1 Methodology

FPL Energy Point Beach applied the ZOI refinement discussed in Section 4.2.2.1.1 of the NRC Staff's Safety Evaluation for NEI 04-07, which allows the use of debris-specific spherical ZOIs. Using this approach, the amount of debris generated within each ZOI is calculated and the individual contributions from each debris type are summed to arrive at a total debris source term.

The sources of debris at PBNP include insulation debris, and latent debris. The evaluation concluded that there are several types of insulation inside the containments that could potentially form debris following a LOCA. These insulations are:

1. Reflective Metallic Insulation (RMI)
2. NUKON® insulation
3. Generic fiberglass insulation
4. Temp-Mat® insulation
5. Mineral wool
6. Asbestos
7. Calcium Silicate ("CalSil") insulation

3.b.2 Destruction Pressure and ZOIs, Bases

The following table lists the destruction pressures and ZOI radii that were used for the PBNP debris generation analyses.

Damage Pressures and Corresponding Volume-Equivalent Spherical ZOI Radii

Insulation Types	Destruction Pressure (psig)	ZOI Radius / Break Diameter
Diamond Power RMI	2.4	28.6
Transco RMI	114	2.0
Asbestos*	6.0	17.0
NUKON®	6.0	17.0
CalSil	24.0	5.45
Fiberglass*	6.0	17.0
Fiberglass blanket*	6.0	17.0
Fiberglass / Mineral Wool Combination	6.0	17.0
Mineral Wool*	6.0	17.0
Temp-Mat / Insulbatte®	10.2	11.7

3.b.3 Debris Using Default Values

Unless designated with an asterisk (*), the ZOI for debris types listed in the preceding table used the approved methodology default ZOI values.

3.b.4 Debris Using Other than Default Values

The ZOI for debris types indicated by an asterisk (*) in the preceding table do not have default values listed in Table 3-2 of NEI 04-07 Volume 2 (Safety Evaluation). Therefore, the values of destruction pressure listed in Table 4-1 of Volume 2 of NEI 04-07 was used as a starting point, and the destruction pressure was reduced by 40%. The new length/diameter value was determined using the reduced destruction pressure.

3.b.5 Additional Destruction Testing

No additional destruction testing was conducted or credited in support of the PBNP debris generation analyses.

3.b.6 Insulation Debris Quantities

All debris quantities are in cubic feet unless otherwise noted. Only the four cases resulting in the maximum total quantity of debris have been tabulated for each of the two units.

Unit 1

Insulation Type	Case 1	Case 2	Case 4	Case 5
RMI (sq. ft.)	5050.13	5386.11	4945.37	5103.05
Asbestos	296.74	275.37	159.70	296.74
CalSil	113.05	110.50	63.57	89.36
Fiberglass	179.38	125.87	98.75	181.40
Temp Mat®	23.44	20.61	11.82	23.44
Mineral Wool	203.11	0.00	0.00	218.99

Unit 2

Insulation Type	Case 1	Case 2	Case 5	Case 7
RMI (sq. ft.)	0.00	0.00	0.00	117.39
Asbestos	116.07	116.07	116.07	116.07
CalSil	88.46	122.72	83.87	111.84
Fiberglass	107.48	90.57	114.70	107.35
Temp Mat®	89.28	99.57	89.42	89.77
Mineral Wool	267.21	323.20	311.30	291.43
NUKON®	1001.10	849.50	1046.65	937.77

3.b.7 Signs, Placards, Tape, etc.

The containment walkdowns identified the potential for up to 148 square feet of total signage, placards, tape, etc. in Unit 1, and up to 189 square feet in Unit 2.

GL 2004-02 Requested Information Item 3c. Debris Characteristics

The objective of the debris characteristics section is to establish a conservative debris characteristics profile for use in determining the transportability of debris and contribution to head loss.

1. *Provide the assumed size distribution for each type of debris.*
2. *Provide bulk densities (i.e., including voids between the fibers/particles) and material densities (i.e., the density of the microscopic fibers/particles themselves) for fibrous and particulate debris.*
3. *Provide assumed specific surface areas for fibrous and particulate debris.*
4. *Provide the technical basis for any debris characterization assumptions that deviate from NRC-approved guidance.*

FPL Energy Point Beach Response

Since a debris transport analysis and acceptable integrated head loss and chemical effects testing have not been completed, the response to this item is deferred in accordance with Reference 8.

GL 2004-02 Requested Information Item 3d. Latent Debris

The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris existing within the containment, and its potential impact on sump screen head loss.

GL 2004-02 Requested Information Item 3d.1. Provide methodology used to estimate quantity and composition of latent debris.

FPL Energy Point Beach Response

The method used to estimate the quantity of latent debris was a representative sampling of containment surfaces as described in the guidance of NEI 04-07 Volume 2, Section 3.5.2.2. The samples were taken by Masslinn® swipes and the amount of accumulated dust and lint quantified by weight. The fiber content of the latent debris was assumed to be 15% by weight, consistent with NEI 04-07 Volume 2, Section 3.5.2.3. The balance of the latent debris is assumed to be particulate, also consistent with Section 3.5.2.3 of NEI 04-07.

Samples were taken to determine the latent debris mass distribution per unit area of representative surfaces throughout containment including vertical surfaces such as the liner and walls. These debris densities were then applied to all of the surface areas inside containment to calculate the total amount of latent debris inside containment. The latent debris density was estimated by weighing Masslinn® swipes before and after sampling, and dividing the net weight increase by the sampled surface area.

There were 21 samples taken in each unit, and included a mix of both horizontal and vertical surfaces, as well as surfaces that are routinely decontaminated and those surfaces that are not such as the top surfaces of overhead duct work, cable trays, etc.

Because of the several different types of insulation used in the two containments, the statistical sample mass collections (e.g., three samples from each category of surface) was not used. FPL Energy Point Beach used an alternative approach to minimize personnel risk and exposure.

Representative samples were taken from accessible surfaces. Visual observations of these sample locations were compared to visual observations of other surfaces and estimates of bounding debris loadings were made. Although similar in magnitude, the data from Unit 1 and the data from Unit 2 were used to substantiate unit-specific latent debris source terms for both units.

GL 2004-02 Requested Information Item 3d. 2. ***Provide the technical basis for assumptions used in the evaluation.***

FPL Energy Point Beach Response

There were three assumptions used in the evaluation of latent debris in containment. These assumptions and their technical bases follow.

Assumption: The top surfaces area of the major structural heat sinks are periodically decontaminated.

Basis: Accessible floor areas are routinely wiped down to control contamination spread and to reduce the quantity of latent debris in containment. While there are top surfaces of major structural heat sinks that are not routinely cleaned due to ALARA concerns or inaccessibility, such as the regenerative heat exchanger room, the bottom of the pressurizer cubicle, etc.), most of these areas are also above the El. 8' sump and sheltered from direct spray impingement and washdown. Additional areas will be added to account for those areas that are not routinely cleaned. Therefore, assuming that 100% of the floor areas are routinely cleaned over-estimates the total area that is routinely cleaned while not diminishing those areas that are not cleaned. The result is a conservatively high estimate of the routinely cleaned horizontal surface areas.

Assumption 2: The horizontal surface area of containment that is not routinely cleaned, and is subject to direct spray impingement and/or wash-down during a LOCA blowdown, is equal to the horizontal surface area that is routinely cleaned per Assumption 1 above.

Basis: The horizontal surface areas not routinely cleaned yet still subject to wash down are primarily limited to those above the refueling floor El. 66'. Horizontal areas above this elevation are very limited, primarily due to the necessity of moving large loads above the floor such as the reactor vessel head, RCP motors, etc. Areas below El. 66' are largely sheltered from direct spray impingement, and only those in the RCS loop compartments may be subjected to scouring during the blowdown phase of a LOCA.

Assumption 3: The vertical surface area of miscellaneous equipment such as cable trays, ladders, tanks, etc. is equal to the vertical surface area of all the major structural heat sinks inside of containment.

Basis: The major structural heat sinks include the containment building wall and all compartment walls. Other major vertical surface areas are equipment such as the steam generators, the pressurizer, the RCP motors, and the reactor vessel. In addition there are various cable trays, piping, ladders, etc. The vertical surface of any tank or vessel is less than the vertical surface of the compartment surrounding it. Considering that much of the vertical surface areas are sheltered from spray impingement by floors above, and that there is a substantial amount of vertical surface area represented by the containment liner itself, the assumption was considered a reasonable and bounding approximation.

***GL 2004-02 Requested Information Item 3d.3.* Provide results of latent debris evaluation.**

FPL Energy Point Beach Response

The results of the latent debris calculation conservatively determined the debris loading to be less than 19 lbs for Unit 1, and 30 lbs for Unit 2. These values are significantly lower than the 150 lbs that had been previously assumed and incorporated as an unverified assumption in the debris generation analyses. To ensure margin, the 150 lb figure was retained.

In lieu of sample analysis, conservative values for debris composition properties were assumed as recommended by NEI 04-07 Volume 2. This results in a conservative estimate of fiber content. This approach results in a fibrous latent debris contribution of 22.5 lbs and a particulate latent debris contribution of 127.5 lbs.

***GL 2004-02 Requested Information Item 3d.4.* Provide amount of sacrificial strainer surface area for miscellaneous latent debris.**

FPL Energy Point Beach Response

The conceptual approach of a "sacrificial strainer area" has been used by some strainer vendors to account for the potential adverse effects of tape, labels, and similar sheet-like debris suspended in the sump fluid. This approach was not used in the design or previously completed testing of the PBNP replacement strainers. Instead, a scaled quantity of cut up tape and labels was added into the test debris mix. The tape and labels had been reduced to small sizes to conservatively maximize their potential to transport to the prototype test screen. A similar approach is expected for the pending confirmatory integrated head loss and chemical effects testing. An additional submittal on the subject of sacrificial screen area is not anticipated.

***GL 2004-02 Requested Information Item 3d.5.* Provide amount of latent debris types.**

FPL Energy Point Beach Response

In addition to the 150 lbs of dust and dirt quantified for Item 3d.3 above, the surface area of resident tape, tags, and labels that are not design basis accident (DBA)-qualified was developed based on the walk-down information. The total area of these "film" type debris was determined to be 148 ft^2 in Unit 1 and 189 ft^2 in Unit 2.

***GL 2004-02 Requested Information Item 3d.6.* Provide physical data for latent debris as requested for other debris under c. above.**

FPL Energy Point Beach Response

To date, density values have only been needed for scaling prototype debris during testing. For that purpose, the fibrous latent debris was assumed to be NUKON® with an as-manufactured density of 2.4 lb/ft^3, while the particulate debris was assumed to have a density of 100 lb/ft^3, and a silica sand mix was used as a test surrogate. These same values for density will be used in the pending confirmatory integrated head loss and chemical effects testing.

Specific surface areas for latent debris (an analytical parameter) were not calculated for the design of the replacement screens because they will be qualified by testing rather than analysis.

***GL 2004-02 Requested Information Item 3.e*. Debris Transport**

The objective of the debris transport section is to estimate the fraction of debris that would be transported from debris sources within containment to the sump suction strainers.

1. *Describe the methodology used to analyze debris transport during the blowdown, washdown, pool-fill-up, and recirculation phases of an accident.*
2. *Provide the technical basis for assumptions used in the analysis that deviate from the approved guidance.*
3. *State whether computational fluid dynamics was used to compute debris transport fractions during recirculation and summarize the methodology used and results.*
4. *Provide a summary of, and supporting technical basis for any credit taken for debris interceptors.*
5. *State whether fine debris was assumed to settle and provide basis for any settling credited.*
6. *Provide the calculated debris transport fractions and the total quantities of each type of debris transported to the strainers.*

FPL Energy Point Beach Response

Although the debris generation calculations performed to date have included transport analyses consistent with the approved guidance in NEI 04-07 for the blowdown, washdown, and pool-fill-up portions of the accident, the total quantity of debris generated, without consideration of where it may be deposited, has been used for screen testing purposes. This approach is conservative and bounding, and it is expected to be used in the pending confirmatory integrated testing of the screens.

Computational fluid dynamics will be used to model debris transport phenomena for the recirculation phase of the accident in the pending integrated testing. A description of the methodology used will be provided in the submittal of those results.

***GL 2004-02 Requested Information Item 3.f*. Head Loss and Vortexing**

The objective of the head loss and vortexing section is to calculate head loss across the sump strainer and to evaluate the susceptibility of the strainer to vortex formation.

1. *Provide a schematic diagram of the emergency core cooling system (ECCS) and containment spray systems (CSS).*
2. *Provide the minimum submergence of the strainer under small break loss of coolant accident (SBLOCA) and large break loss of coolant accident (LBLOCA) conditions.*
3. *Provide a summary of the methodology, assumptions and results of the vortexing evaluation.*
4. *Provide a summary of the methodology, assumptions and results of prototypical head loss testing for the strainer, including chemical effects.*
5. *Address the ability of the design to accommodate the maximum volume of debris that is predicted to arrive at the screen.*
6. *Address the ability of the screen to resist the formation of a "thin bed" or to accommodate partial thin bed formation.*
7. *Provide the basis for the strainer design maximum head loss.*
8. *List all assumptions, margins, and conservatisms used in the head loss and vortexing calculations.*
9. *Provide the methodology, assumptions, bases for the assumptions, and results for the clean strainer head loss calculation.*

10. *Provide the methodology, assumptions, bases for the assumptions, and results for the debris head loss analysis.*
11. *State whether the sump is partially submerged or vented (i.e., lacks a complete water seal over its entire surface) for any accident scenarios and describe what failure criteria in addition to loss of NPSH margin were applied to address potential inability to pass the required flow through the strainer.*
12. *State whether near-field settling was credited for the head-loss testing and provide a description of the scaling analysis used to justify near-field credit.*

***GL 2004-02 Requested Information Item 3.f.1*. Schematic Diagrams**

FPL Energy Point Beach Response

Schematic diagrams of the ECCS and CS systems are provided in Enclosure 2. The diagrams are taken directly from the PBNP Final Safety Analysis Report (FSAR), and while they depict the Unit 2 installation, they are representative of Unit 1 systems.

***GL 2004-02 Requested Information Item 3.f.2*, Minimum Submergence**

FPL Energy Point Beach Response

Initiation of sump recirculation is dependent upon indicated refueling water storage tank (RWST) level, and does not vary with LOCA size. The minimum submergence, including allowance for instrument uncertainty and omitting credit for RCS and safety injection (SI) accumulator volumes spilled to the containment sump is 2" at the initiation of sump recirculation. The submergence continues to increase for the next ~38 minutes as the RWST continues depleting via containment spray, until the level is ~2 feet above the top of the screen.

***GL 2004-02 Requested Information Item 3.f.3*. Vortexing and Bouyant Debris Evaluation**

FPL Energy Point Beach Response

The sump screens are designed with flow control to ensure a uniform velocity distribution over the entire screen surface, regardless of proximity to the outlet pipe (pump suction). Therefore, accelerated flows and the potential for vortex formation close to the suction line are precluded. During the testing performed, vortexing of the PBNP prototype strainer was not observed.

During the debris head loss testing, no instances of buoyant debris were noted that could challenge strainer effectiveness. Introduced debris that was representative of the potential debris in the containment was negatively buoyant and sank if not kept stirred. The test was performed at cold conditions, which were more limiting than hot sump conditions. Under hot conditions, the fluid would be less viscous and less dense, thereby promoting more rapid wetting out and sinking of debris.

While buoyant debris may start to migrate toward a strainer upon initiation of sump recirculation, the increasing level in the containment sump provides increasing margin against loss of NPSH and vortex initiation. While potentially buoyant foam fire seal materials are located inside of the containments, they are not located within LOCA ZOIs, and are capable of withstanding extended fire exposure followed by a fire hose stream without being dislodged.

Therefore, buoyant debris was not a challenge to the proper operation of the replacement ECCS sump strainers.

The planned confirmatory integrated head loss and chemical effects testing is expected to verify this resistance to vortex formation and air entrainment. An additional submittal on the subject of vortex formation and air entrainment is not anticipated unless pending test results are adverse.

GL 2004-02 Requested Information Item 3.f.4 Prototypical Head Loss Testing

FPL Energy Point Beach Response

As discussed in Reference 8, performance of additional confirmatory head loss testing, including suitable surrogates for chemical effects, remains to be completed. Since the testing performed to date did not address all aspects of head loss, the response to this section is being deferred until completion of confirmatory testing.

GL 2004-02 Requested Information Item 3.f.5. Ability to Accommodate the Maximum Quantity of Debris

FPL Energy Point Beach Response

The sump screens are physically located above the surface of the containment floor, and are not in a depressed sump. As such, even if transported debris fills the gaps between the strainer "disks," the free volume of the entire lower level of containment is available to accommodate debris that may be generated. Enclosure 3 provides drawings which depict the general strainer arrangement and their relationship to the containment sump and surrounding structures.

GL 2004-02 Requested Information Item 3.f.6. Ability of the screen to resist the formation of a "thin bed", or to accommodate partial thin bed formation

FPL Energy Point Beach Response

Thin bed formation is defined and discussed in Appendix VIII of the Safety Evaluation for NEI 04-07:

> "The thin bed effect refers to the debris bed condition in a fibrous/particulate bed of debris whereby a relatively high head loss can occur because of a relatively low thin layer of debris, by itself or embedded as a stratified layer within other debris, because the bed porosity is dominated by the particulate, and the bed porosity approaches that of the corresponding particulate sludge."

Several published studies have been conducted demonstrating the effect, yet virtually all were predicated on flow running vertically downward through a simple, flat, horizontal screen element, and at velocities ranging upward from 0.1 fps. One study identified also used an open flume with horizontal flow. However, that study only considered flows in excess of 0.2 fps.

In contrast, the surface area of the PBNP strainers is predominantly vertical and the strainers have a design approach velocity (volumetric flow rate divided by the strainer surface area) of only 0.0033 fps.

The vertical orientation is not conducive to the collection and consolidation of debris into a thin bed, and the low velocity is unlikely to generate sufficient frictional drag to compress fibers and particulates into a dense, consolidated layer: A similar finding is contained in LA-UR-04-1227 (Reference 17).

> "The sump screen conditions, where it can be reasonably justified that the thin-bed configuration cannot form, include (1) the advanced strainer designs, where test data has strongly indicated that thin-bed configurations would not form because of complex surface design; and (2) flow conditions insufficient for the required debris bed formation, which can be substantiated by applicable data. Examples of the advanced strainer design include the stacked-disk strainers, where it has been generally accepted, based on testing of prototypical strainers, that a thin-bed configuration will not form under potential debris loadings. An example of insufficient flow conditions is sump conditions that include a maximum approach velocity of less than 0.1 ft/s..."

Based upon the above, formation of a thin bed is not expected to occur on the PBNP strainers. Pending confirmatory integrated head loss and chemical effects testing is expected to demonstrate this resistance to thin bed formation. An additional submittal on the subject of thin bed formation is not anticipated unless the pending test results are adverse.

***GL 2004-02 Requested Information Item 3.f.7.* Basis for Strainer Design Maximum Head Loss**

FPL Energy Point Beach Response

The strainers have been designed to operate with a head loss of 38" or less. The applicable Emergency Operating Procedures ensure that sump recirculation is not initiated until this minimum level has been reached.

By limiting the head loss across the screens to the head of water in the containment sump, it was possible to segregate the screen design criteria from the detailed NPSH calculations for the ECCS pumps. Those calculations credit only the elevation head of water at the elevation of the containment floor. Further details of this design approach are contained in the response to RAI 39 provided in Enclosure 8.

***GL 2004-02 Requested Information Item 3.f.8.* List all Assumptions, Margins, and Conservatisms used in the Head Loss and Vortexing Calculations.**

FPL Energy Point Beach Response

The assessment of vortexing was based on empirical observations rather than a calculation. Item 3.f.2 above provides a discussion of vortexing.

As discussed in the response to Item 3.f.7 above, the head loss (NPSH) calculation for the ECCS pump screens is separate from and not dependent upon the head loss calculation for the screens.

The calculation of head losses through the screen assembly sums the head losses from three separate sources; (1) Frictional head losses for the connecting piping and fittings; (2) head losses through the screen internals; and (3) head losses through the debris bed on the surface of the screen.

The first two items are calculated, while the third will be obtained from confirmatory integrated screen test results.

The containment sump temperature is assumed to be 212°F. A higher assumed temperature would result in a correspondingly higher containment pressure due to overpressure conditions, but the frictional head losses would be reduced by the dropping fluid viscosity. Conversely, lower temperatures would result in increased fluid frictional losses, but the reduction in vapor pressure results in a net gain in allowable head losses when determining NPSH margin.

When calculating the head losses attributable to just the screen internals and connecting piping and fittings, the following factors ensure a conservative result:

1. A 6% penalty was added to the calculated clean strainer assembly head losses. This was to bound uncertainties in the tests used to develop an empirical head loss relationship for the clean strainer assembly.

2. A 10% penalty was added to the calculated head losses for flow through the junctions connecting adjacent strainer modules.

3. A 10% penalty was added to the calculated head losses for flow through the piping and fittings connecting the strainer assembly to the containment sump outlet.

4. The correlation used to predict the clean strainer element head losses over-predicted the head loss by more than 400% when compared to actual testing.

Additional integrated confirmatory testing to demonstrate acceptable performance in the presence of potential chemical precipitants is pending. Since the measurement of this third element of head loss is not dependent upon calculations, an additional response in this area is not anticipated.

***GL 2004-02 Requested Information Item 3.f.9.* Methodology, Assumptions, Bases, and results for the Clean Strainer Head Loss Calculation**

FPL Energy Point Beach Response

At the design flow rate of 2200 gpm, the clean strainer head loss calculation established that the head loss through the most limiting single PBNP strainer assembly would be 0.4773 feet under hot sump conditions.

The calculation was performed by the same vendor, using the same methodology, assumptions, and bases as the similar calculation prepared for Prairie Island Nuclear Generating Station. The calculation for Prairie Island was reviewed by the NRC during the Prairie Island GSI-191 Audit (ML070750065) (Reference 20). The open item associated with the clean strainer head loss calculation that was applicable to PBNP was:

> Open Item 3.6-2 The licensee did not fully justify that the clean strainer head loss correlation is conservative. The justification provided was based on testing of the PCI Prototype II testing module. Differences between aspects of the PI strainer array compared with the PCI Prototype II testing module include (1) significantly different diameter/length and core tube area/slot open area ratios; (2) an annular flow region in the PI strainer array; and (3) a different number of slots and slot's open area.

The strainer designer prepared a formal response to this open item. The response was provided to the NRC on June 8, 2007 (ML071650462) (Reference 21).

Accordingly, FPL Energy Point Beach concurs with the conclusion of the screen designer that the correlation is valid for the installed strainer and has been applied in a conservative manner.

GL 2004-02 Requested Information Item 3.f.10. Methodology, Assumptions, Bases, and Results for Head Loss Analyses

FPL Energy Point Beach Response

An analytical approach was not taken because of the lack of valid analytical models for predicting the head loss through the PBNP strainers. Though initially used for scoping purposes when designing the screens, the available analytical models, such as NUREG/CR-6224, are not applicable to debris beds containing CalSil. Therefore, the acceptability of the PBNP screens is based on final qualification testing, some of which remains to be completed in accordance with Reference 8.

GL 2004-02 Requested Information Item 3.f.11. Partial Sump Submergence or Venting

FPL Energy Point Beach Response

The PBNP sump screens are designed to be fully submerged at the time sump recirculation is initiated. There are no vent paths through the strainer surface.

GL 2004-02 Requested Information Item 3.f.12. Near Field Settling

FPL Energy Point Beach Response

No credit was taken for "near field settling" in the completed flume testing of the replacement screens. It is anticipated that prototypical settling will be integral to planned integrated head loss and chemical effects testing. A response addressing how this was handled will be provided with the submittal documenting acceptability of integrated head loss test results.

GL 2004-02 Requested Information Item 3.f.13. Flashing Evaluation

FPL Energy Point Beach Response

A containment pressure and temperature analysis for a large break LOCA determined that, with a single train failure of containment cooling and spray, the following containment sump temperatures and pressures would exist at various times post-LOCA:

Time after LOCA (min)*	Containment Pressure (psia)	Sump Temperature (°F)
29	45.4	215
46	39.3	207
63	37.3	201
117	43.9	202
500	36.1	208
750	31.2	208

*The data points were extracted from a more comprehensive listing, and provide a representative example of the results.

The sump screens are designed to generate no more than a 38" differential pressure. By comparing the data above with the graph of the maximum allowable sump temperature contained in NEI 04-07 Volume 2, Figure V-7, containment sump temperature would be lower than the maximum permissible temperature for these conditions. Based on the large margin available, even with full containment cooling capability, the presence of air and non-condensable gases in the containment atmosphere would ensure that sub-cooled sump conditions would prevail and flashing of the sump fluid passing through the strainers would be prevented.

In the event of a less severe LOCA (i.e. a small break LOCA), the reduced mass and energy introduction rate into the containment sump would ensure that the sump fluid would remain subcooled, and that flashing would not be a concern. Additionally, the smaller sized LOCA would result in a reduced quantity of debris being generated, thereby reducing the head losses at the strainers.

GL 2004-02 Requested Information Item 3.g. Net Positive Suction Head (NPSH)

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a LOCA considering a spectrum of break sizes.

1. *Provide applicable pump flow rates, the total recirculation sump flow rate, sump temperature(s), and minimum containment water level.*
2. *Describe the assumptions used in the calculations for the above parameters and the sources/bases of the assumptions.*
3. *Describe the system response scenarios for large and small break LOCAs.*
4. *Describe the operation status for each ECCS and spray pumps before and after the initiation of recirculation.*
5. *Describe the single failure assumptions relevant to pump operation.*
6. *Describe significant assumptions used in the NPSH analysis.*
7. *Verify that the following volumes have been accounted for: empty spray pipe, water droplets, condensation and holdup on horizontal and vertical surfaces.*

8. *Provide assumptions (and their bases) as to what equipment will displace water resulting in higher pool level.*
9. *Provide assumptions (and their bases) as to what water sources provide pool volume and how much volume is from each source.*
10. *Provide the NPSH margin results for pumps taking suction from the sump in recirculation mode.*

FPL Energy Point Beach Response

NPSH calculations have been performed for the injection phase of an accident when the ECCS pumps are drawing from the RWST. These calculations are available for review at PBNP.

GL 2004-02 Requested Information Item 3.g.1 Pump Flows, Sump Flows and Temperatures, and Minimum Sump Level

FPL Energy Point Beach Response

During sump recirculation, flow must go through the RHR pump, regardless what other pumps may be operating. Other ECCS pumps are supplied from the discharge of the RHR pump so their suction pressure is boosted. Additionally, the RHR pump has a greater flow capacity than any one of the other ECCS pumps. Therefore, RHR pump flow is the limiting flow for the ECCS system, and is also the limiting sump flow.

There are several different potential operating alignments of the combined ECCS and CS systems during sump recirculation. The most limiting case of the maximum flows through the RHR pumps during containment sump recirculation is provided below.

ECCS Alignment	RHR Pump Flow (gpm)
R1A: Train A RHR injecting to RV only	2035
R3B: Train B RHR supplying High Head SI only	1205
R4A: Train A RHR supplying RV & High Head SI	2088

Alignment R1A consists of a single RHR pump discharging to the reactor outlet plenum only, with no throttling of the flow. This is a typical configuration for post-LOCA operation when no other pumps are being supplied by the RHR pump discharge. Analyses have shown that of the four installed RHR pumps, minor differences in piping configuration and resistances result in the Unit 1 "A" train RHR pump being the most limiting for NPSH purposes when in this alignment.

Alignment R3B would be used if the RCS pressure exceeded RHR pump shut-off head but sump recirculation criteria had been met. A high head safety injection (HHSI) pump would be supplied from the RHR pump discharge. This "piggyback" alignment provides continued core cooling while the RCS is cooled down and depressurized following a small break LOCA. Analyses have shown that in this alignment, the Unit 2 "B" train RHR pump would have the lowest NPSH margin. However, the low flow rate caused by the limiting restrictions in the HHSI pump and the higher RCS pressure ensure that the NPSH margin available in this configuration is significantly greater than either of the other two alignments.

Alignment R4A is a boron dilution / flushing alignment that would be used during long-term recirculation to ensure that boron does not concentrate to the point of precipitating in the core. The alignment supplies flow to the core through both the direct core deluge flow path to the reactor outlet plenum, and through a parallel throttled HHSI pump discharge. The HHSI pump would be supplied from the RHR pump discharge. In this alignment, the pump with the smallest NPSH margin is the Unit 2 "A" train RHR pump.

As can be seen from the table, the maximum RHR pump flow occurs in the R4A alignment. The flow is 2088 gpm, and is therefore the maximum expected sump outlet flow rate.

The NPSH calculation for the RHR pump uses an assumed sump temperature of 212°F. Actual sump temperature may be somewhat higher during the early stages of containment sump recirculation. However, higher temperature would ensure that a containment pressure of greater than atmospheric would also be present, while viscous fluid frictional losses would be lower. Therefore, the use of 212°F is appropriate. The minimum sump level at the time of switchover to sump recirculation is 38".

<u>GL 2004-02 Requested Information Item 3.g.2</u>. Assumptions, Sources, and Bases for Above Parameters

<u>FPL Energy Point Beach Response</u>

The calculation that determined the above flow parameters assumed:

1. The interior of all piping is at the same constant temperature as the source of the flow, i.e. that there is no heat transfer to or from the fluid en route to the pumps. This is reasonable based on the high velocities of the fluid.

2. The sump temperature is 212°F. Actual sump temperature may be somewhat higher during the early stages of containment sump recirculation. However, this would ensure that a containment pressure of greater than atmospheric would also be present. Therefore, the use of 212°F is appropriate.

3. System alignments will be performed in accordance with controlled plant operating and emergency operating procedures.

4. ECCS system and CS pump seals function properly and seal leakage is sufficiently small that the leakage is neglected. This is reasonable because the seals are qualified for the postulated conditions.

5. The ΔP across the sump screens is no greater than the available height of water above the containment floor. This is an analytical assumption that decouples the NPSH analysis from the design and testing of the screens. The response to RAI question 39 provides the description, bases, and acceptability of this approach.

6. The sump screens do not permit air entrainment through vent paths or vortex formation. See the discussion in response to Item 3.f.3 above regarding air vent paths and vortex formation.

The engineered safety feature (ESF) systems include two trains of emergency cooling pumps. Each train consists of one HHSI pump, one RHR (low pressure injection) pump, and one CS pump.

Only the RHR pumps can be aligned to take a suction directly from the containment sump and each pump has a separate and dedicated strainer.

Each RHR pump's discharge is aligned directly to the reactor vessel outlet plenum via separate and redundant piping, valves, and nozzles in the reactor vessel. In addition, crosstie piping and remotely-operated valves permit supplying each train's HHSI and CS pump from the respective train's RHR pump discharge.

The discharge flow of an RHR pump must be throttled if simultaneously providing more than a single demand (both low head and high head injection, both low head injection and containment spray). Since there is currently no installed safety-related capability to adequately throttle and monitor the low head injection and containment spray flow paths, simultaneous supply to both of these demands is procedurally precluded.

Provisions exist to enable simultaneously supplying both low head and high head injection. This is achieved by throttling the high head flow to keep total RHR pump flow within acceptable limits. This alignment is procedurally driven when coping with a small break LOCA during sump recirculation, or when aligned within 14 hours post-event (as required by the station's license basis) to flush concentrated boric acid from the core.

The strainers were designed and qualified to a flow rate of 2200 gpm.

GL 2004-02 Requested Information Item 3.g.3, 3.g.4 System Response for Large and Small Break LOCAs, and 3.g.4 Operation of ECCS and CS Pumps Before and After Initiation of Recirculation

FPL Energy Point Beach Response

A "small break LOCA" is understood to mean the failure of a pipe equivalent to the severance of a 2" or larger nominal diameter pipe. This limitation is found in section ES.1 of the Safety Evaluation for NEI 04-07 (Reference 12b).

RHR and HHSI pumps start upon receipt of an SI signal. An SI will be generated almost immediately in the case of a large break LOCA. Depending upon the size of the break, there will be a short delay between event initiation and generation of an SI signal in the case of a small break LOCA. In addition, a short sequencing delay to start and load the emergency diesel generators (EDGs) will exist if a concurrent loss of offsite power (LOOP) occurs. The flow paths from the RHR and HHSI pumps to the RCS are open, isolated via check valves only, and do not require valve repositioning to inject.

CS pumps automatically start upon receipt of a containment Hi-Hi signal. This signal is generated by a containment pressure of ≤30 psig. This will occur rapidly in the event of a large break LOCA, and may or may not be received in the event of a smaller break LOCA, depending upon the break size. As with the HHSI and RHR pumps, CS pump start may be delayed for EDG starting and sequencing if a concurrent LOOP occurs.

The CS pump discharges are normally isolated from the containment by closed, automatically operated motor-operated valves. Upon receipt of a CS start signal, these valves stroke open.

Large Break LOCA

The combination of SI accumulator discharge, high volume / low pressure RHR discharge, and HHSI pump discharge rapidly refloods the reactor core. The continued flow refills the reactor vessel.

The operator is directed to verify that only a single train of HHSI and RHR is injecting by securing any unneeded HHSI and/or RHR pump(s). This action slows the depletion rate of the RWST, affording adequate time to prepare for sump recirculation. It also maximizes the settling of potentially suspended debris in the containment sump. Conserving the available RWST inventory also maximizes the duration of containment spray operation, ensuring that the minimum analyzed spray duration can be supported for control of dose.

Upon reaching an indicated level of 34% in the RWST, the operator shifts the suction of the running RHR pump to the containment sump, and the operating HHSI pump is secured. Containment spray continues to operate until the RWST is depleted, whereupon it is secured. Replenishment of the RWST is then commenced using the reactor makeup water system.

The final configuration is a single RHR pump operating, taking a suction from a dedicated sump strainer, and delivering flow through an RHR heat exchanger back to the reactor vessel via outlet plenum injection. Within 14 hours, simultaneous cold leg injection is started using an HHSI pump drawing from the running RHR pump discharge.

