James A. Spina
Vice President

Calvert Cliffs Nuclear Power Plant, Inc.
1650 Calvert Cliffs Parkway
Lusby, Maryland 20657
410.495.5200
410.495-3500 Fax

Constellation Energy
Nuclear Generation Group

February 29, 2008

U. S. Nuclear Regulatory Commission
Washington, DC 20555

ATTENTION: Document Control Desk

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 & 2; Docket Nos. 50-317 & 50-318
Supplemental Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized Water Reactors"

The purpose of this submittal is to provide the Calvert Cliffs Nuclear Power Plant (Calvert Cliffs) supplemental response to the Generic Letter (GL) 2004-02 (Reference a). The Nuclear Regulatory Commission (NRC) issued Reference (a) to request that addressees perform an evaluation of the Emergency Core Cooling System (ECCS) and Containment Spray (CS) system 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 addressees to provide the NRC with a written response in accordance with 10 CFR 50.54(f). The request was based on identified potential susceptibility of the pressurized water reactor recirculation sump screens to debris blockage during design basis accidents requiring recirculation operation of ECCS or CS and on the potential for additional adverse effects due to debris blockage of flowpaths necessary for ECCS and CS recirculation and containment drainage.

An initial response to the GL was followed by supplemental responses. In 2006, the NRC requested additional information from all affected licensees. Reference (b) provided an alternative approach for addressing all outstanding requests for additional information from the NRC, including the expectation that all necessary responses would be provided by December 31, 2007. Reference (c) subsequently extended the time allowed to provide the requested information to February 29, 2008. In accordance with this request, Calvert Cliffs is providing the required supplemental response, addressing the GL actions at Calvert Cliffs Units 1 and 2 in Attachment (1). This response was prepared using the guidelines of Reference (b).

Additionally, please note that an extension was granted for Unit 1 to allow for the installation of a new containment sump strainer to the Spring 2008 refueling outage starting no later than March 2008. The same system was installed on Unit 2 during the spring 2007 refueling outage. Also, References (d) and

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(e) requested an extension for both Units 1 and 2 to June 30, 2008 to complete additional testing and provide the final results to the NRC. This extension request was approved in Reference (f).

Should you have questions regarding this matter, please contact Mr. Jay S. Gaines at (410) 495-5219.

Very truly yours,

STATE OF MARYLAND :
: **TO WIT:**
COUNTY OF CALVERT :

I, James A. Spina, being duly sworn, state that I am Vice President - Calvert Cliffs Nuclear Power Plant, Inc. (CCNPP), and that I am duly authorized to execute and file this response on behalf of CCNPP. To the best of my knowledge and belief, the statements contained in this document are true and correct. To the extent that these statements are not based on my personal knowledge, they are based upon information provided by other CCNPP employees and/or consultants. Such information has been reviewed in accordance with company practice and I believe it to be reliable.

Subscribed and sworn before me, a Notary Public in and for the State of Maryland and County of St. Mary's, this 29th day of February, 2008.

JANET L. SCULLY NOTARY PUBLIC ST. MARY'S COUNTY

WITNESS my Hand and Notarial Seal:

Janet L. Scully
Notary Public

My Commission Expires:

March 1, 2011
Date

JAS/PSF/bjd

Attachments: (1) Supplemental Response to Generic Letter 2004-02
(2) ECCS and CS System Figures

cc: D. V. Pickett, NRC
S. J. Collins, NRC
Resident Inspector, NRC
R. I. McLean, DNR

REFERENCES:

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

(b) Letter from W. H. Ruland (NRC) to A. Pietrangelo (NEI), dated November 21, 2007, Revised Content Guide for Generic Letter 2004-02 Supplemental Responses

(c) Letter from W. H. Ruland (NRC) to A. Pietrangelo (NEI), dated November 30, 2007, Supplemental Licensee Responses to Generic Letter 2004-02

(d) Letter from Mr. J. A. Spina (CCNPP) to Document Control Desk (NRC), dated December 10, 2007, Request for Extension for Completion of Activities Related to Generic Letter 2004-02

(e) Letter from Mr. J. A. Spina (CCNPP) to Document Control Desk (NRC), dated December 20, 2007, Request for Additional Information – Request for Extension for Completion of Activities Related to Generic Letter 2004-02

(f) Letter from Mr. D. V. Pickett (NRC) to Mr. J. A. Spina (CCNPP), dated December 27, 2007, Extension for Completion of Activities Related to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors"

ATTACHMENT (1)

SUPPLEMENTAL RESPONSE TO GENERIC LETTER 2004-02

Calvert Cliffs Nuclear Power Plant, Inc.
February 29, 2008

OVERALL COMPLIANCE

NRC Issue **1**:

Provide information requested in GL 2004-02, "Requested Information." Item 2(a) regarding compliance with regulations. That is, provide 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.

