Progress Energy

Crystal River Nuclear Plant
Docket No. 50-302
Operating License No. DPR-72

Ref: 10 CFR 50.54(f)

August 30, 2005
3F0805-09

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Subject: Crystal River Unit 3 –Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"

Reference: NRC letter dated September 13, 2004, Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors"

Dear Sir:

Pursuant to 10 CFR 50.54(f), Florida Power Corporation (FPC), doing business as Progress Energy Florida (PEF), hereby submits the Crystal River Unit 3 (CR3) response to NRC Generic Letter (GL) 2004-02, which requested specific information prior to September 1, 2005.

Crystal River Unit 3 (CR3) served as a volunteer pilot plant for NRC GSI-191 Resolution and Generic Letter 2004-02 activities (Attachment B, References 1, 2 and 3). Much of the information provided herein has been reviewed by the NRC staff and can be supplemented by the CR3 Pilot Plant Audit Report submitted to James Lyons, Director, Division of Systems Safety and Analysis, NRR, dated June 29, 2005 (Attachment B, Reference 4). CR3 has provided the majority of the analytical and physical design information relative to this Generic Letter for NRC staff review as part of the pilot plant effort. Design changes are planned for CR3, with most hardware modifications being implemented in Refueling Outage 14 scheduled for fall 2005.

The overall strategy for CR3 includes numerous features in addition to increasing the reactor building (RB) sump strainer surface area. The CR3 resolution to GSI-191 and GL 2004-02 involves a variety of design changes integrated into a comprehensive plan to prevent debris blockage. The design changes take advantage of the physical geometry of the containment layout with the basic intent being to force suspended and tumbling debris through a torturous flow path to induce settlement and entrapment, while optimizing the post Loss-of-Coolant Accident (LOCA) recirculation water flow characteristics to minimize debris transport to the sump. Additionally, the water inventory available to meet sump demand is assured by providing higher confidence that recirculation flow paths remain clear and unobstructed.

Progress Energy Florida, Inc.
Crystal River Nuclear Plant
15760 W. Powerline Street
Crystal River, FL 34428

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As an overview, the design strategy for CR3 resolution of GSI-191 includes the following basic features:

- Ensure sufficient water supply reaches the RB sump during long term recirculation. This is an upstream effect improvement accomplished by:
  - Minimizing water holdup in areas of the RB bio-shield compartments, Fuel Transfer Canal (FTC), and other areas
  - Ensuring credited flow paths to the sump remain clear (FTC drain strainer, exit gate at the secondary shield wall - area referred to as the "D-ring")
- Optimize recirculation flow patterns to minimize debris transport by:
  - Minimizing water velocity and turbulence (flow diverter at D-ring exit)
  - Minimizing debris movement in the recirculation pool (induce settling, limit sliding/tumbling)
- Maximize entrapment and minimize transport to the sump by:
  - Providing interception in low turbulence regions (curbing at all D-ring exits, reactor coolant (RC) drain tank room entrapment, new flow interceptor, curb at sump entrance, reactor cavity canal drain, etc.)
  - Creating a long, torturous path for debris (labyrinth exit from D-ring, perforated covers over the south D-ring scuppers, shield plates in front the scuppers near the RB sump, etc.)
- Minimize head loss due to debris accumulation at the sump strainer, improving pump available net positive suction head (NPSHa) by:
  - Increasing surface area of the sump screen by utilizing a complex strainer geometry
  - Providing adequate debris mass capture (interstitial volume) without impacting effective strainer surface area (complex geometry helps induce non-uniform loading and avoids transition to the circumscribed area/footprint of new strainer due to volume overload)
  - Modify sump trash rack geometry to improve debris capture (increased horizontal trash rack surface area and added previously unavailable vertical surface area)
- Minimize latent debris to improve pumps NPSHa by:
  - Maintaining RB close-out cleanliness and foreign material exclusion (FME) standards
  - Continued scraping of degraded qualified coatings
- Improve emergency core cooling system (ECCS) and reactor building spray (BS) pump NPSH margin by:
  - Increasing strainer surface area by over a factor of 13 (from 86 ft^2 to 1139 ft^2)
  - Adding a bell mouth shaped entrance into the ECCS outlet piping (reduces losses)
  - Providing new sump strainer differential pressure (dP) measurement capability for headloss trending purposes
- Decrease strainer penetration to minimize detrimental effects on downstream equipment by:
  - Reducing strainer opening size from ¼ inch square mesh screen to 1/8 inch diameter holes
- Procedural enhancements reflecting the new sump design and other related modifications

In addition to the plant features discussed above, several interim compensatory measures that were adopted in reaction to NRC Bulletin 2003-01 (Attachment B, Reference 5) will be maintained or revised to account for the modified RB sump strainer:

- Operator training on indications and responses to RB sump strainer clogging
- Accident Assessment Team (Technical Support Center and Emergency Operations Facility) guidance such as:
  - Back-flushing the sump strainer (new strainer designed for gravity drain loads)
  - Provision of core decay heat boil-off matching flow versus time curves
  - Terminating unnecessary ECCS and Containment Spray system (CSS) pump operation
  - Commencement of borated water storage tank (BWST) refill following ECCS and CSS pump switchover to the sump in preparation for re-establishing an injection flow path

This letter establishes new regulatory commitments that are listed in Attachment A.

Attachment B to this letter provides the information requested in Section 2 of the Generic Letter.

If you have any questions regarding this submittal, please contact Mr. Sid Powell, Supervisor, Licensing and Regulatory Programs at (352) 563-4883.

Sincerely,

Dale E. Young

Dale E. Young
Vice President
Crystal River Nuclear Plant

DEY/pei

Attachment A: List of Regulatory Commitments

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

xc: NRR Project Manager
Regional Administrator, Region II
Senior Resident Inspector

STATE OF FLORIDA

COUNTY OF CITRUS

Dale E. Young states that he is the Vice President, Crystal River Nuclear Plant for Florida Power Corporation, currently doing business as Progress Energy Florida, Inc. (PEF); that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission the information attached hereto; and that all such statements made and matters set forth therein are true and correct to the best of his knowledge, information, and belief.

Dale E Young

Dale E. Young
Vice President
Crystal River Nuclear Plant

The foregoing document was acknowledged before me this 30 day of August, 2005, by Dale E. Young

Ellen Deppolder

Signature of Notary Public
State of Florida

ELLEN DEPPOLDER
MY COMMISSION # DD 408539
EXPIRES: July 8, 2009
Bonded Thru Notary Public Underwriters

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

Personally Known ✓ -OR- Produced Identification ______

FLORIDA POWER CORPORATION

CRYSTAL RIVER UNIT 3

DOCKET NUMBER 50-302/LICENSE NUMBER DPR-72

ATTACHMENT A

List of Regulatory Commitments

List Of Regulatory Commitments

The following table identifies those actions committed to by Progress Energy Florida (PEF) in this document. Any other actions discussed in the submittal represent intended or planned actions by PEF. They are described to the NRC for the NRC's information and are not regulatory commitments. Please notify the Supervisor, Licensing and Regulatory Programs of any questions regarding this document or any associated regulatory commitments.

Number	Commitment	Due Date
137306-20	The following interim compensatory measures that were adopted in response to NRC Bulletin 2003-01 will be maintained or revised to account for the modified RB sump strainer: • Operator training on indications and responses to RB sump strainer clogging • Accident Assessment Team (Technical Support Center and Emergency Operations Facility) guidance such as: o Back-flushing the sump strainer (new strainer designed for gravity drain loads) o Provision of core decay heat boil-off matching flow versus time curves o Terminating unnecessary ECCS/CSS pump operation o Commencement of borated water storage tank (BWST) refill following ECCS and BS pump switchover to the sump in preparation for re-establishing an injection flow path	12/31/05
137306-21	Modified sump strainer, flow distributer and debris interceptor will be installed in Refueling Outage 14 scheduled for fall 2005.	12/31/05
137306-22	A surveillance procedure, SP-175A, will confirm that the strainer integrity is maintained prior to start-up from Refueling Outages (required by ITS 3.5.2.7). A specific checklist item in this procedure requires inspection to ensure there are no breaches or gaps greater than 1/16 inch in width.	12/31/05
137306-23	Analyses or testing needed to confirm assumptions made for coating zone of influence, chemical effects and downstream effects will be performed.	10/31/06
137306-24	CR3 will revise analyses for debris transport, latent debris and head loss to address issues identified in the pilot plant audit report.	10/31/06
137306-25	Plant modifications determined to be necessary by analyses or testing to address coating zone of influence, chemical effects and downstream effects will be installed in Refueling Outage 15 scheduled for fall 2007.	12/31/07

FLORIDA POWER CORPORATION

CRYSTAL RIVER UNIT 3

DOCKET NUMBER 50-302/LICENSE NUMBER DPR-72

ATTACHMENT B

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

NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004, was sent to all holders of operating licenses for pressurized-water reactors (PWRs), except those who have ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

The Generic Letter requested the following information prior to September 1, 2005:

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.

CR3 intends to be in full compliance with the emergency core cooling system (ECCS) and containment spray system (CSS – called the reactor building spray system, BS, at CR3) recirculation functions under debris loading conditions in accordance with the functional requirements of 10CFR50.46 and the General Design Criteria (GDC) to the extent specified in the Final Safety Analysis Report (FSAR) Principal Architectural and Design Criteria, Section 1.4. CR3 requires long-term Reactor Building (RB) sump recirculation to support ECCS, makeup (MU) and decay heat (DH) systems, cooling requirements per 10CFR50.46 and to support CSS per the July 1967 draft 10CFR50.34 Appendix A "General Design Criteria for Nuclear Power Plant Construction Permits" as discussed in Section 1.4 of the FSAR. Specifically, FSAR Section 1.4.42 (Criterion 42) requires the performance of engineered safeguards (ES) features to be designed to function, without impairment, due to the effects of a Loss-of-Coolant Accident (LOCA). FSAR Section 1.4.44 (Criterion 44) details the ECCS requirements and Section 1.4.52 (Criterion 52) details the post-LOCA containment heat removal requirements, which include the CSS requirements. In addition, the CSS will be fully capable of reducing the accident source term to meet the limits prescribed in 10 CFR 50.67. FSAR Sections 6.1 and 6.2 discuss the ECCS/CSS design basis requirements.

These conditions will be satisfied following implementation of the modifications and analyses described in 2(b) below and following any necessary revisions to the licensing bases 2(e).

2(b) (Part 1) 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.