Small Break LOCA

RCS conditions are assessed to determine whether high head recirculation will be required. If it is not, then the sequence follows that of a large break LOCA. Otherwise, the sequence follows that of a large break LOCA, except that the final alignment has a single RHR pump drawing a suction from the sump, and supplying high head cold leg injection through a running HHSI pump, and low head outlet plenum core injection if RCS pressure has been reduced sufficiently to permit low head injection. Continued RCS cooldown and depressurization will result in being able to secure the HHSI flow path. If the LOCA is large enough to require continued sump recirculation, then simultaneous outlet plenum and cold leg injection may be established for boron concentration control within 14 hours of event initiation.

CS Operation

If initiated automatically, operating containment spray pumps are permitted to run until the RWST has been depleted. This ensures that sufficient sodium hydroxide (NaOH) buffer has been injected for sump chemistry and radioiodine control. The analyzed minimum duration of spray is 65 minutes.

The spray pumps would not currently be operated during sump recirculation due to RHR pump NPSH limitations. However, it may become desirable in the future to operate containment spray in recirculation mode to mitigate the consequences of a postulated severe core damage sequence. In anticipation of such a change, the evaluation of chemical effects included continuous spray operation for a period of up to 6 hours post-event to ensure that such recirculation spray could be accommodated if desired in the future.

***GL 2004-02 Requested Information Item 3.g.5* Single Failure Assumptions for Pump Operation**

FPL Energy Point Beach Response

The ECCS system is designed to meet the acceptance criteria of 10 CFR 50.46(b) with the single most limiting active failure. This failure has been postulated to be the loss of one complete train of ECCS equipment and bounds the failure of any single pump to start or run.

The system does not have an automated securing of the ECCS pumps. In the unlikely event that a pump failed to be secured by a remote manual action from the main control board, it could be secured locally at its breaker.

***GL 2004-02 Requested Information Item 3.g.6* Significant Assumptions used in NPSH Analysis**

FPL Energy Point Beach Response

See the response to Item 3.g.2 above.

***GL 2004-02 Requested Information Item 3.g.7* Accounting for volumes: Empty Spray Pipe, Water Droplets, Condensation and Holdup on Horizontal and Vertical Surfaces**

FPL Energy Point Beach Response

The initial calculation of minimum sump level did not explicitly account for these holdup volumes. Rather, it only credited water transferred from the RWST and did not credit water spilled from the RCS and SI accumulators. An additional calculation was performed that demonstrates the sum of holdup volumes, including the pressurizer cubicle, empty spray system piping, water droplets suspended in the containment atmosphere, uncondensed water vapor in the containment atmosphere, and water filming on vertical and horizontal surfaces, is substantially less than the water volume of the pressurizer, SI accumulators, and steam generators. Therefore, the calculation of minimum sump level remains conservative.

***GL 2004-02 Requested Information Item 3.g.8.* Assumptions and bases on Equipment Displacing Water Resulting in Higher Pool Level**

FPL Energy Point Beach Response

The calculation of containment volume and level only deduct displacement volumes occupied by substantial poured concrete walls, pedestals, and foundation piers, and the volume of the reactor vessel. It is assumed that the displacement volumes of the miscellaneous supports, piping, cable trays, instrumentation and tubing, reactor vessel insulation, etc., are negligible when compared to the calculated open volume.

The basis for this assumption is that a walkdown was performed to verify the displacement volumes of miscellaneous supports, piping, cable trays and instrumentation & tubing. The qualitative walkdown found that the displacement volume of miscellaneous items is negligible when compared to the open volume of the sump, and are therefore not addressed in the calculation.

***GL 2004-02 Requested Information Item 3.g.9.* Assumptions on Water Sources and Quantities Contributing to Pool Volume**

FPL Energy Point Beach Response

The only water source considered to contribute to the pool volume is water transferred from the RWST. The RWST has a Technical Specification minimum allowable volume of 275,000 gallons. Filling the containment sump to the designated minimum switchover level of 38" requires the transfer of only 154,000 gallons, again discounting any spilled RCS and SI accumulator volume.

GL 2004-02 Requested Information Item 3.g.10. NPSH Margins for Pumps Taking Suction from the Sump in Recirculation Mode

FPL Energy Point Beach Response

In the calculated results, NPSH margins are represented as a ratio of the available NPSH to the required NPSH. The following table summarizes the ratio for the limiting RHR pumps during the limiting sump recirculation alignments.

ECCS Alignment	$NPSH_R$ (ft)	NPSH Ratio*	$NPSH_A$ (ft)
R1A: Train A RHR injecting to RV only	11.8	1.15	13.6
R3B: Train B RHR supplying High Head SI only	6.2	3.43	21.33
R4A: Train A RHR supplying RV and High Head SI**	12.75	1.00**	12.75

*Ratio of $NPSH_A$ / $NPSH_R$

**This alignment is used only during simultaneous outlet plenum and cold leg injection to flush concentrated boron from the vessel. In this alignment, flow is throttled manually to prevent exceeding NPSH requirements. Analyzed flow was adjusted to obtain satisfactory results (NPSH ratio of 1), and this establishes the maximum allowable throttled flow for procedure implementation.

GL 2004-02 Requested Information Item 3.h. Coatings Evaluation

The objective of the coatings evaluation section is to determine the plant-specific ZOI and debris characteristics for coatings for use in determining the eventual contribution of coatings to overall head loss at the sump screen.

1. *Provide details on type(s) of coating systems used in containment, e.g., Carboline CZ 11 Inorganic Zinc primer, Ameron 90 epoxy finish coat.*
2. *Describe and provide bases for assumptions made in post-LOCA paint debris transport analysis.*
3. *Discuss suction strainer head loss testing performed as it relates to both qualified and unqualified coatings and what surrogate material was used to simulate coatings debris. Provide bases for the choice of surrogates.*
4. *Describe coatings debris generation assumptions. For example, describe how the quantity of paint debris was determined based on ZOI size for qualified and unqualified coatings.*
5. *Describe what debris characteristics were assumed, i.e., chips, particulate, size distribution and provide bases for the assumptions.*
6. *Describe any ongoing containment coating condition assessment program.*

GL 2004-02 Requested Information Item 3.h.1. Summary Of Types Of Coating Systems Used In [Plant] Containment

FPL Energy Point Beach Response

The field-applied "acceptable" coatings systems in the PBNP containments consist of:

- Dimetcote D-2 or D-6 steel primer with Amercoat 66 epoxy topcoat on carbon steel structures and the containment liner,
- Carboline 195 concrete surfacer with a Carboline Phenoline 305 phenolic modified epoxy topcoat on concrete walls, and

- Carboline Phenoline 305 phenolic modified epoxy on concrete floors.

Repairs to acceptable coatings in excess of 1 square foot are qualified in accordance with ANSI N101.4-1972, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities."

<u>GL 2004-02 Requested Information Items 3.h.2, 3.h.5</u> Assumptions & Bases for Post-LOCA Paint Debris Transport

<u>FPL Energy Point Beach Response</u>

For the completed screen qualification testing purposes, all failed coatings were assumed to be fully transportable. No reductions were taken for debris settling or for sequestering in inactive sumps, upper elevations of containment, etc. These assumptions are consistent with the NRC Safety Evaluation for NEI 04-07 (Section 3.4.3.6 of Volume 2). The pending confirmatory integrated head loss and chemical effects testing is expected to retain these same assumptions. Unless these change, no additional response regarding coatings debris transport is anticipated.

<u>GL 2004-02 Requested Information Item 3.h.3</u> Head Loss Testing

<u>FPL Energy Point Beach Response</u>

For the completed head loss testing, representative surrogates with similar or bounding density, size, and shape characteristics to the debris generation assumptions above were selected.

For coating debris from epoxy and alkyds specified as fine particulate, #325 walnut shell flour which has similar density, size and shape characteristics to these coatings was utilized. The walnut shell flour had a particulate size of <44 microns.

For coating debris from inorganic zinc, the surrogate used was tin powder with a particle size range of 1-5 microns. Tin powder has similar density, size, and shape characteristics as zinc powder.

The completed testing was subsequently determined to be inadequate for reasons not related to coatings debris surrogates. It is expected that the additional integrated head loss and chemical effects testing will use the same surrogates. An additional response on this subject is not anticipated.

<u>GL 2004-02 Requested Information Item 3.h.4.</u> Debris Generation Assumptions

<u>FPL Energy Point Beach Response</u>

The post-DBA debris evaluations of coatings were based on NEI-04-07 or testing as discussed below.

A 4D spherical ZOI was used for the acceptable coating systems on concrete walls (Carboline Phenoline 305 with Carboline 195 surfacer). The 4D ZOI for these coating systems was selected based on the results of the coatings performance tests conducted by FPL and Areva NP (JOGAR Testing).

The untopcoated zinc coatings used to repair galvanized ductwork are not qualified and are assumed to fail in the event of a LOCA.

The default 10D ZOI recommended in the NEI 04-07 Volume 1 for the acceptable coating systems was used for the coatings on structural steel components (Dimetcote Steel Primer top coated with AmerCoat 66 epoxy). Samples of this system are available for supplemental testing and ZOI reduction, but to date testing has not been performed. In the future, testing may be used to reduce the assumed ZOI.

Since there are relatively few coated steel components within the RCS loop compartments, it was not necessary to assume a full, encompassing spherical ZOI so the surface area of a half-sphere was used. The half-sphere conservatively bounds the maximum surface area of steel coatings that would be exposed to the energetic jet from a postulated LOCA.

Thickness

To determine the total quantity (volume) of debris that could be generated by each coating type, field measurements of the thicknesses of coatings on major constituents of the coatings were taken. These measurements were rounded up to the next thousandth of an inch prior to being used in determining total volume of coating debris.

Area

For unqualified and degraded coatings outside of the ZOI, the areas were taken from detailed coatings inspection reports. The area of acceptable coatings within the ZOI was calculated as the surface area of a spherical ZOI, or of the fractional sphere in the case of the acceptable coatings on metal structures.

Total Volume

The volume of coatings debris of each type (i.e. epoxy, inorganic zinc, or alkyd/other) was determined by multiplying the area for each application by the thickness of that application and type. The resulting volume of coatings that would fail outside of the ZOIs were increased by 15% to ensure conservative results and to provide margin against future discoveries of degraded or unqualified coatings pending repair or removal of the coatings. Volumes were then summed for the final results.

***GL 2004-02 Requested Information Item 3.h.6.* Ongoing Containment Coating Condition Assessment Program**

FPL Energy Point Beach Response

FPL Energy Point Beach is committed to performing coatings assessments in containment on a refueling interval frequency to ensure the total inventory of coatings debris remains bounded by the design basis for the sump screens. The coatings assessments are controlled by procedure under the PBNP protective coatings program. The assessment procedure conforms to the intent of ASTM D5163-91 (Reapproved 1996), which is endorsed by RG 1.54, Revision 1 (Reference 22).

The coating assessment procedure requires a general visual inspection of all accessible surface areas inside containment, with thorough inspections performed as needed in areas exhibiting degradation includes such conditions as flaking, blistering, delamination, cracking, checking, pinholes, rust, or damaged or abraded areas. Coating assessment walkdowns are performed by at least two qualified individuals, including the coating program owner and a Quality Control inspector. The qualifications of these individuals meet the intent of EPRI 1003102 (Reference 23) and ASTM D5163-91. The general visual inspection involves comparison of the as-found condition to the previously documented condition and documenting changes or new conditions that are observed. Where new or further degradation of coatings is noted, a more thorough inspection may be performed to better define the extent and cause of degradation.

Inspections may involve several different techniques including visual inspection, non-destructive tests for dry film thickness, and destructive tests for adhesion or destructive sampling for subsequent chemical analysis. Supplemental inspections and tests are performed in accordance with current industry guidance described in EPRI 1003102 and ASTM D5163-91. Where nonconforming conditions are noted that have not been previously evaluated, or where the condition has further degraded as compared to previous results, the corrective action program is used to identify and evaluate the condition.

The general condition of the containment coatings is also summarized in a report, which is issued following each refueling outage. The most recently issued report for each unit contains the log of the total surface area and volume of all unqualified and degraded coatings within the containment, as of the end of the most recent refueling outage for the unit. The report also contains a computation of the current operating margin as compared to the volumes of coating debris used in the design and testing of the containment sump strainers.

FPL Energy Point Beach does not intend to conduct additional tests of existing acceptable coatings to reaffirm DBA performance. Based on available evidence from the industry EPRI 1014883 (Reference 24), as well as plant-specific coating adhesion data, there is reasonable assurance that visually acceptable coatings will remain intact following a DBA, and will not fail.

GL 2004-02 Requested Information Item 3.i. ***Debris Source Term Refinements***

The objective of the debris source term refinements section is to identify any design and operational refinements taken to reduce the plant debris source term.

If any or all of the 5 suggested design and operational refinements given in the guidance report (GR Section 5) and safety evaluation (SE Section 5.1) were used, briefly summarize the application of the refinements.

FPL Energy Point Beach Response

Of the five (5) operational refinements, one was implemented.

Improvements in the containment coatings control program included the sampling and testing of existing coatings that had historically been assumed to be unqualified. As a result, a significant portion of the previously "unqualified" coatings were subsequently determined to be acceptable. The affected coatings are those originally applied to both the polar crane and its rail beam. This resulted in a much smaller inventory of unqualified coatings.

GL 2004-02 Requested Information Item 3.j. ***Screen Modification Package***

The objective of the screen modification package section is to provide a basic description of the sump screen modification.

1. Provide a description of the major features of the sump screen design modification.

FPL Energy Point Beach Response

The intent of the modification was to perform the hardware changes required to bring PBNP into conformance with GSI-191 by replacing the original small area screens with screens having a substantially increased surface area. The replacement screens also correct a deficiency wherein a relatively small quantity of debris could have given rise to a relatively high head loss. This was because of the unique configuration of the sump outlet isolation valves.

Original Screens

The original PBNP ECCS screens consisted of a single vertical cylindrical screen for each train of ECCS. The screens were fabricated from light gauge stainless steel with 1/8" diameter perforations. The screens were each 13.5" in diameter, and 71" tall for each train of ECCS, and were completely enclosed in a single, larger "trash rack" fabricated from ½" thick stainless steel. 1" wide vertical slots were cut in the surface of the trash rack to admit sump water while excluding larger debris. There were approximately 256 slots that were 6" tall, and approximately 32 slots that were 5" tall. The solid top of the rack served to close off the top of the screens and prevent debris intrusion should the screens become totally submerged.

The effective area of each of the original screens was approximately 21 square feet per train if fully submerged. At the time that sump recirculation would have been initiated, the screens would have been only partially submerged with a minimum of ~38" in the sump. The effective area would have then been approximately 11 square feet per train.

In addition, the outlet isolation valve disk for each train consists of a flat disk that seats on the open end of the sump outlet pipe. The disk has a short lift, and has an outer diameter of 12.065". The horizontal disk occupied and obstructed most of the cross section on the inside of the original vertical strainers, leaving only a ~¾" annular gap between the strainer and the edge of the disk. Should an impervious debris bed have formed around the bottom few inches of the strainer, all flow would have had to negotiate this restrictive gap. Although considered unlikely, if this were to have occurred, the resulting head loss could have had a detrimental impact on the operation of the ECCS system during sump recirculation.

Replacement Screens

Enclosure 3 of this submittal provides drawings that depict the general arrangement of the strainer installation, and provides a detail of a single strainer module.

The modification installed a passive, safety-related Sure-Flow ® Strainer assembly engineered and manufactured by Performance Contracting Incorporated (PCI). Each strainer train in each of the PBNP units consists of 11 strainer modules connected to the respective train's sump outlet pipe. The installations were performed during the fall 2006 and spring 2007 refueling outages.

The effective surface area of each replacement strainer train is 1495 ft^2, more than a 70-fold increase over the original screens if the screens would have been fully submerged. When comparing submerged areas at the time of recirculation initiation, the replacement screens have approximately 136 times the effective surface area.

The replacement screens are designed to draw the design flow rate of 2200 gpm evenly across the entire active surface, reducing the screen approach velocity to just 0.0033 fps. The strainer configuration is designed to limit the head loss to no more than 38" during post-LOCA design conditions. The replacement strainers will be fully submerged by the time that sump recirculation initiates.

The 11 modules in each strainer train consist of a core tube and mounting tracks. The modules are nearly identical with the only difference being the flow control hole sizes in the core tube. Each module is independently supported by pinned connections to a mounting track. The modules are connected with thin gauge stainless steel bands that are used to prevent debris from entering the system between adjacent modules. The bands are secured with a seismic latch. This connection permits relative motion in the axial direction as the core tube can slide relative to the stainless steel bands, and accommodates disassembly for inspection, repair, replacement, or installation of additional modules to extend the assemblies, or "strings," of strainer modules.

Each module is made of stainless steel perforated sheet with a nominal hole diameter of 0.066". The perforated sheets are riveted together along the outside edge and fitted to the core tube along the inner edges. Because of the convoluted configuration, and internal and external cross bracing, the modules are inherently rugged and do not require an external trash rack to provide protection from larger debris or incidental damage. The bottom active strainer surfaces on the modules are located approximately 3" above the containment floor.

The mounting tracks are secured to the containment floor by anchor bolts, and the assembly is designed to withstand seismic, static, hydraulic, and differential pressure loads. For additional details of the structural analysis, see the response to Item 3.k. The strainer module strings are the connected to the containment outlets by 16" diameter stainless steel piping anchored and supported against the same loading conditions.

At the point that the 16" diameter piping turns downward to connect to the containment outlets, the piping transitions to an 18" diameter elbow. The large diameter elbow maximizes the annular flow area between the existing sump outlet valve disk and the elbow wall. The slower velocity also serves to minimize the frictional head loss through this transition into the piping.

The strainer core tubes were fabricated from 16" stainless steel pipe. The core tubes have variable sized "windows" cut in the walls to admit flow of strained water from the inside of the perforated strainer sheets. The windows are sized to ensure an even distribution of flow through the entire strainer surface. This provides maximum assurance of even debris loading, while minimizing total head loss and potential for air entrainment.

<u>GL 2004-02 Requested Information Item 3.k.</u> Sump Structural Analysis

The objective of the sump structural analysis section is to structurally qualify the sump strainer modification including seismic loads and loads due to differential pressure, missiles, and jet forces.

Provide the information requested in GL 2004-02 Requested Information Item 2(d)(vii): Verification that the strength of the trash racks is adequate to protect the debris screens from missiles and other large debris. The submittal should also provide verification that the trash racks and sump screens are capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under flow conditions.

<u>GL 2004-02 Requested Information Item 3.k.1.</u> Provide a description of the sump structural analysis including assumptions on which the analysis was based.

<u>FPL Energy Point Beach Response</u>

The abridged structural analyses are provided in Enclosures 4, 5 and 6. Enclosure 4 pertains to the structural analysis for the strainer modules, and is applicable to both units. Enclosure 5 pertains to the structural analysis of the connecting piping and supports for Unit 1. Enclosure 6 pertains to the structural analysis of the connecting piping and supports for Unit 2.

<u>GL 2004-02 Requested Information Item3.k.2.</u> If a backflushing strategy is credited, provide structural analysis considering reverse flow.

<u>FPL Energy Point Beach Response</u>

A backflushing strategy was not pursued.

<u>GL 2004-02 Requested Information Item 3.k.3.</u> Provide a summary description of the ECCS sump strainer structure for the modified sump strainer assembly.

<u>FPL Energy Point Beach Response</u>

See the response to Question 3.j above and Enclosures 4, 5 and 6 for the requested description of the replacement strainers, connecting piping and the interface to the ECCS pump suction piping.

<u>GL 2004-02 Requested Information Item 3.k.4.</u> In the summary description, clarify whether the strainer assembly is entirely inside the crane wall, partially inside and partially outside the crane wall, or entirely outside the crane wall.

<u>FPL Energy Point Beach Response</u>

PBNP does not have a crane wall so this question is not applicable.

<u>GL 2004-02 Requested Information Item 3.k.5.</u> Provide sketches showing the layout of the existing and modified sump strainer structural assembly. Identify and label the various components.

<u>FPL Energy Point Beach Response</u>

Drawings of the general arrangement of the replacement sump strainers are provided in Enclosure 3. Sketches showing the details of sub-components analyzed are included within the structural analyses provided as Enclosures 4, 5 and 6. The original sump screens are no longer installed. The existing screens are the replacement screens are the current screens. The sketches have been provided.

<u>GL 2004-02 Requested Information Item 3.k.6.</u> Provide a summary analysis showing structural qualification of modified sump strainer assembly. Provide a reference list of the source qualification documents.

<u>FPL Energy Point Beach Response</u>

Enclosures 4, 5 and 6 contain the analyses of the replacement sump strainers. Section 2.0 describes the methodology, including the software, used in performing the structural analyses. Section 3.0 describes the Acceptance Criteria, including the applicable design codes, loadings, and load combinations. Section 7.0 details the results and conclusions. Section 8.0 is a listing of the references that support the analyses.

<u>GL 2004-02 Requested Information Item 3.k.7.</u> Summarize the design inputs, loads and load combinations utilized.

<u>FPL Energy Point Beach Response</u>

Please refer to Section 3.0, "Acceptance Criteria," of Enclosures 4, 5 and 6 for the design inputs, loads and load combinations used in the structural analyses.

<u>GL 2004-02 Requested Information Item 3.k.8.</u> List the design codes utilized in the structural design qualification of the sump strainer assembly.

<u>FPL Energy Point Beach Response</u>

The piping connecting the strainers to the containment sump outlet was designed to ANSI/ASME B31.1 1998 edition; the piping supports and base plates, and other mounting hardware was designed to meet AISC 9th Edition. The strainers were also designed to ANSI/ASME B31.1 1998 (through 1999 addenda) to the extent that the piping code was applicable. Being classified as "other pressure retaining components" per Paragraph 104.7 of the B31.1 Code, the guidance of the ASME Boiler and Pressure Vessel Code was used where the guidance of the B31.1 Code was incomplete or inappropriate for the strainers. Refer to the "Acceptance Criteria" section (Section 3.0) in each of Enclosures 4, 5 and 6 for a discussion of the application of the Codes.

<u>GL 2004-02 Requested Information Item 3.k.9.</u> Provide a summary of the structural qualification results and design margins for the various components of the sump strainer structural assembly.

<u>FPL Energy Point Beach Response</u>

As documented in Section 7.0, "Results & Conclusions," of Enclosures 4, 5 and 6, the interaction ratio (IR) of each subcomponent is less than 1, and therefore is acceptable. The noted enclosures provide a detailed listing of the IR (design margin) of each subcomponent.

***GL 2004-02 Requested Information Item 3.k.10.* Provide a summary of evaluations performed for dynamic effects such as pipe whip and jet impingement associated with high energy line breaks (as applicable). List the reference evaluation documents and calculations.**

FPL Energy Point Beach Response

Containment sump recirculation is used when makeup to the RCS is required, and other sources are not available or are of such small volume as to be insufficient. This could only occur after a LOCA has breached the RCS pressure boundary and the RWST has been depleted. As such, the license and design bases of PBNP only credit containment sump recirculation following a LOCA. Since sump recirculation is not credited following other potential high energy line breaks (HELBs) such as feedwater or main steam line breaks, the potential dynamic effects of a HELB were not evaluated for the replacement strainers.

In Safety Evaluations dated June 6, 2005, (Reference 25) November 7, 2000, (Reference 26) (and supplemented on February 7, 2005, Reference 27), December 15, 2000, (Reference 28) (also supplemented on February 7, 2005), and December 18, 2000, (Reference 29) the NRC reviewed and accepted analyses demonstrating that a rapidly propagating failure of the large bore RCS piping components at PBNP is highly unlikely (Leak Before Break analyses). These analyses included the RCS primary loop piping, SI accumulator discharge lines to the RCS, the pressurizer surge line, and the high pressure RHR piping connections to the RCS. As such, consideration of missile impacts or other dynamic effects of a LOCA per 10 CFR 50 General Design Criterion 4 (Plant specific GDC 40) are no longer part of the design bases for PBNP.

The replacement screens have been located outside of the thick walled reactor coolant loop compartments and are away from openings in the walls to the extent practicable. The strainers are also inherently robust, owing to the tough and relatively thick material used for the strainer active surfaces (18 gauge stainless steel), the internal reinforcements to prevent deformation under the design differential pressure, the convoluted form that precludes large, unbroken diaphragm surfaces, and the external bracing for seismic loading. As such, they are unlikely to tear or be perforated by incidental impacts from debris or rebounding missiles, tending rather to deform or dent. The strainers in each unit are routed away from each other such that no single missile would be capable of impacting both strainers.

***GL 2004-02 Requested Information Item 3.k.11.* Provide a summary of evaluations performed for dynamic effects such as the effects of missile impact (as applicable). List the reference evaluation documents and calculations.**

FPL Energy Point Beach Response

As discussed in the response to Item 3.k.10 above, consideration of the dynamic effects of a HELB or LOCA are not applicable to PBNP.

GL 2004-02 Requested Information Item 3.k.12. ***Provide confirmation that outage maintenance and inspection activities will include checking for or prevention of any damage to the new sump strainer assembly during outage maintenance activities.***

FPL Energy Point Beach Response

Technical Specifications require that the strainers be visually inspected once per cycle for evidence of structural distress, corrosion, or restrictions from debris. This requirement is implemented by approved plant procedures.

GL 2004-02 Requested Information Item 3.l ***Upstream Effects***

The objective of the upstream effects assessment is to evaluate the flow paths upstream of the containment sump for holdup of inventory which could reduce flow to and possibly starve the sump.

Provide a summary of the upstream effects evaluation including the information requested in GL 2004-02 Requested Information Item 2(d)(iv): The basis for concluding that the water inventory required to ensure adequate ECCS or CSS recirculation would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return flow paths.

1. *Summarize the evaluation of the flow paths from the postulated break locations and containment spray wash down to identify potential choke points in the flow field upstream of the sump.*
2. *Summarize measures taken to mitigate potential choke points.*
3. *Summarize the evaluation of water holdup at installed curbs and/or debris interceptors.*
4. *Describe how potential blockage of reactor cavity and refueling cavity drains has been evaluated, including likelihood of blockage and amount of expected holdup.*

FPL Energy Point Beach Response

The floors of the PBNP containment are supported independently of, and without contact with, the containment building walls. The resulting annular flow areas at each floor preclude significant accumulation and hold-up of spray or break flow. In addition, the poured concrete floors at each level of containment are punctuated by two staircases that do not have curbs at the nose of the top tread which could retard water flow.

The flow paths from the RCS loop compartments are several large open areas in each of the loop compartment walls (several of which are on the order of 10' wide and 7' high) at the bottom of the loop compartments. The floor of the loop compartments are 2' higher than the surrounding general area containing the sump screens. The replacement ECCS suction strainers are located in this surrounding general area. As such, there are ample direct flow paths from the postulated break locations evaluated, directly to the ECCS suction screens without intervening choke-points.

The reactor cavity drain is maintained open, with an installed strainer to ensure that containment spray (or breakflow emanating from the head region) drains freely to the El. 8' of containment. The insulation on the reactor head is entirely RMI, and located within the reactor head shroud. The strainer in the refueling canal sump contains 200 1" diameter holes (net open area of 157 in^2), varying in elevation from 1" to ~18" above the floor of the reactor cavity sump.

The strainer, combined with the limited quantity of RMI insulation, is of sufficient to preclude complete blockage of the drain path to the containment basement. Additionally, a LOCA originating from a break in the reactor head region would be terminated when the RCS has been depressurized and normal RHR cooling in mid-loop is restored.

Other spaces / locations in the containment subject to direct containment spray (such as the open-topped steam generator cubicles, reactor coolant pump cubicles, etc. (except as noted in the response to Item 3.g.7 on the subject of hold up volumes), drain to El. 8' of the containment. Condensate from the containment fan coolers and all floor drains are routed to the containment building sump, which in turn, has open communication with the 8' elevation in the case of containment flooding. The containment building sump is located below El 8'.

***GL 2004-02 Requested Information Item 3.m.1* Downstream effects - Components and Systems**

The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the containment sump screen on the function of the ECCS and CSS in terms of potential wear of components and blockage of flow streams.

Provide the information requested in GL 04-02 Requested Information Item 2.(d)(v) and 2.(d)(vi) regarding blockage, plugging, and wear at restrictions and close tolerance locations in the ECCS and CSS downstream of the sump.

GL 2004-02 Requested Information Item 2(d)(v): The basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface.

GL 2004-02 Requested Information Item 2(d)(vi) Verification that the close-tolerance subcomponents in pumps, valves and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.

1. *If approved methods were used (e.g., WCAP-16406-P), briefly summarize the application of the methods.*
2. *Provide a summary and conclusions of downstream evaluations.*
3. *Provide a summary of design or operational changes made as a result of downstream evaluations.*

FPL Energy Point Beach Response

FPL Energy Point Beach developed a calculation to address ex-vessel (i.e. component and systems) downstream effects. The calculation was developed in accordance with PWROG WCAP-16406-P, Revision 0 (Reference 14a), and incorporated the additional guidance provided by a supplemental letter from Westinghouse regarding depletion coefficients for fibrous and non-fibrous debris (August 2005), and an addenda to Appendix F and Section 7 (August 2005).

A revision of the calculation is pending to incorporate changes in the WCAP to resolve NRC comments. The changes are expected to be limited to wear of the HHSI pump internals (a multi-stage pump that will require use of the Archard wear model) and to the wear of orifices in the CS and ECCS process piping.

The revision scope is not expected to impact the final conclusions of the calculation however.

The HHSI pumps are not needed for long-term decay heat removal for either a large break or small break LOCA. As discussed in the response to Item 3.g.3, operation of the HHSI pumps for a small break LOCA will be terminated by cooling down and depressurizing the RCS within several hours post-event; a large break LOCA would not require use of the HHSI pumps on sump recirculation, except for boron concentration control prior to achieving subcooled decay heat removal. In addition, the outlet plenum injection configuration of PBNP precludes the postulated mechanism for boron concentration in the reactor.

The need for short-term operation of the HHSI pump(s) while on sump recirculation is not expected to result in excessive wear, even when the Archard wear model is used.

Similarly, the subject orifices are flow limiting orifices in the CS lines and flow metering orifices in the low head (RHR), high head and containment spray lines.

In the case of the flow limiting orifices, wear is expected to be limited by the relatively short duration of operation with particulate laden sump fluid (up to 6 hours post-event, of which a portion is injection with clean RWST water). The revised calculation is expected to demonstrate that the orifice wear will remain within acceptable limits.

The flow metering orifices are needed for accurate indication during the relatively short period that flow would be split between core injection and either the containment spray or high head flow paths during the first several hours post-event. During this time, flow would be actively managed by throttling to obtain desired indicated flows. The revised wear calculation is expected to demonstrate that the orifice wear will remain within acceptable limits for the limited duration of concern.

The completed calculation evaluates the downstream effects of debris ingestion of the auxiliary equipment in PBNP, including the valves, pumps, heat exchangers, orifices, spray nozzles, and instrumentation tubing, following the methodology in WCAP-16406-P Revision 0 (Reference 14a), and incorporates the previously cited supplemental guidance from Westinghouse regarding debris depletion coefficients. The effects of debris ingested through the containment sump strainers during the recirculation mode of the ECCS and CSS include erosive wear, abrasion and potential blockage of equipment and flow paths. The calculation also documents an assessment of changes in system or equipment operation caused by wear, including an evaluation of pump hydraulic performance because of internal wear. These effects were determined to be acceptable.

The calculation also determined that the ECCS and CS pump seals (John Crane Type 1 and 1B seals) would function acceptably and not suffer failure because of the pumping of debris laden fluid.

GL 2004-02 Requested Information Item 3.m.2. *Downstream Effects - Fuel and Vessel*

The objective of the downstream effects, fuel and vessel section is to evaluate the effects that debris carried downstream of the containment sump screen and into the reactor vessel has on core cooling.

1. *Show that the in-vessel effects evaluation is consistent with or bounded by the industry generic guidance. Provide a basis for any exceptions.*

FPL Energy Point Beach Response

WCAP-16793-NP (Reference 15) demonstrated that there is reasonable assurance of long-term core cooling for all plants in the following areas:

1. The size of holes in replacement sump screen designs limit the size of debris that is passed through the screen during operation of the ECCS in the recirculation mode.

2. The characteristic dimension of the debris is typically less than the screen hole size, even for fibrous debris. Consequently, debris buildup at critical locations in the reactor vessel and core is not expected.

3. The small size of the debris and its tendency to not adhere strongly to fuel indicates that long-term core cooling of the fuel will not be impaired by either the collection of fibrous and particulate debris in fuel elements, or by the collection of fibrous debris on fuel cladding surfaces.

4. Supporting calculations have demonstrated long-term core cooling will be maintained with about 99.4% of the core blocked. The cladding temperature response to blockage at grids and the collection of precipitation on clad surfaces was also demonstrated to be acceptable with the resulting cladding temperatures less than 400°F.

The above conclusions of the WCAP are applicable to PBNP.

The fifth and final conclusion of WCAP-16793-NP (Reference 14b) is dependent upon a site-specific calculation of chemical plate-out within the reactor core. This calculation will be performed and the results submitted in summary form in a separate later submittal as committed to in Reference 8.

***GL 2004-02 Requested Information Item 3.n.* Chemical Effects**

The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on head loss and core cooling.

1. *Provide a summary of evaluation results that show that chemical precipitates formed in the post-LOCA containment environment, either by themselves or combined with debris, do not deposit at the sump screen to the extent that an unacceptable head loss results, or deposit downstream of the sump screen to the extent that long-term core cooling is unacceptably impeded.*

FPL Energy Point Beach Response

A detailed inventory of metallic aluminum in both containments has been completed, and the results were documented. The data obtained was then used to calculate the maximum quantity of chemical precipitants that may occur under design basis conditions. The calculation of chemical precipitants followed the guidance of Westinghouse WCAP-16530-NP (Reference 13).

The analysis performed several cases to define a bounding envelope of chemical conditions that might result from various LOCA scenarios. These cases included sufficient variations in input parameters to provide results that can be used for sensitivity analyses in the future. The most limiting applicable result used a combination of input assumptions that could not occur simultaneously in a single LOCA event, but conservatively bounds anticipated worst-case conditions. The assumptions of that case included:

- Long spray injection duration (implying a small-break LOCA)
- High continuous injection spray pH (long injection spray duration would deplete the chemical spray additive earlier in spray injection and would result in a reduced spray pH.)
- High containment temperature profile consistent with a large break LOCA
- A high containment sump level that maximizes the total precipitate formed.