Response to Issue 1:

At Calvert Cliffs, an emergency recirculation sump is provided for each unit. Each Emergency Core Cooling System (ECCS) sump serves both trains of the ECCS and the Containment Spray (CS) system. In response to the Nuclear Regulatory Commission (NRC) Generic Letter (GL) 2004-02, Calvert Cliffs Nuclear Power Plant is significantly modifying the containment ECCS sump strainer with a passive strainer system designed, manufactured and tested by Control Components, Incorporated (CCI) of Winterthur, Switzerland. This system has a strainer surface area of approximately 6,000 ft^2. The sump strainer system is designed to ensure the allowable head loss is not exceeded following a loss-of-coolant event (LOCA), thereby not impacting the operability of the ECCS and CS system.

The containment sump strainer system was installed on Unit 2 in the Spring 2007 refueling outage and will be installed during the Unit 1 Spring 2008 refueling outage. The system has three strainer module rows utilizing 33 strainer modules connected to a central water duct that discharges directly into the sump, which houses the two ECCS pump suction lines. Each strainer module has a series of strainer cartridges constructed of perforated stainless steel plate. Following a LOCA event, all liquid used for recirculation must pass through these strainer cartridge perforations or similar sized strainer system gaps prior to entering the sump. The strainer in the Containment is sized for the expected full design basis debris load.

Strainer head loss testing performed in the vendor's Large Scale Loop facility using fiber and coating debris loads generated from a double-ended guillotine break of the Reactor Coolant System (RCS) hot leg demonstrated a strainer head loss on the order of 1-2". This head loss allows for ample net positive suction head (NPSH) margin for the ECCS and CS pumps even assuming the only NPSH available is the static head of water from the sump pool to the pump suction.

Quality-assured strainer head loss testing performed using fiber, coating, and chemical precipitant debris loads generated from a double-ended guillotine break of the RCS hot leg demonstrated a strainer head loss that exceeded the allowable head loss limit as noted in Reference 1. While overall compliance with the applicable regulatory requirements can not be formally demonstrated at present, non-quality assured testing was conducted in January 2008 using debris loads estimated based on a reduction of the zones of influence, non-transportability of certain coatings, and reduced aluminum loads inside Containment. Acceptable results were achieved. This non-quality assured testing will be followed up with formal quality-assured testing in spring 2008.

The Calvert Cliffs licensing basis will be updated in accordance with the requirements of 10 CFR 50.71 to reflect the results of the analyses and the modifications performed to demonstrate compliance with the regulatory requirements. There are no currently identified licensing actions or exemption requests needed to support changes to the plant licensing basis as a result of the Generic Safety Issue (GSI)-191 improvements.

GENERAL DESCRIPTION OF AND SCHEDULE FOR CORRECTIVE ACTIONS

NRC Issue 2:

Provide a general description of actions taken or planned, and dates for each. For actions planned beyond December 31, 2007, reference approved extension requests or explain how regulatory requirements will be met as per "Requested Information" Item 2(b). That is provide 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.

Response to Issue 2:

As of December 31, 2007, Calvert Cliffs Units 1 and 2 have completed the following GL 2004-02 actions, analyses and modifications.

- Latent debris walkdowns
- Debris generation analysis (being revised)
- Containment debris transport analysis (being revised)
- Hydraulic model of the ECCS
- Bypass testing
- Detailed structural analysis of the new strainers
- Installed 6000 ft^2 surface area replacement strainer system in Unit 2

As of December 31, 2007, the following activities were completed on behalf of Calvert Cliffs Units 1 and 2. However, based on the initial test results, additional testing will be performed in the Spring 2008. This additional testing affects completion of certain required analyses and activities as noted.

- Head loss analysis (pending strainer test results)
- ECCS and CS system net positive suction head analysis (pending strainer test results)
- Vendor strainer head loss testing (partially complete)
- Calcium-silicate insulation removal or banding within the zone of influence (Unit 2 complete, Unit 1 pending)

Calvert Cliffs Units 1 and 2 have requested (References 1 and 2) and received approval for (Reference 3) an extension until June 30, 2008 for the completion of the additional testing identified above and the following activities.