<u>General Description of Corrective Actions:</u>

The following modifications will be performed during Refueling Outage 14 (RFO-14), scheduled to begin in fall 2005:

1) <u>Sump strainer</u>: The existing ¼ inch square mesh sump screen (86 ft^2 of flat plane screened area) will be replaced with a new complex geometry sump strainer (top hat style designed by Enercon

Services, Inc.) that has an effective surface area of 1139 ft^2 (Reference 11). The new strainer is manufactured from perforated stainless steel plate, rolled and welded into pipe shapes (Refer to Appendix 1). The plate thickness is 14 gauge and the perforations are 1/8 inch in diameter. This perforation size was selected to preclude blockage of downstream piping components, of which the minimum identified opening (throttle valve, orifice, spray nozzle, etc.) was 3/16 inch. The new strainer assembly consists of a 4 x 8 array of vertical perforated pipes that will be installed in the existing sump. Thirty (30) of the strainer sections are made from two concentric perforated pipes. The diameter of the outer pipe is 12 inches and the diameter of the inner pipe is 8 inches. The annular gap between the inner and outer pipe will be sealed at the top. Two (2) of the strainer sections are made of a single perforated 12 inch diameter pipe, with a removable top to permit access for inspection and/or cleaning below the assembly. Each top hat strainer assembly is fastened to a stainless steel support structure located near the bottom of the sump pit. Fluid from the sump pool flows from the inner pipe inside diameter (ID) and the outer pipe outside diameter (OD) into the annular gap between the two pipes. The filtered fluid then flows through the annular gap, into the sump below the strainer support structure, and finally into the sump outlet piping. The sump outlet piping is being modified by improving the existing square edged flange entrance with a bell mouth shaped flange entrance in order to reduce the head loss value (equivalent to approximately 6 inches of water column improvement at full design flow). The larger strainer accommodates the maximum postulated quantity of accident generated and latent debris that could reach the sump, without structurally overloading the strainer or changing the effective strainer complex shape to the circumscribed area (which could reduce to two flat planes if it occurred). The larger strainer also ensures that ECCS/CSS net positive suction head (NPSH) margin is assured, even when considering the amount of post-LOCA debris that has been recently determined by mechanistic analyses to have the potential to reach and accumulate at the sump.

2) Strainer trash rack: The containment sump trash rack is being increased in size from approximately 55 ft^2 of horizontal surface area (existing) to approximately 100 ft^2 of horizontal and 15 ft^2 (25 lineal feet) of vertical surface areas (Reference 11). The horizontal trash rack surface will be stainless steel floor grating, constructed of 1-1/2 inch x 3/16 inch bearing bars and 5/16 inch cross bars, with about 77% open area in 4 inch x 1 inch segments. The vertical trash surface will be fabricated from 3/8 inch x 2 inch stainless steel bar, vertically spaced in approximately 8 inch x 7-1/4 inch open segments. The larger trash rack surface area is more tolerable of large debris capture, while the vertical sections preclude the possibility of a large piece of debris (insulation panel, plastic sheet, etc.) from completely obstructing the flow to the strainer below and starving the ECCS and CSS pump demand.

3) Curbing and compartmentalization: The sump will be protected by a 4 inch high curb, located within the periphery of the trash rack. Additionally, the recirculating coolant must negotiate 7 inch high curbs at the D-ring personnel access door and 12 inch high curbs at each 1 foot x 1 foot flow scupper out of the bio-shield wall. All of these curbs are existing and are not credited for debris capture, but they certainly enhance the ability to capture or trap denser debris, minimizing transport to the sump. The compartmentalization and layout of CR3's RB basement floor induces a convoluted/tortuous path for debris-laden coolant flow. In addition to trapping sinking debris inside the D-rings, in the RC Drain Tank room, in the Incore Trench, and in the hallway outside the north D-ring, floating debris will tend to be retained inside the D-ring/RC Drain Tank room due to the 2 foot minimum water level depth being higher in elevation than any of the unconfined exit paths (the D-ring personnel exit has a cyclone fence gate).

4) Flow distributor: To further optimize the post-LOCA containment pool flow characteristics and induce sedimentation of debris, a flow distributor is being added to minimize localized flow streaming and to reduce recirculation flow turbulence (References 11 and 19). The physical design features of the distributor were established by a series of computational fluid dynamics (CFD) analysis iterations with the intention of spreading the volumetric flow rate across as large a flow area as possible, which reduces velocity following transfer from the borated water storage tank (BWST) injection to RB Sump recirculation mode of cooling (conservatively assuming the minimum expected water level on the containment floor). The flow distributor acts as a baffle, providing a thru flow opening of about 7-1/2 inches x 8 foot long about 1 foot above the floor, but forcing the remaining flow around the distributor. The net effect is that the fluid is slowed to create a nearly homogenous flow pattern, minimizing the bulk stream velocity and turbulence.

5) Debris Interceptor: A 15 inch high stainless steel debris interceptor is being installed across the entire width of the floor between the D-ring wall and the containment liner. The interceptor will enhance the ability to trap debris that has settled and could be sliding or tumbling along the floor in the recirculation stream (Reference 11 and 19). The location was selected where CFD analyses indicate the flow velocity and turbulence is minimized, to preclude debris carry over the interceptor. The interceptor is a series, or string, of seven removable stainless steel units in series, each about 6 feet long and covered with perforated plate having 3/16 inch diameter holes, intended to permit water thru-flow but to capture debris such as paint chips and fibrous matter. Since the minimum predicted LOCA flood height is two feet above the floor level, the interceptor (15 inch height) will not block flow from the RB sump even if it becomes completely clogged with debris. Although large quantities of debris are not expected because of the low flow characteristics of the upstream recirculation pool, the interceptor is capable of trapping at least 95 cubic feet of debris. This is considered to be especially important during the potential sheeting action of the water along the containment floor as the containment initially fills up with water (prior to switchover to sump recirculation).

6) Scupper covers: There are eight 1 foot by 1 foot scuppers that permit flow through the D-ring and RC Drain Tank room walls, then around the D-ring walls to the sump. The four located on the south D-ring (which is physically near the sump) are currently covered with ¼ inch screen. This screen is being replaced with stainless steel plate with 3/16 inch diameter perforations (Reference 11). The four scuppers on the north D-ring side (one in the RC Drain Tank room) are open (not covered with perforated plate) and will remain open. This helps ensure that a water flow path to the sump is always available and unobstructed, but forces larger debris items (greater than 3/16 inch in size) through a lengthy and tortuous path before reaching the sump, thereby increasing the likelihood for entrapment or settling prior to reaching the sump.

7) Refueling Cavity Drain Trash Rack: A 22 inch by 14 inch by 22 inch box-shaped trash rack with a 5-sided through-flow strainer surface area of about 7.5 ft^2 (85.3% open area) is being placed over the 6 inch diameter drain path to the Reactor vessel cavity (Reference 11). This drain path is credited in the analysis (Reference 15) that concludes that a minimum water level of at least 2 foot above the basement floor is maintained. The trash rack is constructed of stainless steel floor grating (¾ inch x 3/16 inch bearing bars on 2-3/8 inch centers and ¼ inch cross bars on 4 inch centers) and sits about 6 inches above the cavity floor. This feature could result in 6 inches of water and debris in the Fuel Transfer Canal (FTC) canal, but provides reasonable assurance that the 6 inch diameter drain path will remain open and that the deep end of the FTC will not hold up excessive amounts CSS water. The trash rack is rugged in design, but is also protected by the

D-ring walls and the north-most fuel up-ender support structure minimizing the chance of it becoming damaged during a LOCA event.

8) RB Sump Level Instrumentation Enhancements: The Regulatory Guide 1.97 Sump Level indicator is currently a ball float style device. This type of indicator will remain as a back-up to a new Rosemount differential pressure (dP) cell being installed as an enhancement (Reference 12). The dP cell provides post-accident sump level indication for the plant operator at the Main Control Board and will also provide the capability for Accident Assessment teams to trend the effects of debris accumulation on the sump strainer by monitoring the differential pressure across the strainer via the plant computer. This feature provides the Emergency Operations Facility (EOF) and Technical Support Center (TSC) accident assessment teams a means to determine if sump strainer debris accumulation is occurring and permit proactive measures, such as flow throttling or strainer backwashing, to be taken to ensure pump NPSH margin is maintained.

9) Programmatic Controls: The programmatic controls and compensatory actions discussed in CR3's response to Bulletin 2003-01 are being made permanent (such as refilling the BWST), Emergency Operating Procedure (EOP) actions to monitor and respond to indications of sump strainer blockage, throttling flows, etc.). Enhanced guidance for monitoring sump strainer head loss and for the performance of sump back-flushing is planned for TSC guidance procedures (EM-225 series procedures) following implementation of the sump and sump level instrument modifications. Additionally, earlier high pressure injection (HPI) pump termination (prior to switchover to sump suction) is a new EOP enhancement, based on adequate low pressure injection (LPI) flow confirmation. Containment close-out inspections (SP-324) are being revised to ensure the assumptions made in the debris generation, debris transport (and CFD refinements), head loss, and NPSH analyses are preserved. This includes verification that flow paths are clear, interceptors, trash racks, and flow distributors are installed, and that the sump strainer is intact and free of debris, breaches, or gaps. CR3 plans to continue scraping degraded qualified coatings back to sound substrate as outage schedule and budget permits. There are no plans at this time to replace any concrete coatings above the flood plane that have been or will be removed. CR3 refueling outage decontamination controls involve washing most of the surfaces inside the D-rings. This process also greatly reduces the resident latent debris term.

The following modification is planned to be performed during the steam generator replacement project currently scheduled for RFO-16 (which is scheduled to begin on fall 2009):

1) Insulation Replacement: CR3 plans to replace the majority of the encapsulated mineral wool insulation that is currently installed inside the D-rings with Reflective Metal Insulation (RMI) coincident with the steam generator replacement effort. This reduction in fibrous debris source is not credited in any of the debris generation, transport, and accumulation analyses, but it is part of the long range plan to increase NPSH margin for the ECCS/BS pumps during post-LOCA recirculation. This replacement is expected to leave only a small amount of fibrous matter source term remaining inside the D-ring structures.

Assumptions requiring additional confirmation:

1) Coatings: A Zone of Influence (ZOI) with a radius of 4 pipe diameters has been used as a design input for determining the amount of qualified containment coating debris in CR3 debris generation analyses. This value has not yet been validated, but confirmation will be complete by

October 31, 2006, providing adequate time to perform additional modifications during RFO-15 (fall 2007) if the analysis assumption turns out to be non-conservative.