The quantity of chemical precipitants calculated under these conditions was 194 kg of Sodium Aluminum Silicate ($NaAlSi_3O_8$).

To ensure that the chemical effects analysis bounds all credible conditions, silica inhibition of aluminum corrosion was not credited in the analyses and testing performed to date. It is not expected that corrosion inhibition will be credited in the final analyses and testing. No further response on the subject of corrosion inhibition effects is anticipated.

The results of the analysis will be used to determine the quantity of chemical precipitant to be used in the pending integrated head loss and chemical effects screen testing remaining to be performed as committed to in Reference 8. The results of this integrated testing will be used to conclusively demonstrate the acceptability of the screens in the presence of a bounding quantity of chemical precipitant.

***<u>GL 2004-02 Requested Information Item 3.o</u>* License Amendments**

The objective of the license amendments section is to provide information regarding any changes to the plant licensing basis due to the sump evaluation or plant modifications.

Provide the information requested in GL 04-02 Requested Information Item 2.(e) regarding changes to the plant licensing basis. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10 CFR 50.59 evaluation for the change to the licensing basis. A general description of and planned schedule for any changes to the plant licensing bases resulting from any analysis or plant modifications made to ensure compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included.

<u>FPL Energy Point Beach Response</u>

The corrective actions taken to address the issues identified in GL 2004-02 did not, and will not require license amendments. The existing Technical Specifications require visual inspection of the ECCS screens, but do not describe the previously installed "trash rack." The Technical Specifications, as currently written, are acceptable for continued application and do not require a change to remove verbiage regarding the trash rack.

The PBNP Final Safety Analysis Report (FSAR) has been updated to include a description of the replacement screens. After the final transmittal of requested information as committed in Reference 8, FPL Energy Point Beach will update the FSAR in accordance with the requirements of 10 CFR 50.71(e).

GL 2004-02 Requested Information Item 3.p. ***Foreign Material Control Programs***

The objective of the foreign material control programs section is to provide information regarding the adequacy of programmatic controls taken to limit debris sources in containment into the future.

1. *Provide the information requested in GL 04-02 Requested Information Item 2.(f) regarding programmatic controls taken to limit debris sources in containment: A description of the existing or planned programmatic controls that will ensure that potential sources of debris introduced into containment (e.g., insulations, signs, coatings, and foreign materials) will be assessed for potential adverse effects on the ECCS and CSS recirculation functions. Addressees may reference their responses to GL 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," to the extent that their responses address these specific foreign material control issues.*

2. *In particular, for all-RMI/low fiber plants, provide a description of programmatic controls to maintain the latent debris fiber source term into the future.*

FPL Energy Point Beach Response

To maintain the required configuration of the containment recirculation function that supports the inputs and assumptions utilized to perform the evaluation of this function, FPL Energy Point Beach has implemented programmatic and process controls as described below.

Plant procedures, programs and design requirements were reviewed to determine those that could impact the analyzed containment or recirculation function configuration.

The engineering-related documents that were revised or developed to support and maintain the required configuration control for maintenance of the inputs and assumptions that support the GSI-191 issue resolution are:

- A new procedure, NP 7.2.28,"Containment Debris Control Program," was developed to integrate the various aspects debris and debris source controls for the containment buildings. This procedure defines personnel roles and responsibilities, and summarizes the controls that exist pertaining to containment debris sources. These controls include control of thermal insulation quantities and configuration, applied coatings, metallic aluminum, and non-metallic articles, such tags, labels, tape, etc. This procedure also discusses operational parameters, such as water levels, flow rates, containment temperatures, that could affect the design bases for the sump strainers and provides guidance on how to assess proposed changes in these parameters.
- Specification PB-485, "Insulation and Asbestos Abatement," was revised to insert a note in appropriate locations that prior engineering approval is required for all non-identical insulation changes inside of containment. The specification also precludes the use of any microporous insulation inside of containment.
- The "Design Input Checklist," QF-0515B, was revised to include specific questions as to whether a modification changes the amount of exposed aluminum in containment; adds or removes coatings (qualified or unqualified) in containment; adds, removes, or modifies insulation in the containment; adds or removes non-metallic components or subcomponents in

containment; or changes post-LOCA water drainage paths.

These changes are to prompt the evaluator to further consider potential adverse impact on ECCS sump recirculation performance:

- The protective coatings program, NP 8.4.15, was improved and expanded to explicitly document requirements for inspecting and assessing the condition of coatings inside containment.
- The containment coatings inspection procedure, NDE 802, was substantially expanded to provide detailed direction for the conduct of coatings inspections, including the makeup and qualification requirements for the inspection team, scope and frequency of inspections, pre-inspection reviews of known conditions and documentation, inspection conduct, acceptance criteria, inspection documentation, evaluation of inspection findings, including volumetric calculations of potential coatings debris, and the routing of inspection results.
- PBNP is a high fiber plant, and the effects of latent debris are minimal when compared to LOCA-generated debris. A recurrent inspection for latent debris accumulations was established to confirm that existing practices and procedures continue to control latent debris to well below the analyzed limits. These inspections are currently performed every other refueling outage, however, the frequency may be relaxed once a predictable trend with margin has been established.

The procedure for foreign material exclusion controls was revised to define containment as a special foreign materials exclusion area above MODE 5, and controls were implemented to minimize and control potential transient debris sources and quantities that might challenge the sump screens during these modes of operation.

As required by Technical Specifications, FPL Energy Point Beach inspects the sump suction inlet to not be restricted by debris and inspects the ECCS screens for evidence of structural distress or abnormal corrosion.

In summary, FPL Energy Point Beach has implemented the necessary programmatic and process controls to ensure the recirculation function will be maintained into the future.

ENCLOSURE 2

FPL ENERGY POINT BEACH, LLC

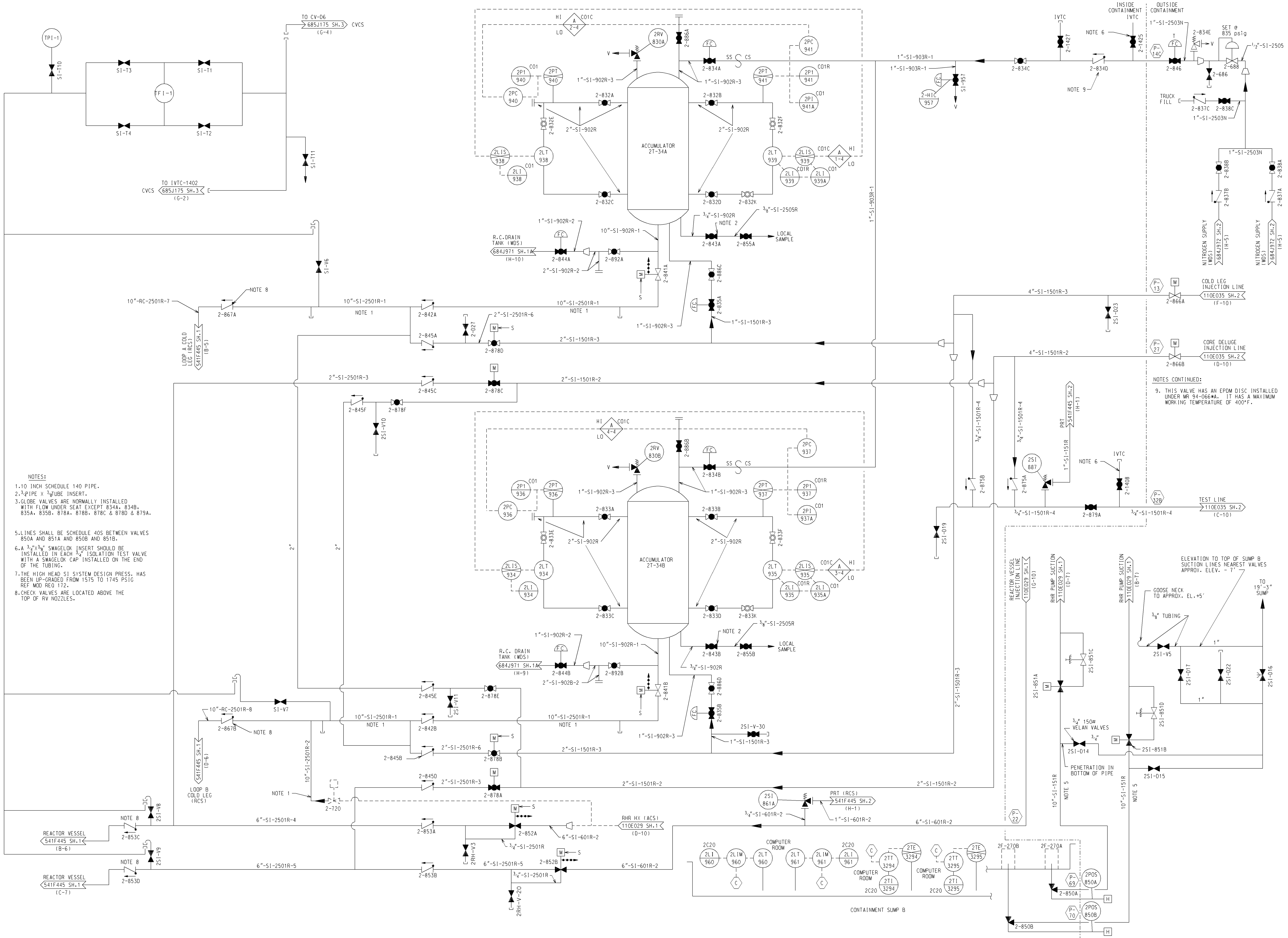
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

**SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02
"POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"**

SCHEMATIC DIAGRAMS OF ECCS AND CS SYSTEMS

3 Pages Follow

06/2007



NOTES:

1. 10 INCH SCHEDULE 140 PIPE.
2. 3/4 PIPE X 3/8 TUBE INSERT.
3. GLOBE VALVES ARE NORMALLY INSTALLED WITH FLOW UNDER SEAT EXCEPT 834A, 834B, 835A, 835B, 878A, 878B, 878C & 878D & 879A.

5. LINES SHALL BE SCHEDULE 40S BETWEEN VALVES 850A AND 851A AND 850B AND 851B.
6. A 3/4"X3/8" SWAGELOK INSERT SHOULD BE INSTALLED IN EACH 3/4" ISOLATION TEST VALVE WITH A SWAGELOK CAP INSTALLED ON THE END OF THE TUBING.
7. THE HIGH HEAD SI SYSTEM DESIGN PRESS. HAS BEEN UP-GRADED FROM 1575 TO 1745 PSIG REF MOD REQ 172.
8. CHECK VALVES ARE LOCATED ABOVE THE TOP OF RV NOZZLES.

NOTES CONTINUED:

9. THIS VALVE HAS AN EPDM DISC INSTALLED UNDER MR 94-066*A. IT HAS A MAXIMUM WORKING TEMPERATURE OF 400°F.

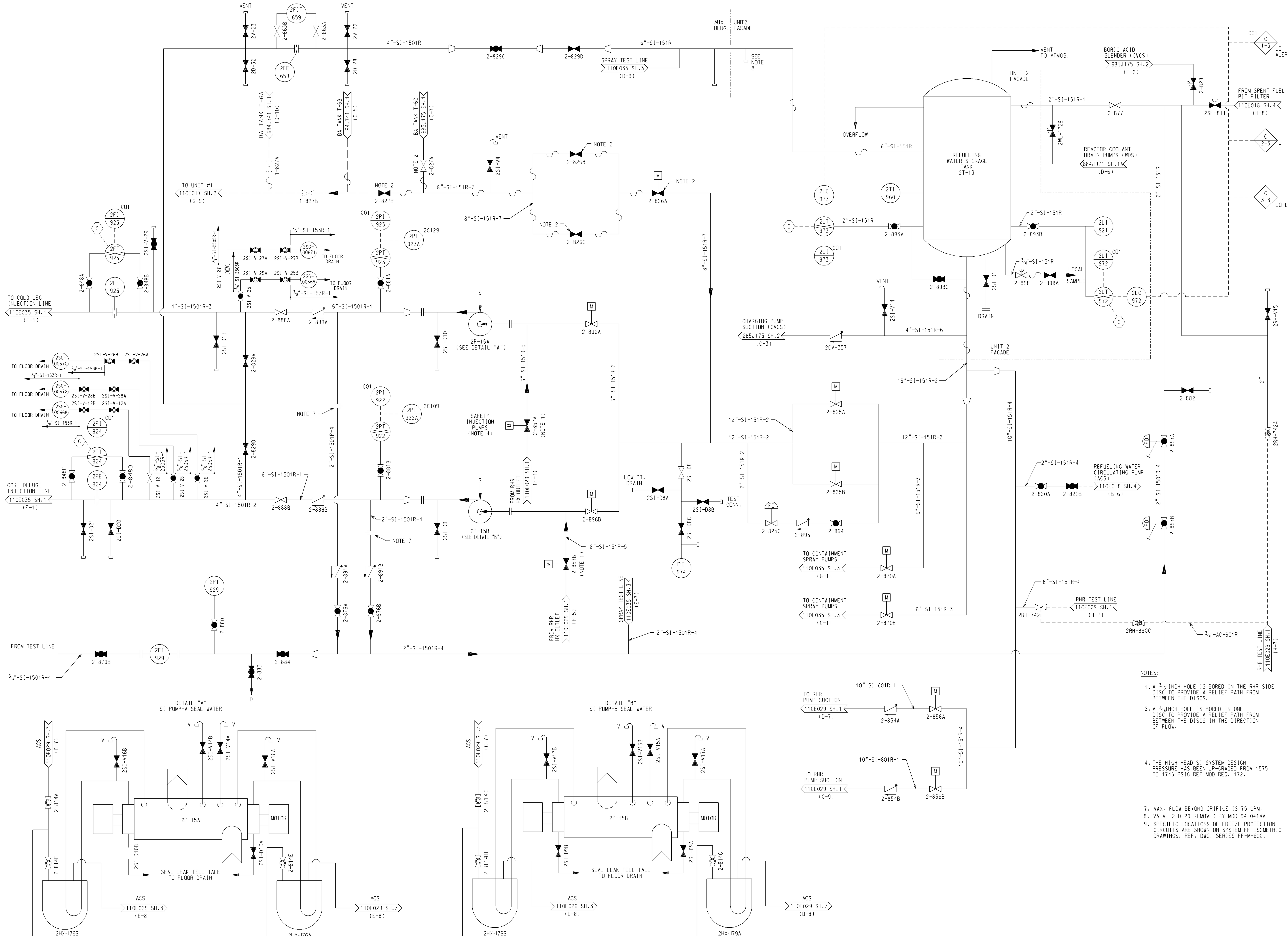
WEST 110E035 SH.1

UNIT 2
SAFETY INJECTION SYSTEM

FIGURE 6.2-1 SH.1

FSAR drawings are "INFORMATION ONLY" and do not necessarily reflect the most current drawing revision nor actual plant configuration under different operating modes.

08/2006



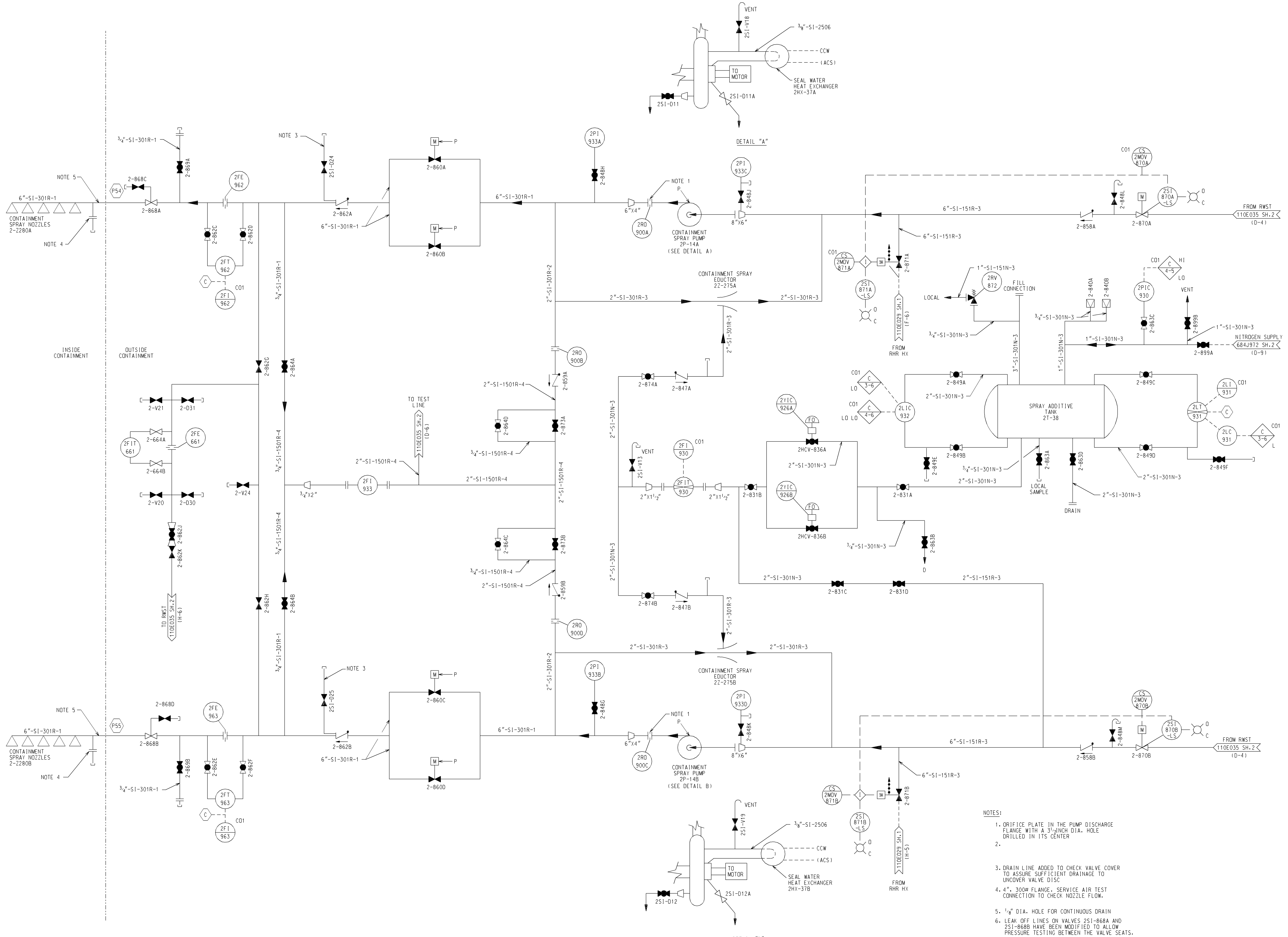
NOTES:

1. A 3/16 INCH HOLE IS BORED IN THE RHR SIDE DISC TO PROVIDE A RELIEF PATH FROM BETWEEN THE DISCS.
2. A 3/16 INCH HOLE IS BORED IN ONE DISC TO PROVIDE A RELIEF PATH FROM BETWEEN THE DISCS IN THE DIRECTION OF FLOW.
4. THE HIGH HEAD SI SYSTEM DESIGN PRESSURE HAS BEEN UP-GRADED FROM 1575 TO 1745 PSIG REF MOD REQ. 172.
7. MAX. FLOW BEYOND ORIFICE IS 75 GPM.
8. VALVE 2-D-29 REMOVED BY MOD 94-041*A
9. SPECIFIC LOCATIONS OF FREEZE PROTECTION CIRCUITS ARE SHOWN ON SYSTEM FF ISOMETRIC DRAWINGS. REF. DWG. SERIES FF-M-600.

WEST 110E035 SH.2

UNIT 2
SAFETY INJECTION SYSTEM

FIGURE 6.2-1 SH.2



NOTES:

1. ORIFICE PLATE IN THE PUMP DISCHARGE FLANGE WITH A $3\frac{1}{2}$ INCH DIA. HOLE DRILLED IN ITS CENTER
2.
3. DRAIN LINE ADDED TO CHECK VALVE COVER TO ASSURE SUFFICIENT DRAINAGE TO UNCOVER VALVE DISC
4. 4", 300# FLANGE. SERVICE AIR TEST CONNECTION TO CHECK NOZZLE FLOW.
5. $\frac{1}{8}$" DIA. HOLE FOR CONTINUOUS DRAIN
6. LEAK OFF LINES ON VALVES 2SI-868A AND 2SI-868B HAVE BEEN MODIFIED TO ALLOW PRESSURE TESTING BETWEEN THE VALVE SEATS.

WEST 110E035 SH.3

UNIT 2
SAFETY INJECTION SYSTEM

FIGURE 6.2-1 SH.3

ENCLOSURE 3

FPL ENERGY POINT BEACH, LLC

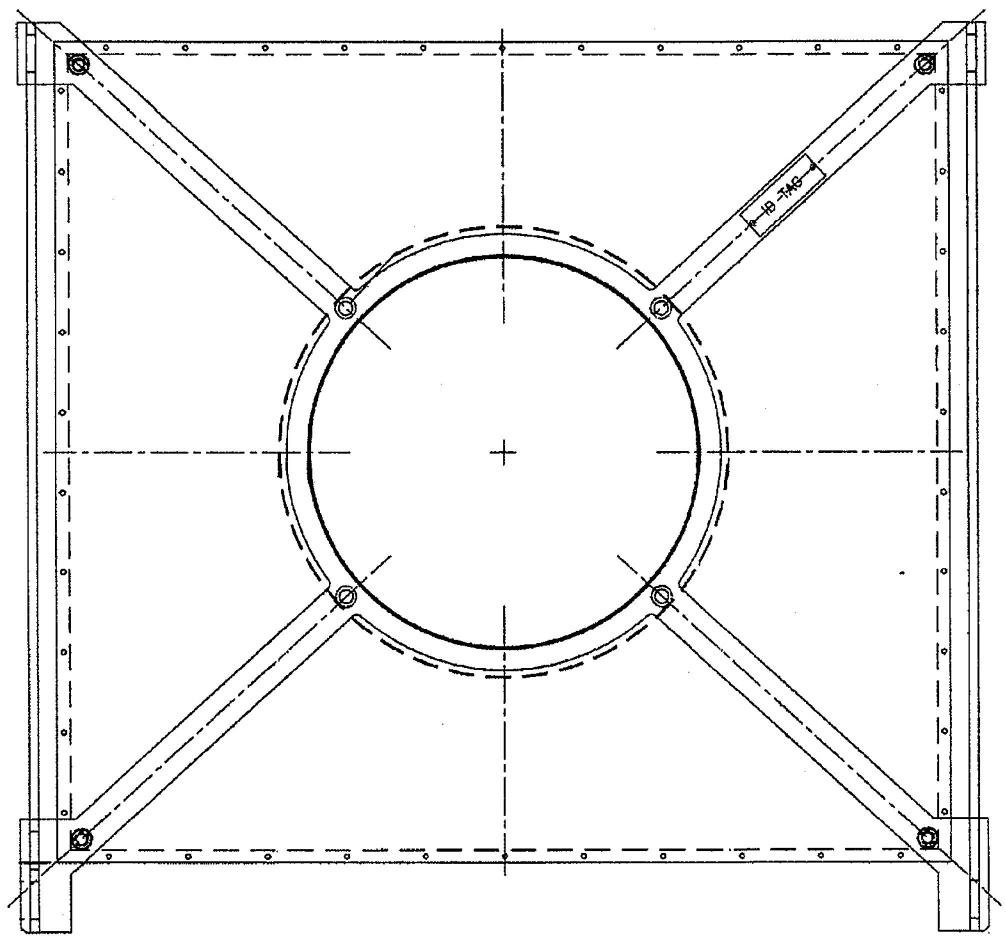
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

**SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02
"POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"**

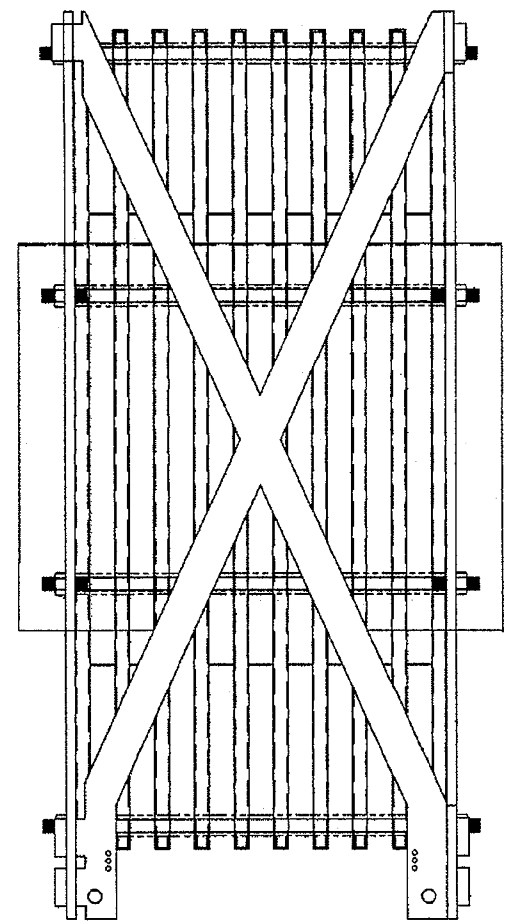
GENERAL ARRANGEMENT DRAWINGS OF ECCS STRAINERS

5 Pages Follow

REPLACEMENT STRAINER MODULES
(11 PER TRAIN)

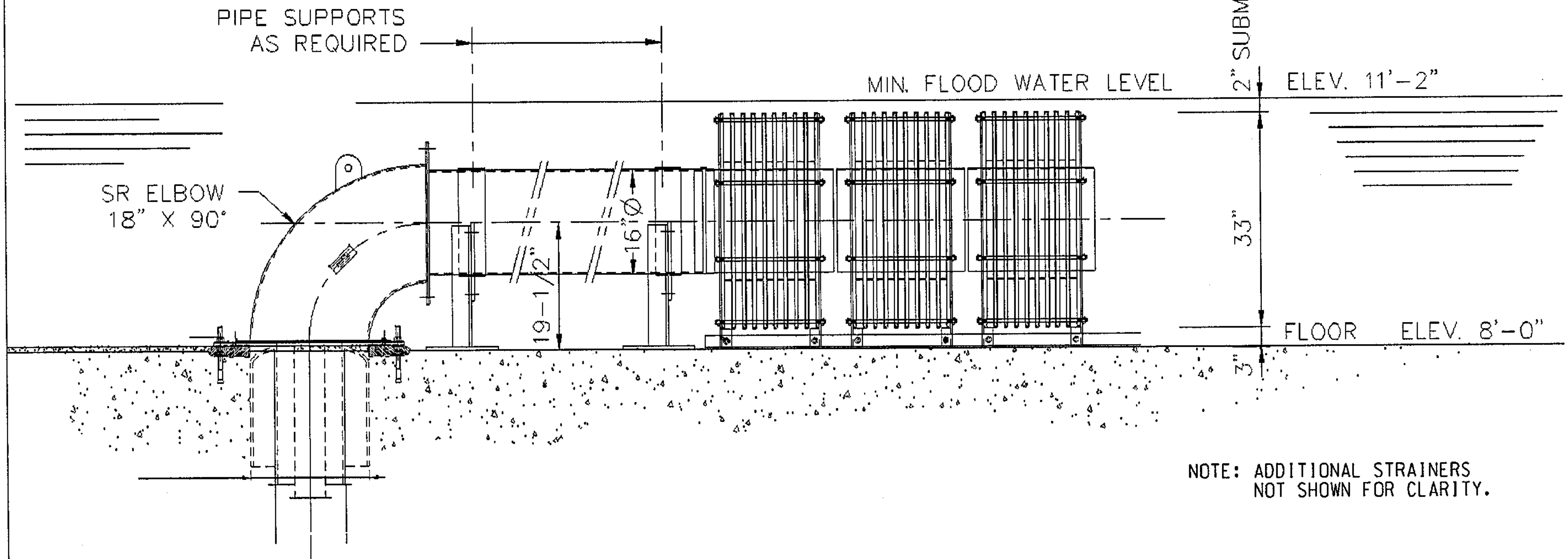


END VIEW



SIDE VIEW

REPLACEMENT STRAINER TYPICAL INSTALLATION



NOTE: ADDITIONAL STRAINERS
NOT SHOWN FOR CLARITY.

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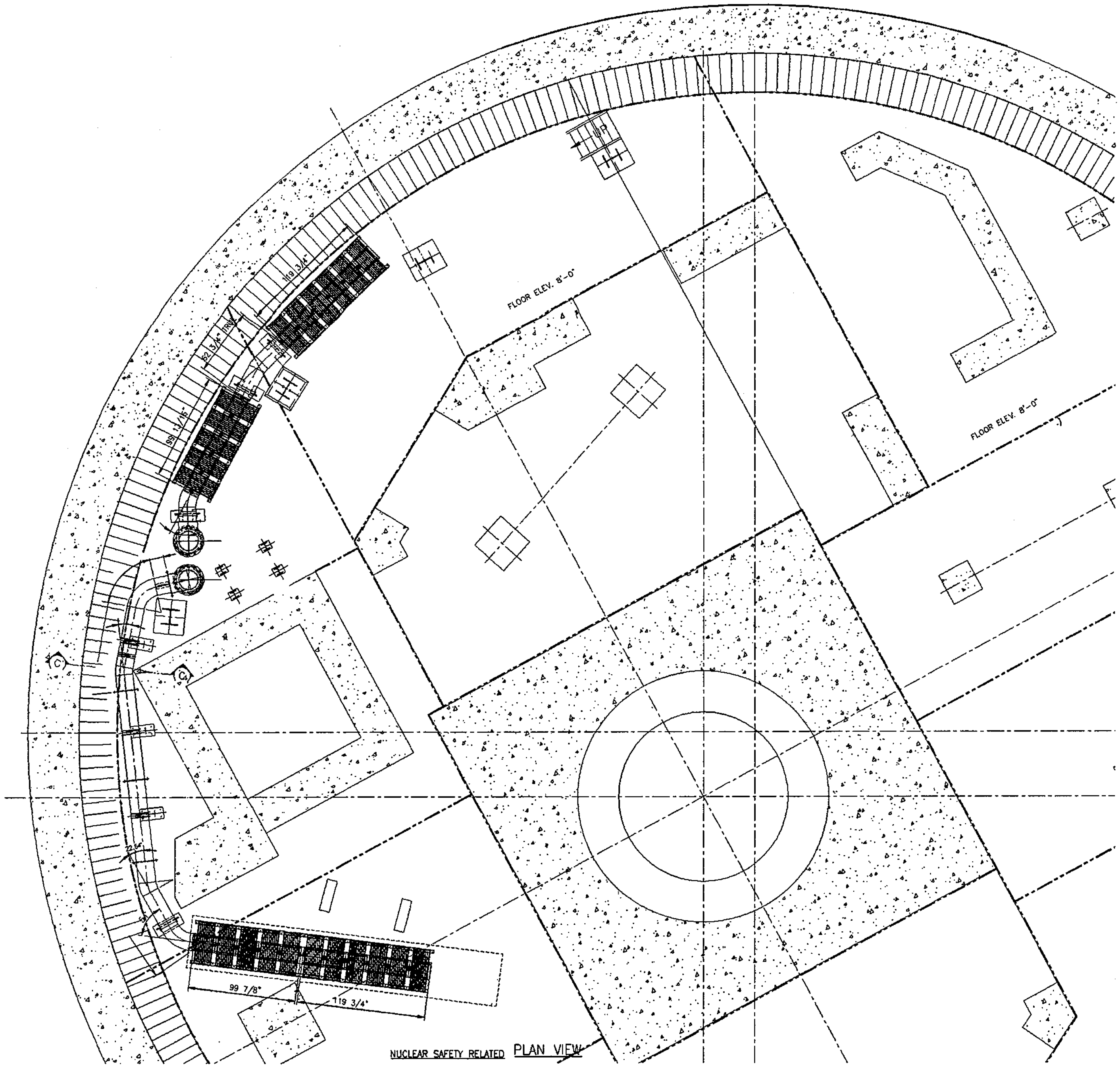
UNIT 1
ECCS STRAINER GENERAL ARRANGEMENT



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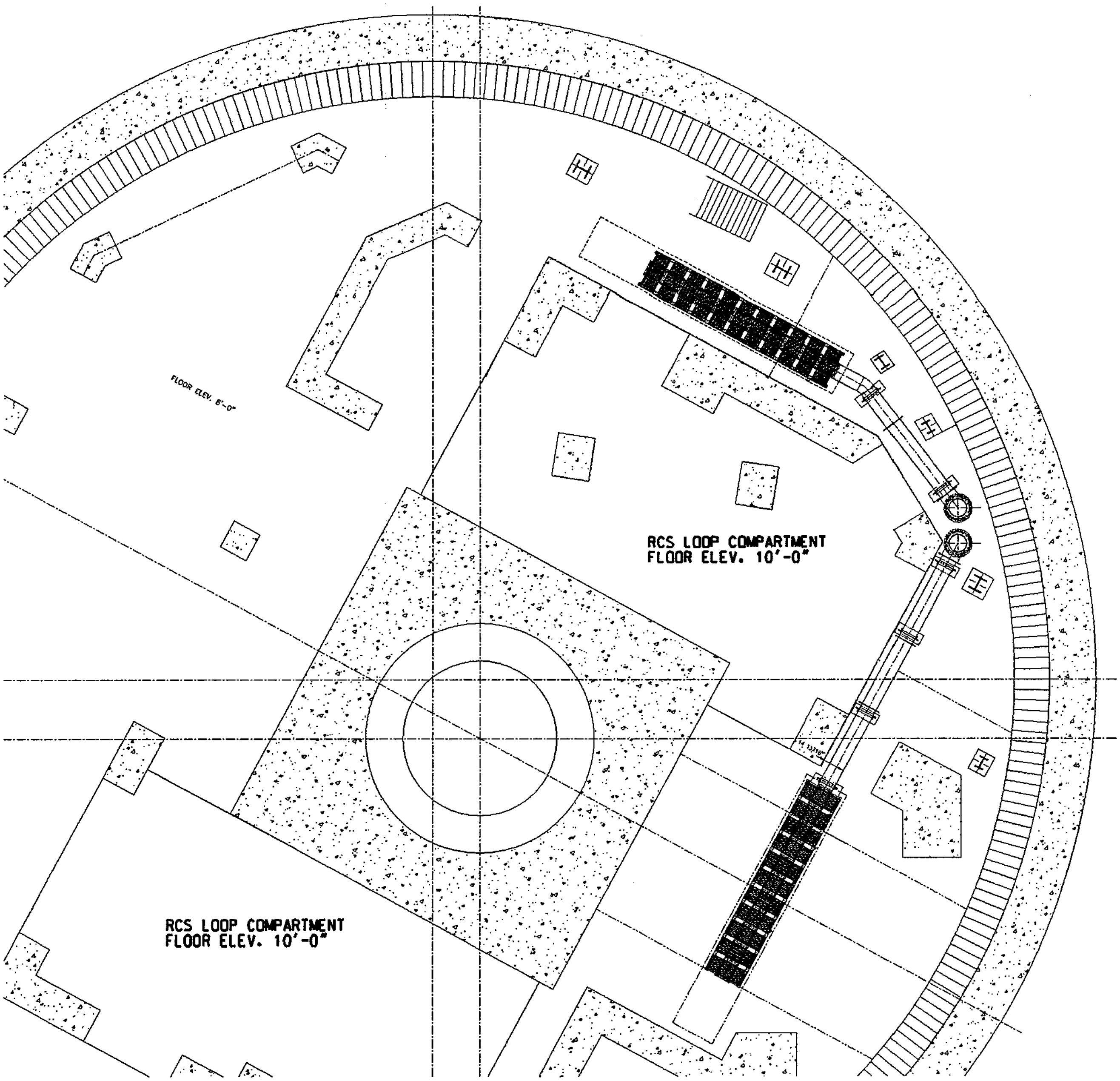
UNIT 2