- Downstream wear and blockage analysis
- ECCS throttle valve wear and blockage testing
- High pressure safety injection (HPSI) cyclone separator blockage testing
- Aluminum abatement
- CS and HPSI pump mechanical seal testing
- Vortex testing and/or analysis
- Debris interceptor testing
- Latent debris walkdowns

SPECIFIC INFORMATION REGARDING METHODOLOGY FOR DEMONSTRATING COMPLIANCE

NRC Issue 3a:

Break Selection

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

1. *Describe and provide the basis for the break selection criteria used in the evaluation.*
2. *State whether secondary line breaks were considered in the evaluation (e.g., main steam and feedwater lines) and briefly explain why or why not.*
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.*

Response to Issue 3a1:

A number of breaks were considered to ensure that the breaks that bound variations in debris generation by the size, quantity, and type of debris are identified. The selection of line break locations to be evaluated depends on both maximizing debris generation, and maximizing debris types which might create the worst-case debris mixture for strainer head loss. Based on various postulated break locations, the following break locations were evaluated to maximize the postulated debris created.

The reactor cavity wall and bio-shield walls of the containment interiors divide the RCS piping into two completely separate compartments which are closed at the top and sides, and partially closed at the bottom. The compartment size is such that a break in the hot leg (42" ID) can adversely affect all the non-encapsulated insulation inside the compartment in which it is located. Therefore, the maximum insulation debris generation is a hot leg break (which is larger than a cold leg break) located at the base of the steam generator (largest source of insulation) as this will maximize the amount of insulation removed from the steam generator.

A break in 11/21 Steam Generator compartment would generate more insulation debris because the pressurizer surge line, and the pressurizer spray lines are located in these compartments. A break in 12/22 Steam Generator compartment was also reviewed since there is more mineral wool insulation (from the regenerative heat exchanger) in this compartment. This evaluation showed that no mineral wool insulation debris would be generated by the limiting hot leg break location. Therefore, a hot leg break in 11/21 Steam Generator compartment was found to be bounding.

Breaks in other parts of the RCS hot leg would generate less steam generator insulation debris. Breaks in the RCS cold leg and surge lines will generate the same types of insulation debris in smaller quantities plus a small amount of mineral wool. A break in the reactor cavity (inside the primary shield wall) will only generate reflective metal insulation debris, and thus will have much less impact on strainer head loss.

Response to Issue 3a2:

For feedwater line breaks and main steam line breaks, recirculation from the ECCS sump is not credited for the accident response for Calvert Cliffs. Therefore, analysis of breaks in the main steam and feedwater lines were not performed in response to GL 2004-02.

Response to Issue 3a3:

Based on the above discussion, the break selection included the location with the greatest effect on insulation, has the most direct path to the ECCS sump, and generated the largest amount of coating debris. Since this results in the greatest impact on head loss and wear of downstream components the hot leg break in the 11/21 Steam Generator compartment is currently considered to be the biggest challenge to post-accident sump performance. However, walkdowns are being conducted during the Spring 2008 refueling outage using reduced zones of influence for coatings. The results of these walkdowns may indicate that cold leg break could generator more coatings debris.

<u>*NRC Issue 3b*</u>:

Debris Generation/Zone of Influence (zone of influence) (excluding coatings)

The objective of the debris generation/zone of influence 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 zone of influences for generating debris. Identify which debris analyses used approved methodology default values. For debris with zone of influences not defined in the guidance report (GR)/safety evaluation (SE), or if using other than default values, discuss method(s) used to determine zone of influence and the basis for each.*
2. *Provide destruction zone of influences and the basis for the zone of influences for each applicable debris constituent.*
3. *Identify if destruction testing was conducted to determine zone of influences. 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).*
4. *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.*
5. *Provide total surface area of all signs, placards, tags, tape, and similar miscellaneous materials in containment.*

<u>Response to Issues 3b1 and 3b2</u>:

The current debris generation analysis uses approved methodology default values for Transco reflective metal insulation, Transco mineral wool, unjacketed Temp-Mat, and jacketed generic fiberglass.

Destructive testing was used to determine the zone of influences of the remaining debris sources listed below.

Material	Zone of Influence Radius Break Diameter	Reference
Transco reflective metal insulation	2	Reference 4, page 30
Transco mineral wool	2	Note 1
Nukon jacketed w/standard bands	7	Reference 5, page 1-6 (Note 2)
Transco Thermal Wrap	7	Note 3
Calcium-silicate insulation	3	Reference 6, page 1-4 (Note 4)
Generic fiberglass insulation	17	Note 5
Temp-Mat insulation	17	Note 6
Inorganic zinc coatings without topcoat	5	Reference 7, page 1-2
Epoxy coatings	4	Reference 7, page 1-3
Marinite board	8	Reference 8, page 4-3

Note 1: The mineral wool at Calvert Cliffs was procured from Transco using the same specification as the Transco reflective metal insulation. Both insulations are encapsulated in an identical

manner. Therefore a zone of influence equal to Transco reflective metal insulation is employed. Use of a relatively small zone of influence in this application is corroborated by the work done in Reference 5 for encapsulated Min-K insulation where a small zone of influence was also observed.