2) Chemical Effects: CR3 has assumed a sump strainer head loss margin of 50% above that calculated by the generation, transport, and accumulation analyses (References 17 thru 20). This margin has been applied in the ECCS/CSS pump NPSH calculation (Reference 14). CR3 anticipates this margin is adequate to compensate for the uncertainties inherently associated with chemical reactions in the post-LOCA environment, but will be following the industry efforts relative to this unknown effect. However, the Integrated Chemical Effects Testing (ICET test No. 2) performed with tri-sodium phosphate (TSP) as a pH buffer and fiberglass insulation, indicates that CR3's post-LOCA recirculation solution (with a TSP buffered pH between 7.0 and 8.0 per Reference 24, with mineral wool fiber insulation, and with minimal aluminum and zinc surfaces submerged in the flood plane), should have negligible impact on a debris-laden sump strainer head loss. CR3 plans to complete the Chemical Effects evaluations by October 31, 2006, to ensure adequate time for hardware re-design, should the assumption turn out to be non-conservative. Refer to Appendix 2 for CR3 specific parametric comparison to ICET test No. 2.

3) Downstream effects: CR3 is nearing completion of the evaluation of downstream equipment, and ensuring the ability for all equipment to process debris-laden fluid that can pass through the 1/8 inch diameter openings in the new sump strainer. There are three areas still requiring further evaluation (ongoing):

   a. Reactor Fuel Assembly debris filters: The CR3 core is loaded with 177 fuel assemblies with a mixture of fuel assembly designs (84 Mark-B-HTP, 93 Mark-B10). In RFO-14 (fall 2005) there will be 169 Mark-B-HTP and 8 Mark-B10 fuel assemblies loaded in the vessel for Cycle 15 operation (Reference 23) and eventually all fuel will be Mark-B-HTP by Cycle 16 (RFO-15, fall 2007). The lower end fitting on the Mark-B-HTP fuel assemblies includes a Framatome FUELGUARD debris filter, which has a finer mesh strainer and is more restrictive than the Mark-B10 lower end fittings (long end plug design), so the Mark-B-HTP design will be the focus of this discussion (it is also the design selected for replacement fuel assemblies).

   The flow path openings (wavy slots) in the Mark-B-HTP debris filter are approximately 3/32 inch x 3/8 inch. This debris resistant lower end fitting has been evaluated (by Framatome ANP) for the B&W 177 FA lower loop design, and they have concluded that there is no safety significance as long term cooling is readily provided for both cold leg and hot leg LOCA events, even should the debris filters become completely clogged. However, as pointed out in the NRC pilot audit report, additional, more detailed evaluations are necessary to confirm that CR3 specific characteristics, such as vessel internals and fuel design, quantities and types of debris, etc., will not adversely affect this conclusion. This assumption will be validated by engineering analysis before October 31, 2006.

   b. High pressure (HP) auxiliary pressurizer spray: There is a manual throttle valve (DHV-126) in the HP auxiliary pressurizer spray line that is initially about 0.08 inches open from the full closed position. The resulting restriction could result in a clogged flow path if the line were used to control long term post-LOCA boron precipitation concentration in a cold leg break event. This setting was established with the intent to ensure the pressurizer cooling rate limit is not inadvertently challenged if this flow path is utilized to deliver flow from a makeup pump through the RC Pump seal injection line. The DHV-126 throttle setting is not a design basis requirement and the valve can be further opened if required. It should be noted that DHV-126 is not relied upon as the primary means to address boron precipitation, but it is a back-up method should other equipment be unavailable. The preferred alternative is for operators to adjust auxiliary pressurizer spray flow from the control room via RCV-53, with the motive force being the "A" train decay heat pump (DHP-1A). This operational concern will be analyzed by October 31, 2006 and, if required, modified by December 31, 2007.

c. <u>LPI and CS pump seals</u>: CR3 employs the use of cyclone separators to scrub debris from the mechanical seal flush water in all ECCS and CSS pumps, which includes the HPI (MU system), LPI (DH system), and CSS (BS system) pumps. The HPI pump cyclone separator piping assemblies have a 3/16 inch orifice as the limiting flow restriction. This condition has been evaluated by the original equipment manufacturer (OEM) (Reference 25) as being acceptable for 1% debris-laden fluid (by volume with particulate up to ¼ inch in size) for at least 60 days (the pumps have a 30 day mission time). Therefore, it is not anticipated that the HPI pump cyclone separator will require modification. The LPI and CS pumps use the same model cyclone separator, but due to the hydraulic head developed by the pumps, the flow through the separators must be throttled in order for them to function properly (a specific dP range, required by the manufacturer, is established by operating procedure). It has been recently determined that the Velan throttle valves are needle valves, that even when fully opened provide an annulus gap of only about 0.050 (1/20) inch wide. Analysis is expected to determine that there will be a need for a design modification related to the mechanical seal flush piping assemblies for the DH and BS pumps. This evaluation will be complete by October 31, 2006. If a modification to the mechanical seal flush water piping becomes necessary, the corrective action will be implemented and functional no later than December 31, 2007.

<u>Implementation Schedule for Corrective Actions</u>:

1) Installation of the new sump screens, flow diverter, debris interceptors, and associated hardware modifications will be performed during RFO-14 (scheduled to begin fall 2005). Follow up corrective actions, if necessary due to new information relative to the uncertainties associated with the unconfirmed assumptions discussed above, will be implemented no later than December 31, 2007.

2 Evaluation of the effects of operation with debris laden fluid on downstream components is currently underway. Corrective actions necessary to address any concerns identified by this evaluation will be identified by October 31, 2006. Design change packages will be developed and implemented by RFO-15, currently scheduled to begin in fall 2007, and all downstream component changes (modifications, procedure revisions, license updates, etc.) will be complete by December 31, 2007.

2(c) A description of the methodology that was used to perform the analysis of the susceptibility of the ECCS and CSS recirculation functions to the adverse effects of post-accident debris blockage and operation with debris-laden fluids. The submittal may reference a guidance document (e.g., *Regulatory Guide 1.82, Rev. 3, industry guidance) or other methodology previously submitted to the NRC. (The submittal may also reference the response to Item 1 of the Requested Information described above. The documents to be submitted or referenced should include the results of any supporting containment walkdown surveillance performed to identify potential debris sources and other pertinent containment characteristics.)*

The susceptibility of the ECCS and CSS recirculation functions to the adverse effects of post-accident debris blockage and operation with debris-laden fluids are being analyzed by methods intended to conform to NEI Guidance Report 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology" (Reference 9) and the Safety Evaluation by the Office of NRR related to NRC Generic Letter 2004-02" (Reference 3). Analyses for determining the impact on ECCS and CSS operation with debris-laden fluid are being supplemented using guidance from WCAP-16406, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191" (Reference 10). Plant walkdowns were performed for debris source term establishment in October 2003 and met the intent of NEI 02-01 (Reference 8). The debris source locations were input to CR3 debris generation analyses (Reference 17) for determination of contribution to containment pool loading, based on destruction ZOI's specific to each debris source type. The plant walkdown document (Reference 16) has been reviewed by the NRC staff during the pilot plant audit effort and was found to be acceptable. A tabular summary of the walkdown results, and debris source term due to a large-break LOCA (LBLOCA) is included as Appendix 2.

At CR3, the sump pool debris transport portion of the baseline NEI methodology was further refined by CFD modeling. The NRC Safety Evaluation Conditions and Limitations applicable to use of refined transport methodologies are incorporated into the analyses. The NRC staff stated that they planned to perform additional reviews of the CR3 CFD model, subsequent to the pilot plant audit review (Reference 4, Section 3.5.9).

Exceptions to the NRC approved methodology were identified in letter PE&RAS-05-008, "Response to NRC Generic Letter 2004-02" (Reference 13). Additionally, the pilot plant audit resulted in several NRC staff questions that CR3 intends to clarify through revisions to the design basis calculations created with the intent to bring CR3 into conformance with GSI-191 identified concerns. The following list includes a summary of these additional concerns, as well as updates to the previously identified exceptions:

1) The ZOI for qualified epoxy coatings has been established as a sphere with a radius of four times the pipe break diameter. This radius is less than the ten pipe break diameters recommended in Volume 2, Section 3.4.2.1 of the NRC methodology (Reference 3). However, it is expected that the smaller diameter ZOI will be supported by industry and/or CR3 specific testing, with resolution expected by October 31, 2006. If this assumption proves to be non-conservative, then additional analyses and possibly hardware design re-work may be necessary, with implementation occurring during RFO-15 (fall 2007).

2) Degraded qualified epoxy coatings outside the ZOI are assumed to fail as chips, with a size characteristic dependent upon coating thickness. Section 3.4.3.6 of the NRC methodology recommends that unqualified epoxy coatings outside the ZOI fail as particulate with a diameter of 10 microns. However, the 10-micron size is associated with erosion of coatings due to high pressure jet impingement inside the ZOI. Coatings outside the ZOI will not be exposed to jet

impingement and therefore the predominant failure mechanism will not be erosion. The NRC staff has agreed that this is a reasonable assumption (Reference 4, Section 3.7.2).

3) Debris transport analyses assume that 25% of the fibrous insulation (mineral wool) deposited in the upper elevations of containment during blowdown remains there. Section 3.6.3 of the NRC methodology assumes that all fibrous debris is washed back down into the sump pool. Further justification of mineral wool properties and characteristics is planned by October 31, 2006, as a follow up to questions raised by the NRC staff (Reference 4, Sections 3.5.2 and 3.5.9).

4) CR3 fibrous insulation inside containment is primarily mineral wool, a man-made high density fiber centrifuge spun from molten, naturally occurring crystalline (mineral) compounds. The final product is also termed rock wool or slag wool, depending on the raw material used. A phenolic resin binder is applied if the fiber is formed into batts or blankets. Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) of typical CR3 mineral wool indicate high signals for Calcium, Silicon, and Aluminum, with some trace amounts of Iron, Titanium, and Magnesium, all primary constituents of basalt rock and slag wool. CR3 mineral wool insulation used in containment is encapsulated in stainless steel cassettes.