ECCS STRAINER GENERAL ARRANGEMENT



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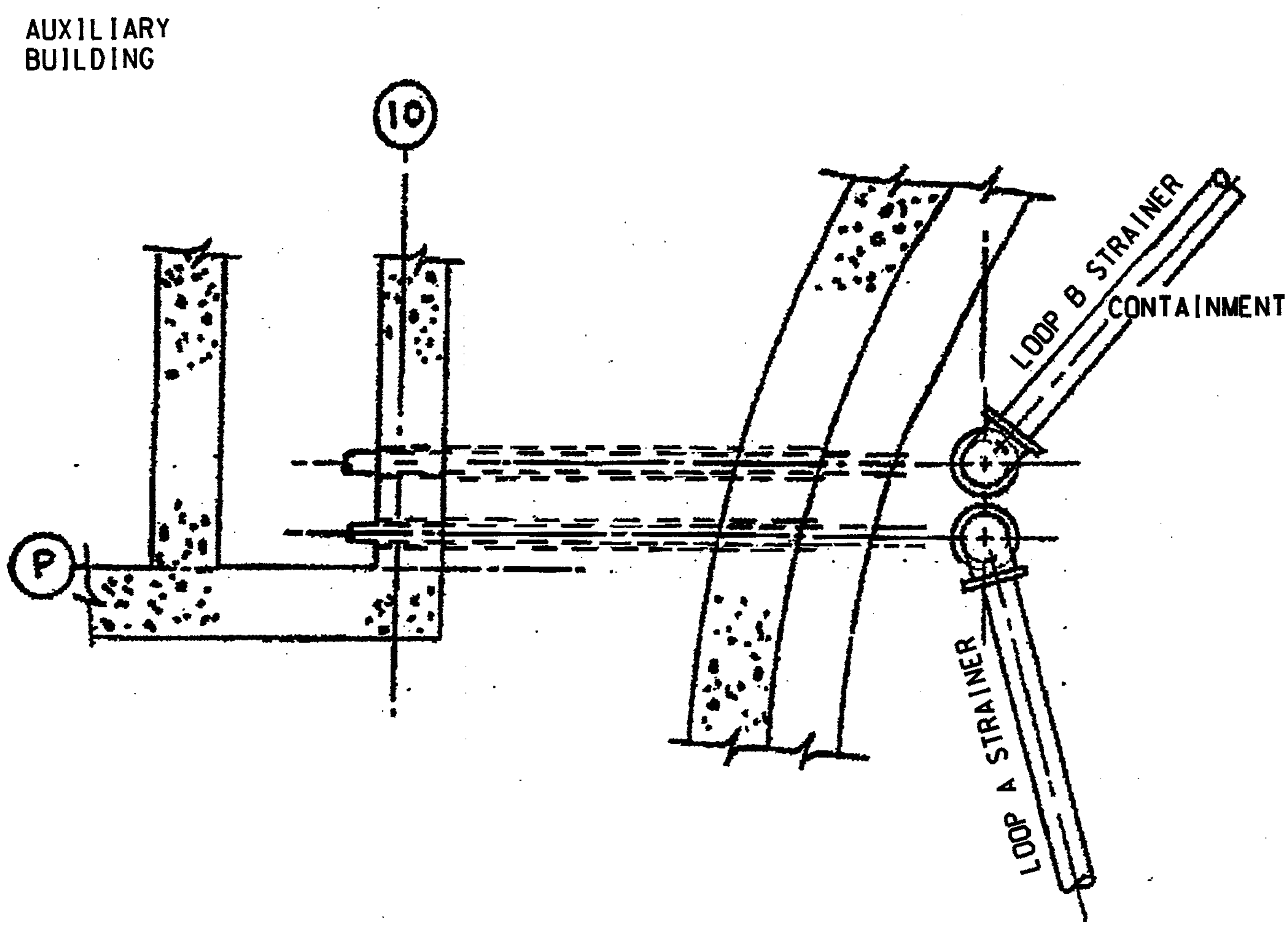

CONTAINMENT DRAINS - PLAN

ENCLOSURE 4

FPL ENERGY POINT BEACH, LLC

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02
"POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

STRUCTURAL EVALUATION OF ECCS SCREENS (ABRIDGED)

29 Pages Follow

Calculation Number:	PCI-5344-S01
Calculation Title:	Structural Evaluation of Containment Emergency Sump Strainers
Client: Performance Contracting Inc.	**Station:** Point Beach
Project Number: PCI-5344	**Unit(s):** 1 & 2
Project Title:	Point Beach Strainer Qualification

Safety Related Yes ☒ No ☐

Revision	Affected Pages	Revision Description	Approval Signature / Date	Signature / Initials of Preparers & Reviewers
0	All	Initial Issue.	[redacted] 03/04/2006	**Prepared by:** [redacted] **Reviewed by:** [redacted]
1	1-5, 7, 16, 19, 20, 21, 22, 32, 33, 35, 38-43, 49, 54, 57, 58, 60, 81-84, 86, 94-97, 99-102, 106, 107, 110-113, 115, 116, 118, 122, 124-141, 144-155, 157-165 Attachment A	This revision addresses any differences between Point Beach Units 1 and 2 that affect the analysis of the strainer modules and associated supporting structures. (Attachments B-H which are labeled with "Calculation PCI-5344-S01 Rev.0" are still applicable for Revision 1).	[redacted] 07/20/2006	**Prepared by:** [redacted] **Reviewed by:** [redacted]
2	1-4, 11, 12, 19-22, 30, 31, 33, 55-57, 63, 64, 81, 83, 85-88, 91, 93, 97-101, 103-106, 110, 111, 114-117, 119, 122, 126, 128-164, 166, 167, 169-175 Attachment I	Revised to incorporate latest drawings, to include the unbalanced differential pressure load on the end module, and other miscellaneous enhancements. This revision resolves CAR 06-006. (Attachments A-H which are labeled with "Calculation PCI-5344-S01 Rev.0" or "Calculation PCI-5344-S01 Rev.1" are still applicable for Revision 2).	[redacted] 10/11/2006	**Prepared by:** [redacted] **Reviewed by:** [redacted]

Revision	Affected Pages	Revision Description	Approval Signature / Date	Signature / Initials of Preparers & Reviewers
3	1-3, 161, 162, 163, 171, 175 Added 1A, 162A-162D, and 163A	Revised to incorporate various Engineering Change Notices (specifically EC 9306, 9355, and 9364) related to field installation changes. (Attachments A-I which are labeled with "Calculation PCI-5344-S01 Rev.0", "Calculation PCI-5344-S01 Rev.1", or "Calculation PCI-5344-S01 Rev.2" are still applicable for Revision 3).	[redacted] 11/10/2006	**Prepared by:** [redacted] **Reviewed by:** [redacted]
4	1-3, 172, 173 175 Added 162E-162L Attachment J	Revised to incorporate various Engineering Change Notices (specifically EC 10627 and 10581) related to field installation changes. (Attachments A-I which are labeled with "Calculation PCI-5344-S01 Rev.0", "Calculation PCI-5344-S01 Rev.1", or "Calculation PCI-5344-S01 Rev.2" are still applicable for Revision 4).	[redacted] 04/26/2007	**Prepared by:** [redacted] **Reviewed by:** [redacted]
5	1-3, 141-144, 147, 163, 163A, 170, 171	Revised to correct weld stress allowable. This revision resolves CAR 07-004. (Attachments A-J which are labeled with "Calculation PCI-5344-S01 Rev.0", "Calculation PCI-5344-S01 Rev.1", "Calculation PCI-5344-S01 Rev.2", or "Calculation PCI-5344-S01 Rev.4" are still applicable for Revision 5).	[redacted] 12/26/2007	**Prepared by:** [redacted] **Reviewed by:** [redacted] (KJH)

TABLE OF CONTENTS

1.0 PURPOSE/OBJECTIVE

The purpose of this calculation is to qualify the Performance Contracting Inc. (PCI) Suction Strainers to be installed in Nuclear Management Corporation's Point Beach Nuclear Plant, Units 1 and 2. This calculation evaluates, by analysis, the strainer modules as well as the supporting structures associated with the new strainers.

2.0 METHODOLOGY

The evaluations are performed using a combination of manual calculations and finite element analyses using the GTSTRUDL Computer Program, (Reference [21]), and the ANSYS Computer Program (Reference [25]). The evaluations follow the requirements of the Strainer Design Specification PB-681 (Reference [1]). Exceptions from these requirement, when taken, are discussed and justified within this calculation.

Seismic Loads

The strainer is categorized as Seismic Class I equipment and is required to be operable during and after a safe shutdown earthquake (SSE) without exceeding normal allowable stresses as specified in Section 5.4.7 of DG-C03 Seismic Design Criteria Guideline (Reference [15]). Strainer Design Specification PB-681 (Reference [1]), requires the strainer to be evaluated for two operating conditions. The first condition is a "dry" condition with no recirculation water inside or external water present. The second condition is a submerged "wet" condition with recirculation water. For the seismic evaluation the strainer will be considered submerged and full of water. The water level is considered to be a minimum of 3'- 2" above the 8' floor elevation (El. 11'- 2"). The piping "dry" state with its associated mass being much less, will not be considered as it is less severe than the "wet" state.

Per the specification, the seismic evaluation is required to take into account any seismic slosh (analyzed at the seismic worst-case water level) of the recirculation water. Based on Reference [8], because of the negligible load magnitudes, it is determined that the seismic slosh loads in PWR containments are insignificant by comparison with other seismic loads. Therefore, seismic slosh loads are neglected from the analysis (refer to Section 6.2.3 for further explanation). Note that the sloshing calculation of Reference [8] is done for the Prairie Island strainer project and it is representative for all PWR containments in general, and therefore, it is applicable for use in this calculation. The "wet" strainer operating condition considers the strainer assemblies submerged in still water at the seismic worst-case water level when subjected to seismic inertial loads. The inertial effects of the added hydrodynamic mass due to the submergence of the strainer is considered.

The strainer is seismically qualified using the response spectra method. The applicable seismic spectra are provided in Seismic Qualification Specification Sheet SQ-002243 (Reference [2]). These loads are applied to the strainer through base motion response spectra as detailed in the Seismic Design Criteria Guideline DG-C03 (Reference [15]).

The strainer is located on the 8' floor elevation of the containment. The response spectrum chosen is for the 6.5' elevation of the containment. The containment liner plate is located at the 6.5' elevation and there is an additional 1.5' of concrete on top of the liner plate. The slab between the 6.5' elevation and the 8' elevation is very rigid. Thus it is appropriate to use the response spectrum for the 6.5' elevation. The vertical direction response spectrum is 2/3 the value of the maximum ground horizontal response spectra.

The strainer is excited in each of the three mutually perpendicular directions, two horizontal and one vertical. Per Reference [11], the modal combination is performed by the use of the double sum method to account for the effects of modal coupling in the response (i.e. closely spaced modes). An earthquake duration of 30.24 seconds was used in the analysis per DG-C03, Appendix C. Appendix N of the ASME code indicates that the maximum accelerations generally occur in the first 10 seconds. Two analysis were run - one with 10 sec and one with 30.24 sec. Since the results were the same, the analysis with 30.24 seconds is the official documented seismic analysis. Responses from the vertical and one horizontal direction (worst case direction) are applied simultaneously and combined by absolute summation (Reference [15], paragraph 5.4.4.b). The cutoff frequency is taken at 30 hz or a minimum of 5 modes are included. Zero Period Acceleration (ZPA) residual mass effects will be considered. The ZPA response will be added to the response spectra loads by SRSS.

The strainer is considered as a "bolted steel frames" structure and the damping values for seismic loads are taken as 2% for the Operating Basis Earthquake (OBE) and 5% for the Safe Shutdown Earthquake (SSE) as required by Seismic Design Guide DG-C03 (Reference [15]).

Operating Loads

Operating loads are comprised of weight and pressure loads. The weight of the strainer includes the weight of the strainer self weight and the weight of the debris, which accumulates on the strainer. The debris weight is taken from Reference [27].

The pressure load acting on the strainer is the differential pressure across the strainer perforated plates in the operating condition. Conservatively, this is taken as the hydrostatic pressure associated with the maximum allowed head loss through the debris covered strainers. This is defined as 38 inches of water in Section 4.1 of Design Specification PB 681 (Reference [1]).

There are no thermal expansion loads since the strainers are basically free to expand without restraint. Note that the piping is not rigidly attached to the strainer modules, therefore the piping is also free to expand without imposing any thermal loads on the strainers. The design temperature is taken equal to the maximum operational inlet temperature to the RH Exchangers of 250 °F (Reference [1]).

Software

MathCad software is used to generate the calculations. All MathCad calculations are independently verified for accuracy and correctness as if they were manually generated. ANSYS is used for the analysis of the inner gap plate. ANSYS Version 5.7.1 is fully verified with no restrictions or limitations. GTSTRUDL Version 25 is used in the seismic response spectra analysis of the strainer modules. GTSTRUDL Version 25.0 is verified and validated under the AES QA program as documents in the AES validation and maintenance file (Reference [21]). The validation of GTSTRUDL was a partial validation and only validated certain commands. These commands are listed in the validation report. The GTSTRUDL runs utilized several commands outside the scope of this validation. A list of these commands, and their alternate validation method used for this particular application, is provided below:

Command	Validation Method
GENERATE REPEAT	The GENERATE and REPEAT commands are used to automatically generate member nodes and incidences. These generated items for these models are verified manually.

Command	Validation Method
JOINT TIES SLAVE RELEASES	The JOINT TIES and SLAVE RELEASES commands are used in conjunction with MEMBER TEMPERATURE LOADS to account for the preload on the connecting rods. The commands also constrain the pipe spacers and connecting rods to move together in certain degrees of freedom. Their use is acceptable because the nodal displacements are manually compared for these nodes to confirm the command is working as planned.
MEMBER TEMPERATURE LOADS	This command applies a specified temperature increase/decrease to a given member. This command is used as a simple way to generate preload in the rods. Its use is acceptable because the preloads produced by this load are verified manually.
DEFINE GROUP	This command groups members and/or joints together for easier specification of member properties and load placements. This command is verified by checking manually that the cross sections and loads are applied properly to each member.
MEMBER ADDED INERTIA	This command was used to apply the water weight of the system directly on to members that would carry that water for a certain direction of motion. This command was verified manually by listing the dynamic mass summary and comparing the total dynamic mass in each direction to the calculated masses.

PIPE	PIPE is a command used to specify the cross section of the core tube. It is necessary to use this command rather than referencing a pipe cross section from a table because the diameter and thickness are unique to the strainer and are not available in the provided tables. Because GTSTRUDL uses only the section properties when code checking, the properties are printed out for selected members defined by this command and those properties are verified manually.
TABLE 'RBARS' TABLE 'BARS' TABLE 'ROUND' TABLE 'MYCHAN'	'RBARS', 'BARS', 'ROUND', and 'MYCHAN' are predefined GTSTRUDL tables that contain steel cross sections for rectangular, round (for both 'BARS' and 'ROUND'), and channel shapes. The members that are defined by these tables are subjected to loadings and then code checked in GTSTRUDL. These tables are verified in the same fashion as for the PIPE command listed above. In addition any code checks performed by GTSTRUDL for these sections are manually verified.

The limitations and program error reports for GTSTRUDL Version 25 (Reference [21]) were reviewed for applicability to the GTSTRUDL runs made for this calculation. The limitations for the ASD9 Code check were found not to be applicable for this calculation (none of the components are subjected to significant torsion, therefore warping torsion stresses would be negligible). Also, steel cross sections that were not available in the GTSTRUDL cross section libraries had to be created for the face disk edge channels, the external radial stiffeners, the debris stops, the seismic stiffeners, the ends of the connecting rods to account for the threading, and the ends of the external radial stiffeners where they are welded to the seismic stiffeners. These cross sections were verified by outputting the computed properties of the cross sections and checking these values manually. All known issues, including Part 21 notifications, have been reviewed for applicability in accordance with the AES QA program. Work arounds to existing issues or errors have been utilized as required.

3.0 ACCEPTANCE CRITERIA

The strainer components shall meet the requirements of the strainer design specification PB-681 (Reference [1]). As stated in PB-681, the detailed evaluations are to be performed using the rules, as applicable, of ANSI/ASME B31.1 Power Piping 1998 Edition through 1999 Addenda (Reference [5]).

The strainers are classified as "other pressure-retaining components" as described in Paragraph 104.7 of the B31.1 Code (Reference [5]). Under Paragraph 104.7.2, the code allows "The pressure design of components not covered by the standards listed in Table 126.1 or for which design formulas and procedures are not given in this Code shall be based on calculation consistent with the design criteria of this Code. These calculations shall be substantiated by one or more of the means stated in (A), (B), (C), and (D) below. Based on this paragraph, since the B31.1 Code does not provide specific design rules for a pressure retaining component such as a strainer, design guidance will be taken from the ASME Boiler and Pressure Vessel Code (Reference [3]).

The ASME Code is consistent with the B31.1 Code and is a logical alternative to B31.1 rules. The substantiation method described in Paragraph 104.7 of the B31.1 Code is Alternative D, which allows for "detailed stress analysis, such as the finite element method, in accordance with the ASME Boiler and Pressure Vessel Code, Division 2, Appendix 4, except that the basic material allowable stress from the Allowable Stress Tables of Appendix A shall be used in place of S_m." Section III, Subsection NC of the ASME Code will be used as this presents the most general criteria for the design of pressure retaining components.

The use of the ASME Code is primarily for the qualification of pressure retaining parts of the strainer which are not covered in B31.1 (perforated plate, and internal wire stiffeners). Some parts of the strainers (radial stiffeners, connecting rods, edge channels, seismic stiffeners, etc.) are classified as part of the support structure. These types of components are covered under the AISC Code (Reference [9]). Additional guidance is also taken from other codes and standards where the AISC does not provide specific rules for certain aspects of the design. For instance, the strainers are made from stainless steel materials. The AISC Code does not specifically cover stainless steel materials. Therefore, ANSI/AISC N690-1994, "Specification for the Design, Fabrication, and Erection of Steel Safety Related Structures for Nuclear Facilities", Reference [30] is used to supplement the AISC in any areas related specifically to the structural qualification of stainless steel. Note that only the allowable stresses are used from this Code and load combinations and allowable stress factors for higher service level loads are not used.

The strainer also has several components made from thin gage sheet steel, and cold formed stainless sheet steel. Therefore, SEI/ASCE 8-02, "Specification for the Design of Cold-Formed Stainless Steel Structural Members", (Reference [31]) is used for certain components where rules specific to thin gage and cold form stainless steel should be applicable. The rules for Allowable Stress Design (ASD) as specified in Appendix D of this code are used. This is further supplemented by the AISI Code (Reference [22]) where the ASCE Code is lacking specific guidance. Finally guidance is also taken from AWS D1.6, "Structural Welding Code - Stainless Steel", (Reference [23]) as it relates to the qualification of stainless steel welds. Detailed acceptance criteria for each type of strainer component is provided in the sections below.

The core tube is evaluated as piping per B31.1 Paragraph 104.8 as applicable. The effects of the core tube holes on the pipe stresses are incorporated using Stress Intensification Factors (SIF) for the localized effects and effective net cross section properties for global effects.

For the perforated plates, the B31.1 Code does not provide any design guidelines as discussed above. Therefore, the equations from Appendix A, Article A-8000 of the ASME B&PV Code, Section III, 1998 Edition (Reference [3]) is used to calculate the perforated plate stresses. Note that Article A-8000 refers to Subsection NB for allowable stresses, which are defined in terms of stress intensity limits, S_m. However, in keeping with the B31.1 maximum principal stress design philosophy, principal stresses are calculated and compared to the allowables based on the ASME allowable stress limit, S, taken from ASME Section II, Part D (Reference [4]). Specific limits for each component are described in further detail below.

The edge channel and the attached perforated plate work as a combined section to resist bending loads. The effective width of the perforated plate that acts in combination with the edge channel is based on Section 6.2 of the ASCE Code (Reference [31]), which provides design guidelines for very thin stainless steel members such as the perforated plate. The effective width of the plate is limited by the width to thickness ratios such that local buckling of the plate will not occur for the compression face. The minimum spacing and edge distance required for the rivets is based on the AISI (Reference [22]) requirements for screw spacing.

The seismic stiffeners, external radial stiffeners and the mounting hardware are evaluated to AISC 9th Edition (Reference [9]) as permitted in paragraph 120.2.4 of the B31.1 Code (Reference [5]). The analysis of the anchorage to the containment concrete slab will be in accordance with the Hilti technical Guide (Reference [10]).

Load Combinations

The applicable load combinations for the strainers are those for Section 6.7.1 of DG-M10 (Reference [14]) and 6.0 of DG-M09 (Reference [11]).

Load Condition	Combination
(1a) Normal Operating	DP + DW
(1b) Normal Operating (Outage/Lift Load)	DW + LL
(2) Upset	DP + DW + WD + OBE
(3) Emergency/Faulted	DP + DW + WD + SSE

where,

DW = Dead Weight Load

LL = Live Load (additional loads on strainers during outages or during installation, live load is not applicable during operation)

WD = Weight of Debris

DP = Differential Pressure

OBE = Operating Basis Earthquake

SSE = Safe Shutdown Earthquake

Note that combination (3) is classified as Emergency Condition for all ASME Code evaluations and Faulted for all components governed by AISC and ACI Codes. Also note that wind, snow, tornado, and jet force loads are not applicable. Flood loads are considered for Load Combinations 2 and 3. Flood loads consist of the effects due to earthquake in a submerged condition (sloshing and added mass). There is no hydrostatic pressure loads associated with flooding since the flood waters are present on all sides. Thermal expansion stresses are considered negligible as described in Section 2.0.

Core tube

The core tube is evaluated as piping per B31.1 Paragraph 104.8 as applicable. Since the B31.1 does not explicitly identify how to incorporate the Emergency SSE loads, PBNP uses ASME Section III as a guide as discussed in Section 6.0 of DG-M09 (Reference [11]).

B31.1 Eq. No	Load Condition	Load Combination	Allowable Stress
	Normal	DW	1.0 S_h
12 (OBE)	Upset	DW + OBE	1.2 S_h
12 (SSE)	Emergency	DW + SSE	1.8 S_h

Strainer Pressure Retaining Plates

For the pressure retaining plates, such as the perforated plate and the core tube end cover stiffener plate, the B31.1 Code does not provide any design guidelines as discussed above. For the perforated plate, the equations from Appendix A, Article A-8000 of the ASME B&PV Code, Section III, 1998 Edition through 1999 Addenda (Reference [3]) is used to calculate the stresses. Note that Article A-8000 refers to Subsection NB for allowable stresses, which are defined in terms of stress intensity limits, S_m. However, in keeping with the B31.1 maximum principal stress design philosophy, principal stresses are calculated and compared to the allowables based on the ASME allowable stress limit, S.

Stress limits for the pressure retaining plates are taken from NC-3321 (Reference [3])

Load Condition	Stress Type	Allowable Stress	Design Level
Normal/Upset*	Primary Membrane Stress	1.0 S_h	Level A
	Primary Membrane (or Local) + Bending	1.5 S_h	
Emergency	Primary Membrane Stress	1.5 S_h	Level C
	Primary Membrane (or Local) + Bending	1.8 S_h	

*Allowable stresses for Upset condition may be increased by 10% as permitted by NC-3321 (Reference [3])

Strainer Structural Components

Based on the discussion provided earlier in this section, the allowable stresses on the strainer structural components is based on the AISC 9th Edition (Reference [9]). The allowable stress for the SSE Load Combinations is taken from Section 6.9 of DG M10 (Reference [14]).

Load Condition	Load Combination	Allowable Stress
Normal Operating	1a, 1b	1.0 AISC
Upset	2	1.0 AISC
Faulted	3	1.5 AISC but not to exceed 0.9 S_y

Additional details for the various types of support components are provided below

Compression

Per Reference [30], because stainless steel does not display a single, well defined modulus of elasticity, the allowable compression stress equations from the AISC are not applicable for stainless steels. Therefore, the allowable compression stress will be based on the lower allowables from Reference [30] as opposed to those provided in the AISC Code (Reference [9]). Per Q1.5.9.2 of Reference [30], the allowable stresses for tension, shear, bending and bearing for stainless steel can be taken as the same allowables provided for carbon steel, therefore the AISC 9th Edition will be used for allowables for these types of stresses.

GTSTRUDL Code Check

Most support components are qualified using the GTSTRUDL code check features. The use of the 9th Edition Code check feature of GTSTRUDL is acceptable for this application with the exception of the allowable compression stress as described above. The effective buckling length factor, K, will be manually adjusted to account for the lower compression stress allowable. See Section 6.5.8 for additional discussion.

Edge Channels

The edge channel and the attached perforated plate work as a combined section to resist bending loads. The effective width of the perforated plate that acts in combination with the edge channel is based on Section 2.3 of the ASCE Standard for Cold-Formed Stainless Steel Structural Members (Reference [31]), which provides design guidelines for very thin members such as the perforated plate. The effective width of the plate is limited by the width to thickness ratios such that local buckling of the plate will not occur for the compression face. The minimum spacing and edge distance required for the rivets is based on the AISI (Reference [22]) requirements for screw spacing.

Welds

There are no provisions given in the B31.1 Code for the strainer structural welds to the piping components (radial stiffener to core tube). Therefore, these welds are evaluated in accordance with paragraph NC-3356(c) of the ASME B&PV Code, Section III (Reference [3]). Welds for strainer support components, such as for the seismic stiffeners to radial stiffeners, end cover connecting tabs, and those for the floor track support system, are qualified per the AISC 9th Edition (Reference [9]). AWS D1.6 (Reference [23]) was reviewed to ensure that any special qualification requirements associated with stainless steel welding were considered. Since the weld allowables provided in AWS D1.6 are essentially the same as allowed for carbon steel welds under AWS D1.1 (Reference [13]), no special adjustments are required to account for stainless steel.

Rivets

There are four areas in the strainer module where rivets are used as fasteners. The disk faces are riveted to the perforated edge channels. The gap disk is fashioned into a ring using two rivets. The sleeve that connects adjacent module core tubes together is held in place by two latches that uses four rivets each to attach to the thin gauge steel. The end cover perforated plate is riveted to the end cover stiffener. The rivets' capacities are based on testing. From Reference [18], the capacities of the rivets are taken as the average value from six tests (six tests for shear and six tests for tension). A factor of safety is then calculated according to the ASCE Standard (Reference [31]) as supplemented by the AISI Code (Reference [22]) accounting for the capacities being found experimentally via a small sample group (n = 6). This factor of safety will be used on these ultimate capacities for OBE. An increase of 1.5 is allowed for SSE, resulting in a FS/1.5 for SSE.

Mounting Hardware

Hilti Kwik-Bolt IIIs will be used to mount the strainers to the floor. The analysis and design of expansion anchors shall be in accordance with the Hilti Technical Guide (Reference [10]) however a Factor of Safety of 4 against ultimate will be used. Qualifications of the bolts/pins used to attach the strainers to the track will be based on the ASCE Standard (Reference [31]). Neither of the AISC Codes (References [9] & [30]), provide specific bolting allowables for stainless steel bolting.

4.0 ASSUMPTIONS

None

5.0 DEFINITIONS AND DESIGN INPUT

Define, $ksi \equiv 10^3 \cdot psi$ $kips \equiv 10^3 \cdot lbf$ $kPa := 1000 \cdot Pa$ $ORIGIN \equiv 1$

5.1 Material Properties

Material Types per Reference [6b]:

Perforated Plate:	Stainless Steel ASTM A-240, Type 304
Core Tube:	Stainless Steel ASTM A-240, Type 304
Radial Stiffeners:	Stainless Steel ASTM A-240, Type 304
Wire Stiffeners:	Stainless Steel ASTM A-493, Type 304 (Drafted to 110 ksi - 130 ksi)
Rivets:	Stainless Steel ASTM A-240, Type 304
Connecting Rods:	Stainless Steel ASTM A-276, Type 304
Nuts:	Stainless Steel ASTM A-194, Grade 8
Washers:	Stainless Steel ASTM A-240, Type 304
Spacer Sleeves:	Stainless Steel ASTM A-312, Type 304
Seismic Stiffeners:	Stainless Steel ASTM A-240, Type 304
Angle Iron:	Stainless Steel ASTM A-276, Type 304
Mounting pins:	Stainless Steel ASTM A-276, Type 304
Hitch Pins:	Stainless Steel ASTM A-580, Type 304
End Cover Stiffeners:	Stainless Steel ASTM A-240, Type 304
Latch and Strike Plate:	Stainless Steel ASTM A-240, A-580, A-313, Type 304
Latch Rivets:	Stainless Steel ASTM A-493/A-313, Type 304

Design Temperature $T_{des} = 250°\ F$ (Reference [1])

All Type 304 Steels (Based on A-240, Type 304)

Modulus of Elasticity at 250° F (Reference [4]), $E_s := 27300 \cdot ksi$

Yield strength at 250° F (Reference [4]), $S_y := 23.6 \cdot ksi$

Ultimate Strength at 250° F (Reference [4]), $S_u := 68.6 \cdot ksi$

B31.1 Allowable Stress at 250° F (Reference [5]), $S_h := 17.2 \cdot ksi$

Note these properties are conservative for the Type 304 wire stiffeners which are drafted to a higher tensile strength than standard Type 304 stainless steels

Other Miscellaneous Properties

Density of stainless steel from Reference [20], $\rho_{steel} := 501 \cdot \frac{lbf}{ft^3}$

Poisson's Ratio from Reference [20], $\nu := 0.305$

Density of water at temperature of 68°F(Ref. [12]) $\gamma_{H20.1} := 62.4 \cdot \frac{lbf}{ft^3}$

* Density of water at temperature of 250°F(Ref. [38]) $\gamma_{H20.2} := 58.8 \cdot \frac{lbf}{ft^3}$

Coefficient of Thermal Expansion (CTE) of stainless steel, (going from 70°F to 250°F (Ref. [4]) $CTE := 9.1 \cdot 10^{-6}$

* Hydrodynamic mass is based on the density of water at temperature. Since the yield strength of stainless steel decreases with temperature faster than the density of water decreases, it is acceptable to use the lower density of water as long as the material yield strengths are also reduced for temperature.

5.2 Strainer Geometry and Dimensions

All data are per Ref. [6d] unless otherwise noted.

Perforated Plate Dimensions

Thickness of 18 gage perforated plate as per Reference [35] $t_{perf} := 0.048 \cdot in$

Hole diameter of perforated disk plate, $D_{disk.holes} := 0.066 \cdot in$ Ref. [6g]

Pitch distance between perforation holes in disk plate (Center-to-center distance) $P_{disk.holes} := 0.125 \cdot in$ Ref. [6g]

Disk Dimensions

Strainer disk size

$L1_{disk} := 33.0 \cdot in$

$L2_{disk} := 36.0 \cdot in$

Number of disks per strainer module

$N_{disk} := 10$

Strainer disk edge channel dimensions

$d_{chan} := 0.5 \cdot in$ Ref. [6g]

$b_{chan} := 0.5 \cdot in$ Ref. [6g]

Width of each middle disk assembly

$W_{disk} := d_{chan} + 2 \cdot t_{perf}$ $W_{disk} = 0.596\ in$

Width of gap spacing between consecutive disks

$W_{gap} := 1.0 \cdot in$

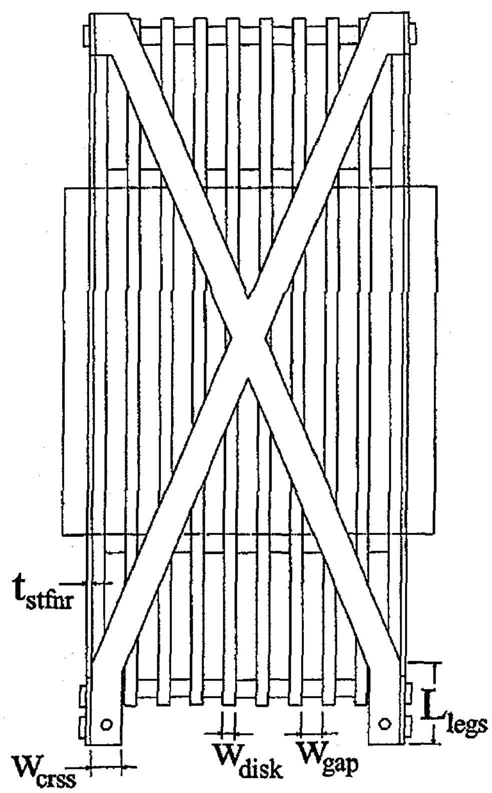

Figure 5.2-1 - Side view of Strainer Module

External Radial Stiffener and Seismic Stiffener Dimensions

The disks are supported by radial stiffeners which are welded to the core tube.