Note 2: Reference 5 actually justifies a zone of influence of 5 L/D; however, for conservatism the document recommends a zone of influence of 7 L/D.

Note 3: Transco Thermal Wrap is a low-density fiberglass insulation nearly identical to Nukon, and are jacketed in nearly identical manner. Therefore, the same zone of influence shall be applied.

Note 4: Use of the specified zone of influence assumes that jacketing is banded at 3" centers. All calcium-silicate insulation with the potential of being in a zone of influence has been banded at 3" centers.

Note 5: Our generic fiberglass insulation, while a low-density fiberglass, does not have the cloth jacketing of Nukon or thermal wrap, and its jacketing is of a thinner gauge and is held on by rivets, not bands. At present, the conservative zone of influence for unjacketed Nukon from page 30 of Reference 4 will be applied. If future head loss testing necessitates or if margin is needed in the debris generation calculation, additional work may be conducted to remove this conservatism.

Note 6. Temp-Mat is a heavier insulation than Nukon, and per Table 3-2 of Reference 4 it has a zone of influence of 11.7 when a stainless steel wire retainer is used. Since stainless steel jacketing is not always employed, the zone of influence for Temp-Mat will also be taken as that of unjacketed Nukon from page 30 of Reference 4.

Response to Issue 3b3:

The current debris generation analysis uses approved methodology default values for Transco reflective metal insulation, Transco mineral wool, unjacketed Temp-Mat, and jacketed generic fiberglass.

Destructive testing was used to determine the zones of influence of the remaining debris sources listed in the response above. Documentation of this testing is provided in References 5 through 8. A summary description of the test procedure and results is provided below.

The following description applies to all the WCAP testing:

Testing was conducted at Wyle Labs. The jet model described in American National Standards Institute/American Nuclear Society Standard 58.2-1988 was used to evaluate the placement of test articles in front of the jet nozzle. A two-phase jet originating from a sub-cooled, high pressure, high temperature reservoir was directed at the test articles. A rupture disk was used to simulate a pipe break. This is a similar approach as that taken by the NRC for testing reported in Appendix VI.3.2.2 of Reference 4, and by others as reported in Section 3.2.2 of Reference 9.

WCAP-16710-P: The test article consisted of jacketed Nukon fiber wrapped around an 8" schedule 80 pipe. At a zone of influence of 5 diameters (D) no damage to the Nukon pillow was observed beyond that attributed to the impact and abrasion of the test fixture.

WCAP-16720-P: The test article consisted of jacketed calcium-silicate insulation banded at 3" centers mounted on a 2" schedule 160 pipe. At a zone of influence of 3D, the stainless steel jacketing was bent and torn between the clamps, and the calcium-silicate insulation appeared intact along the length of the specimen.

WCAP-16568-P: The test articles of interest to Calvert Cliffs included non-topcoated inorganic zinc primer on a steel substrate and inorganic zinc primer with two coats of epoxy topcoat on a steel substrate. For epoxy-based coatings regardless of the substate to which they were applied no detectible coating loss was determined at the tested length/diameters (L/D) of 2.06 and 1.37. The non-topcoated inorganic zinc primer showed some loss of coating thickness at an L/D = 3.23, and less at an L/D = 3.68. Extrapolation determined that no coating loss would occur at an L/D of 4.28.

SL-009195: Testing was conducted at Wyle Labs using their hot water blowdown test facility. The test article consisted of ½" Marinite board attached to 16-gauge galvanized steel cable tray sections. At zones of influence less than 8.0 D, erosion was observed at the point of jet impingement. The maximum specimen weight-loss was found to be 0.87%.