   CR3 has performed head loss testing with representative samples of mineral wool (taken from CR3 applications) and particulate matter, the results of which conclude that the NUREG/CR-6224 correlation is conservative for CR3 mineral wool fiber. In response to some NRC staff questions regarding mineral behavior and characteristics (incipient tumbling velocities, buoyancy/floatation, similarity to Nukon fiber relative to debris size distribution, erosion, high temperature exposure effects, etc.), CR3 is planning an additional revision to the debris transport and strainer headloss series of analyses that were the basis for the development of the overall course of action for GSI-191. These will be complete by October 31, 2006, in order to ensure adequate time is available to take any corrective actions, if necessary.

5) In response to an NRC staff suggestion from the pilot plant audit, CR3 is planning to collect more latent debris samples (dirt/dust) during RFO-14 to strengthen the assumptions made in the debris generation analysis (Reference 17). If the samples do not support existing assumptions, the analysis will be revised by October 31, 2006.

6) CR3 intends to strengthen the technical justification in the debris transport and head loss series of analyses as a result of NRC staff questions raised during the pilot plant audit. Examples include coating chip size assumptions, uniform debris bed formation assumptions being conservative, interstitial volume fill uncertainty impact on strainer head losses, air bubble formation potential within the strainer, and paint chip tumbling velocities. This will be combined with the items above in a revision to the GSI-191 set of calculations (References 17 through 22), as necessary, by October 31, 2006. If any hardware changes become necessary due to the analysis revisions, they will be completed before December 31, 2007.

2(d)(i) The minimum available NPSH margin for the ECCS and CSS pumps with an unblocked sump screen.

The following table represents the minimum margin (in feet of water column) for the DH pumps, 3% reduction in total dynamic head (TDH) and BS pumps, 5% reduction in TDH, with a clean sump screen* (maximum error corrected ECCS/CSS flow rates, while pumping saturated water):

	DHP-1A	DHP-1B	BSP-1A	BSP-1B	Sump Strainer
Flow Rate (gpm)	2992	2992	1362	1362	8508
NPSH Margin (ft)	2.8	2.1	2.9	2.4	n/a

* This table does not include the debris/chemical induced head loss term from the bounding case study (Case 3) in CR3 NPSH calculation M90-0021 (Reference 14), but assumes LBLOCA low-low water level of 2 feet above the sump (calculation M90-0023, Reference 15) with the DH pump in piggy-back supplying 580 gallons per minute (gpm) to an HPI pump, 2312 gpm to the vessel, and 100 gpm in mini-recirculation.

The NPSH methodology and margin determinations for CR3 pumps have been reviewed and accepted by the NRC staff (Reference 4, Section 3.6.4). However, the values cited in that report are based on the NPSH calculation for the existing sump screen. Those in the above table are for the new sump strainer, so there is a small difference. The MU pumps have over 200 feet of NPSH margin when in piggy-back on the DH pumps (Reference 46, Sections 3.6.2 and 3.8). The NRC staff did question the use of Miller frictional resistance coefficients for pipe fittings and the impact on NPSH margin when compared to more traditional handbook values, such as those published in Crane or Idlechik literature. A sensitivity case was run using the Applied Flow Technology Fathom hydraulic model in Reference 14, and the results indicated that head loss margin would be lowered by about 0.4 feet if these values were used in place of the Miller values. CR3 maintains that the use of Miller is more accurate than the more conservative handbook values since it is based on empirical data.

2(d)(ii) The submerged area of the sump screen at this time and the percent of submergence of the sump screen (i.e., partial or full) at the time of the switchover to sump recirculation.

1) At the time of switchover, the submerged area of the new sump strainer is 1139 $ft.^2$
2) At the time of switchover, 100% of the new strainer is fully submerged.

2(d)(iii) The maximum head loss postulated from debris accumulation on the submerged sump screen, and a description of the primary constituents of the debris bed that result in this head loss. In addition to debris generated by jet forces from the pipe rupture, debris created by the resulting containment environment (thermal and chemical) and CSS washdown should be considered in the analyses. Examples of this type of debris are disbonded coatings in the form of chips and particulates and chemical precipitants caused by chemical reactions in the pool.

The maximum postulated debris/chemical induced head loss across the sump strainer is 1.2 feet of water column. Calculation M04-0007 (Reference 20) determines the debris induced head loss associated with the 1139 square foot surface area laden with debris generated by a LBLOCA. Calculation M04-0019 (Reference 22) determines the clean strainer head loss (CSHL) associated with a 1097 square foot top hat strainer (a conservatively low area).

The total strainer head loss correlation is a function of the clean screen head loss and the head loss due to debris that can reach the sump. Summing the two head loss effects from References 20 and 22, the maximum anticipated head loss from debris accumulation becomes 0.20 feet at 3000 gpm, 0.44 feet at 6000 gpm, and 0.88 feet at 9000 gpm. The following conservative combination of parameters was considered in this assessment:

- Flat plate configuration (conservative compared to a complex geometry strainer)
- 139 square feet of obstruction (plastics, tags, paper, etc. leaving 1000 square feet of strainer area)
- 150 °F sump water (increases head loss vs. 212 °F water)
- 46 cubic feet of mineral wool insulation (approximates thin bed w/non-uniform loading, higher fibrous loading would result in a reduction in pressure drop)
- 200 pounds. dirt and dust (conservatively high combination of 170 pound particulate, 30 pound fibrous)
- 263 pounds of Plasite paint particulate/chips (approximately 5000 square feet of qualified coatings)
- 47 pounds of unknown, unqualified paint particulate (approximately 1000 square feet original equipment manufacturer (OEM) coatings)

Using the same inputs, but increasing the head loss by 50% at each of the 3 flow rates for uncertainties such as environmental and/or chemical effects, a conservatively high debris-laden head loss correlation becomes 0.30 ft/3000, 0.66 ft/6000, and 1.32 ft/9000. A curve fitting application was used to develop the following conservative relationship of head loss (dH) vs. flow (Q) for the strainer, based on these three points:

$$\mathbf{dH = 0.0012 + 0.000054Q + 0.00000001Q^2}$$

This is considered to be a very conservative head loss correlation, based on the Integrated Chemical Effects Testing (ICET) that has been performed to date. CR3 sump solution is buffered with TSP and a recirculation mode pH range between 7.0 and 8.0 (Reference 24), based on the amount of BWST actually injected into containment (between empty and 15 feet remaining in the tank). These conditions were simulated most closely by ICET Test No. 2, where the average TSP buffered solution pH was about 7.35. Very little precipitant evolved during Test No. 2. Appendix 2 compares CR3 containment constituents to those used in the ICET testing. Other than CR3 fibrous insulation being primarily mineral wool (ICET used fiberglass), the submerged materials are bounded by the test results. As discussed in 2(c)4, CR3 intends to further justify the mineral wool properties relative to the Nukon fiberglass insulation used in the testing.

The highest flow rate expected across the strainer is 8508 gpm (Reference 14), which includes all six (6) ECCS/BS pumps running at the operator throttled set points and conservatively accounting for instrumentation uncertainty (Reference 14). The head loss that corresponds to this flow rate, based on the above correlation, is 1.2 feet of water column. When compared to the NPSH margin table presented in 2(d)i, the limiting pump (DHP-1B) still has approximately 0.9 foot of NPSH margin available, even when accounting for the very high level of conservatism used in the NPSH determination approach (Reference 14). Examples of uncredited conservatism include; no credit for containment overpressure (due to the partial pressure of the air or due to non-condensable gas heating), no credit for sump water sub-cooling (due to stratification and due to the massive structure heat sink), no credit for additional BWST inventory during transfer to the sump, no credit for an NPSH temperature correction factor (Hydraulic Institute published value), the algebraic addition of instrument uncertainties (versus square root of the sum of the squares methodology). The net effect of these conservatisms provides an additional 8 to 10 feet of NPSH margin over that discussed in 2(d)i. However, this impact is not credited because it provides considerable margin for any uncertainties in the overall GSI-191 strategy and resolution approach. As a result, CR3 is confident that post-LOCA ECCS/CSS pump operation is assured even under the most detrimental set of circumstances in the post-accident environment.

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 flowpaths.

CR3 Calculation M90-0023 (Reference 15) provides the water inventory analyses for several sets of circumstances and assumptions. In summary, the minimum possible inventory injected from the BWST is supplied to the containment structure and the maximum holdup volume in systems and compartments is assumed to occur. This set of conservative assumptions results in a lowest possible water level on the containment floor i.e., directly above the sump. The resulting 2 foot water level represents only 21,436 ft^3 of the 38,853 ft^3 minimum injected BWST inventory. This volume is equivalent to 290,640 gallons of the 415,200 gallons required storage by Improved Technical Specifications (ITS) 3.5.4.2 injected to containment in a LBLOCA (Reference 15, Section 6.10.D). The following table represents the water inventory assumed to be held up elsewhere inside containment and not available for sump pool recirculation height contribution (equivalent to approximately 1.3 feet over when spread over the 10,704 ft^2 floor area):

Source	**Volume (ft^3)**
1. Elevation 160 foot and 119 foot	478 + 419 = 897
2. Reactor Cavity > Elevation 104 foot	5,117
3. Fuel Transfer Canal	1,524
4. Instrumentation Tunnel < Elevation 104 foot	1,951
5. Floor Cut-out @ 94'	258
6. RB Sump Fill-up	1,124
7. BS and DH Dry Pipe Volume	520
8. RC Drain Tank	844
9. 95' Floor Drains	43
10. Core Flood Room	24
11. Condensation on Surfaces	149
12. Pressurizer Steam Space	570
13. RCS Shrinkage	2,943
14. Refueling Crane Rail Space	40
15. RCP Lube Oil Collection System	115
Subtotal:	**16,119**
16. 204.7°F Sat. Steam in atmosphere	1,139
17. Containment Spray Mist in atmosphere	127
18. Break flow water in transit to the pool	32
Total:	$\mathbf{V_{retained} = 17,417\ ft^3}$

In order to preserve the assumptions and inputs used in Reference 15, a strainer/trash rack will be installed over the Fuel Transfer Canal drain during RFO-14 (fall 2005). This ensures the deep end of the fuel transfer pool will not prevent excessive amounts of water from reaching the sump. Additionally, there are eight (8) water exits out of the D-rings and one (1) from the RC Drain Tank room permitting line break flow to reach the sump (eight 1 foot by 1 foot scuppers and one 7 foot by 4 foot personnel access gate). The four scuppers nearest the sump will be covered with perforated plate to preclude larger debris items from short circuiting the torturous flow path out of the D-rings. The other scuppers are open, minimizing chances for complete D-ring exit flow blockage. The personnel gate is a cyclone fence material (2.5 inch square open mesh), but the lower 10 inches is left open to minimize accumulation of debris at the floor level that could obstruct flow. All of these flow paths are verified to be clear for water flow during containment close-out inspections following outage activities (Surveillance Procedure SP-324).