Thickness of external radial external stiffeners and debris stops	$t_{stfnr} := 0.375 \cdot in$	Ref. [6f]
Width of external radial stiffeners	$w_{stfnr} := 1.5 \cdot in$	
Width of debris stop	$W_{d.stop} := 0.84375 \cdot in$	
Outer diameter of the debris stop	$OD_{debris} := 17.565 \cdot in$	
Width of top and bottom external radial stiffener ends	$w_{end} := 2.0 \cdot in$	
Length of top stiffener ends	$L_{T.end} := 2.5 \cdot in$	
Length of bottom stiffener ends	$L_{B.end} := 4.5 \cdot in$	
Length of the support legs	$L_{legs} := 4.5 \cdot in$	
Width of support legs and seismic stiffeners	$w_{crss} := 1.5 \cdot in$	
Thickness of support legs and seismic stiffeners	$t_{crss} := 0.375 \cdot in$	Ref. [6f]
Seismic stiffener to radial stiffener weld thickness	$t_{w.cb} := 0.1875 \cdot in$	
Seismic stiffener to radial stiffener weld length (on either side of tab)	$w_{w.cb} := 1 \cdot in$	

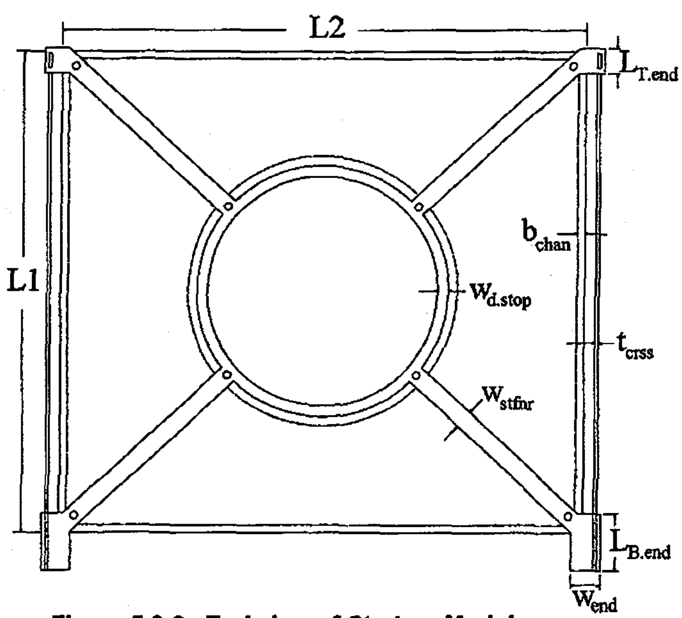

Figure 5.2-2 - End view of Strainer Module

Connecting Rod Dimensions

Number of connecting rods		$N_{rod} := 8$	
Connecting rod diameter		$OD_{rod} := 0.5 \cdot in$	Ref. [6f]
Connecting Rod tensile diameter	$OD_{tens} := OD_{rod} - \frac{0.9743 \cdot in}{13}$	$OD_{tens} = 0.425\ in$	Ref. [9]
Outside diameter of spacers (1/2" ID, SCH 80)		$OD_{spacer} := 0.84 \cdot in$	Ref. [9]
Thickness of spacers (1/2" ID, SCH 80)		$t_{spacer} := 0.147 \cdot in$	Ref. [9]
Eccentricity between edge of disk and outer connecting rod		$e_{rod} := 0.9375 \cdot in$	
Connecting rod tightening torque		$T_{rod} := 20 \cdot ft \cdot lbf$	
Diameter of centerline of inner tension rods		$BC_{rod} := 17.254 \cdot in$	

Core Tube Dimensions

Outer diameter of perforated core tube		$OD_{tube} := 15.815 \cdot in$	
Corrosion/Fabrication Allowance		$t_{ca} := 0.0 \cdot in$	
Core tube wall thickness (16 ga.)		$t_{16ga} := 0.0595 \cdot in$	Ref. [35]
Core tube wall thickness after allowance	$t_{tube} := t_{16ga} - 2 \cdot t_{ca}$	$t_{tube} = 0.0595\ in$	Ref. [6f]
Core tube extension beyond last disk face		$L_{stub} := 2.25 \cdot in$	
Outer diameter of disk gap		$OD_{gap} := 18.19 \cdot in$	
Number of rows of core tube holes		$N_{hole} := 5$	Ref. [6e]
Number of holes per row		$N_{hole.circ} := 4$	Ref. [6e]
Radial stiffener to core tube weld thickness		$t_{w.ct} := 0.0625 \cdot in$	
Radial stiffener to core tube weld length (per individual weld)		$w_{w.ct} := 1.5 \cdot in$	
The orientation of the hole along the circumference		$\phi := \begin{pmatrix} 0 \\ 90 \\ 180 \\ 270 \end{pmatrix} \cdot deg$	Ref. [6e]

Rivet Dimensions

Number of edge channel rivets per disk side (excluding corner rivets)	$N1_{rivet} := 10$	$N2_{rivet} := 11$	
End cover, face/gap disk rivet head diameter (item #'s PR64FFP and PR62FFP, respectively. See Ref. [29])	$c_{disk.rivet} := 0.375 \cdot in$		Ref. [6f] Ref. [6h]
Sleeve Rivet diameter (1/8" Stainless Steel Rivets)	$c_{slv.rivet} := 0.125 \cdot in$		

Rivet Dimensions (continued)

Number of intermediate disk face rivets		$N_{rivet.face} := 0$	
Number of inner gap rivets holding the hoop together		$N_{rivet.hoop} := 2$	Ref. [6g]
Number of rivets to attach latches and strikes to sleeve connector		$N_{rv.latch} := 8$	Ref. [6h]
Number of end cover rivets		$N_{rivet.end} := 60$	Ref. [6h]
Eccentricity between the edge channel rivets and the adjacent edge of disk		$e_{rivet} := 0.25 \cdot in$	
Offset from line connecting center of core tube and center of outer rod (Refer to subsection Internal Wire Stiffeners in Section 6.1 for more detail)		$e_{off} := 1.25 \cdot in$	

Internal Wire Stiffener Dimensions (All data per Ref. [6g] unless otherwise noted)

Number of intermediate circumferential stiffeners		$N_{circ} := 1$	
Diameter of radial wire stiffeners (7 ga)		$d_{wire.rad} := 0.177 \cdot in$	Ref. [6b]
Diameter of circumferential wire spacers (8 ga)		$d_{wire.circ} := 0.162 \cdot in$	Ref. [6b]
Inner circumferential stiffener width	$L_{circ.in} := OD_{tube} + 1.5 \cdot in$	$L_{circ.in} = 17.32\ in$	
Outer circumferential stiffener width (Side 1)	$L1_{circ.out} := L1_{disk} - 2 \cdot e_{rod}$	$L1_{circ.out} = 31.125\ in$	
Outer circumferential stiffener width (Side 2)	$L2_{circ.out} := L2_{disk} - 2 \cdot e_{rod}$	$L2_{circ.out} = 34.125\ in$	
Corner distance for outer circumferential		$L_{circ.cor} := 1.5 \cdot in$	

End Cover Stiffener Dimensions (All data per Ref. [6k] unless otherwise noted)

Number of radial spokes		$N_{spoke} := 12$
Number of circumferential rings		$N_{circ.end} := 1$
Thickness of spokes and rings (spider)		$t_{spdr} := 0.375 \cdot in$
Width of radial spokes		$w_{spoke} := 0.25 \cdot in$
Width of circumferential rings		$w_{circ} := 0.25 \cdot in$
Radius of circumferential rings		$R_{circ.end} := \begin{pmatrix} 0.5 \\ 4.125 \end{pmatrix} \cdot in$
Thickness of end cover clamp		$t_{cover} := 0.375 \cdot in$
Inner diameter of end cover clamp		$ID_{cover} := 15.875 \cdot in$
Outer diameter of end cover clamp	$OD_{cover} := ID_{cover} + 2 \cdot t_{cover}$	$OD_{cover} = 16.625\ in$
Width of end cover clamp		$w_{cover} := 3 \cdot in$

End Cover Stiffener Dimensions (cont'd)

End cover spider support ring to end cover clamp weld thickness		$t_{w.ring} := 0.125 \cdot in$
Width of the end cover spider support rings		$w_{ring} := 0.375 \cdot in$
Thickness of the end cover spider support rings		$t_{ring} := 0.25 \cdot in$
Length of end cover radial arms (approximate maximum)		$L_{arm} := 17 \cdot in$
Width of rectangular end cover radial arms		$w_{arm} := 2.5 \cdot in$
Thickness of end cover radial arms		$t_{arm} := 0.5 \cdot in$
Width of the flange portion of the end cover		$w_{flange} := 2 \cdot in$
Thickness of end cover flanges		$t_{ec.fl} := 0.5 \cdot in$
End cover clamp to radial arm weld thickness		$t_{w.arm} := 0.1875 \cdot in$
Average length of top and bottom end cover plates	$L_{ec.plt} := \frac{(2.6875 + 3.75) \cdot in}{2}$	$L_{ec.plt} = 3.219\ in$
Average width of top and bottom end cover plates	$w_{ec.plt} := \frac{(5.125 + 5.375) \cdot in}{2}$	$w_{ec.plt} = 5.25\ in$
Thickness of end cover plates		$t_{ec.plt} := 0.25 \cdot in$
Height from center of core tube to top of top stiffener arm		$h_{ec.sa.t} := 17.875 \cdot in$
Height from center of core tube to bottom of bottom stiffener arm		$h_{ec.sa.b} := 14.125 \cdot in$
Width from center of core tube to edge of stiffener arms		$w_{ec.sa} := 19.15625 \cdot in$

Other Miscellaneous Dimensions

Diameter of mounting pin connecting the strainer to the angle iron track	$OD_{pin} := 0.5 \cdot in$	Ref. [6h]
Angle iron thickness	$t_{angle} := 0.25 \cdot in$	Ref. [6i]
Length of vertical leg of the angle iron track	$L_{vert.leg} := 2 \cdot in$	Ref. [6i]
Eccentricity from bolt connection to bottom of angle	$e_{bolt} := 1.125 \cdot in$	Ref. [6i]
Eccentricity from corner of angle to anchor bolt	$e_{hkb.1} := 1.5 \cdot in$	
Eccentricity from edge of angle leg to anchor bolt	$e_{hkb.2} := 1.5 \cdot in$	
Span between two adjacent anchor bolts	$L_{hkb} := 19.9567 \cdot in$	Ref. [6i]
Eccentricity between two adjacent module supports	$e_{sprt} := 6.5 \cdot in$	Ref. [6i]
Length of alternate angle iron segment in case of rebar interference:	$L_{alt} := 4.5 \cdot in$	Ref. [6c]
Alternate angle iron segment to angle iron track weld length (full)	$w_{w.alt} := 2 \cdot in$	Ref. [6c]

Other Miscellaneous Dimensions (cont'd)

Alternate angle iron segment weld thickness	$t_{w.alt} := 0.1875 \cdot in$	Ref. [6c]
Diameter of hitch pin	$OD_{hitch} := 0.177 \cdot in$	Ref. [6b]
Diameter of Hilti Kwik anchor bolt	$OD_{hkb} := 0.625 \cdot in$	Ref. [6c]
Diameter of core tube connection sleeve	$OD_{sleeve} := 15.8723 \cdot in$	Ref. [6h]
Thickness of sleeve connecting two adjacent modules (22 ga. See Ref. [35])	$t_{sleeve} := 0.0293 \cdot in$	Ref. [6h]
Width of sleeve connecting two adjacent modules	$w_{sleeve} := 3.5 \cdot in$	Ref. [6h]
Number of latches per sleeve	$N_{latch} := 2$	Ref. [6h]
Span between two module supports for a given module	$L_{sprt} := 13.4567 \cdot in$	Ref. [6i]

Pool Boundaries (All data per Ref. [6a] unless otherwise noted)

Minimum height of the water above the floor		$H_w := 38 \cdot in$	
Gap between the bottom of the strainer and the floor		$g_f := 3 \cdot in$	
Gap between the top of the strainer and the minimum water level surface		$g_t := 2 \cdot in$	
Approximate distance from containment wall/floor interface to adjacent strainer train (Unit 1 controls)		$e_w := 6 \cdot in$	Ref. [6j]
Angle of the reactor containment wall	$\alpha_{wall} := \operatorname{atan}\left(\frac{10 \cdot ft}{3 \cdot ft}\right)$	$\alpha_{wall} = 73.30\ deg$	Ref. [6j]
Minimum average gap between the side of the strainer and the nearest wall (Unit 1 controls)	$g_w := e_w + \frac{0.5 \cdot L1_{disk} + g_f}{\tan(\alpha_{wall})}$	$g_w = 11.85\ in$	Ref. [6j] and Ref. [6a]

Strainer Trains

The hole/slot distributions along the length the core tube are given in terms of dimensions H (the width of the slot or the diameter of the hole) and L2 the length of the slot. The length of the slot (L2) is orientated along the axis of the core tube. There are four holes around the circumference of each row. There are N_{hole} number of rows. H is provided in array format and L2 and L_{lig} are provided as constants *(see Reference [6e]), where the* rows are the hole locations, the first row being the smallest hole on the end module, and the last being the largest hole on the end module. The first column represents the holes associated with the 0 and 180 degree locations of the end the module, and the second column represents the holes associated with the 90 and 270 *degree locations of the end module.*

$k := 1 .. N_{hole}$ $\quad j := 1 .. 2$

0 90 deg

$$H := \begin{pmatrix} 1.56 & 1.59 \\ 1.67 & 1.70 \\ 1.79 & 1.83 \\ 1.94 & 1.98 \\ 2.09 & 2.14 \end{pmatrix} \cdot in$$

$L2 := 2.49 \cdot in$

$L_{lig} := 0.5 \cdot in$

$r_{hole} := \min\left(\frac{H}{2}, 0.25 \cdot in\right)$

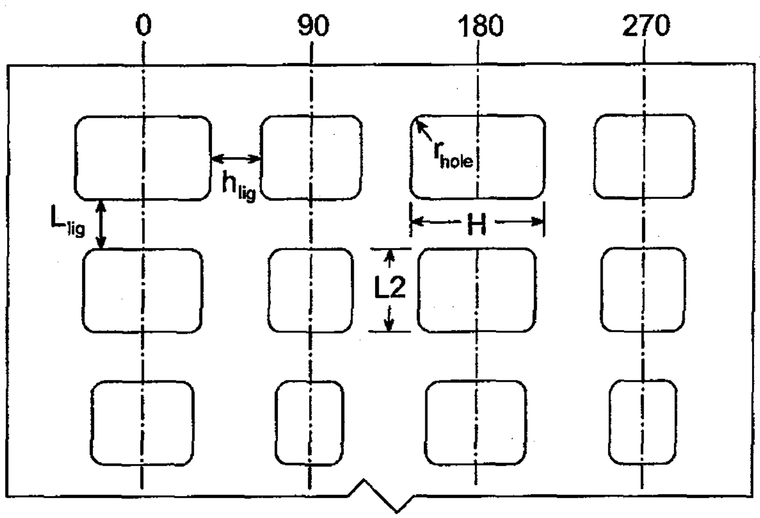

Figure 5.2-3 - Partial View of Strainer Trains

(Figure is a partial view of complete layout, see Ref. [6e])

Note the holes at 0 degrees and 180 degrees are the same size, and the holes at 90 degrees and 270 degrees are also the same size (see "Sure-Flow Strainer Trains" Reference [6e]).

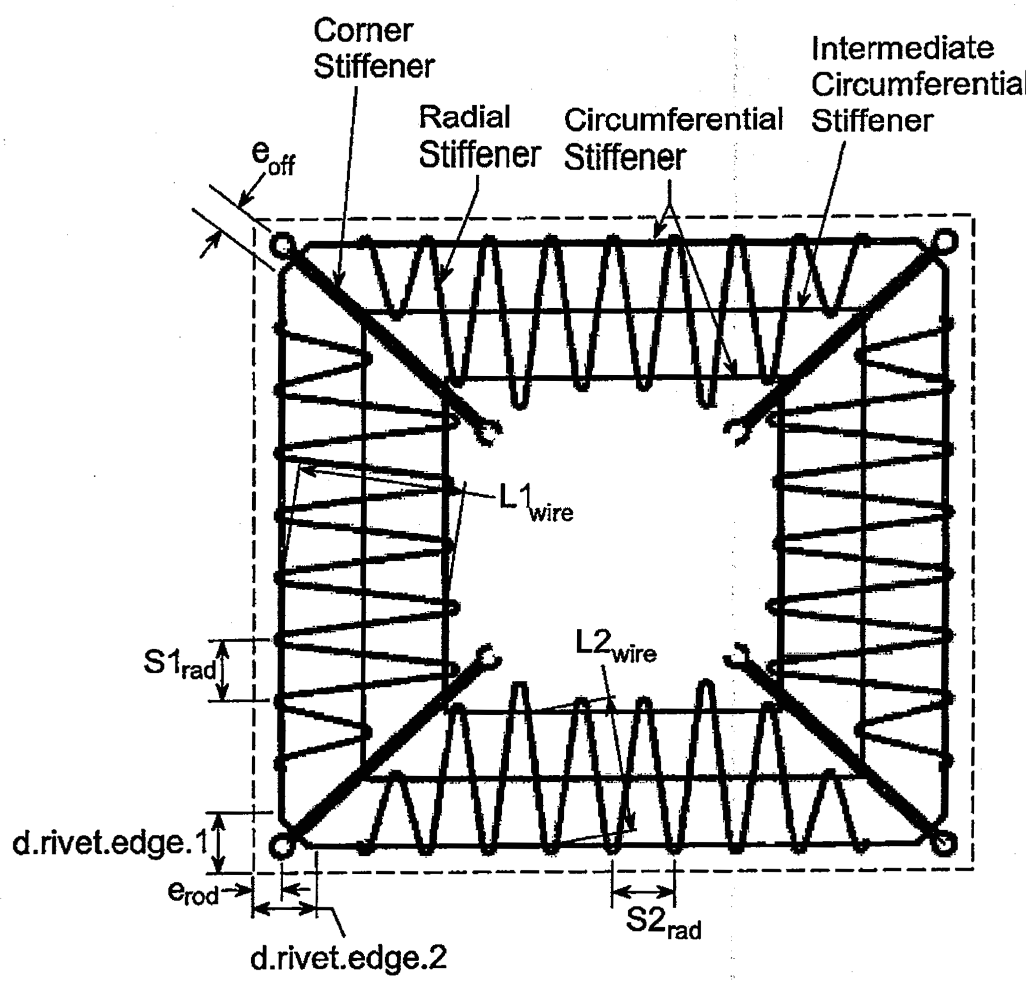

Figure 6.1-1 - Intermediate Wire Stiffener Pattern and Notation

7.0 RESULTS AND CONCLUSIONS

The results of this calculation indicate that the strainers meet the acceptance criteria for all applicable loadings. A summary of the maximum stress Interaction Ratios (calculated stress divided by allowable stress) is provided below.

Strainer Component	Ref. Section	Interaction Ratio (OBE SSE)
External Radial Stiffener (Including Debris Stops)	6.6	$IR_{rad.stfnr}^T = (0.91 \quad 0.98)$
Connecting Rods	6.6	$IR_{rod}^T = (0.96 \quad 0.86)$
Edge Channels	6.6	$IR_{chan}^T = (0.65 \quad 0.82)$
Seismic Stiffeners	6.6	$IR_{seis.stfnr}^T = (0.81 \quad 0.86)$
Spacers	6.6	$IR_{spacer}^T = (0.56 \quad 0.53)$
Core Tube (Biggest Holes)	6.8	$IR_{tube}^T = (0.02 \quad 0.01)$
Perforated Plate (DP Case)	6.9.1	$IR_{face.dp}^T = (0.28 \quad 0.24)$
Perforated Plate (Seismic Case)	6.9.1	$IR_{face.bp}^T = (0.42 \quad 0.45)$
Perforated Plate (Edge Channels)	6.9.3	$IR_{edge}^T = (0.05 \quad 0.04)$
Perforated Plate (Inner Gap)	6.9.4	$IR_{gap}^T = (0.12 \quad 0.11)$
Wire Stiffener	6.10	$IR_{wire} = 0.53$
Perforated Plate (Core Tube End Cap DP Case)	6.11.1	$IR_{front.end}^T = (0.65 \quad 0.60)$
Perforated Plate (Core Tube End Cap Seismic Case)	6.11.1	$IR_{back.end}^T = (0.16 \quad 0.17)$
Radial Stiffening Spokes of the End Cover Stiffener	6.11.2	$IR_{spoke}^T = (0.60 \quad 0.56)$
Circumferential Rings of the End Cover Stiffener	6.11.2	$IR_{circ}^T = (0.02 \quad 0.02)$
End Cover Sleeve	6.11.5	$IR_{cover}^T = (0.65 \quad 0.60)$
Welds of End Cover	6.12.1	$IR_{w.cover}^T = (0.23 \quad 0.17)$
Weld of Radial Stiffener to Core Tube	6.12.2	$IR_{weld.ct}^T = (0.20 \quad 0.27)$

RESULTS AND CONCLUSIONS (Cont.)

Strainer Component	Ref. Section	Interaction Ratio
Weld of Radial Stiffener to Seismic Stiffener	6.12.3	$IR_{weld.cb}^T = (0.46 \quad 0.44)$
Edge Channel Rivets	6.13.1	$IR_{rv.face}^T = (0.13 \quad 0.13)$
Inner Gap Hoop Rivets	6.13.2	$IR_{rv.gap}^T = (0.03 \quad 0.02)$
End Cover Rivets	6.13.3	$IR_{rv.end}^T = (0.01 \quad 0.01)$
Mounting Pins	6.14.1	$IR_{pin}^T = (0.29 \quad 0.27)$
Clevis Hitch Pins	6.14.1	$IR_{hitch}^T = (0.56 \quad 0.66)$
Angle Iron Tracks	6.14.2	$IR_{angle}^T = (0.53 \quad 0.78)$
Expansion Anchors to Floor	6.14.3	$IR_{hkb}^T = (0.64 \quad 0.96)$
Angle Iron-to-Angle Iron Track Weld	6.14.4	$IR_{weld.alt}^T = (0.07 \quad 0.07)$
Module-to-module Sleeve	6.15.1	$IR_{sleeve}^T = (0.26 \quad 0.23)$
Module-to-module Latch Connection	6.15.2	$IR_{latch}^T = (0.98 \quad 0.96)$
Lift Case	6.16	$IR_{lift} = 0.26$
Outage Case	6.17	$IR_{outage} = 0.19$

8.0 REFERENCES

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[2] Point Beach Nuclear Plant Seismic Qualification Specification Sheet SQ #002243, Revision 0.

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[4] ASME B&PV Code, Section II, Part D, Material Properties, 1998 Edition, through 1999 Addenda.

[5] ANSI/ASME B31.1 Power Piping Code, 1998 Edition, through 1999 Addenda.

[6] Performance Contracting, Inc.(PCI), Sure-Flow Suction Strainer Drawings.

- 6a. PCI Drawing No. SFS-PB2-GA-00, "Sure-Flow Strainer Recirc Sump System Layout", Revision 2.
- 6b. PCI Drawing No. SFS-PB2-GA-01, "Sure-Flow Strainer General Notes", Revision 7.
- 6c. PCI Drawing No. SFS-PB2-GA-02, "Sure-Flow Strainer A Strainer", Revision 9.
- 6d. PCI Drawing No. SFS-PB2-PA-7100, "Sure-Flow Strainer Module Assembly", Revision 1.
- 6e. PCI Drawing No. SFS-PB2-PA-7101, "Sure-Flow Strainer Trains", Revision 1.
- 6f. PCI Drawing No. SFS-PB2-PA-7102, "Sure-Flow Strainer Module Assembly", Revision 3.
- 6g. PCI Drawing No. SFS-PB2-PA-7103, "Sure-Flow Strainer Sections and Details", Revision 0.
- 6h. PCI Drawing No. SFS-PB2-PA-7105, "Sure-Flow Strainer Sleeves/Cover/Supports/Pins", Revision 4.
- 6i. PCI Drawing No. SFS-PB2-PA-7150, "Sure-Flow Strainer Mounting Track A1/B1", Revision 2.
- 6j. PCI Drawing No. SFS-PB1-GA-00, "Sure-Flow Strainer Recirc Sump System", Revision 6.
- 6k. PCI Drawing No. SFS-PB2-PA-7106, "Sure-Flow Strainer End Cover", Revision 1.
- 6l. PCI Drawing No. SFS-PB1-GA-01, "Sure-Flow Strainer General Notes", Revision 9.
- 6m. PCI Drawing No. SFS-PB1-GA-02, "Sure-Flow Strainer A Strainer", Revision 6.
- 6n. PCI Drawing No. SFS-PB1-PA-7100, "Sure-Flow Strainer Module Assembly", Revision 2.
- 6o. PCI Drawing No. SFS-PB1-PA-7101, "Sure-Flow Strainer Trains", Revision 0.
- 6p. PCI Drawing No. SFS-PB1-PA-7102, "Sure-Flow Strainer Module Assembly", Revision 1.
- 6q. PCI Drawing No. SFS-PB1-PA-7103, "Sure-Flow Strainer Sections and Details", Revision 1.
- 6r. PCI Drawing No. SFS-PB1-PA-7105, "Sure-Flow Strainer Sleeves/Cover/Supports/Pins", Revision 8.

6s. PCI Drawing No. SFS-PB1-PA-7150, "Sure-Flow Strainer Mounting Track A1, B1", Revision 1.

6t. PCI Drawing No. SFS-PB1-PA-7106, "Sure-Flow Strainer End Cover", Revision 2.

6u. PCI Drawing No. SFS-PB1-GA-03, "Sure-Flow Strainer B Strainer", Revision 6.

6v. PCI Drawing No. SFS-PB2-GA-03, "Sure-Flow Strainer B Strainer", Revision 9.

6w. PCI Drawing No. SFS-PB1-PA-7151, "Sure-Flow Strainer Mounting Track A2, B2", Revision 2.

6x. PCI Drawing No. SFS-PB2-PA-7151, "Sure-Flow Strainer Mounting Track A2/B2", Revision 3.

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[17] "Theory of Plates and Shells" by Stephen P. Timoshenko and S. Woinowsky-Krieger, 2nd Edition, McGraw-Hill, 1959.

[18] PCI Intra -Company Correspondence from Greg Hunter, Dated February 20, 2006, Subject, "Testing of 3/16" Blind Rivets and 3/16" Closed End Rivets" (with test reports attached). (Attachment C)

[19] ASME Publication, "Pressure Vessel and Piping: Design and Analysis," Volume 2, 1972, Components and Structural Dynamics, Paper Title " Design of Perforated Plate," by O'Donnell & Langer Reprinted from Journal of Engineering for Industry, 1962.

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[27] PCI Technical Document TDI-6007-04, "Module Debris Weight - Point Beach Nuclear Plant Units 1/2", Revision 3.

[28] Nukon Pipe ESD-TR-14B, "Latch and Strike Tensile Strength Test," August 11, 1993. (Attachment D)

[29] Jay-Cee Sales and Rivet Inc, "Expanded Product Line", 4th Edition. (Attachment E)

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[35] Stainless Steel Sheet Thickness Table from Hendrick book. (Attachment H)

Automated Engineering Services Corp	CALCULATION SHEET	Page: 175 of 175
		Calc. No.: PCI-5344-S01
Client: Performance Contracting Inc.		**Revision:** 4
Station: Point Beach, Units 1 & 2		**Prepared By:** [redacted]
Calc. Title: Structural Evaluation of Containment Emergency Sump Strainers		**Reviewed By:** [redacted]
Safety Related Yes [X] No [ ]		**Date:** 4/26/07

[36] Bechtel Drawing No. C-128, Containment Structure Interior Plans at El. 10'-0", EL. 21'-0", EL. 24'-8", and EL. 38'-0", Rev. 9. (Unit 1)

[37] Bechtel Drawing No. C-2128, Containment Structure Interior Plans at El. 10'-0", EL. 21'-0", EL. 24'-8", and EL. 38'-0", Rev. 8. (Unit 2)

[38] "Fundamentals of Engineering Thermodynamics, SI Version" by John R. Howell and Richard O. Buckius, McGraw-Hill, 1987.

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[40] EC No. 9306 affecting drawing "SFS-PB2-GA-02, and SFS-PB2-GA-03, Revision 8", Revision 0.

[41] EC No. 9355 affecting drawing "SFS-PB2-GA-02, Revision 8", Revision 0.

[42] EC No. 9364 affecting drawing "SFS-PB2-GA-03, Revision 8", Revision 0.

[43] EC No. 10627 affecting drawings "SFS-PB1-GA-03, Revision 6 and SFS-PB1-GA-04, Revision 5", Revision 0.

[44] ACI Structural Journal, January-February 1995, VOL. 92 NO. 1 (Attachment J)

[45] EC No. 10581 affecting drawings "SFS-PB1-GA-00, Revision 6 and SFS-PB1-GA-02, Revision 6", Revision 0.

ENCLOSURE 5

FPL ENERGY POINT BEACH, LLC

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02 "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

STRUCTURAL EVALUATIONS OF SUMP COVER AND PIPING FOR SUMP STRAINERS, UNIT 1 (ABRIDGED)

19 Pages Follow

Automated Engineering Services Corp.	# Calculation Package	Page 1	of 114

Calculation Number:	PCI-5344-S03		
Calculation Title:	Evaluation of Sump Cover and Piping for the Containment Sump Strainers		
Client:	Performance Contracting, Inc. (PCI)	**Station:**	Point Beach
Project Number:	PCI-5344	**Unit(s):**	1
Project Title:	Point Beach Strainer Engineering		

Safety Related Yes ☒ No ☐

Revision	Affected Pages	Revision Description	Approval Signature / Date	Signature / Initials of Preparers & Reviewers
0	All	Initial Issue	[redacted] 07/21/06	**Prepared by:** [redacted] **Reviewed by:** [redacted]
1	1-4, 6, 11, 14-16, 25-32, 34-68, 70-105, 107 Attachment A Attachment B Attachment C	Incorporated pressure thrust load on piping due to strainer pressure imbalance. Revised sole plate design to bolt directly to floor, evaluated uplift load on sole plate from valve testing and the application of lubricants during flange bolt-ups. Minor other editorial changes. Renumbered all pages from p. 8 forward. This revision resolves AES CAR 06-006	[redacted] 1/30/07	**Prepared by:** [redacted] **Reviewed by:** [redacted]
2	1-4, 6, 26, 29-31, 34, 37, 38, 40-42, 44-47, 55-68, 70-80, 82-92, 95-98, 100-103, 105, 106, 108-112, 114 & Attachment A	Incorporated ECN's 10580, 10581, 10653 & DIT for EC 10720. Reanalyzed static analysis (Attachment A) to incorporate gaps of 3/32" at the U-bolt/pipe side of the 2-way restraints (PS3). Renumbered all pages from page 73 forward.	[redacted] 4/27/07	**Prepared by:** [redacted] **Reviewed by:** [redacted]

Revision	Affected Pages	Revision Description	Approval Signature / Date	Signature / Initials of Preparers & Reviewers
3	1-3, 69-71, 83, 85, 93-94, 110-111 Added 1A	Changed faulted shear stress allowable to agree with DG-M10 and the effective shear stress area for angle and tee sections to agree with paragraph C3 (p. 5-315) of AISC 9th Edition Commentary on the Specification for Allowable Stress of Single-Angle Members. This resolves CAR-07-004.	[redacted] 12/27/07	Prepared by: [redacted] Reviewed by: [redacted]

Client: Performance Contracting Inc.	Revision: 2
Station: Point Beach - Unit 1	Prepared By: [redacted]
Calc. Title: Evaluation of Sump Cover and Piping for the Containment Sump Strainers	Reviewed By: [redacted]
Safety Related Yes [X] No [ ]	Date: 4/27/07

TABLE OF CONTENTS

Attachments

Client: Performance Contracting Inc.	Revision: 1
Station: Point Beach - Unit 1	Prepared By: [redacted]
Calc. Title: Evaluation of Sump Cover and Piping for the Containment Sump Strainers	Reviewed By: [redacted]
Safety Related Yes [X] No [ ]	Date: 1/30/07

1.0 PURPOSE/OBJECTIVE

The purpose of this calculation is to qualify the sump cover, piping, and piping supports associated with the Performance Contracting Inc. (PCI) Suction Strainers to be installed in Nuclear Management Corporation's Point Beach Nuclear Plant Unit 1. This calculation evaluates, by analysis, the piping as well as the supporting structures associated with the new piping. The evaluations encompass all piping from and including the sump cover plate (sole plate) attached to the El. 8' floor slab to the strainer connections including intermediate support structures.

2.0 METHODOLOGY

The evaluations are performed using a combination of manual calculations and computerized piping using the AutoPIPE Program (Reference [16]). The piping is considered as an attachment or extension to the strainers and are therefore subject to the requirements of Strainer Design Specification PB-681(Reference [1]). Exceptions from these requirements, if taken, are discussed and justified within this calculation.

Seismic Loads

The strainer piping is categorized as Seismic Class I equipment and is required to be operable during and after a safe shutdown earthquake (SSE) without exceeding normal allowable stresses as specified in Section 5.4.7 of DG-C03 Seismic Design Criteria Guideline (Reference [14]). Strainer Design Specification PB-681 (Reference [1]), requires the piping to be evaluated for two operating conditions. The first condition is a "dry" condition with no recirculation water inside or external water present. The second condition is a submerged "wet" condition with recirculation water. For the seismic evaluation the piping will be considered submerged and full of water. The water level is considered to be a minimum of 3'- 2" above the 8' floor elevation (El. 11'- 2"). The piping "dry" state with its associated mass being much less, will not be considered as it is less severe than the "wet" state.

Per the specification, the seismic evaluation is required to take into account any seismic slosh (analyzed at the seismic worst-case water level) of the recirculation water. Based on Reference [20], because of the negligible load magnitudes, it is determined that the seismic slosh loads in PWR containments are insignificant by comparison with other seismic loads. Therefore, seismic slosh loads are neglected from the pipe stress analysis. Note that the sloshing calculation of Reference [20] is done for the Prairie Island strainer project and it is representative for all PWR containments in general, and therefore, it is applicable for use in this calculation. The "wet" strainer operating condition will consider the strainer assemblies submerged in still water at the seismic worst-case water level when subjected to seismic inertial loads. The inertial effects of the added hydrodynamic mass due to the submergence of the piping is considered.