These actions ensure that the assumptions made in the water level calculations are confirmed to be valid during plant power operations. Floor drains are not credited flow paths but should be available, since they are also inspected. But, they are covered with screening and therefore are potentially susceptible to blockage.

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.

Calculation M04-0016 (Reference 21) evaluates all components that may be required to pass debris-laden fluid during LOCA recirculation cooling. The strainer perforations are 1/8 inch diameter holes. As stated in Section 2(b), there are 3 components that have been determined to be susceptible to blockage due to debris passage through the 1/8 inch diameter openings (DH/BS cyclone separator throttle valves, a high pressure auxiliary spray throttle valve, and the fuel assembly lower end fitting debris strainers). These susceptible configurations will be evaluated and appropriate corrective actions will be taken, as appropriate. All corrective actions, including modifications, will be completed by December 31, 2007.

The design requirements being imposed on the installation of the top hat strainer configuration includes limiting gaps and bypass breaches to 1/16 inch in width. A new surveillance procedure, SP-175A, will confirm that the strainer integrity is maintained prior to start-up from Refueling Outages (required by ITS 3.5.2.7). A specific checklist item in this procedure requires inspection to ensure there are no breaches or gaps greater than 1/16 inch in width.

2(d)(vi) Verification that 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.

As stated in 2(d)(v), calculation M04-0016 (Reference 21) evaluates all components that may be required to process debris-laden fluid during LOCA recirculation cooling and some items have been identified as being susceptible to plugging. Also as stated, these restrictive components will be addressed and if any corrective actions or modifications are required, they will be completed by December 31, 2007.

Wear and abrasion evaluations were also performed for CR3 components relied upon to pass debris-laden fluid. Attachment 8 of Reference 21 (performed by AREVA-Framatome) follows the guidance of topical report WCAP-16406-P (Reference 29) for evaluation (hydraulic performance, mechanical seals, vibration) of the pump capability to meet designated mission times (for CR3 the mission time requirement for all ECCS and CSS pumps is 30 days), and determined that there are no concerns introduced by the Los Alamos National Laboratory (LANL) Screen Penetration Test Report (Reference 30) or Reference 29 that would indicate the MU, DH, and BS pumps will not perform their intended design function for 30 days in post-LOCA, debris-laden fluid.

Additionally, Attachment 8 of Reference 21 evaluated the effects of wear and abrasion on CR3 specific orifices, heat exchanger tubing, process piping, instrumentation tubing, and valves. Although some abrasive wear due to debris-laden fluid is expected to occur, the wear rates have been determined to be low, concluding that the components will all perform their intended design functions for the 30-day mission time duration.

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 predicted flow conditions.

The only reactor coolant system (RCS) related high energy line in the vicinity of the containment sump is the letdown line. All other RCS pressurized components are inside the secondary shield wall (biological shield wall), which provides adequate protection for the sump components from expanding jets and/or missiles resulting from a line rupture. The letdown line connects to the RCS at the RCP-1D suction line (cold leg) and connects to the Letdown coolers (MUHE-1A/B/C) in their respective compartments. The letdown line, which has 2.5 inch and 3 inch nominal pipe size (NPS) branches, runs 8 and 13 feet above the RB sump structure respectively, which is at least 30 pipe diameters away to dissipate any energy from an arbitrary or intermediate line break. Ruptures of the letdown line were originally postulated to occur at any location along the high energy portion of the line. However, as part of the effort to re-evaluate RCS attached piping for the effects of high-energy line breaks (HELBs), all intermediate line breaks have been eliminated using the stress criteria specified in GL 87-11 (Reference 35), as approved by CR3 License Amendment No. 181, dated July 27, 1999 (Reference 34).

As a result, only circumferential terminal end breaks are postulated at the nozzle connection to the 28 inch RCS cold leg and at the nozzle connections to each of the three letdown coolers. The sump strainer and trash rack structures are protected from the effects of these break locations (expanding jets and missiles) by intervening concrete barriers (Reference 36). In addition, SER Section 7.1 (Reference 3) states that certain breaks that have been reviewed and approved by the NRC for exclusion from the plant design basis need not be considered in the sump screen structural design. Since there are no intermediate breaks that need to be postulated, the RB sump strainer is not evaluated for breaks in the high energy letdown line.

Therefore, the sump trash rack and strainer are not subject to missile loading per CR3's licensing basis, although protection is provided by the distance away from the energy source. In any event, the trash rack is designed for dead weight, seismic inertia, and 100 pounds/ft^2 of live loading (traffic or debris). The strainer assembly is designed for 3 psid in both directions (normal and backwash) in combination with dead load and seismic loads, therefore normal and upset operating loads, including the effects of debris accumulation, have been acceptably evaluated (References 31 and 32).

2(d)(viii) If an active approach (e.g., backflushing, powered screens) is selected in lieu of or in addition to a passive approach to mitigate the effects of the debris blockage, describe the approach and associated analyses.

The new CR3 sump strainer is a passive strainer. However, backflushing is possible by gravity draining either the reactor vessel (through the DH drop line) or the BWST to the sump. This evolution is termed "dump-to-sump" and is prescribed in boron precipitation management procedures for cold leg break scenarios. Some refinement to the dump-to-sump guidance is planned to be provided to Accident Assessment teams following RFO-14, when using the process for the purpose of sump strainer backflushing. It is intended to detail using HPI injection from the BWST during the backflush, while terminating all ECCS flow from the RB sump. This will prevent the beneficial reverse cleansing flow from short-circuiting the backflush path and being drawn into the operating recirculation train.

It has been determined that the maximum flow rate from the RCS drop line is about 22,500 gpm when the RCS pressure is 284 psig and two-phase flow does not occur (Reference 47). The maximum flow rate from one BWST pipe (full BWST) has been determined to be about 10,000 gpm if the RB pressure is atmospheric (Reference 48). The calculated head loss associated with back flow rates of 25,000 gpm and 10,000 gpm is 0.557 feet and 0.096 feet respectively (Reference 21). The strainer is designed for 3 psid (Reference 31), or about 6.9 feet of water column and therefore can easily handle the pressure drops associated with reverse direction flow rates of this magnitude, and higher. The cleaning capability has not been established but 14 inch NPS line velocities are 59.3 ft/second and 23.7 ft/second at these respective flow rates and localized perforation velocities are estimated to be on the order 0.16 ft/second and 0.065 ft/second (respectively) for a 30% open area strainer. There is room in the lower area of the normal duty side of the sump for debris to fall and collect (see Appendix 1).

2(e) 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.

Proposed Licensing Bases Description and Schedule

CR3 plans to update the licensing bases relative to the ECCS/CSS functions of the RB sump recirculation functions once all plant modifications and evaluations related to the issue are complete. Confirmation of compliance with the regulatory requirements listed in GL 2004-02 will occur when all necessary activities are complete, which will be prior to December 31, 2007. Most of the hardware modifications are being installed during RFO-14 in fall 2005. However, CR3 and industry testing associated with coating ZOI and chemical effects could result in the necessity to do further evaluations and/or modifications. Downstream effects studies indicate that cyclone separator assemblies for the mechanical seals to the ECCS/CSS pumps may require a physical modification to remove flow restrictions that could clog with debris and challenge mechanical seal integrity. Modifications to these assemblies will be completed by December 31, 2007.

CR3 does not expect to require NRC staff review for any of the corrective actions and modifications planned for full compliance with this GSI-191. Additionally, CR3 does not expect to make any changes to the Improved Technical Specifications. Therefore, there are no plans to submit License Amendment Request to close GSI-191. The current licensing basis, which assumes a maximum sump screen blockage of 50% will be maintained until all analyses and modifications are complete, including the validation of analysis assumptions, as discussed in section 2(b), and any necessary design re-work is complete. All work and corrective actions will be complete by December 31, 2007. It is anticipated that the Licensing Basis changes will be made in accordance with 10CFR50.59 without the need for NRC staff review upon completion of these corrective actions.

Related Regulatory Actions for CR3

Regulatory Guide 1.82:

The CR3 sump design pre-dates the initial issue of Regulatory Guide (RG) 1.82 Revision 0 (June 1974). CR3 is not committed to any portion of this RG, however responses to GL 97-04 and GL 98-04 adopt the 50% screen blockage assumption discussed in the RG 1.82 Rev. 0. CR3 is maintaining this licensing basis for the sump strainer modifications performed under Engineering Change (EC) 58982. Ultimately, when the head loss impact due to uncertainties such as chemical precipitants and coating ZOI is established, and when downstream component impact evaluations are completed, CR3 will update the current licensing basis (CLB) based on fully mechanistic debris induced head losses. At this time, RG 1.82, Revision 3 (Reference 7, November 2003) is the current version. CR3 sump modifications and the supporting analyses generally follow the guidance presented in RG 1.82, Revision 3, but due to the vintage of the plant's design certain features cannot be altered (for example, CR3 has a single RB sump. Therefore requiring two redundant sumps and associated debris screens is impractical). CR3 is not committing to comply with any portion of RG 1.82, but has considered many of the recommendations from the document in the new strainer design. Specific sections of RG 1.82, Revision 3, to which CR3 conformance has not or cannot be established include:

Section 1.1.1.1	minimum of 2 sumps (one per train)
Section 1.1.1.2	physical separation by structural barriers - damage prevention small break LOCA
Section 1.1.1.3	vertical, or near vertical trash rack – upstream curb high enough to prevent jump-over
Section 1.1.1.5	drains from upper containment regions – not in close proximity to sump
Section 1.1.1.7	top of the trash rack to be a solid cover
Section 1.1.2.2	fibrous insulation source abatement procedures
Section 1.1.2.3	minimize chemical reactions with pool water with metals in containment
Section 1.1.3	audible warning of impending loss of NPSH for ECCS pumps
Section 1.3.1.9	NPSH calculations as a function of time
Section 1.3.2.4	particulate debris due to HELB erosion of concrete
Section 1.3.2.7	continued degradation of insulation and other debris considerations
Section 1.3.4.1	rate of debris accumulation on the sump screen

Bulletin 93-02:

On May 11, 1993, the USNRC issued Bulletin 93-02, "Debris Plugging of Emergency Core Cooling Suction Strainers" (Reference 49). The purpose of the Bulletin was to notify licensees of a previously unrecognized contributor to ECCS pump NPSH challenge during the recirculation phase of LOCA recovery. Based on an industry experience and Sandia National Laboratory testing, it was determined that unexpected, rapid differential pressure increase across sump strainers was possible due to fibrous matter collection and subsequent filtering of suspended corrosion products, dust, and other debris. The Bulletin requested licensees to identify all fibrous air filters or other temporary sources of fibrous material, and to take prompt action to remove such material from containment. In response, CR3 removed all fiberglass air filter media (AHFL-10A/B) from the Reactor Cavity Air Cooling Coils, identified as the only temporary or air handling filters located within the reactor building. Bulletin 93-02 actions were closed by receipt of NRC to FPC letter, 3N0594-04, dated May 3, 1994.

Generic Letter 97-04:

On October 7, 1997 the NRC issued Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps," (Reference 37). The purpose of the generic letter was to collect information necessary for NRC to confirm the adequacy of the net positive suction head (NPSH) available for emergency core cooling (including core spray and decay heat removal) and containment heat removal pumps. CR3 reported that only static water head is considered available to overcome piping friction and strainer head losses, while providing adequate NPSH at the pump impellers. The strainer head loss analysis assumed 53% surface area reduction, consistent with RG 1.82, Revision 0, which stated, "The available surface area used in determining the design coolant velocity should be based on one-half of the free surface area of the fine inner screen to conservatively account for partial blockage."

The response also credits the automatic flow controllers downstream of the DH pumps to preclude the necessity of the operator controlling pump runout, which could affect pump NPSH. The NRC has reviewed and accepted the response to GL 97-04 submitted by CR3 (NRC to FPC letter, 3N0798-11, dated October 7, 1997) which confirmed the adequacy of the NPSH available for the ECCS (LPI/HPI) and BS Pumps. The method of calculating NPSH margin described in the response to GL 97-04 remains applicable.

Generic Letter 98-04:

On July 14, 1998, NRC issued 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," (Reference 38). The GL addressed, in part, licensee programs for the use of protective coatings inside containment at PWR facilities. Significant in the CR3 response to GL 98-04 are the regulatory positions:

- "CR-3 has assumed that the systems that draw from the sump for emergency core cooling and containment spray systems may experience sump blockage of approximately 50% of the effective sump area from debris generated as a result of a LOCA. At the time CR-3 was licensed, no distinction was drawn between the various potential sources for post-LOCA debris: these systems were intended to function, even with debris partially obstructing the sumps, from whatever source derived"

- "Coatings are not treated separately in the licensing basis for CR3 because the sump screen blockage assumption does not distinguish among the sources of LOCA generated debris"

The NRC has reviewed and accepted the response to GL 98-04 submitted by CR3 (NRC to FPC letter 3N1199-04, dated November 9, 1999). CR3 maintains its protective coatings program consistent with its response to GL 98-04. Although the current licensing basis is that only 50% of the screen needs be considered for differential pressure effects, irrespective of the source term potential, this program provides assurance that coatings do not contribute significantly to the transportable debris that may be generated during either normal plant operation, or accident conditions. Increasing the strainer surface area to 1139 ft^2 increases the 50% accumulation limit by over 500 ft^2, a significant increase in safety margin.

Bulletin 2003-01:

On June 9, 2003, NRC issued Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors," (Reference 5). The purpose of the bulletin was, in part, to either 1) request that licensees either confirm their compliance with 10 CFR 50.46(b)(5) and other existing applicable regulatory requirements, or 2) describe any compensatory measures implemented to reduce the potential risk due to post-accident debris induced sump blockage as evaluations to determine compliance proceed. CR3 determined that the loss of sump recirculation ability due to entire screen blockage is beyond the current design basis and had not previously been considered. Therefore, Option 2 in the Bulletin was chosen and the interim compensatory measures have been established, as discussed in FPC to NRC letter 3F0803-03, dated August 8, 2003. As stated previously, CR3 intends to make the interim compensatory measures, which were established in response to Bulletin 03-01, permanent features of the overall post-LOCA mitigation strategy.

CR3 Improved Technical Specifications:

CR3 ITS 3.5.2.7 requires bi-annual sump, sump strainer, and sump trash rack inspection to ensure the ECCS/CSS functional requirements of the sump will be met during the operating cycle. The inspections will be implemented by new procedure SP-175A (Reference 43).

2(f) 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, to the extent that their responses address these specific foreign material control issues.

Existing and planned programmatic controls are described below.

1. Insulation inside containment. Insulation replacement is controlled by plant specification and design control procedures (types and quantities of insulation) to ensure the inputs resulting from the plant walkdown in RFO-13 remain valid. Engineering change screening criteria (checklist) for design change control (Reference 41) specifically cautions the engineer to determine if the change can "create or alter the potential sources of debris which could interfere with the ECCS

suction or reactor building sump pumps." The CR3 insulation specifications (SP-5903 and SP-5953) provide the guidance for insulation and jacketing types permitted inside the reactor building. Engineering change procedures (Reference 39) provide the programmatic controls for insulation products that can be used in the plant.

2. Coatings inside containment. The existing Coatings Program (Reference 42) recommends periodic visual inspections to monitor the condition of coatings inside containment. CR3 implements this inspection each refueling outage through site procedure PM-156 (Reference 50). CR3 has two quality levels of post-LOCA "qualified" epoxy coatings, defined as Service Level I and Service Level II inside containment.

   Service Level I coatings are coatings applied to areas within containment where failure in a post-LOCA environment could have a detrimental effect on plant safety, i.e., the sump performance. These areas are those where sump pool fluid velocity and turbulence that could be experienced during post-LOCA recovery, are sufficiently high enough to transport failed coatings to the sump and potentially contribute to blockage of the sump strainer (Reference CR3 Generic Letter 98-04 response, 3F1198-02, dated November 6, 1998). Service Level I coatings are fully design basis accident (DBA) qualified.

   Service Level II coatings are coatings applied to areas outside the Service Level I areas, where transport of failed coatings to the sump during post-LOCA recirculation is unlikely. Service Level II coating products are DBA qualified and applied with the same products, work processes, and documentation controls as Service Level I coatings, with an exception that verification and inspection activities may be performed by a qualified Work Supervisor instead of a Quality Control Inspector. CR3 treats both Service Levels as 'qualified' coatings for the purpose of post-LOCA debris generation, transport, and sump strainer impact considerations.

   Service Level I and II coatings outside the ZOI that are degraded (delaminated, peeling, cracking, etc.) are assumed to fail as chips. Unqualified coatings are assumed to fail as particulate fines. The transport of failed coating chips is a function of location within the sump pool, pool turbulence (TKE), and pool velocity. CR3 has installed a flow diverter to minimize local flow streaming and turbulence and has installed a debris interceptor in a low velocity, low turbulence region of the recirculation flow path to induce paint chip settling and/or entrapment. Due to these modifications and the existing curbs at the D-ring openings, degraded qualified paint chips from Service Level II areas are not expected to be able to reach the sump in any LOCA event. However, if some portion were to reach the sump, parametric studies show that the sump strainer head loss analysis is not significantly sensitive to the paint chip source term (Reference 20).

3. Equipment labeling. The equipment labeling procedure (Reference 44) specifies the use of labels that will not readily transport and potentially impact sump recirculation. For example, equipment labels used inside the containment are required to be stainless steel or porcelain-baked stainless steel, neither of which is expected to contribute to debris source term or transport under maximum sump pool velocities. The attaching device for stainless-steel tags is specified to be stainless-steel braided wire. Normally, only qualified materials are allowed inside containment. However, many original (plant construction era up to 1997) adhesive vinyl equipment labels are present in containment. The sump strainer head loss analysis (Reference 20) accounts for these labels with adequate margin for uncertainty in the actual count, and it accounts for limited use of paper and plastic equipment clearance tags. The equipment tag replacement program (with

porcelain style) is an ongoing process, which continually recovers design margin as the labels are upgraded.

4. Signs and postings. CR3 limits signs and Health Physics (HP) postings inside containment in Modes 1 through 4 to those areas posted High Radiation Areas. Lexan and porcelain baked stainless steel materials have been evaluated by CR3 Engineering to be acceptable for this purpose. An Operating Experience (OE 20754) notice regarding the potential for Lexan to break down under exposure to post-LOCA environmental conditions is under review and appropriate corrective actions will be taken, if necessary.

5. Foreign Material Exclusion. The containment closeout inspection procedure (Reference 40), administered by a Senior Reactor Operator, ensures foreign material remaining inside containment, in operating Modes 1 through 4, is limited. Specifically, the following items are not permitted inside the reactor building:

   - Temporary lead shielding blankets
   - Unapproved scaffolding
   - Ladders
   - Fire extinguishers
   - Loose debris, including trash and foreign objects

   The containment close-out procedure also ensures that all credited flow paths are clear and unobstructed, and that all trash racks and strainers required to ensure recirculation pool characteristics, including water level, will match the analytical inputs and assumptions, such as:

   - Post-LOCA scuppers are open and unobstructed (4 have perforated plate covers)
   - The debris interceptor is in place and secured
   - The flow distributor is in place and secured
   - The Fuel Transfer Canal trash rack is bolted in place
   - All HP postings are either removed or of an approved design
   - All storage boxes are in approved locations with lids closed, and tied off if necessary
   - Floor drains are free of visible obstructions and grates/screens installed

   Additionally, the pre-job briefing procedure (Reference 45) contains a checklist item to remind all workers performing tasks in the reactor building about the importance of containment housekeeping requirements, including reactor building FME and cleanliness control, relative to the requirements for RB sump performance following a design basis LOCA.

6. Sump Strainer integrity. CR3 ITS 3.5.2.7 requires bi-annual sump, sump strainer, and sump trash rack inspection to ensure the ECCS/CSS functional requirements of the sump will be met during the operating cycle. The inspections will be implemented by new procedure SP-175A (previously implemented in SP-175). The design requirements being imposed on the installation of the top hat strainer configuration includes limiting gaps and bypass breaches to 1/16 inch in width. Inspections performed per SP-175A (Reference 43) will confirm that the strainer integrity is maintained prior to start-up from Refueling. A specific checklist item in this procedure requires the inspector to ensure breaches and gaps greater than 1/16 inch in width do not exist (other than the 1/8 inch diameter perforations in the top hats).