The piping is seismically qualified using the response spectra method. The applicable seismic spectra are provided in Seismic Qualification Specification Sheet SQ-002243 (Reference [2]) These loads are applied to the piping through base motion response spectra as detailed in the Seismic Design Criteria Guideline DG-C03 (Reference [14]).

All piping is located on the 8' floor elevation of the containment. The response spectrum chosen is for the 6.5' elevation of the containment. The containment liner plate is located at the 6.5' elevation and there is an additional 1.5' of concrete on top of the liner plate. The slab between the 6.5' elevation and the 8' elevation is very rigid. Thus it is appropriate to use the response spectrum for the 6.5' elevation. The vertical direction response spectrum is 2/3 the value of the maximum ground horizontal response spectra.

The piping is considered as vital piping and the damping values for seismic loads is taken as 0.5% for both the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) as required by Seismic Design Guide DG-C03. The response spectra inputs are for the OBE environment. For evaluating stresses, displacements, loads, etc., for the maximum credible earthquake (SSE), the values obtained from the OBE analysis are to be increased by a factor of 2.0 (Reference [11]).

The piping is excited in each of the three mutually perpendicular directions, two horizontal and one vertical. Per Reference [11], the modal combination is performed by the use of the double sum method to account for the effects of modal coupling in the response (i.e. closely spaced modes). An earthquake duration of 30.24 seconds was used in the analysis per DG-C03, Appendix C. Appendix N of the ASME code indicates that the maximum accelerations generally occur in the first 10 seconds. Two analysis were run - one with 10 sec and one with 30.24 sec. Since the results were the same, the analysis with 10 seconds is the official documented seismic analysis. Responses due to the three spatial components are combined by SRSS. (Reference [11], paragraph 5.6.5). The cutoff frequency is taken at 30 hz or a minimum of 5 modes are included.

Zero Period Acceleration (ZPA) residual mass effects are considered since they may significantly affect the piping. The ZPA response is combined with the response spectra response by SRSS.

Since all piping is supported from the same El. 8' floor slab, there are no relative seismic anchor movements.

Operating Loads

Operating loads are comprised of weight, thermal expansion and pressure loads.

The thermal expansion is taken at a temperature equal to the maximum operational inlet temperature to the RH Exchangers of 250 °F (Reference [1]). Small gaps (3/32") are modeled on the u-bolt side only of the two-way restraints (Type PS3) on the "B" train piping (Reference [37]. These gaps were modeled to reduce the high thermal loads encountered due to the several bends associated with the "B" train piping. The design drawings (Ref. [6b]) ensure that these gaps will be available. Note the Autopipe model was rerun to account for these modified gaps.

Because the attached piping is connected to the strainer with flexible joint it essentially behaves as an open ended system, this pressure differential will also create an axial thrust force on the piping. The maximum differential pressure load acting on the piping is the hydrostatic pressure associated with the maximum allowed head loss through the debris covered strainers. This is defined as 38 inches of 212 °F water in Section 4.0 of Design Specification PB- 681 (Reference [1]) .

Automated Engineering Services Corp	CALCULATION SHEET	Page: 7 of 114
		Calc. No.: PCI-5344-S03
Client: Performance Contracting Inc.		Revision: 1
Station: Point Beach - Unit 1		Prepared By: [redacted]
Calc. Title: Evaluation of Sump Cover and Piping for the Containment Sump Strainers		Reviewed By: [redacted]
Safety Related Yes [X] No [ ]		Date: 1/30/07

Software

MathCad software is used to generate most of the calculations. All MathCad calculations are independently verified for accuracy and correctness as if they were manually generated. AutoPIPE Version 8.05 is used for the piping analysis. AutoPIPE Version 8.05 is verified and validated under the AES QA program as documented in the AES validation and maintenance files (Reference [16]). Because the AutoPIPE Version 8.05 only performs piping evaluations using the 2001 Edition of the B31.1 Code instead of the required 1998 Edition, a reconciliation of the 2001 Code to the older 1998 Code is performed.

The only provisions of the code that could potentially affect the results of the piping analysis are changes in material properties and design equation provisions. A review of the codes and the material specifications shows that the only physical properties of material that affect the design of code items are the minimum yield, the tensile strengths and the coefficient of thermal expansion because these are the basis for the allowable stresses and the tabulated "E" and "α" values at temperature. As long as the specified tensile properties of the material have not changed, use of the later Edition does not affect the end result.

The material allowables stresses are included manually into AutoPIPE based on the ASME B31.1 - 1998 Edition, which is the design code for pipe stress analysis. In addition, a review of the two the codes was performed to identify revisions to the design equation provisions and to determine if any material properties associated with "E" and "α" had changed. There have been no design dependent revisions to the piping material and to the design code equations. The flexibility and stress intensification factors, and the method for combining moments are the same for both code editions. Therefore, the results between the two code editions will be identical.

3.0 ACCEPTANCE CRITERIA

The strainer suction piping shall meet the requirements of the strainer design specification PB-681 (Reference [1]). As stated in PB-681, the detailed evaluations are to be performed using the rules, as applicable, of ANSI/ASME B31.1 Power Piping 1998 Edition (Reference [5]).

The piping supports, baseplates and other mounting hardware is evaluated to AISC 9th Edition as permitted in paragraph 120.2.4 of the B31.1 Code. Additional guidance is also taken from other codes and standards where the AISC does not provide specific rules for certain aspects of the design. For instance, the cover plates, stiffeners angles, support components are made from stainless steel materials. The AISC Code does not specifically cover stainless steel materials. Therefore, ANSI/AISC N690-1994, "Specification for the Design, Fabrication, and Erection of Steel Safety Related Structures for Nuclear Facilities", Reference [25] is used to supplement the AISC in any areas related specifically to the structural qualification of stainless steel. Note that only the allowable stresses are used from this Code and load combinations and allowable stress factors for higher service level loads are not used.

SEI/ASCE 8-02, "Specification for the Design of Cold-Formed Stainless Steel Structural Members", (Reference [24]) is used for certain components (stainless steel bolts and pins) since the AISC does not provide specific bolting allowables for stainless steel bolting. The rules for Allowable Stress Design (ASD) as specified in Appendix D of this code are used. Finally guidance is also taken from AWS D1.6, "Structural Welding Code - Stainless Steel", (Reference [26]) as it relates to the qualification of stainless steel welds. Detailed acceptance criteria for each type of strainer component is provided in the sections below.

Load Combinations

The applicable load combinations for the piping are those from Section 6.0 of DG-M09 (Reference [11]).

Load Condition	Combination
(1) Normal	P + DW
(2) Upset	P + DW + OBE
(3) Emergency/Faulted	P + DW + SSE
(4) Thermal	T1

where,

DW = Dead Weight Load

P = Differential Pressure

OBE = Operating Basis Earthquake

SSE = Safe Shutdown Earthquake

T1 = Thermal Expansion

The thermal expansion stresses are based on a stress range from the ambient condition of 70 °F to the maximum operating condition of 250 °F (ΔT = 180 °F).

Piping

The piping is evaluated in accordance with ANSI B31.1 Paragraph 104.8 as applicable. Since the B31.1 does not explicitly identify how to incorporate the emergency SSE loads, PBNP uses ASME Section III as a guide as discussed in Section 6.0 of DG-M09 (Reference [11]).

B31.1 Eq. No	Load Condition	Stress Combination	Allowable Stress
11	Normal (Sustained)	P + DW	1.0 S_h
12 (OBE)	Upset (Occasional)	P + DW + OBE	1.2 S_h
12 (SSE)	Emergency (Occasional)	P + DW + SSE	1.8 S_h
13	Thermal (Displacement)	T1	1.0 S_A

Flanges

Since specific detailed guidance is not provided in B31.1, the bolted flange connections at each end of the piping elbows will be evaluated in accordance with ASME Section III, Appendix L (Reference [8]) guidelines. The flange bolts are qualified to the criteria presented in ASME III, Appendix L (Reference [8]). Note that these are non-standard flanges which do not meet the generic requirements of B31.1 (such as weld size). As stated in the forward of of the B31.1 Code (Reference [5]), "a designer who is capable of a more rigorous analysis than is specified in the Code may justify a less conservative design, and still satisfy the basic intent of the Code." Use of a detailed stress evaluation of the flange and the flange weld, based on ASME analysis equations, certainly falls within this category of satisfying the basic intent of the Code.

Piping Support Structural Components

The allowable stresses on the piping support components are based on the AISC 9th Edition (Reference [9]). Also, the allowables stresses for the sump sole plate tabs, bolts, and welds are based on the AISC 9th Edition. The allowable stress for the SSE Load Combinations is taken from Section 6.9 of DG M10 (Reference [13]).

Load Condition	Load Combination	Allowable Stress
Normal	DW + T1	1.0 AISC
Upset	DW + OBE + T1	1.0 AISC
Faulted	DW + SSE + T1	1.5 AISC but not to exceed 0.9 S_y

Compression

Per Reference [25], because stainless steel does not display a single, well defined modulus of elasticity, the allowable compression stress equations from the AISC are not applicable for stainless steels. Therefore, the allowable compression stress will be based on the lower allowables from Reference [25] as opposed to those provided in the AISC Code (Reference [9]). Per Q1.5.9.2 of Reference [25], the allowable stresses for tension, shear, bending and bearing for stainless steel can be taken as the same allowables provided for carbon steel, therefore the AISC 9th Edition will be used for allowables for these types of stresses.

Welded Joints

Allowable stresses for piping welds, such as the flange fillet welds, are per ASME Section III (Reference [8]), Paragraph NC-3356. IWA welds are in accordance with ASME Code Case N-318-5 (Reference [19]). The allowable stresses for all other welds are based on the AISC 9th Edition (Reference [9]). AWS D1.6 (Reference [26]) was reviewed to ensure that any special qualification requirements associated with stainless steel welding were considered. Since the weld allowables provided in AWS D1.6 are essentially the same as allowed for carbon steel welds under AWS D1.1, no special adjustments are required to account for stainless steel. The allowable stress for the SSE Load Combinations is taken as 1.5 times the AISC weld material allowable per Reference [13].

Integral Welded Attachment Evaluation

The localized stresses developed in the pipe due to the integral welded attachments (shear lugs) are added to the stresses calculated by AutoPIPE and compared to B31.1 allowables. ASME Code Case N-318-5 (Reference [19]) is used to calculate the local stresses since this is the latest version of the Code Case available.

Mounting Hardware

Hilti Kwik-Bolt IIIs are used to mount the support baseplates to the floor. The analysis and design of expansion anchors shall be in accordance with the Hilti Technical Guide (Reference [18]), however, a Factor of Safety of 4 against ultimate loads will be used. Prying factors are calculated in accordance with DG-C01 (Reference [10]). Qualifications of the stainless steel bolts/pins used to attach the saddle plates to the structural angles is based on the ASCE Standard (Reference [24]). The AISC Code (References [9]) does not provide specific bolting allowables for stainless steel bolting.

4.0 ASSUMPTIONS

None.

5.0 DEFINITIONS AND DESIGN INPUT

Define, $ksi \equiv 10^3 \cdot psi$ $kips \equiv 10^3 \cdot lbf$ $ORIGIN \equiv 1$ $psi \equiv 1 \cdot \frac{lbf}{in^2}$

5.1 Material Properties

The specific materials for the piping and support components are taken from Reference 6m

Piping:	Stainless Steel ASTM A312, Type 304 or Type 304L (Dual Certified)
Pipe Fittings	Stainless Steel ASTM A240, Type 304 or A774, Type 304L (Dual Certified)
Structural Steel:	Stainless Steel ASTM A276, Type 304
Flange:	Stainless Steel ASTM A-240, Type 304
Flange Bolting:	Stainless Steel ASME A-193, Gr. B8, Class II

Design Temperature $T_{des} = 250\ °F$ (Reference [1])

Properties for the pipe components and support structural components are taken from ASME/ANSI B31.1, Power Piping Code, 1998 Edition (Reference [5]). Yield strength values for support structural components and flange bolting properties are not available in ANSI B31.1 Code and are taken from ASME B&PV Code, Section II, Part D (Reference [4]). For Dual Certified materials only the controlling properties are used.

Yield strength value for stainless steel A240 Type 304 material at 250 °F:	$S_{Y304} := 23.6 \cdot ksi$	(Ref. [4])
Modulus of Elasticity of stainless steel material at 250 °F:	$E := 27300 \cdot ksi$	(Ref. [5])
Allowable pipe stress at design temperature (250 °F),	$S_h := 17.20 \cdot ksi$	(Ref. [5])
Allowable design stress for flange at design temperature (250 °F),	$S_f := 17.20 \cdot ksi$	(Ref. [5])
Allowable bolt stress at design temperature (250 °F),	$S_b := 25.0 \cdot ksi$	(Ref. [4])
Modulus of Elasticity (flange)	$E_f := 27300 \cdot ksi$	(Ref. [5])
Modulus of Elasticity (bolts)	$E_b := 27300 \cdot ksi$	(Ref. [4])

Other Miscellaneous Properties

Density of stainless steel (Ref. [28]). $\rho_{steel} := 501 \cdot \frac{lbf}{ft^3}$

Poisson's ratio of stainless steel (Ref. [28]). $\nu := 0.305$

Density of water at temperature of 68°F (Ref. [12]) $\gamma_{H20} := 62.4 \cdot \frac{lbf}{ft^3}$

5.2 Pipe Geometry and Dimensions

Pipe Dimensions

Outer diameter of pipe (Ref. [6b])	$OD_{pipe} := 16.0 \cdot in$
Pipe wall thickness (sch.10) (Ref. [6b])	$t_{pipe} := 0.25 \cdot in$
Inside diameter of pipe: $ID_{pipe} := OD_{pipe} - 2 \cdot t_{pipe}$	$ID_{pipe} = 15.50\ in$
Radius of pipe: $r := \frac{OD_{pipe}}{2}$	$r := 8.0 \cdot in$
Corrosion Allowance/Fabrication Tolerance	$t_{ca} := 0.0 \cdot in$

Pool Boundaries

Length from top of floor to centerline of pipe (Ref. [6a])	$c_f := 19.5 \cdot in$
Minimum height of the water above the floor (Ref. [6a])	$H_w := 38 \cdot in$
Distance (left side) from wall to pipe centerline (see Section 6.3.1)	$c_{wl} := 13.85 \cdot in$
Distance (right side) from wall to pipe centerline (see Section 6.3.1)	$c_{wr} := 24 \cdot in$

Flange Dimensions

Outer diameter of flange at top of elbow (Ref. [6f])	$OD_{flange} := 25.0 \cdot in$
Inside diameter of flange at top of elbow (Ref. [6f])	$ID_{flange} := 18.125 \cdot in$
Flange thickness (Ref. [6f])	$t_{flange} := 0.25 \cdot in$
Outer diameter of 16 pipe in-line flanges (Ref. [6b])	$OD_{flg\_16} := 23.5 \cdot in$
Inside diameter of 16 pipe in-line flanges (Ref. [6b])	$ID_{flg\_16} := 16.125 \cdot in$

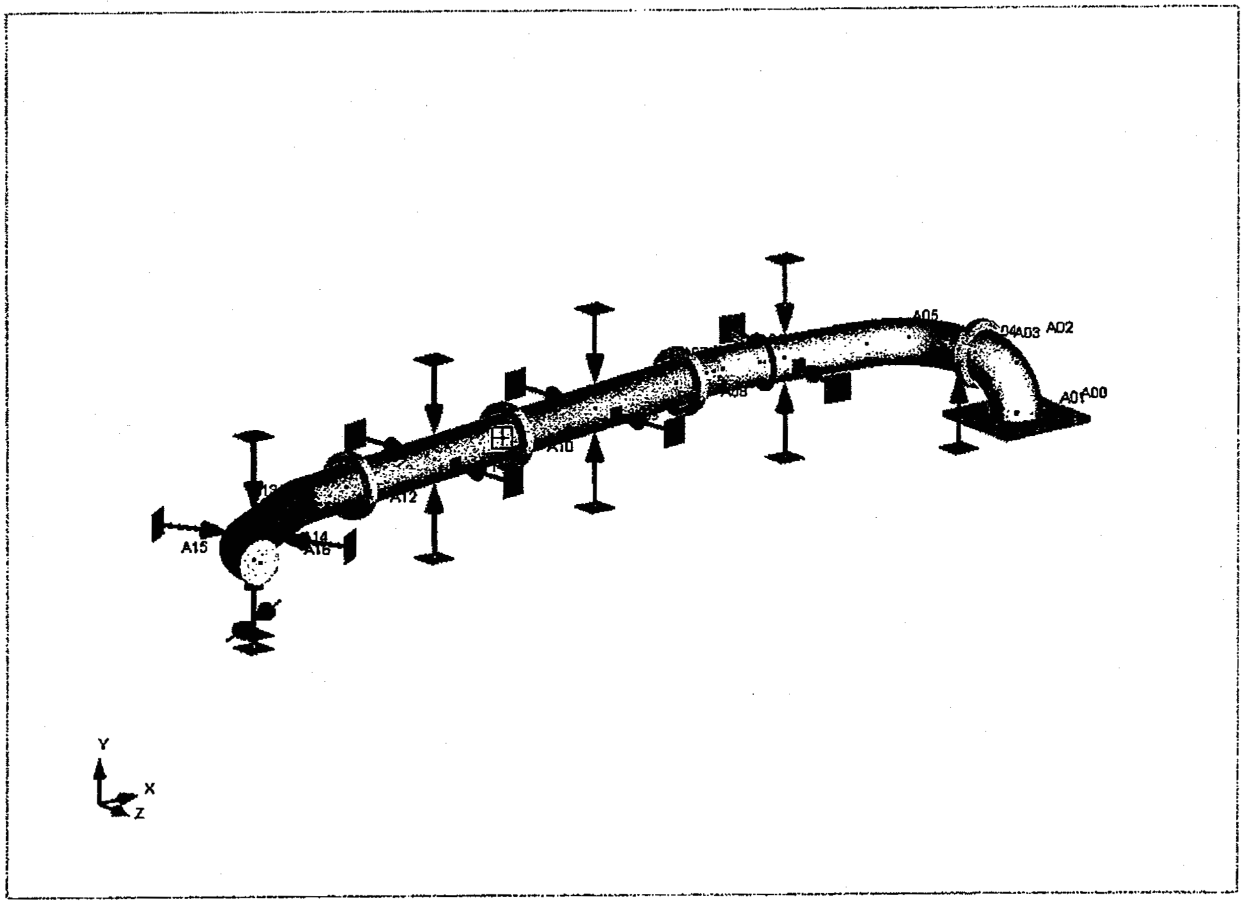
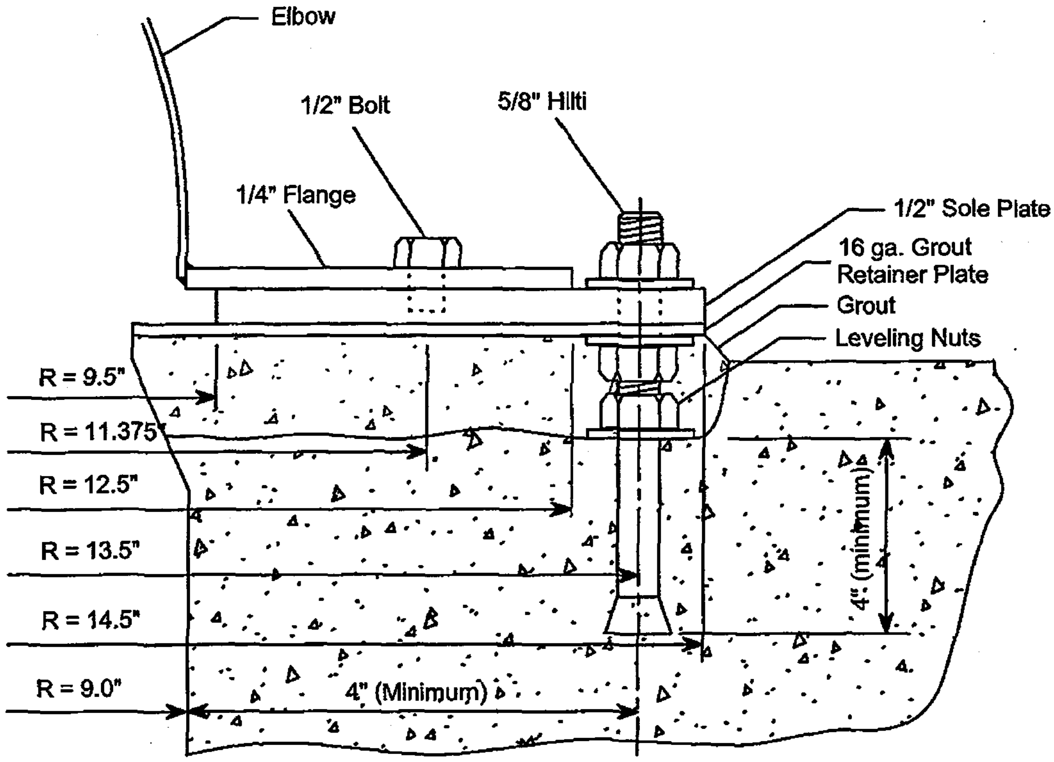


Figure 6.4.1 - Model Plot of "B" Strainer Pipe

Sole Plate Connection

As shown in figure below the connection consists of two parts. The fabricated pipe flange is identical to the flange on the opposite side of the elbow, the 1/2" annular sole plate is held down by twelve (12) 5/8" Hilti III expansion anchors (Reference [6c]).

Note that the 4" minimum distance to the edge of the sump drain concrete opening as shown in the sketch below has been reduced to a minimum of 3" in EC 10581 (Reference [35]). The centerline of the bottom end of the elbow and the associated base ring may be offset a maximum of 1" from the centerline of the sump drain pipe sleeve during installation to avoid interferences.



All three types of flanges (in-line, top of elbow, sole plate) will be analyzed concurrently using arrays. Loads for the in-line flanges will be divided into Normal/Upset and Emergency/Faulted loads, but enveloped between all flange pairs. Dimensional parameters are adjusted as required for each type of flange.

7.0 RESULTS AND CONCLUSIONS

A summary of the maximum calculated piping stresses is shown in Section 6.4. Calculated support component stresses are shown in Section 6.7. The interaction ratio for the pipe stresses, flanges, sole plate, and supports is shown below:

Pipe Stresses

B Strainer Pipe $IR_{Bpipe} := \max(IR_{B11}, IR_{B12B}, IR_{B12C}, IR_{B13})$ $IR_{Bpipe} = 0.09$

Stress Summary for other Components

Component	Ref. Section	Interaction Ratio	
Flanges			
Flange Bolting	6.5	$IR_{bolt1} = \begin{pmatrix} 0.68 \\ 0.61 \\ 0.68 \end{pmatrix}$	In-line Flanges Top of Elbow At Sole Plate
Flange Bending	6.5	$IR_{flange1} = \begin{pmatrix} 0.88 \\ 0.35 \\ 0.74 \end{pmatrix}$	
Flange Weld to Pipe	6.5	$IR_{w1} = 0.22$	
Missing Bolts			
Flange Bolts	6.5	$IR_{bolt.missing} = 0.77$	
Flange Bending	6.5	$IR_{flange.missing} = 0.78$	
Sole Plate Connection			
Sole Plate	6.6	$IR_{sole.plate} = \begin{pmatrix} 0.12 \\ 0.27 \end{pmatrix}$	Normal/Upset Emergency/Faulted
Sole Plate Expansion Anchors	6.6	$IR_{spl.anchor} = 0.80$	

Component	Ref. Section	Interaction Ratio
Type PS1/PS2 Restraint		
Angle Normal Stress	6.7	$IR_{ang\_norm} = \begin{pmatrix} 0.48 \\ 0.59 \end{pmatrix}$ Normal/Upset / Emergency/Faulted
Angle Shear Stress	6.7	$IR_{ang\_sh} = \begin{pmatrix} 0.07 \\ 0.08 \end{pmatrix}$
Expansion Anchors (Type PS1)	6.7	$IR_{bolt\_PS1} = 0.66$
Expansion Anchors (Type PS2)	6.7	$IR_{bolt\_PS2} = 0.78$
Baseplate	6.7	$IR_{bpl} = 0.63$
Weld of Angle to Baseplate	6.7	$IR_{weld} = \begin{pmatrix} 0.36 \\ 0.39 \end{pmatrix}$
Saddle Plate Bending	6.7	$IR_{spl\_bd} = \begin{pmatrix} 0.10 \\ 0.12 \end{pmatrix}$
Saddle Plate Shear	6.7	$IR_{spl\_sh} = \begin{pmatrix} 0.42 \\ 0.57 \end{pmatrix}$
Saddle Plate Welds	6.7	$IR_{wld\_spl} = \begin{pmatrix} 0.10 \\ 0.11 \end{pmatrix}$
Saddle Plate Pins	6.7	$IR_{pin} = \begin{pmatrix} 0.12 \\ 0.17 \end{pmatrix}$
Shear Lugs	6.7	$IR_{lugs} = \begin{pmatrix} 0.05 \\ 0.06 \end{pmatrix}$
Integral Welded Attachments	6.8.1	$IR_{PS2.iwa} = 0.13$

Automated Engineering Services Corp	CALCULATION SHEET	Page: 111 of 114
		Calc. No.: PCI-5344-S03
Client: Performance Contracting Inc.		Revision: 3
Station: Point Beach - Unit 1		Prepared By: [redacted]
Calc. Title: Evaluation of Sump Cover and Piping for the Containment Sump Strainers		Reviewed By: [redacted]
Safety Related Yes [X] No [ ]		Date: 12/27/07

Type PS3 Restraint

IR shown are for Faulted Loads (SSE) versus Upset Allowables (OBE)

W6x15 Normal Stress	6.7.2	$IR_{normW6} = 0.18$
W6x15 Shear Stress	6.7.2	$IR_{shearW6} = 0.05$
Expansion Anchors	6.7.2	$IR_{bolt\_PS3} = 0.42$
Baseplate	6.7.2	$IR_{bpl\_PS3} = 0.38$
Weld of W6x15 to Baseplate	6.7.2	$IR_{weld\_PS3} = 0.08$
Angle Normal Stress	6.7.2	$IR_{ang\_normPS3} = 0.76$
Angle Shear Stress	6.7.2	$IR_{ang\_shPS3} = 0.23$
Weld of Angle to W6x15	6.7.2	$IR_{weld\_ang3x2} = 0.45$
U-Bolt Normal Load	6.7.2	$IR_{Ubolt} = 0.21$

Type PB1 Restraint

Stanchion Plate Bolts	6.7.3	$IR_{bolt\_PB1} = 0.08$
Integral Welded Attachments	6.8.2	$IR_{PB1.iwa} = 0.11$

Other Piping Components

Slip Joint	6.9	$IR_{band} = \begin{pmatrix} 0.59 \\ 0.50 \end{pmatrix}$	Upset Emerg

The evaluation of the piping and piping supports associated with the suction strainers has shown that the pipe stresses and support loads are acceptable. The piping stresses, flanges, and support component stresses are within their respective applicable limits and are therefore acceptable.

8.0 REFERENCES

[1] Point Beach Nuclear Plant Specification PB-681, "Replacement of Containment Sump Screens", Revision 2

[2] Point Beach Nuclear Plant Seismic Qualification Specification Sheet SQ #002243, Revision 0

[3] *ASME/ANSI B31.1, Pressure Piping Code, 2001 Edition.*

[4] ASME B&PV Code, Section II, Part D, Material Properties, 1998 Edition, through 1999 Addenda

[5] ASME/ANSI B31.1 Pressure Piping Code, 1998 Edition, through 1999 Addenda

[6] Performance Contracting, *Inc.(PCI), Sure-Flow Suction Strainer* Drawings

- 6a. PCI Drawing No. SFS-PB1-GA-00, "PB Unit 1 Sure-Flow Strainer, Recirc Sump System", Revision 6
- 6b. PCI Drawing No. SFS-PB1-GA-04, "PB Unit 1 Sure-Flow Strainer, Piping B Layout", Revision 5
- 6c. PCI Drawing No. SFS-PB1-GA-05, "PB Unit 1 Sure-Flow Strainer, Piping A Layout", Revision 9
- 6d. PCI Drawing No. SFS-PB1-PA-7105, "PB Unit 1 Sure-Flow Strainer, Sleeves/Covers/Supports/Pins", Revision 8.
- 6e. PCI Drawing No. SFS-PB1-PA-7160, "PB Unit 1 *Sure-Flow Strainer, Sump Inlet Cover*", Revision 1.
- 6f. PCI Drawing No. SFS-PB1-PA-7161, "PB Unit 1 Sure-Flow Strainer, Sump Connection Elbow A1/B1", Revision 0.
- 6g. PCI Drawing No. SFS-PB1-PA-7162, "PB Unit 1 Sure-Flow Strainer, Pipe B2", Revision 2.
- 6h. PCI Drawing No. SFS-PB1-PA-7163, "PB Unit 1 Sure-Flow Strainer, Pipe B3", Revision 1.
- 6i. PCI Drawing No. SFS-PB1-PA-7164, "PB Unit 1 Sure-Flow Strainer, Pipe B4", Revision 1.
- 6j. PCI Drawing No. SFS-PB1-PA-7165, "PB Unit 1 Sure-Flow Strainer, Pipe B5", Revision 3.
- 6k. PCI Drawing No. SFS-PB1-PA-7166, "PB Unit 1 Sure-Flow Strainer, Pipe A2", Revision 2.
- 6l. PCI Drawing No. SFS-PB1-PA-7167, "PB Unit 1 Sure-Flow Strainer, Pipe A3", Revision 2.
- 6m. PCI Drawing No. SFS-PB1-GA-01, "PB Unit 1 Sure-Flow Strainer, General Notes", Revision 9

[7] "Formulas for Natural Frequency and Mode Shape," by Robert D. Blevins,1979,Van Nostrand Reinhold.

[8] ASME B&PV Code, Section III, Division 1, Subsections NB, NC, and NF, 1998 Edition through 1999 Addenda, including Appendices.

[9] AISC Manual of Steel Construction, 9th Edition.

[10] Wisconsin Electric Guideline DG-C01,"Guidelines for Design, Qualification, and Installation of Concrete Expansion Anchors at Point Beach Nuclear Plant" (with revisions per NPM 92-0428, April 27, 1992), Revision 0

[11] Wisconsin Electric Guideline DG-M09, Design Requirements for Piping Stress Analysis, Revision 2.

[12] "Engineering Fluid Mechanics" by John A. Roberson and Clayton T. Crowe, 2nd Edition, Rudolf Steiner Press, 1969, Library of Congress Catalog Number 79-87855.

[13] Wisconsin Electric Guideline DG-M10, Pipe Support Guidelines, Revision 2.

[14] Wisconsin Electric Guideline DG-C03, Seismic Design Criteria Guideline, Revision 0.

[15] AES Calculation PCI-5344-S01, "Structural Evaluation of Containment Emergency Sump Strainers", Revision 0.

[16] AutoPipe Version 8.05 QA Release 08.05.00.16 Verification Report, AES File AES.1000.0513.

[17] Welding Formulas and Tables for Structural & Mechanical Engineers & Pipe Support Designers Published by I.V.I. Structural Design Service, Copyright 1983.

[18] Hilti Product Technical Guide, Copyright 2005.

[19] Cases of ASME Boiler and Pressure Vessel Code, Case N-318-5, "Procedure for Evaluation of the Design of Rectangular Cross Section Attachments on Class 2 or 3 Piping", April 28, 1994.

[20] AES Calculation PCI-5343-S03, "Prairie Island Strainer Sloshing Evaluation", Revision 0.

[21] Roark's Formulas for Stress and Strain, Warren C. Young, 6th Edition.

[22] "Design of Welded Structures" by Omer W. Blodgett, 1969, Library of Congress Catalog Number 66-23123.

[23] Mechanical Engineering Design by Joseph Edward Shigley and Larry D. Mitchell, McGraw Hill, 1983.

[24] ASCE Standard SEI/ASCE 8-02, "Specification for the Design of Cold-Formed Stainless Steel Structural Members", Copyright 2002.

[25] ANSI/AISC N690, "Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities" Copyright 1994.

[26] ANSI/AWS D1.6:1999, "Structural Welding Code - Stainless Steel".

[27] Bechtel Drawing No. C-128, Containment Structure Interior Plans at El. 10'-0", EL. 21'-0", EL. 24'-8", and EL. 38'-0", Rev. 9. (Unit 1)

[28] "Marks' Standard Handbook for Mechanical Engineers", Avallone & Baumeister, 9th Edition, McGraw-Hill

[29] Good Bolting Practice, Volume 1, EPRI Report NP-5067

[30] Rigid Frame Formulas, A. Kleinlogel, 2nd Edition, Frederick Ungar Book Publishing

[31] PBNP Design Information Transmittal (DIT) for Modification MR 05-017 , Point Beach Unit 1 Sump Strainer New Base Plate Design, from T. Corbin (NMC) to C. Warchol (AES) and J. Bleigh (PCI), dated 01-12-07

[32] AISI Specification for the Design of Cold-Formed Steel Structural Members, 1996 Edition.

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[34] Engineering Change Notice 10580 to Modification EC 1602 (MR 05-017), Revision 0, Dated 4/7/07

[35] Engineering Change Notice 10581 to Modification EC 1602 (MR 05-017), Revision 0, Dated 4/11/07

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[37] Design Information Transmittal for Point Beach EC 10720, "Thermal Expansion Gap Requirements, Dated 4/27/07

[38] ACI Structural Journal, January-February 1995, VOL. 92 NO. 1
(Included as Attachment J to Calculation PCI-5344-S01)

ENCLOSURE 6

FPL ENERGY POINT BEACH, LLC

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02 "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

STRUCTURAL EVALUATIONS OF SUMP COVER AND PIPING FOR SUMP STRAINERS, UNIT 2 (ABRIDGED)

19 Pages Follow

Automated Engineering Services Corp.	**Calculation Package**	Page 1	of 82

Calculation Number:	PCI-5344-S02
Calculation Title:	Evaluation of Sump Cover and Piping for the Containment Sump Strainers
Client: Performance Contracting, Inc. (PCI)	**Station:** Point Beach
Project Number: PCI-5344	**Unit(s):** 2
Project Title:	Point Beach Strainer Engineering

Safety Related Yes ☒ No ☐

Revision	Affected Pages	Revision Description	Approval Signature / Date	Signature / Initials of Preparers & Reviewers
0	All	Initial Issue	[redacted] 03/04/06	[redacted]
1	5, 6, 9, 26, 34, 41-43, 65-68, 75, 78, 81-83	Incorporated miscellaneous comments. Included section for missing bolt evaluation. Revised baseplate and anchor bolts evaluation to address distance to edge of concrete for Type PS2 support.	[redacted] 04/26/06	[redacted]
2	1-4, 7, 11, 14, 27-31, 36-45, 52-53, 62-66, 68-74, 77-79, 81-87, 89 Attachment A Attachment C	Incorporated pressure thrust load on piping due to strainer pressure imbalance. Updated drawing revisions. Minor other editorial changes. Renumbered all pages from p. 14 forward. This revision resolves AES CAR 06-006	[redacted] 10/11/06	[redacted]
3	1-3, 6-7, 10, 14, 24, 26-33, 35-46, 53-64, 66-71, 74-78, 81 Attachment A Attachment B Attachment C Attachment D	Revised to incorporate field changes required for installation as per PBNP DIT for Modification MR 05-018 dated 11-03-06. Revised sole plate design to bolt directly to floor, changed 3-way supports to 2-way supports, evaluated uplift load on sole plate from valve testing, and incorporated various other ECNs.	[redacted] 11/03/06	[redacted]
4	1-4, 35, 42-43, 55, 60-61, 78, 82	Incorporated EC 9409 and the application of lubricants during flange bolt-ups.	[redacted] 11/10/06	[redacted]

Revision	Affected Pages	Revision Description	Approval Signature / Date	Signature / Initials of Preparers & Reviewers
5	1-3, 66-68, 75, 79 Added 1A	Changed faulted shear stress allowable to agree with DG-M10 and the effective shear stress area for angle and tee sections to agree with paragraph C3 (p. 5-315) of AISC 9th Edition Commentary on the Specification for Allowable Stress of Single-Angle Members. This resolves CAR-07-004.	[redacted] 12/26/2007	**Prepared by:** [redacted] **Reviewed by:** [redacted]

TABLE OF CONTENTS

Attachments

1.0 PURPOSE/OBJECTIVE

The purpose of this calculation is to qualify the sump cover, piping, and piping supports associated with the Performance Contracting Inc. (PCI) Suction Strainers to be installed in Nuclear Management Corporation's Point Beach Nuclear Plant Unit 2. This calculation evaluates, by analysis, the piping as well as the supporting structures associated with the new piping. *The evaluations encompass all piping from and* including the sump cover plate (sole plate) attached to the El. 8' floor slab to the strainer connections including intermediate support structures.

2.0 METHODOLOGY

The evaluations are performed using a combination of manual calculations and computerized piping using the AutoPIPE Program (Reference [16]). The piping is considered as an attachment or extension to the strainers and are therefore subject to the requirements of Strainer Design Specification PB-681(Reference [1]). Exceptions from these requirements, if taken, are discussed and justified within this calculation.

Seismic Loads

The strainer piping is categorized as Seismic Class I equipment and is required to be operable during and after a safe shutdown earthquake (SSE) without exceeding normal allowable stresses as specified in *Section 5.4.7 of DG-C03 Seismic Design Criteria* Guideline (Reference [14]). Strainer Design Specification PB-681 (Reference [1]), requires the piping to be evaluated for two operating conditions. The first condition is a "dry" condition with no recirculation water inside or external water present. The second condition is a submerged "wet" condition with recirculation water. For the *seismic evaluation the piping will be* considered submerged and full of water. The water level is considered to be a minimum of 3'- 2" above the 8' floor elevation (El. 11'- 2"). The piping "dry" state with its associated mass being much less, will not be considered as it is less severe than the "wet" state.

Per the *specification*, the seismic evaluation is required to take into account any seismic slosh (analyzed at the seismic worst-case water level) of the recirculation water. Based on Reference [20], because of the negligible load magnitudes, it is determined that the seismic slosh loads in PWR containments are insignificant by comparison with other seismic loads. Therefore, seismic slosh loads are neglected from the pipe stress analysis. Note that the sloshing calculation of Reference [20] is done for the Prairie Island strainer project and it is representative for all PWR containments in general, and therefore, it is applicable for use in this calculation. The "wet" strainer operating condition will consider the strainer assemblies submerged in still water at the seismic worst-case water level when subjected to seismic inertial loads. The inertial effects of the added hydrodynamic mass due to the submergence of the piping is considered.

The piping is seismically qualified using the response spectra method. The applicable seismic spectra are provided in Seismic Qualification Specification Sheet SQ-002243 (Reference [2]) These loads are applied to the piping through base motion response spectra as detailed in the Seismic Design Criteria Guideline *DC-C03 (Reference [14]).*

All piping is located on the 8' floor elevation of the containment. The response spectrum chosen is for the 6.5' elevation of the containment. The containment liner plate is located at the 6.5' elevation and there is an additional 1.5' of concrete on top of the liner plate. The slab between the 6.5' elevation and the 8' elevation is very rigid. Thus it is appropriate to use the response spectrum for the 6.5' elevation. The vertical direction response spectrum is 2/3 the value of the maximum ground horizontal response spectra.

The piping is considered as vital piping and the damping values for seismic loads is taken as 0.5% for both the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE) as required by Seismic Design Guide DG-C03. The response spectra inputs are for the OBE environment. For evaluating stresses, displacements, loads, etc., for the maximum credible earthquake (SSE), the values obtained from the OBE analysis are to be increased by a factor of 2.0 (Reference [11]).

The piping is excited in each of the three mutually perpendicular directions, two horizontal and one vertical. Per Reference [11], the modal combination is performed by the use of the double sum method to account for the effects of modal coupling in the response (i.e. closely spaced modes). An earthquake duration of 30.24 seconds was used in the analysis per DG-C03, Appendix C. Appendix N of the ASME code indicates that the maximum accelerations generally occur in the first 10 seconds. Two analysis were run - one with 10 sec and one with 30.24 sec. Since the results were the same, the analysis with 30.24 seconds is the official documented seismic analysis. Responses due to the three spatial components are combined by SRSS. (Reference [11], paragraph 5.6.5). The cutoff frequency is taken at 30 hz or a minimum of 5 modes are included.

Zero Period Acceleration (ZPA) residual mass effects are considered since they may significantly affect the piping. The ZPA response is combined with the response spectra response by SRSS.

Since all piping is supported from the same El. 8' floor slab, there are no relative seismic anchor movements.

Operating Loads

Operating loads are comprised of weight, thermal expansion and pressure loads.

Since the piping is open-ended, the maximum differential pressure load acting on the piping is the hydrostatic pressure associated with the maximum allowed head loss through the debris covered strainers. This is defined as 38 inches of 212 °F water in Section 4.0 of Design Specification PB- 681 (Reference [1]).

The thermal expansion is taken at a temperature equal to the maximum operational inlet temperature to the RH Exchangers of 250 °F (Reference [1]). Small gaps are modeled for certain supports in the thermal analysis to account for the gaps in the pipe supports. A 1/16" gap is modeled on top of the pipe for all supports. The gaps are included to minimize unrealistic thermal loads on the sump cover plate. The design drawings ensure that these gaps will be available. Because the attached piping is connected to the strainer with flexible joint it essentially behaves as an open ended system, this pressure differential will also create an axial thrust force on the piping.

Software

MathCad software is used to generate most of the calculations. All MathCad calculations are independently verified for accuracy and correctness as if they were manually generated. AutoPIPE Version 8.50 is used for the piping analysis. AutoPIPE Version 8.50 is verified and validated under the AES QA program as documented in the AES validation and maintenance files (Reference [16]). Because the AutoPIPE Version 8.50 only performs piping evaluations using the 2001 Edition of the B31.1 Code instead of the required 1998 Edition, a reconciliation of the 2001 Code to the older 1998 Code is performed.

The only provisions of the code that could potentially affect the results of the piping analysis are changes in material properties and design equation provisions. A review of the codes and the material specifications shows that the only physical properties of material that affect the design of code items are the minimum yield, the tensile strengths and the coefficient of thermal expansion because these are the basis for the allowable stresses and the tabulated "E" and "α" values at temperature. As long as the specified tensile properties of the material have not changed, use of the later Edition does not affect the end result.

The material allowables stresses are included manually into AutoPIPE based on the ASME B31.1 - 1998 Edition, which is the design code for pipe stress analysis. In addition, a review of the two the codes was performed to identify revisions to the design equation provisions and to determine if any material properties associated with "E" and "α" had changed. There have been no design dependent revisions to the piping material and to the design code equations. The flexibility and stress intensification factors, and the method for combining moments are the same for both code editions. Therefore, the results between the two code editions will be identical.

3.0 ACCEPTANCE CRITERIA

The strainer suction piping shall meet the requirements of the strainer design specification PB-681 (Reference [1]). As stated in PB-681, the detailed evaluations are to be performed using the rules, as applicable, of *ANSI/ASME B31.1 Power Piping 1998 Edition (Reference [5])*.

The piping supports, baseplates and other mounting hardware is evaluated to AISC 9th Edition as permitted in paragraph 120.2.4 of the B31.1 Code. Additional guidance is also taken from other codes and standards where the AISC does not provide specific rules for certain aspects of the design. For instance, the cover plates, stiffeners angles, support components are made from stainless steel materials. The AISC Code does not specifically cover stainless steel materials. Therefore, ANSI/AISC N690-1994, "Specification for the Design, Fabrication, and Erection of Steel Safety Related Structures for Nuclear Facilities", Reference [25] is used to supplement the AISC in any areas related specifically to the structural qualification of stainless steel. Note that only the allowable stresses are used from this Code and load combinations and allowable stress factors for higher service level loads are not used.

SEI/ASCE 8-02, "Specification for the Design of Cold-Formed Stainless Steel Structural Members", (Reference [24]) is used for certain components (stainless steel bolts and pins) since the AISC does not provide specific bolting allowables for stainless steel bolting. The rules for Allowable Stress Design (ASD) as specified in Appendix D of this code are used. Finally guidance is also taken from AWS D1.6, "Structural Welding Code - Stainless Steel", (Reference [26]) as it relates to the qualification of stainless steel welds. Detailed acceptance criteria for each type of strainer component is provided in the sections below.

Load Combinations

The applicable load combinations for the piping are those from Section 6.0 of DG-M09 (Reference [11]).

Load Condition	Combination
(1) Normal	P + DW
(2) Upset	P + DW + OBE
(3) Emergency/Faulted	P + DW + SSE
(4) Thermal	T1

where,

DW = Dead Weight Load

P = Differential Pressure

OBE = Operating Basis Earthquake

SSE = Safe Shutdown Earthquake

T1 = Thermal Expansion

The thermal expansion stresses are based on a stress range from the ambient condition of 70 °F to the maximum operating condition of 250 °F (ΔT = 180 °F).

Piping

The piping is evaluated in accordance with ANSI B31.1 Paragraph 104.8 as applicable. Since the B31.1 does not explicitly identify how to incorporate the emergency SSE loads, PBNP uses ASME Section III as a guide as discussed in Section 6.0 of DG-M09 (Reference [11]).

B31.1 Eq. No	Load Condition	Stress Combination	Allowable Stress
11	Normal (Sustained)	P + DW	1.0 S_h
12 (OBE)	Upset (Occasional)	P + DW + OBE	1.2 S_h
12 (SSE)	Emergency (Occasional)	P + DW + SSE	1.8 S_h
13	Thermal (Displacement)	T1	1.0 S_A

Flanges

Since specific detailed guidance is not provided in B31.1, the bolted flange connections at each end of the piping elbows will be evaluated in accordance with ASME Section III, Appendix L (Reference [8]) guidelines. The flange bolts are qualified to the criteria presented in ASME III, Appendix L (Reference [8]). Note that these are non-standard flanges which do not meet the generic requirements of B31.1 (such as weld size). As stated in the forward of of the B31.1 Code (Reference [5]), "a designer who is capable of a more rigorous analysis than is specified in the Code may justify a less conservative design, and still satisfy the basic intent of the Code." Use of a detailed stress evaluation of the flange and the flange weld, based on ASME analysis equations, certainly falls within this category of satisfying the basic intent of the Code.

Piping Support Structural Components

The allowable stresses on the piping support components are based on the AISC 9th Edition (Reference [9]). Also, the allowables stresses for the sump sole plate tabs, bolts, and welds are based on the AISC 9th Edition. The allowable stress for the SSE Load Combinations is taken from Section 6.9 of DG M10 (Reference [13]).

Load Condition	Load Combination	Allowable Stress
Normal	DW + T1	1.0 AISC
Upset	DW + OBE + T1	1.0 AISC
Faulted	DW + SSE + T1	1.5 AISC but not to exceed 0.9 S_y

Compression

Per Reference [25], because stainless steel does not display a single, well defined modulus of elasticity, the allowable compression stress equations from the AISC are not applicable for stainless steels. Therefore, the allowable compression stress will be based on the lower allowables from Reference [25] as opposed to those provided in the AISC Code (Reference [9]). Per Q1.5.9.2 of Reference [25], the allowable stresses for tension, shear, bending and bearing for stainless steel can be taken as the same allowables provided for carbon steel, therefore the AISC 9th Edition will be used for allowables for these types of stresses.

Welded Joints

Allowable stresses for piping welds, such as the flange fillet welds, are per ASME Section III (Reference [8]), Paragraph NC-3356. IWA welds are in accordance with ASME Code Case N-318-5 (Reference [19]). The allowable stresses for all other welds are based on the AISC 9th Edition (Reference [9]). AWS D1.6 (Reference [26]) was reviewed to ensure that any special qualification requirements associated with stainless steel welding were considered. Since the weld allowables provided in AWS D1.6 are essentially the same as allowed for carbon steel welds under AWS D1.1, no special adjustments are required to account for stainless steel. The allowable stress for the SSE Load Combinations is taken as 1.5 times the AISC weld material allowable per Reference [13].

Mounting Hardware

Hilti Kwik-Bolt IIIs are used to mount the support baseplates to the floor. The analysis and design of expansion anchors shall be in accordance with the Hilti Technical Guide (Reference [18]), however, a Factor of Safety of 4 against ultimate loads will be used. Prying factors are calculated in accordance with DG-C01 (Reference [10]). Qualifications of the stainless steel bolts/pins used to attach the saddle plates to the structural angles is based on the ASCE Standard (Reference [24]). The AISC Code (References [9]) does not provide specific bolting allowables for stainless steel bolting.

4.0 <u>ASSUMPTIONS</u>

None.

5.0 DEFINITIONS AND DESIGN INPUT

Define, $ksi \equiv 10^3 \cdot psi$ $kips \equiv 10^3 \cdot lbf$ $ORIGIN \equiv 1$ $psi \equiv 1 \cdot \frac{lbf}{in^2}$

5.1 Material Properties

The specific materials for the piping and support components are taken from Reference 6k

Piping:	Stainless Steel ASTM A312, Type 304 or Type 304L (Dual Certified)
Pipe Fittings	Stainless Steel ASTM A240, Type 304 or A774, Type 304L (Dual Certified)
Structural Steel:	Stainless Steel ASTM A276, Type 304
Flange:	Stainless Steel ASTM A-240, Type 304
Flange Bolting:	Stainless Steel ASME A-193, Gr. B8, Class II

Design Temperature $T_{des} = 250\ °F$ (Reference [1])

Properties for the pipe components and support structural components are taken from ASME/ANSI B31.1, Power Piping Code, 1998 Edition (Reference [5]). Yield strength values for support structural components and flange bolting properties are not available in ANSI B31.1 Code and are taken from ASME B&PV Code, Section II, Part D (Reference [4]). For Dual Certified materials only the controlling properties are used.

Yield strength value for stainless steel A240 Type 304 material at 250 °F:	$S_{Y304} := 23.6 \cdot ksi$	(Ref. [4])
Modulus of Elasticity of stainless steel material at 250 °F:	$E := 27300 \cdot ksi$	(Ref. [5])
Allowable pipe stress at design temperature (250 °F),	$S_h := 17.20 \cdot ksi$	(Ref. [5])
Allowable design stress for flange at design temperature (250 °F),	$S_f := 17.20 \cdot ksi$	(Ref. [5])
Allowable bolt stress at design temperature (250 °F),	$S_b := 25.0 \cdot ksi$	(Ref. [4])
Modulus of Elasticity (flange)	$E_f := 27300 \cdot ksi$	(Ref. [5])
Modulus of Elasticity (bolts)	$E_b := 27300 \cdot ksi$	(Ref. [4])

Other Miscellaneous Properties

Density of stainless steel (Ref. [29]).	$\rho_{steel} := 501 \cdot \frac{lbf}{ft^3}$
Poisson's ratio of stainless steel (Ref. [29]).	$\nu := 0.305$
Density of water at temperature of 68°F (Ref. [12])	$\gamma_{H20} := 62.4 \cdot \frac{lbf}{ft^3}$

5.2 Pipe Geometry and Dimensions

Pipe Dimensions

Outer diameter of pipe (Ref. [6b]) $OD_{pipe} := 16.0 \cdot in$

Pipe wall thickness (sch.10) (Ref. [6b]) $t_{pipe} := 0.25 \cdot in$

Inside diameter of pipe: $ID_{pipe} := OD_{pipe} - 2 \cdot t_{pipe}$ $ID_{pipe} = 15.50\,in$

Radius of pipe: $r := \frac{OD_{pipe}}{2}$ $r := 8.0 \cdot in$

Corrosion Allowance/Fabrication Tolerance $t_{ca} := 0.0 \cdot in$

Pool Boundaries

Length from top of floor to centerline of pipe (Ref. [6a]) $c_f := 19.5 \cdot in$

Minimum height of the water above the floor (Ref. [6a]) $H_w := 38 \cdot in$

Distance (left side) from wall to pipe centerline (Ref. [6a]) $c_{wl} := 14.8125 \cdot in$

Distance (right side) from wall to pipe centerline (Ref. [6a]) $c_{wr} := 45 \cdot in$

Flange Dimensions

Outer diameter of flange (Ref. [6f]) $OD_{flange} := 25.0 \cdot in$

Inside diameter of flange (Ref. [6f]) $ID_{flange} := 18.125 \cdot in$

Flange thickness (Ref. [6f]) $t_{flange} := 0.25 \cdot in$

Outer diameter of 16 pipe in-line flanges (Ref. [6f]) $OD_{flg\_16} := 23.5 \cdot in$

Inside diameter of 16 pipe in-line flanges (Ref. [6f]) $ID_{flg\_16} := 16.125 \cdot in$

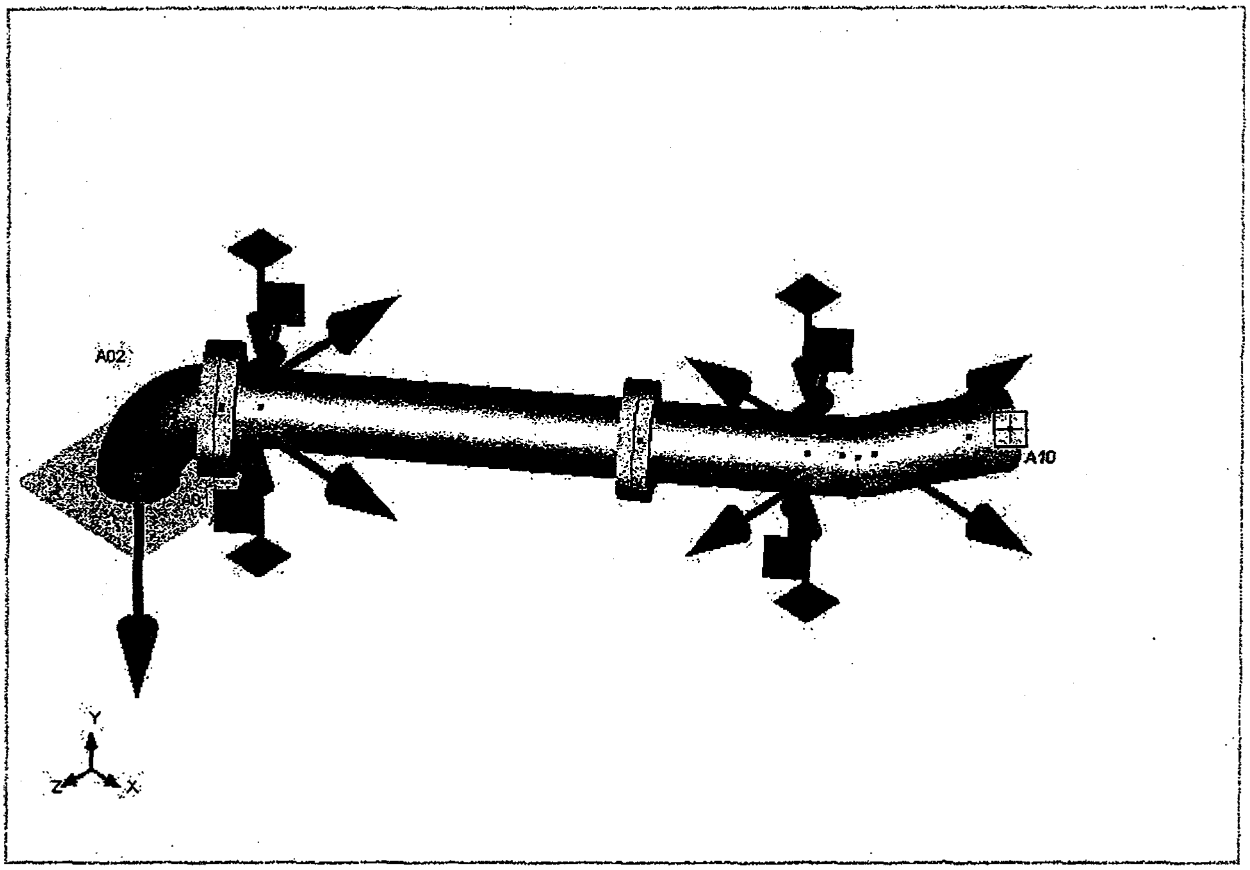


Figure 6.4.1 - Isometric of Strainer A Pipe

Load case U1 pressure load vectors are shown

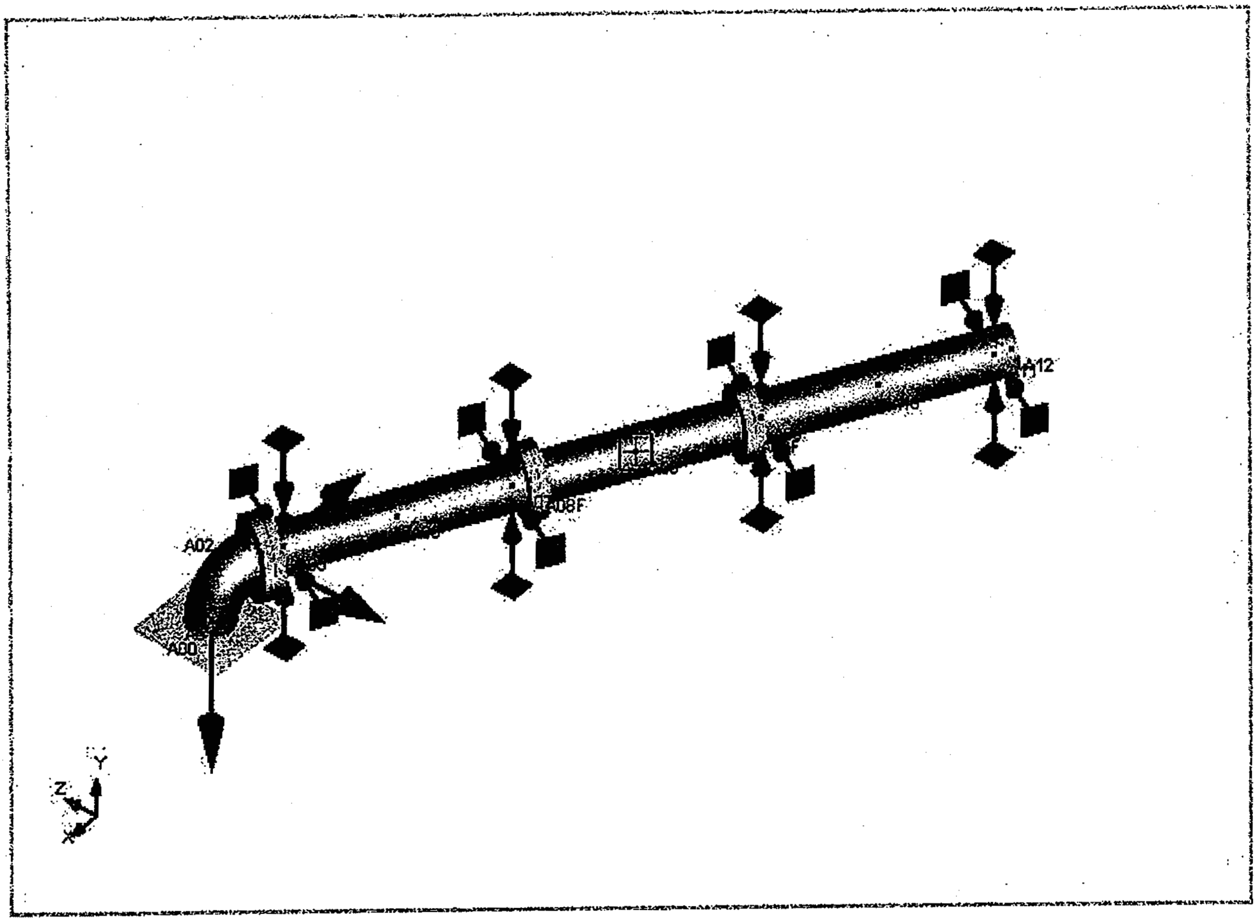
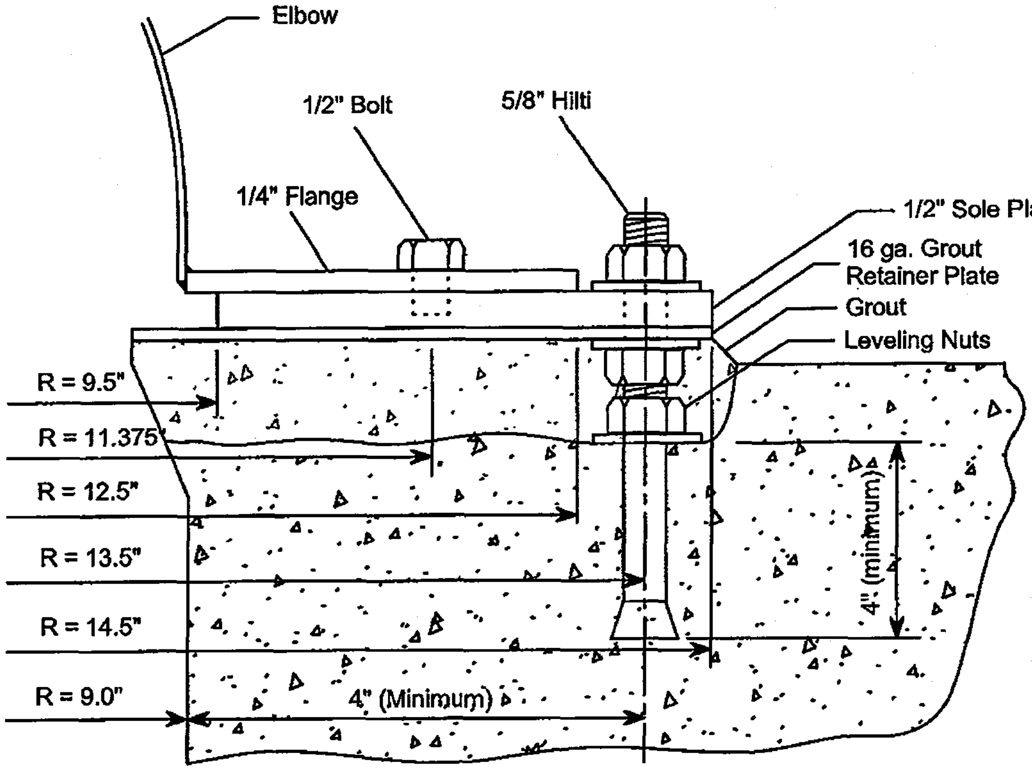


Figure 6.4.2 - Isometric of Strainer B Pipe

Load case U1 pressure load vectors are shown

Sole Plate Connection

As shown in figure below the connection consists of two parts. The fabricated pipe flange is identical to the flange on the opposite side of the elbow, the 1/2" annular sole plate is held down by twelve (12) 5/8" Hilti III expansion anchors (Reference [40]).



All three types of flanges, in-line, top of elbow and flange to sole plate, will be analyzed concurrently using arrays. Loads for the in-line flanges will be enveloped between all flange pairs. Likewise, the loads for the top of elbow, and sole plate will be enveloped between Strainer A & B. Dimensional parameters are adjusted as required for each type of flange.

7.0 RESULTS AND CONCLUSIONS

A summary of the maximum calculated piping stresses is shown in Section 6.4. Calculated support component stresses are shown in Section 6.7. The interaction ratio for the pipe stresses and supports is shown below:

Pipe Stresses

A Strainer Pipe $IR_{Apipe} := \max(IR_{A11}, IR_{A12B}, IR_{A12C}, IR_{A13})$ $IR_{Apipe} = 0.06$

B Strainer Pipe $IR_{Bpipe} := \max(IR_{B11}, IR_{B12B}, IR_{B12C}, IR_{B13})$ $IR_{Bpipe} = 0.06$

Stress Summary for other Components

Component	Ref. Section	Interaction Ratio	Load Case
Flanges			
Flange Bolting	6.5	$IR_{bolt1} = \begin{pmatrix} 0.66 \\ 0.61 \\ 0.73 \end{pmatrix}$	In-line Flanges Top of Elbow At Sole Plate
Flange Bending	6.5	$IR_{flange1} = \begin{pmatrix} 0.76 \\ 0.32 \\ 0.88 \end{pmatrix}$	
Flange Weld to Pipe	6.5	$IR_{w1} = \begin{pmatrix} 0.42 \\ 0.11 \\ 0.22 \end{pmatrix}$	
Missing Bolts			
Flange Bolts	6.5	$IR_{bolt.missing} = 0.87$	
Flange Bending	6.5	$IR_{flange.missing} = 0.94$	
Sole Plate Connection			
Sole Plate	6.6	$IR_{sole.plate} = \begin{pmatrix} 0.15 \\ 0.27 \end{pmatrix}$	Design Testing
Sole Plate Expansion Anchors	6.6	$IR_{spl.anchor} = 0.85$	Design Testing

Component	Ref. Section	Interaction Ratio	Load Case
Pipe Supports			
Angle Normal Stress	6.7	$IR_{ang\_norm} = \begin{pmatrix} 0.27 \\ 0.34 \end{pmatrix}$	Upset Emerg
Angle Shear Stress	6.7	$IR_{ang\_sh} = \begin{pmatrix} 0.03 \\ 0.03 \end{pmatrix}$	
Expansion Anchors	6.7	$IR_{bolt\_supp} = \begin{pmatrix} 0.46 \\ 0.72 \end{pmatrix}$	
Baseplate	6.7	$IR_{bpl} = \begin{pmatrix} 0.35 \\ 0.46 \end{pmatrix}$	
Weld of Angle to Baseplate	6.7	$IR_{weld} = \begin{pmatrix} 0.19 \\ 0.21 \end{pmatrix}$	
Saddle Plate Bending	6.7	$IR_{spl\_bd} = \begin{pmatrix} 0.08 \\ 0.09 \end{pmatrix}$	
Saddle Plate Shear	6.7	$IR_{spl\_sh} = \begin{pmatrix} 0.04 \\ 0.05 \end{pmatrix}$	
Saddle Plate Welds	6.7	$IR_{wld\_spl} = \begin{pmatrix} 0.21 \\ 0.23 \end{pmatrix}$	
Saddle Plate Pins	6.7	$IR_{pin} = \begin{pmatrix} 0.16 \\ 0.26 \end{pmatrix}$	

The evaluation of the piping and piping supports associated with the suction strainers has shown that the pipe stresses and support loads are acceptable. The piping stresses, flanges, and support component stresses are within their respective applicable limits and are therefore acceptable.

8.0 REFERENCES

[1] Point Beach Nuclear Plant Specification PB-681, "Replacement of Containment Sump Screens", Revision 1

[2] Point Beach Nuclear Plant Seismic Qualification Specification Sheet SQ #002243, Revision 0

[3] ASME/ANSI B31.1, Pressure Piping Code, 2001 Edition.

[4] ASME B&PV Code, Section II, Part D, Material Properties, 1998 Edition, through 1999 Addenda

[5] ASME/ANSI B31.1 Pressure Piping Code, 1998 Edition, through 1999 Addenda

[6] Performance Contracting, Inc.(PCI), Sure-Flow Suction Strainer Drawings

- 6a. PCI Drawing No. SFS-PB2-GA-00, "PB Unit 2 Sure-Flow Strainer, Recirc Sump System Layout", Revision 1.
- 6b. PCI Drawing No. SFS-PB2-GA-04, "PB Unit 2 Sure-Flow Strainer, Piping Assembly Layout", Revision 4.
- 6c. PCI Drawing No. SFS-PB2-PA-7105, "PB Unit 2 Sure-Flow Strainer, Sleeves/Covers/Supports/Pins", Revision 4.
- 6d. PCI Drawing No. SFS-PB2-PA-7160, "PB Unit 2 Sure-Flow Strainer, Sump Connection Elbow A1/B1", Revision 3.
- 6e. PCI Drawing No. SFS-PB2-PA-7161, "PB Unit 2 Sure-Flow Strainer, Strainer A2 Pipe", Revision 2.
- 6f. PCI Drawing No. SFS-PB2-PA-7162, "PB Unit 2 Sure-Flow Strainer, Strainer B2 Pipe", Revision 3.
- 6g. PCI Drawing No. SFS-PB2-PA-7163, "PB Unit 2 Sure-Flow Strainer, Sump Inlet Base Plate", Revision 2.
- 6h. PCI Drawing No. SFS-PB2-PA-7164, "PB Unit 2 Sure-Flow Strainer, Piping A3", Revision 3.
- 6i. PCI Drawing No. SFS-PB2-PA-7165, "PB Unit 2 Sure-Flow Strainer, Pipe B3", Revision 2.
- 6j. PCI Drawing No. SFS-PB2-PA-7166, "PB Unit 2 Sure-Flow Strainer, Pipe B4", Revision 2.
- 6k. PCI Drawing No. SFS-PB2-GA-01, "PB Unit 2 Sure-Flow Strainer, General Notes", Revision 6.