References

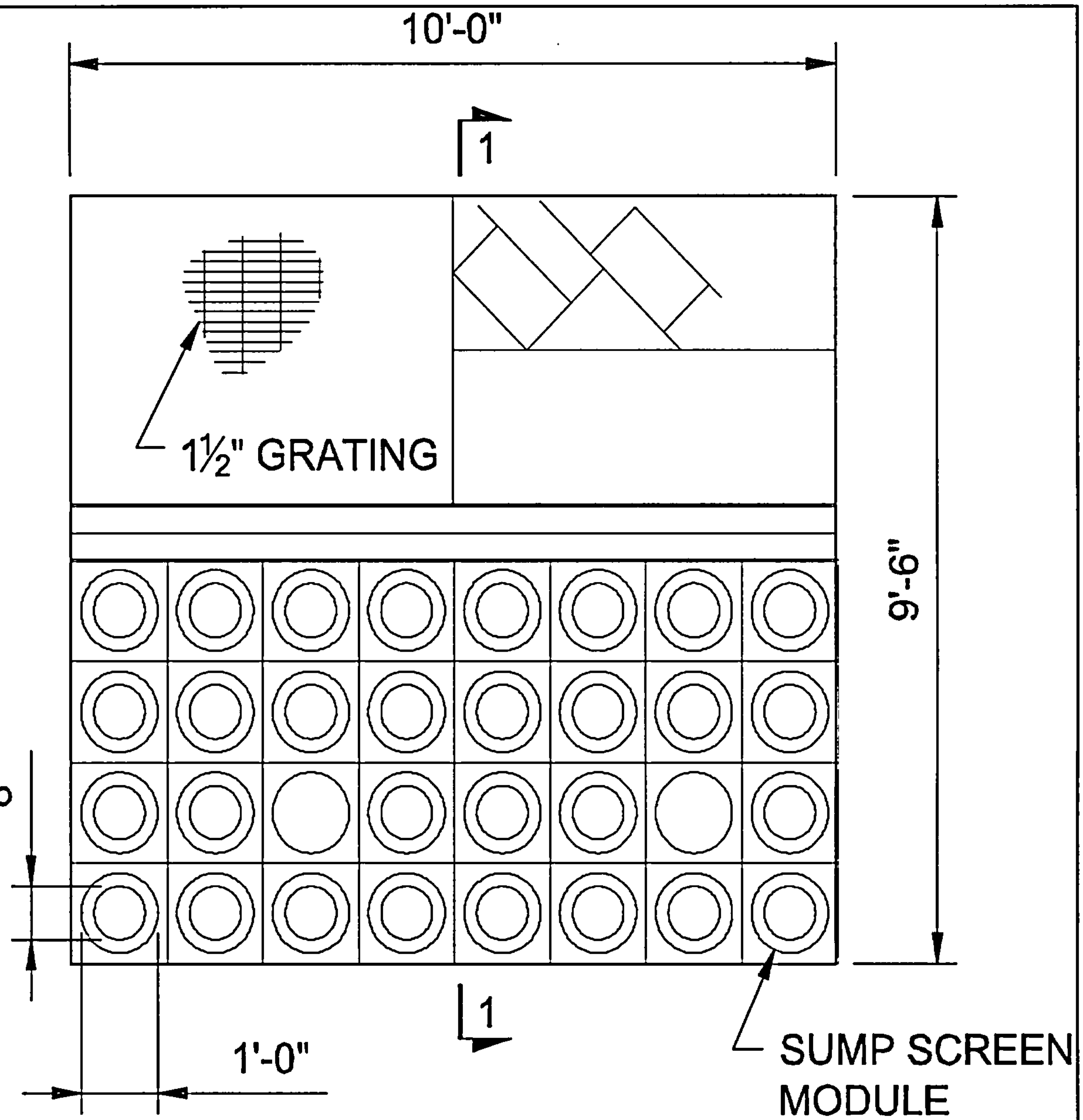
1. NRC Generic Safety Issue (GSI) 191, "Assessment of Debris Accumulation on PWR Sump Performance," prioritized September, 1996.
2. NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage of Emergency Recirculation During design basis Accidents at Pressurized-Water Reactors," dated September 13, 2004.
3. GSI-191 SE, Revision 0, "Safety Evaluation of NEI Guidance on PWR Sump Performances," dated December 6, 2004.
4. NRC Audit Report, "Crystal River Unit 3 Pilot Plant Audit Report – Analyses Required for the Response to Generic Letter 2004-02 and GSI-191 Resolution.," memo from Ralph Architzel (NRC) to James Lyons (NRC), dated June 29, 2005.
5. NRC Bulletin 2003-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors," dated June 9, 2003.
6. NRC Regulatory Guide (RG) 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps," dated November 2, 1970.
7. NRC Regulatory Guide (RG) 1.82, Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," dated November 2003.
8. NEI 02-01, "Condition Assessment Guidelines – Debris Sources Inside PWR Containments" Revision 1, dated September 2002.
9. NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology", Volume 1 – "Pressurized Water Reactor Sump Performance Evaluation Methodology", Revision 0, December 2004.
10. WCAP-16406, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191, Revision 0.
11. CR3 Engineering Change (EC) 58982, "RB Sump Strainer, RB Flow Distributor, and RB Debris Interception Modifications."
12. CR3 Engineering Change (EC) 59476, "RB Sump Level Indication."
13. Progress Energy PE&RAS-05-008, "Response to NRC Generic Letter 2004-02 – Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," dated March 4, 2005.
14. CR3 Calculation M90-0021, Revision 13, "Building Spray and Decay Heat Pump NPSHa/r."
15. CR3 Calculation M90-0023, Revision 9, "Reactor Building Flooding."
16. CR3 Containment Walkdown, Framatome document 77-5036736-00 "Debris Source Inventory Walkdown Report," dated December 16, 2003.
17. CR3 Calculation M04-0004, Revision 1, "CR3 Reactor Building GSI 191 Debris Generation Calculation."
18. CR3 Calculation M04-0005, Revision 1, "CR3 Reactor Building GSI-191 Debris Transport Calculation."
19. CR3 Calculation M04-0006, Revision 1, "CR3 RB LOCA Pool CFD Transport Analysis."
20. CR3 Calculation M04-0007, Revision 1, "CR3 RB Sump Head Loss Calculation for a Debris Laden Screen."
21. CR3 Calculation M04-0016, Revision 0, "RB Sump Screen – Downstream Effects Evaluation."
22. CR3 Calculation M04-0019, Revision 0, "RB Sump Screen – Clean Screen Head Loss, Surface Area, Interstitial Volume."
23. Engineering Changes 48755R5 and 55540R0 (draft), CR3 Cycle 14 and 15 Reload Core Design and Safety Analyses.
24. CR3 Calculation M05-0009, Revision 1, "CR3 Sump Solution pH Calculation – Report."
25. CR3 Engineering Evaluation EEM98-001, Revision 1, "MU/HPI Pump Qualification."

26. Test Plan: Characterization of Chemical and Corrosion Effects Potentially Occurring inside a PWR Containment Following a LOCA," Westinghouse, EPRI, NRC, dated July 20, 2005.
27. CR3 Calculation M85-1004, Revision 4, "Hydrogen Generation."
28. CR3 Calculation S89-0050, Revision 10, "Allowable Quantities of Coating Failures."
29. WCAP-16406-P, Revision 0, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191, Westinghouse Owner's Group, June 2005.
30. LA-UR-04-5416, Screen Penetration Test Report, submitted to the USNRC, Bruce C. Letellier and Crystal B. Dale (LANL), Arup Maji, Kerry Howe, and Felix Carles (UNM), November 2004.
31. CR3 Calculation S04-0006, Revision 0, "RB Sump Strainer Structural Design."
32. CR3 Calculation S04-0007, Revision 0, "RB Sump Trash Rack Structural Design."
33. CR3 Calculation S04-0008, Revision 0, "RB Flow Distributor, Debris Interceptor and Fuel Transfer Canal Drain Trash Rack Structural Design."
34. CR3 Topical Design Basis Document (TDBD) Tab 9/5, Revision 4, "High Energy Line Breaks Inside Containment."
35. NRC Generic Letter 87-11, "Relaxation in Arbitrary Intermediate Pipe Rupture Requirements."
36. CR3 Drawing 304-818, Revision 1, "High Energy Line Breaks Locations and Pipe Whip/Jet Impingement Zones – Inside Containment."
37. NRC Generic Letter 97-04, "Assurance of Sufficient Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Pumps."
38. NRC Generic Letter 98-04, "Potential for Degradation of the Emergency Core Cooling System after a Loss-of-Coolant-Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment."
39. Progress Energy Procedure EGR-NGGC-0005, Revision 23, "Engineering Change."
40. CR3 Procedure SP-324, Revision 53, "Containment Inspection."
41. MNT-NGGC-0007, Revision 5, "Foreign Material Exclusion Program."
42. CPL-XXXX-W-005, Revision 9, "Specification for Nuclear Power Plant Protective Coatings."
43. CR3 Procedure SP-175A, Revision 0, Reactor Building Emergency Sump Inspection."
44. CR3 Procedure AI-516, Revision 3, "Plant Labeling Guidelines."
45. CR3 Procedure AI-607, Revision 17, "Pre-Job and Post-Job Briefings."
46. CR3 Calculation M98-0123, Revision 4, "CR3 HPI Hydraulic Analysis (Post 11R modifications to the MU System)."
47. CR3 Calculation M96-0020, Revision 0, "Decay Heat Drop Line Maximum Flow and Velocity Analysis."
48. CR3 Calculation M97-0008, Revision 0, "Eval of BWST Draining for Appendix R Issue."
49. NRC Bulletin 93-02, "Debris Plugging of Emergency Core Cooling Suction Strainers."
50. CR3 Procedure PM-156, Revision 8, "Visual Inspection of Plant Structures."

Appendices

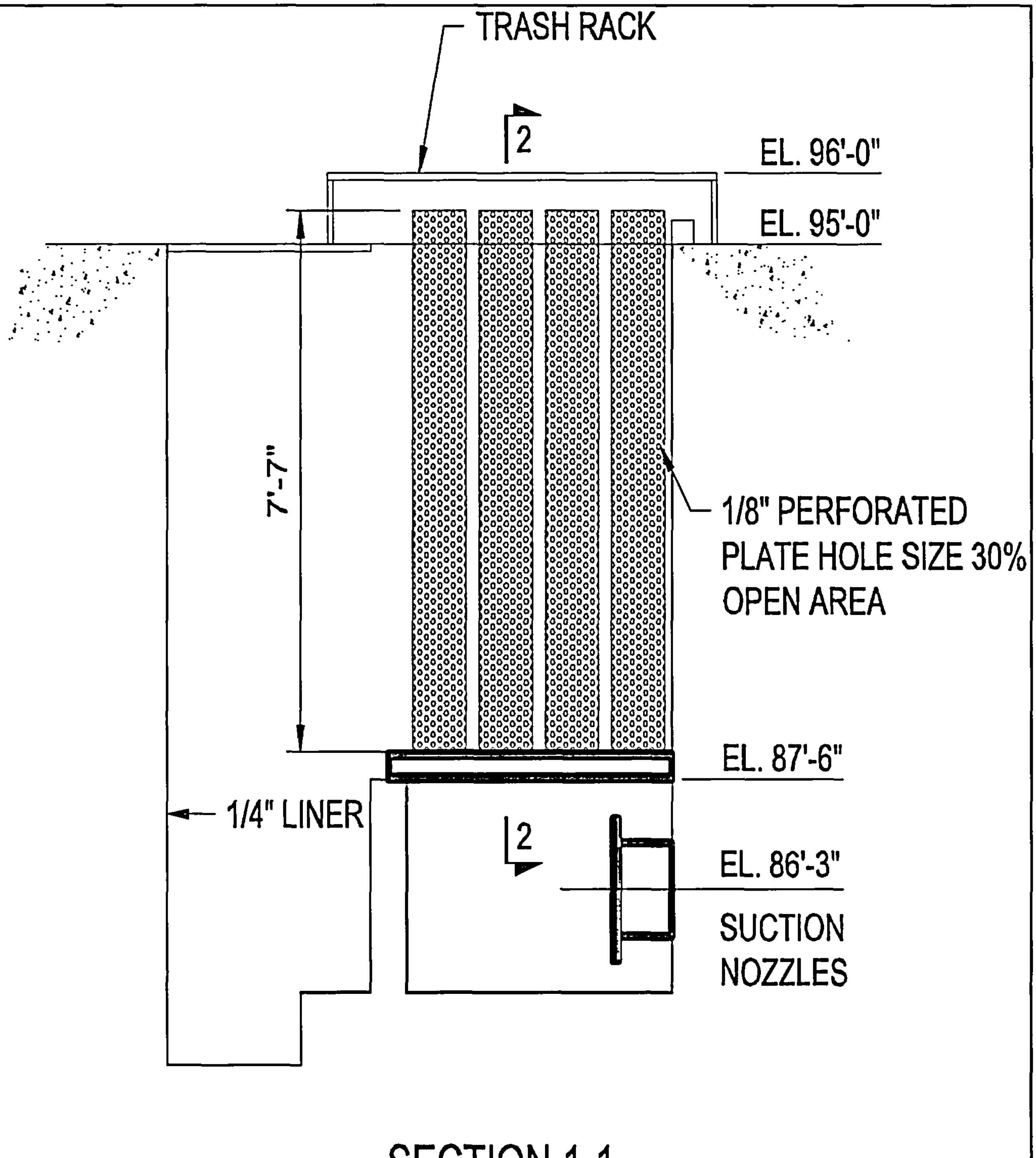
1. Schematic of new CR3 Sump Strainer Assembly
2. CR3 Containment Walkdown Surveillance Results
3. CR3 Plant Specific Comparison to ICET

Appendix 1 (CR3)
Schematic of new RB Sump Strainer Assembly



PLAN

REACTOR BUILDING EMERGENCY SUMP @ EL. 96'-0"
(TRASH RACK NOT SHOWN FOR CLARITY)


TRASH RACK
2
EL. 96'-0"
EL. 95'-0"
7'-7"
1/8" PERFORATED
PLATE HOLE SIZE 30%
OPEN AREA
EL. 87'-6"
1/4" LINER
2
EL. 86'-3"
SUCTION
NOZZLES

SECTION 1-1

Appendix 2 (CR3)
Containment Walkdown Surveillance Results
(Calc M04-0004, Reference 17)

Insulation Quantity by Location

Insulation Type	Quantity by Location					
	Total	Inside Primary Bio-Shield	Inside Secondary Bio-Shield	North D-Ring	South D-Ring	Outside Bio-Shields
RMI	199,207 ft^2	28,012 ft^2	114,528 ft^2	64,425 ft^2	50,103 ft^2	6,326 ft^2
Mineral Wool	2,731 ft^3	0 ft^3	800 ft^3	405 ft^3	395 ft^3	1220 ft^3
NUKON®	46 ft^3	0 ft^3	41 ft^3	41 ft^3	0 ft^3	5 ft^3
Armaflex	507 ft^3	0 ft^3	49 ft^3	28 ft^3	21 ft^3	458 ft^3

Fibrous Insulation Debris Source Term – LBLOCA

Insulation Type	Total Amt. Destroyed	Fines (individual fibers)	Small pieces (< 6 inches on a side)
Mineral Wool	405 ft^3	81 ft^3	324 ft^3
Nukon®	41 ft^3	8 ft^3	33 ft^3

Reflective Metal Insulation Debris Source Term – LBLOCA

Total Amount Destroyed	Density lbm/ft^3	Amount Destroyed by Size Distribution					
		¼ inch	½ inch	1 inch	2 inches	4 inches	6 inches
7341 ft^2	484	316 ft^2	1483 ft^2	1534 ft^2	1879 ft^2	1233 ft^2	896 ft^2

Failed Coating Debris Source Term

Coating Description	Failed Surface Area (ft^2)	Applied Thickness	Volume (ft^3)	Density (lb/ft^3)	Weight (lbs)	Failed Size
Plasite 9028 MI	1809.6	8 mil	1.21	119.8	144.5	10□
Plasite 9009	1809.6	8 mil	1.21	95.5	115.6	10□
Hi-Heat Aluminum	1467	0.75 mil	0.092	90	8.28	10□
Unqualified Coatings	1000	6 mil	0.5	94	47.0	6 mil
Failed D-Ring 9028MI	9066	8 mil	6.04	119.8	723.6	8 mil
Failed D-Ring 9009	9066	8 mil	6.04	95.5	576.8	8 mil

Latent Debris Source Term

Latent Debris Type	Reactor Building Area				
	El 95'-0"	El 119'-0"	El 160'-0"	North D-Ring	South D-Ring
Labels – Adhesive Labels	309 Labels ($19.3 ft^2$)	903 Labels ($56.4 ft^2$)	107 Labels ($6.6 ft^2$)	875 Labels ($54.6 ft^2$)	750 Labels ($46.8 ft^2$)
Tags – Ceramic hanging Tags	298 Tags ($69.8 ft^2$)	397 Tags ($93.0 ft^2$)	23 Tags ($5.4 ft^2$)	75 Tags ($17.5 ft^2$)	60 Tags ($14.0 ft^2$)
Marinite and Fire Boards	Yes (1) in Cable Tray near ceiling	Yes, in Cable Trays	NA	NA	NA
Radiant Shields	Yes (1)	None	NA	NA	NA

Latent Debris Type	Mass (lbm)	Density	Size
Dirt & Dust	170	168 lbm/ft^3	5.68 E-05 ft
Latent Fiber	30	94 lbm/ft^3	2.3 E-05 ft

ZOI Radii for CR3 Insulation and Coating Materials

Insulation Types	Destruction Pressure (psi)	ZOI Radius (Radius/Break Diameter) Value Used
Protective Coatings	1000 (assumed)	4.0
Mirror® with Sure-Hold® Bands	90	2.4
Unjacketed Nukon® Jacketed Nukon® with standard bands	6	17.0
Mirror® with standard bands	2.4	28.6

Appendix 3 (CR3)
Plant-Specific Comparison to ICET

Material	Ratio Tested[4] (ratio units)	Test Percent Submerged[4]	Plant-Specific Ratio[5] (ratio units)	Refs.	Plant-Specific Percent Submerged
Zinc in Galvanized Steel	8.0 (ft^2/ft^3)	5	8000 ft^2 / 18633ft^3 (0.43 ft^2/ft^3)	27/15	< 10%
Inorganic Zinc Primer Coatings (non-top coated)	4.6 (ft^2/ft^3)[1]	4	400 ft^2 / 18633ft^3 (0.02 ft^2/ft^3)	28/15	~ 50%
Inorganic Zinc Primer Coatings (top coated)	0.0 (ft^2/ft^3)[2]	0	0	N/A	N/A
Aluminum	3.5 (ft^2/ft^3)	5	3040 ft^2 / 18633 ft^3 (0.16 ft^2/ft^3)	27/15	< 10%
Copper (including Cu-Ni alloys)	6.0 (ft^2/ft^3)	25	unknown	xx/15	0%
Carbon Steel	0.15 (ft^2/ft^3)	34	0	N/A	0%
Concrete(surface)	0.045 (ft^2/ft^3)	34	0	N/A	0%
Concrete(particulate)	0.0014 (lbm/ft^3)	100	200 lbm / 18633 ft^3 (dirt/dust) (0.01 lbm/ft^3)	20/15	100%
Insulation material[3] (mineral wool & fiberglass)	0.137 (ft^3/ft^3)	75	446 ft^3 / 18633 ft^3 (0.023 ft^3/ft^3)	20/15	75%

Buffer	Tested pH[4]	Plant-Specific pH
Trisodium Phosphate	7.35	7.0 – 8.0

1. This value addresses both untopcoated zinc-rich primer applied as an untopcoated system as well as zinc-rich primer exposed as a result of delamination of topcoat.

2. Topcoated inorganic zinc coatings are protected against exposure to both containment spray and the liquid inventory of the containment pool by the topcoat. Therefore, they do not contribute to the development of corrosion products. Also, epoxy-based protective coatings provide for small quantities of leachable material, typically less than 200 ppm of the applied coating. Therefore, epoxy topcoats are judged to not contribute to the corrosion product mix post-accident and are not included in this test program.

3. Two tests are to be conducted using 100% fiberglass as the insulation material. Two additional tests are to be run with 80% calcium silicate and 20% fiberglass as the insulation material. In both cases, the same ratio of insulation material-to-sump liquid inventory will be used.

4. Tested ratio, tested percent submerged, and test pH are from Tables 1, 3 and 4, respectively of "Test Plan: Characterization of Chemical and Corrosion Effects Potentially Occurring inside a PWR Containment Following a LOCA", Revision 13, dated 07/20/05.

5. Volume of 18633 ft^3 represents SBLOCA water level. The 21436 ft^3 used in the response to request 2(d)(iv) represents LBLOCA water level. Use of SBLOCA level is conservative for ratio determination.