[7] "Formulas for Natural Frequency and Mode Shape," by Robert D. Blevins,1979,Van Nostrand Reinhold.

[8] ASME B&PV Code, Section III, Division 1, Subsections NB, NC, and NF, 1998 Edition through 1999 Addenda, including Appendices.

[9] *AISC Manual of Steel Construction, 9th Edition.*

[10] Wisconsin Electric Guideline DG-C01,"Guidelines for Design, Qualification, and Installation of Concrete Expansion Anchors at Point Beach Nuclear Plant" (with revisions per NPM 92-0428, April 27, 1992), Revision 0

[11] Wisconsin Electric Guideline DG-M09, Design Requirements for Piping Stress Analysis, Revision 2.

[12] "Engineering Fluid Mechanics" by John A. Roberson and Clayton T. Crowe, 2nd Edition, Rudolf Steiner Press, 1969, Library of Congress Catalog Number 79-87855.

[13] Wisconsin Electric Guideline DG-M10, Pipe Support Guidelines, Revision 2.

[14] Wisconsin Electric Guideline DG-C03, Seismic Design Criteria Guideline, Revision 0.

[15] AES Calculation PCI-5344-S01, "Structural Evaluation of Containment Emergency Sump Strainers", Revision 0.

[16] AutoPipe Version 8.50 QA Release 08.05.00.16 Verification Report, AES File AES.1000.0513.

[17] Welding Formulas and Tables for Structural & Mechanical Engineers & Pipe Support Designers Published by I.V.I. Structural Design Service, Copyright 1983.

[18] Hilti Product Technical Guide, Copyright 2005.

[19] Cases of ASME Boiler and Pressure Vessel Code, Case N-318-5, "Procedure for Evaluation of the Design of Rectangular Cross Section Attachments on Class 2 or 3 Piping", April 28, 1994.

[20] AES Calculation PCI-5343-S03, "Prairie Island Strainer Sloshing Evaluation", Revision 0.

[21] Roark's Formulas for Stress and Strain, Warren C. Young, 6th Edition.

[22] "Design of Welded Structures" by Omer W. Blodgett, 1969, Library of Congress Catalog Number 66-23123.

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[24] ASCE Standard SEI/ASCE 8-02, "Specification for the Design of Cold-Formed Stainless Steel Structural Members", Copyright 2002.

[25] ANSI/AISC N690, "Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities" Copyright 1994.

[26] ANSI/AWS D1.6:1999, "Structural Welding Code - Stainless Steel".

[27] Bechtel Drawing No. C-128, Containment Structure Interior Plans at El. 10'-0", EL. 21'-0", EL. 24'-8", and EL. 38'-0", Rev. 9. (Unit 1)

[28] Bechtel Drawing No. C-2128, Containment Structure Interior Plans at El. 10'-0", EL. 21'-0", EL. 24'-8", and EL. 38'-0", Rev. 8. (Unit 2)

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[33] PBNP Engineering Change Notice EC 9287, Rev. 0

[34] PBNP Engineering Change Notice EC 9324, Rev. 0

[35] PBNP Engineering Change Notice EC 9356, Rev. 0

[36] PBNP Design Information Transmittal (DIT) for Modification MR 05-018 , Point Beach Unit 2 Sump Strainer Revised Base Plate Design, from J. Fischer (NMC) to C. Warchol (AES) and J. Bleigh (PCI), dated 11-03-06

[37] Not Used

[38] PCI Design Change Notice DCN 6007-24, Dated 11/03/2006

[39] *PBNP Engineering Change Notice EC 9357, Rev. 0*

[40] PBNP Engineering Change Notice EC 9409, Rev. 0

ENCLOSURE 7

FPL ENERGY POINT BEACH, LLC

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02 "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

MATRIX LISTING OF RAI AND RESPONSE LOCATIONS

The following matrix provides a listing of the RAIs that apply to PBNP and where the responses are located. Since not all of the generic RAIs (1-29) applied to PBNP, there are gaps in the numbering sequence.

RAI #	Description	Response Location	
		Encl #	Item #
2	Itemized Listing of metals in pool, spray zones; compare with applicable ICET	9	2
3	Weight and Area of scaffolding stored in containment	9	3
4	Metallic paints or non-stainless insulation jacketing subjected to chemical immersion or spray	9	4
5	Sump pool pH at BOL and EOL	9	5
6	Compare & reconcile ICET conditions with post accident sump conditions	9	6
7	Time of initiation of sump recirculation for a LBLOCA. Include sump temperature and volume	9	7
8	Strategy for evaluating chemical effects	2	3.n
9	Plans for materials removal and/or chemical buffer changes	2	2
10	Reconcile bench-top chemical testing results with plant post-accident conditions	Deferred*	
11	Details of chemical effects testing	Deferred*	
12	Maximum projected head loss from chemical effects	Deferred*	
17	Assurance that credit for corrosion inhibition due to CalSil is conservative	2	3.n
25	Coatings assessments, and how coatings debris are calculated	2	3.h.6
30	Coatings debris characteristics	2	3.h.2, 5
31	Details of latent debris characterization	2	3.d
32	Downstream effects evaluation	2	3.m.1, 2
33	Active approaches considered	9	33
34	Conduct of walkdowns	2	2
35	Details of break selection	2	3.a
36	Explain difference in number of breaks evaluated between the two units	2	3.a
37	Destruction pressures and zones of influence	2	3.b
38	Debris characteristics	Deferred*	
39	Address alternative sump screen failure criteria described in 9/1/05 response	9	39
40	Near field effects	2	3.f.12
41	Vents or other penetrations on the strainer	2	3.f.11
42	Minimum strainer submergence	2	3.f.2
43	Describe computational fluid dynamics (CFD) usage	Deferred*	

*In accordance with Reference (8) the response to these items is deferred to the submittal addressing integrated head loss and chemical effects testing.

ENCLOSURE 8

FPL ENERGY POINT BEACH, LLC

POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02 "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS"

RESPONSES TO REQUESTS FOR ADDITIONAL INFORMATION (RAI)

NRC Request for Additional Information (RAI) 2.

Identify the amounts (i.e., surface area) of the following materials that are:

(a) submerged in the containment pool following a loss-of-coolant accident (LOCA),
(b) in the containment spray zone following a LOCA:

i. aluminum
ii. zinc (from galvanized steel and from inorganic zinc coatings)
iii. copper
iv. carbon steel not coated
v. uncoated concrete

Compare the amounts of these materials in the submerged and spray zones at your plant relative to the scaled amounts of these materials used in the Nuclear Regulatory Commission (NRC) nuclear industry jointly-sponsored Integrated Chemical Effects Tests (ICET) (e.g., 5x the amount of uncoated carbon steel assumed for the ICETs).

FPL Energy Point Beach Response

More recent developments in evaluating potential chemical effects have focused on aluminum as the dominant contributor. Point Beach Nuclear Plant (PBNP) is applying a higher degree of rigor in establishing parameters associated with aluminum inventories and is using more general approaches in estimating the quantities of other materials consistent with the current focus on aluminum.

Sump Volume

In the event of a LOCA, for consistent scaling to compare with the integrated chemical effects test (ICET) #4 results, the ratio of surface area to sump volume is used. The volume of the containment sump would be constant once the refueling water storage tank (RWST) is depleted. This occurs at 9% indicated RWST level. Omitting the volume that would be contributed by spilled reactor coolant system inventory and the two safety injection (SI) accumulators, and assuming that the injection started from the minimum allowable RWST level (95%), this volume is 243,810 gallons (32,595 ft^3).

Aluminum

Walkdowns were performed in both containments to validate aluminum inventories previously used for hydrogen generation analyses. These walkdowns evaluated whether the aluminum would be exposed to the containment spray solution or submerged in the sump. The results of the walkdown inspections were documented in engineering evaluations, and are summarized in the following table. The quantities in the table include a 10% contingency margin above that currently known to reside in the containments.

Unit 1	**Wt (lbs)**	**Area (in^2)**
Sprayed Aluminum	325	44,100
Submerged Aluminum	30	2,400
Unit 2		
Sprayed Aluminum	310	43,000
Submerged Aluminum	59	4,200
Bounding Composite		
Sprayed Aluminum	325	44,100
Submerged Aluminum	59	4,200

The following table converts the above data to common units and ratios, and compares them to ICET #4

	PBNP Bounding Composite (ft^2/ft^3)	**ICET #4 (ft^2/ft^3)**
Sprayed Aluminum	9.4E-3	3.3
Submerged Aluminum	8.9E-4	0.175

From these comparisons, it can be seen there are 2 to 3 orders of magnitude less metallic aluminum in the PBNP containments than was present in the ICET series of tests.

Zinc

There are areas of bare galvanized steel in the form of heating, ventilation and air conditioning (HVAC) ducting, conduits, stair treads, and structural supports located at or below the expected flood level in the containment sumps. The majority of the galvanized steel surface area in the sump consists of ductwork running through the access "keyway" to the under-vessel sump.

In addition to the zinc of the galvanizing, the ductwork also has a bare inorganic zinc (IOZ) coating on welds. The coating is not qualified for post-accident conditions and is used on galvanized ductwork throughout the containment building. It is periodically inspected as part of the coatings program.

The amount of bare IOZ coating in the keyway area is 270 ft^2 in each unit. The total amount of IOZ touch-up coating throughout Unit 1 containment is 3,299 ft^2. Unit 2, the total amount is 3,767 ft^2. Based on a ratio of 270:3299, about 8% of the IOZ touch-up on ductwork in the containments is within the keyway areas. Therefore, it may be assumed that 8% of the ductwork inside the containments are within the keyway areas. The total surface area of galvanized ductwork in each containment is 49,430 ft^2. Taking 8% of this amount, there is approximately 4000 ft^2 of galvanized ductwork in the keyway area of each containment. Assuming a similar amount of 4000 ft^2 of galvanized steel is also present on other miscellaneous conduits, stair treads, structural supports, and small equipment in the sump, it was determined that there could be as much as 8000 ft^2 of galvanized steel immersed in the containment sump following an accident.

The ratio of sump galvanized steel surface area to containment sump volume is
8,000 ft^2/32,595 f^3 = 0.245 ft^2/ft^3.

The ICET #4 test had a ratio of galvanized steel of 8.0 ft^2/ft^3, of which 5% (0.4 ft^2/ft^3) was submerged. The ratio of zinc surface area to sump volume in ICET #4 was nearly twice what has been conservatively estimated for the PBNP containments.

With 270 ft^2 of bare IOZ coating in the keyway area, and an estimated 200 ft^2 of degraded coatings that expose an IOZ primer, there is an estimated 470 ft^2 of submerged exposed IOZ coating in the sump. The ratio of sump IOZ surface area to containment sump volume, then, is (470 ft^2/32,595 ft^3) = 0.0144 ft^2/ft^3.

The ICET #4 test had a ratio of bare IOZ of 4.6 ft^2/ft^3, of which 4% (0.184 ft^2/ft^3) was submerged. The ratio of IOZ surface area to sump volume in ICET #4 was more than an order of magnitude greater than estimated for the PBNP containments.

For the evaluation of unsubmerged portions of zinc surfaces, it is conservatively assumed that none of the containment zinc inventory is submerged, and all of it is exposed to containment spray. The quantities of zinc above the containment sump and the resulting area-to-volume ratios are:

Source	Area (ft^2)	Sump Volume (ft^3)	Ratio (ft^2/ft^3)
Unit 1			
Top-coated unqualified IOZ primer	12,095	32,595	0.371
Bare IOZ coating	3,299	32,595	0.101
Galvanized Steel	125,441	32,595	3.85
Unit 2			
Top-coated unqualified IOZ primer	12,095	32,595	0.371
Bare IOZ coating	3,767	32,595	0.116
Galvanized Steel	127,755	32,595	3.92

For consistent scaling to compare with the ICET #4 results, the ratio of surface area to sump volume is used.

The ICET #4 test did not include top-coated IOZ since it is not directly exposed to spray. For the purposes of comparison of PBNP data against the ICET #4 test, it was assumed that the topcoated unqualified IOZ fails, and the IOZ layer is exposed to spray. Thus, for the purpose of comparison, the topcoated and untopcoated amounts of IOZ coating can be combined and considered altogether as bare IOZ. From the above table, this results in a ratio of (12,095 ft^2+3767 ft^2)/32,595 ft^3 = 0.487 ft^2/ft^3.

The ICET #4 test had a bare IOZ to sump ratio of 4.6 ft^2/ft^3, of which 96% (4.42 ft^2/ft^3) was not submerged. The ratio of zinc surface area to sump volume in ICET #4 for unsubmerged IOZ coating was an order of magnitude greater than what would be expected for the PBNP containments, without considering the assumption that 100% of the estimated IOZ surfaces are exposed to the spray solution.

The ICET #4 test had a ratio of galvanized steel of 8.0 ft^2/ft^3, of which 95% (7.6 ft^2/ft^3) was not submerged. The ratio of zinc surface area to sump volume in ICET #4 for unsubmerged galvanized steel was about twice that expected for the PBNP containments, without considering the assumption that 100% of the estimated galvanized steel surfaces are exposed to the spray solution.

Copper

The primary source of copper in the containment is the tubes and fins of the containment fan coil units. While the cooling coils are not exposed to direct spray impingement, the air / steam mix is drawn into these high volume units without benefit of demisting filters. Therefore, it is assumed that 100% of the copper is subjected to spray impingement. This assumption bounds other minor sources of copper such as the breathing air piping and manifolds located on the lower elevations of containment.

Each fan cooler unit contains 7076 square feet of copper, and there are four (4) fan coolers per containment. Therefore, the area to sump volume ratio for copper in the containments is 28,304 ft^2 / 32,595 ft^3 = 0.87 ft^2/ft^3.

The ICET #4 test had a copper surface area to liquid volume ratio 6.0 ft^2/ft^3, of which 75% was un-submerged (4.5 ft^2/ft^3). The ratio of copper surface area to sump volume in ICET #4 was more than 5 times that which can be expected for the PBNP containments. This includes an assumption that 100% of all the fan coil copper surfaces are wetted by the spray solution.

Uncoated Carbon Steel

The only carbon steel surfaces that are intentionally uncoated and potentially exposed to the containment spray solution are piping supports on high temperature piping. This includes the main steam piping, blow down piping, and feedwater piping. Piping supports for these lines may have areas that are uncoated and exposed to spray. Carbon steel coatings that are degraded as a result of coating failure or mechanical damage also contribute to the total surface area of uncoated carbon steel.

Carbon steel located below the surface of the sump pool would be containment liner plate steel; structural steel columns supporting the reactor coolant pumps (RCPs), steam generators, reactor vessel; and various miscellaneous supports in the areas outside of the reactor coolant loop compartments. The lower several feet of the liner plate and these supports could be submerged. The liner plate and these supports are coated with an acceptable coating system and unless located within the LOCA ZOI, would be expected to remain coated.

Only exposed carbon steel on or above the El. 66' refueling floor, inside the open topped steam generator, RCP, or the pressurizer cubicles, located on El. 21' in the reactor vessel head laydown area, or on or very near the liner plate would be exposed to containment spray. Exposed carbon steel in other locations would be shielded by substantial overhead structural floors.

The ICET #4 test had an uncoated carbon steel area to liquid volume ratio of 0.15 ft^2/ft^3. Of this, 34% (0.05 ft^2/ft^3)was submerged, and 66% (0.1 ft^2/ft^3) was unsubmerged. Multiplying these values by the PBNP sump volume of 32,595 cubic feet implies a submerged area of 1660 ft^2 and an unsubmerged area of 3,230 ft^2.

In the containments of both units, there is an estimated 300 ft^2 of uncoated carbon steel in the submersion zone, and 900 ft^2 of uncoated steel in the spray zone. These amounts are each a factor of about 3 to 5 less than what was used in the ICET #4 test. Therefore, the submerged ratio is 300 ft^2/32,595 ft^3 = 0.0092 ft^2/ft^3, and the unsubmerged ratio is 900 ft^2/32,595 ft^3 = 0.0276 ft^2/ft^3.

Uncoated Concrete

From the containment coatings walkdowns, an estimate of the total surface area of exposed concrete in the containment sump (i.e. submerged) can be made. The result is about 1500 ft^2 in Unit 1 containment, and 2400 ft^2 in Unit 2. The majority of these amounts are due to abraded concrete floor surfaces.

Only degraded areas of concrete coatings on or above the El. 66' refueling floor, or inside the steam generator, RCP, or pressurizer cubicles, or located on the El. 21' reactor vessel head laydown area would be expected to be subjected to exposure to containment spray. From the coatings inspection reports, the total area for these locations is about 1300 ft^2 in Unit 1 containment, and 3400 ft^2 in Unit 2. A significant portion of these amounts is on abraded concrete floor surfaces.

The ICET #4 test had an uncoated concrete area to liquid volume ratio of 0.045 ft^2/ft^3. Of this, 34% was submerged, and 66% was unsubmerged. Multiplying these values by the PBNP sump volume of 32,595 cubic feet implies a submerged area of 498 ft^2, and an unsubmerged area of 968 ft^2. The actual amounts of uncoated concrete in the PBNP containments as stated above are significantly greater than those used in the ICET #4 test. However, since this question was asked, no published papers or concerns have been identified that suggest exposed concrete to be a contributor to adverse effects during containment sump recirculation when the chemical buffer is NaOH.

Summary

Material	**Submerged**			**Unsubmerged**		
	ICET Ratio	**PBNP Ratio**	**ICET/PBNP**	**ICET Ratio**	**PBNP Ratio**	**ICET/PBNP**
Aluminum	0.175	8.9E-4	197	3.3	9.4E-3	351
IOZ Primed	0.184	0.0144	12.8	4.42	0.487	9.1
Galvanized	0.40	0.245	1.6	7.6	3.92	1.9
Copper	Assumed to all be sprayed			4.5	0.87	5.2
Carbon Steel	0.051	0.0092	5.5	0.099	0.0276	3.6
Concrete	0.0153	0.0736	0.21	0.0297	0.104	0.29

NRC Request for Additional Information (RAI) 3,

Identify the amount (surface area) and material (e.g., aluminum) for any scaffolding stored in containment. Indicate the amount, if any, that would be submerged in the containment pool following a LOCA. Clarify if scaffolding material was included in the response to Question 2.

FPL ENERGY POINT BEACH Response

Aluminum scaffolding components are not used in containment unless the reactor is in MODE 5 (Cold Shutdown), MODE 6 (Refueling) or Defueled. This is controlled by procedure.

Scaffolding components have not been stored in containment as a matter of past practice. The controlling procedure has been revised to preclude storage of scaffolding in the containment in the future.

Non-aluminum scaffolding may be erected or left in place inside of containment in MODES 1, 2, 3, and 4, but is subject to administrative controls to ensure that safety-related equipment is not jeopardized, and is subject to either the restrictions of 10 CFR 50.65 (Maintenance Rule), or a review for prior NRC approval under 10 CFR 50.59 if the intent is to leave the scaffolding in place for greater than 90 days.

Since scaffolding is not normally installed or stored inside of containment, the quantities of material cited in the response to Question 2 did not include scaffolding

NRC Request for Additional Information (RAI) 4,

Provide the type and amount of any metallic paints or non-stainless steel insulation jacketing (not included in the response to Question 2) that would be either submerged or subjected to containment spray.

FPL Energy Point Beach Response

PBNP has been unable to specifically identify the exact metallic coatings that may have been used in containment. While the purchase specifications of various pressure vessels such as the reactor vessel and pressurizer, specify that exterior surfaces be coated with a paint resistant to heat and a two percent boric acid solution, the identity of the coatings actually used could not be conclusively determined for the original components. Based on contemporary practices, it is believed that those coatings were aluminum pigmented, silicone based paints. It has been determined that the coating on the Unit 1 replacement steam generators is a black silicone modified paint and does not contain aluminum. Unit 2 steam generators are not coated. This leaves only the surfaces of the reactor vessel, which is substantially shielded from a LOCA by the surrounding primary shield wall, and the pressurizer, which is substantially shielded from a LOCA by its support skirt and the supporting floor slab, that may be minimally exposed to the scouring effects of a LOCA jet.

The minimal aluminum pigmented coatings that may be present in the containments were not included in the evaluation of chemical effects. If aluminum pigmented coatings were used, they would be encased in the binder. Since these binders are specifically formulated to withstand high temperatures, they are not subject to thermal decomposition. Therefore, the encased pigments would not be exposed to containment spray or sump fluids. This is consistent with the guidance of WCAP-16530-NP for organic mastics. Based on these considerations, the pigment in these coatings are not considered contributors to the aluminum inventory available for reaction.

Insulation jacketing used inside containment is stainless steel.

NRC Request for Additional Information (RAI) 5.

Provide the expected containment pool pH during the emergency core cooling system (ECCS) recirculation mission time following a LOCA at the beginning of the fuel cycle and at the end of the fuel cycle. Identify any key assumptions.

FPL Energy Point Beach Response

The calculated sump pH varies depending on the values of volumes and boric acid concentrations in the refueling water storage tank (RWST), reactor coolant system (RCS), and the safety injection (SI) accumulators. It also varies depending upon the volumetric flow rate and concentration of the chemical buffer additive (NaOH) to the containment spray (CS) system and the duration of spray chemical addition.

An analysis was performed using combinations of these inputs that would bound the maximum and minimum sump pHs. The analysis concluded that the sump pH at the end of chemical addition via the containment spray system (a minimum of ~70 minutes post-event) could range from 7.65 to 9.4 standard pH units. When the long-term potential effects of radiolysis of containment contents (including air, water, and chloride bearing electrical cable insulation and jacketing), core inventory spilled to the sump, and accumulations of dry boric acid due to a postulated pre-existing leak were included, the pH at the end of the mission time was predicted to be as much as 0.23 standard pH units lower. This could result in a final sump pH as low as 7.42 (7.65-0.23).

The analysis did not segregate beginning-of-life (BOL) and end-of-life (EOL) cases because core burnup is just one of several factors that can affect sump pH. However, the BOL case tends to minimize pH because the concentration of boric acid is high at BOL, while the EOL case tends to maximize pH because the concentration of boric acid is low at EOL. These cases are bounded by the range reported above.

Key Inputs / Assumptions:

1. Range of RCS volume:	5231 - 6389 ft^3
2. Range of RCS Boron Concentration:	0 - 2200 ppm
3. Range of SI Accumulator liquid volume:	1100 - 1136 ft^3 each
4. Range of SI Accumulator Boron concentration:	2600 - 3100 ppm
5. Range of RWST BA concentration:	2700 - 3200 ppm
6. Minimum RWST contribution to sump:	226,575 gal
7. Maximum RWST measurable volume:	37,901 ft^3
8. Range of Spray Add Tank NaOH concentration:	30 - 33%
9. Maximum NaOH addition rate:	20.2 gpm.

NRC Request for Additional Information (RAI) 6,

For the ICET environment that is the most similar to your plant conditions, compare the expected containment pool conditions to the ICET conditions for the following items: boron concentration, buffering agent concentration, and pH, identify any other significant differences between the ICET environment and the expected plant-specific environment.

FPL Energy Point Beach Response

The ICET #4 test is the most applicable for PBNP. It included both Calcium Silicate and fibrous insulation with a sodium hydroxide buffer.

Parameter of interest	ICET #4	Point Beach
B* (mg/L)	2800	2,376-3,067
[NaOH] (mole/L)	N/A*	0.036 - 0.124
pH	9.7-9.9	7.65 - 9.39
Temperature (deg F)	140	216 → Ambient**

*Erroneously tabulated as "H_3BO_3" in ICET report

**The concentration of sodium hydroxide was not reported for ICET #4. Rather, NaOH was titrated to obtain the desired pH of 10.

***These temperatures are representative of the start of sump recirculation through long-term cooldown. Please see the response to RAI 7 for a more detailed assessment of post-accident sump temperatures.

No significant environmental differences between ICET #4 and the expected PBNP sump conditions are expected.

NRC Request for Additional Information (RAI) 7.

For a large-break LOCA (LBLOCA), provide the time until ECCS external recirculation initiation and the associated pool temperature and pool volume. Provide estimated pool temperature and pool volume 24 hours after a LBLOCA. Identify the assumptions used for these estimates.

FPL Energy Point Beach Response

An evaluation of the containment spray duration established the time for three sets of conditions, two of which bound all Large Break LOCAs (LBLOCAs):

1. Single ECCS train failure (maximum time)
2. Full ECCS actuation (minimum time)

Single Train Failure (maximum time to recirculation)

Key Assumptions:

- Only a single train of ECCS actuates (1 HHSI, 1 RHR, 1 CS pump)
- All ECCS pump operating on degraded curve
- Maximum RWST level at start of injection
- Sump recirculation initiated upon reaching 34% RWST level (no delay for manual switchover)
- RCS and containment are at containment design pressure (74.7 psia)

This set of assumptions minimizes the injection flow rates, prolonging the time to reach sump recirculation criteria. As a result, the time to start of sump recirculation is ~57 minutes.

Full ECCS Actuation (minimum time to recirculation)

Key Assumptions:

- Injection pumps actuate and deliver flow without delay (2 HHSI, 2 RHR pumps)
- All ECCS pumps operating on enhanced curves (+3%)
- Minimum allowable RWST volume at start of injection
- One HHSI, and one RHR pump are manually secured (per procedure) at 60% indicated RWST level.
- Sump recirculation initiated upon reaching 34% RWST level (no delay for manual switchover)
- RCS and containment are at atmospheric pressure (14.7 psia)

This set of assumptions maximizes the injection flow rates, minimizing the time to reach sump recirculation criteria. As a result, the time to start of sump recirculation is ~27 minutes.

Pool Volume

In both cases, switchover to sump recirculation uses the same criterion of 34% indicated level remaining in the RWST. Since the assumed initial volume in the RWST is different, the pool volume would also vary at the start of sump recirculation.

Discounting any volume contributed by spilled RCS inventory and the safety injection accumulators (i.e. the only volume is due to transferred RWST inventory) the volume ranges from approximately 166,000 to 187,000 gallons.

By 24 hours post-event, the RWST would have been depleted to the point of securing the containment spray pumps. Water that may have potentially been "held up" in the form of suspended air droplets would have settled. The volume of water in the spray headers that are otherwise empty would have drained through the holes located low in these headers to keep them dry. Water condensing in the fan coolers would be drained to the containment sump via the installed drain piping. Minor volumes of "held up" water actively sheeting down containment structures and equipment would have completed draining to the sump. As described in Enclosure 1, Section 3.g of this response there are no significant potential water hold-up volumes in the containment.

The maximum sump pool volume at 24 hours post-event includes all water transferred from the RWST, the ruptured RCS and the SI Accumulators. The total volume, assuming that the pool had cooled to ambient conditions (60°F), would therefore be approximately 43,300 ft^3 (~324,000 gallons).

Pool Temperatures

A separate analysis provided containment pressure and temperature profiles, including a temperature profile for the containment sump. That analysis used the following significant inputs and assumptions:

- Initial containment temperature of 120°F
- Initial containment pressure of 15.0 psia
- RWST temperature of 100°F
- 1 containment spray pump starts after a 63-second delay
- Spray is secured at ~58 minutes post-event
- Only a single train of fan coolers operates
- Sump recirculation starts at ~38 minutes (consistent with only 1 train of ECCS)

This analysis differs from the one used to obtain sump volumes, but is conservative for the purposes of estimating the sump temperature. At 1,746 seconds (~29 minutes), the sump temperature was analyzed to be 215.2°F. At 12.5 hours post-event (4.5E+4 seconds), the analyzed sump temperature is 208°F. The analysis ends at this point, and with the temperatures trending down.

A plot of the sump temperature points shows that temperature peaks at ~10 hours, and slowly decreases thereafter. A linear extrapolation of the temperature trend to 24 hours projects a temperature of ~206°F. Since the curve is concave downward, it is expected that this estimate is a conservative upper bounding temperature.

A review of the license bases temperature profiles for the other three domestic two-loop PWRs (Kewaunee, Ginna, and Prairie Island) found the sump temperatures at 24 hours to be between ~140°F and ~190°F. This confirms that the estimate of 206°F for PBNP sumps at 24 hours is conservatively high.

NRC Request for Additional Information (RAI) 33.

Your response to GL 2004-02 question (d) (viii) indicated that an active strainer design will not be used, but does not mention any consideration of any other active approaches (i.e., backflushing). Was an active approach considered as a potential strategy or backup for addressing any issues?

FPL Energy Point Beach Response

Effort was expended to further develop the possible strategy of backwashing an ECCS strainer using gravity induced flow from a replenished RWST. These efforts culminated in a meeting with the NRC staff on March 1, 2007 (ML070720404). At this meeting, the considerations were discussed that would need to be addressed in a license submittal crediting backwashing as a primary success path.

After further internal review, it was concluded that the concept of active backwash would be a departure from both industry and published NRC-sponsored testing and research. At this time, there has been extensive testing performed for passive screen solutions.

Since the PBNP design employs a relatively open and unobstructed containment sump, and has installed large extended surface strainers with very low approach velocities, the passive screen approach was selected as a design feature in lieu of the more complicated and untested option of backwashing.

NRC Request for Additional Information (RAI) 39.

The September 2005 response to GL 2004-02 stated that "Adequate NPSH without crediting submergence of the ECCS suctions is being retained as a working design criterion for the replacement screens. In other words, head losses through the replacement screens must be no greater than the minimum submergence depth of the screens." However the NRC staff notes that Appendix A to Regulatory Guide 1.82, Revision 3, indicates that the failure of partially-submerged sumps should be assumed to occur when the head loss across the debris bed is greater than, or equal to, half of the submerged screen height. Please justify the use of the alternative failure criterion described in your GL response, of assuming the failure of a partially-submerged sump screen when the head loss exceeds the submerged screen height, rather than half the submerged height.

FPL Energy Point Beach Response

The September 2005 response to GL 2004-02 (ML052500302), page 12 of Enclosure 1, states that the replacement screens are designed to be fully submerged. As such, air entrainment due to a partially submerged screen is not a factor, and the portion of Regulatory Guide 1.82 Revision 3 associated with partial screen submergence is not applicable.

The minimum depth of water in the containment sump at the time of recirculation initiation is 38" above the floor of containment. The height of the top of the strainer surface above the floor of the containment is now 36". The screens will be fully submerged with a minimum of 2" above the topmost active screen surface. This is a fully submerged screen conforming to Reg Guide 1.82 Figure A-3(a).

To calculate the net positive suction head available ($NPSH_A$) to the RHR pumps, the following equation is used:

$$NPSH_A = (Z_{ctmt\ lvl} - Z_{pump}) + (P_{ctmt} - P_{vapor}) / \rho - h_f$$

Where:

$Z_{ctmt\ lvl}$ is the elevation of the surface of the water in the containment sump
Z_{pump} is the elevation of the pump eye
P_{ctmt} is the pressure at the surface of the water in the containment sump
P_{vapor} is the vapor pressure of the water at the eye of the pump impellor
ρ is the density of the water in the sump and connected piping, and
h_f is the frictional head loss of the sump water as it is drawn through the screens and downstream piping, fittings, etc. to the pump.

To ensure that adequate NPSH is available, it is assumed that containment pressure is equal to the vapor pressure of the sump fluid. This eliminates the second term:

$$NPSH_A = (Z_{ctmt\ lvl} - Z_{pump}) - h_f$$

Separating the frictional head loss term into the portion attributable to the screen and associated connecting piping (h_{screen}), and the portion attributable to all of the downstream piping and fittings located below the floor of containment (h_{piping}) gives:

$$NPSH_A = (Z_{ctmt\ lvl} - Z_{pump}) - (h_{screen} + h_{piping})$$

Previous evaluations of NPSH had intentionally omitted the depth of water above the containment sump as a conservative simplification. To accommodate the head loss that would be created by the new screens, it was necessary to determine this depth and ensure that the frictional head loss across the screens and appurtenances does not exceed this depth:

$$h_{screen} \leq Z_{ctmt\ lvl} - Z_{sump\ floor}$$

Expanding the term for h_{screen} then gives:

$$\begin{aligned} NPSH_A &= (Z_{ctmt\ lvl} - Z_{pump}) - (Z_{ctmt\ lvl} - Z_{sump\ floor} + h_{piping}) \\ &= Z_{sump\ floor} - Z_{pump} - h_{piping} \end{aligned}$$

This handling of the available elevation head separates it into two distinct portions; one allocated for the design and operation of the screens, and one for the operation of the pumps.

The segregation of the available elevation heads into two portions permits analytically decoupling the screen design analyses from the ECCS NPSH calculations. The decoupling also serves to sequester and protect margin in both of the analyses.

In the PBNP response to GL 2004-02 dated 9/1/2005 (ML052500302), additional supporting information regarding the minimum available NPSH margin was to be submitted after the final screen design had been completed. The design has been completed and the supporting hydraulic analyses have been revised. The results are summarized below.

The hydraulic analysis does not credit the depth of water above the containment floor. That depth is allocated for the functioning of the ECCS strainers. The results of the NPSH analyses are not dependent upon sump screen blockage as long as the differential pressure across the sump screens does not exceed the height of water in the sump. The following table summarizes the most limiting results of the hydraulic analysis for NPSH.

ECCS Alignment	RHR Pump Flow (gpm)	$NPSH_R$ (ft)	NPSH Ratio*	$NPSH_A$ (ft)
R1A: Train A RHR injecting to reactor vessel only	2035	11.8	1.15	13.6
R3B: Train B RHR supplying high head SI only	1205	6.2	3.43	21.33
R4A: Train A RHR supplying reactor vessel & high head SI**	2088	12.75	1.00**	12.75

*Ratio of $NPSH_A$ / $NPSH_R$
**This alignment is used only during simultaneous outlet plenum and cold leg injection to flush concentrated boron from the vessel. In this alignment, flow is throttled manually to prevent exceeding NPSH requirements. Analyzed flow was adjusted to obtain satisfactory results (NPSH ratio of 1), and this establishes the maximum allowable throttled flow for procedure development.