Response to Issue 3b4:

Table 3b4-1
Summary of LOCA Generated Debris

Debris Name	Debris Type	11 Compartment Volume (ft^3)	12 Compartment Volume (ft^3)	21 Compartment Volume (ft^3)	22 Compartment Volume (ft^3)	Bounding Volume (ft^3)
Mineral wool insulation	Fiber	0.00	6.12	0.00	6.12	6.12
Generic fiberglass	Fiber	82.10	73.87	71.93	111.40	111.40
Temp-Mat insulation	Fiber	12.80	26.32	12.80	23.76	26.32
Transco Thermal Wrap insulation	Fiber	477.18	476.39	467.74	474.39	477.18
Nukon insulation	Fiber	355.50	284.60	407.50	336.20	407.50
Transco reflective metal insulation	Metal	28.60	28.60	0	0	28.60
Qualified coatings	Particulate	7.15 (Note 1)	7.15 (Note 1)	7.15 (Note 1)	7.15 (Note 1)	7.15 (Note 1)
Unqualified coatings	Particulate	30.00	30.00	30.00	30.00	30.00
Latent debris	Particulate	4.29 (Note 1)	4.29 (Note 1)	4.29 (Note 1)	4.29 (Note 1)	4.29 (Note 1)
Labels	Particulate	0.57	0.57	0.57	0.57	0.57

Note 1: Walkdowns conducted during the 2008 refueling outage are re-verifying these results. These results may change based on the walkdown data and will be used in future testing.

Response to Issue 3b5:

The strainer design allows for 270 ft^2 of sacrificial surface area. This is to account for the stick-on type labels applied to items such as cable trays. Valve tag labels are made of materials that will sink intact. Procedures require that all placards be chained so they won't transport to the sump strainer.

***NRC Issue 3c*:**

Debris Characteristics

The objective of the debris characteristics determination process is to establish a conservative debris characteristics profile for use in determining the transportability of debris and its 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.*

Response to Issue 3c1:

The debris sources at Calvert Cliffs include insulation, coating, and latent debris.

Table 3c1–1
Debris Sources

Material	Percentage Small Fines	Percentage Large Pieces
Nukon insulation	60	40
Transco Thermal Wrap insulation	60	40
Temp-Mat insulation	60	40
Generic fiberglass	100	0
Fire barrier in zone of influence	Note 1	0
Coatings in zone of influence	100 (<10 μm)	0
Qualified coatings outside zone of influence	0	0
Unqualified coatings outside zone of influence	See Response to Issue 3c4	See Response to Issue 3c4
Fire barrier (covered) outside zone of influence	0	0
Fire barrier (uncovered) outside zone of influence	0	0
Latent debris	100 (<100 μm)	0

Note 1: Calvert Cliffs uses Marinite board as a fire barrier material for cable trays. It has been assumed that all Marinite board in the zone of influence became small fines. As part of the effort to reduce strainer head loss, Calvert Cliffs will use data from Reference 8 to determine the percentage of small fines of Marinite board in the zone of influence.

Response to Issue 3c2:

The bulk densities of material and destroyed debris are provided in the debris generation calculation and listed in the table below. These values are obtained from the NRC approved methodology or vendor specific information in the case of coatings.

Table 3c2-1
Debris Densities

Insulation Type	Density of Individual Fiber (lbm/ft^3)	Density of a Blanket of Product (lbm/ft^3)
Nukon	159	2.4
Transco Thermal Wrap	159	2.4
Generic fiberglass	159	2.4
Temp-Mat	162	11.8
Mineral wool	90	7-8

Coating Material	Material Density (lbm/ft^3)	Characteristic Size (ft)
Inorganic zinc	457	$3.2x10^{-5}$
Alkyd coating	98	$3.2x10^{-5}$

Topcoats

Vendor	Trade Name	Dry Film Density (lb/gal)	Dry Film Density (lb/ft^3)
Carboline	Carboguard 890	14.52	109
Ameron	Amercoat 66	14.04	105
Ameron	Amercoat 90	14.80	111
Valspar	89 Series	14.04	105

Primers

Vendor	Trade Name	Density (lb/gal)	Density (lb/ft^3)
Carboline	Carboguard 890	14.52	109
Carboline	Starglaze 2011 S	19.28	144
Ameron	Dimetcote 6	40.1	300
Ameron	Nu-Klad 110AA	20.1	150
Valspar	13-F-12	40.1	300

From Section 3.5.2.3 of Reference 10 the following properties are to be used for latent debris:

Fiber density = 62.4 lbm/ft^3
Particulate density = 100 lbm/ft^3
Particulate diameter = 10 μm ($3.28x10^{-5}$ ft)

Response to Issue 3c3:

Since the head loss across the ECCS strainers is determined via testing, these values are not used in the design basis for Calvert Cliffs. Therefore, these values are not provided as part of this response.

Response to Issue 3c4:

The Calvert Cliffs debris generation, transport, and head loss analyses have used the debris characterization assumptions provided in Reference 4. Specifically, the size of particulates is consistent with 10 microns for coatings particulate. Coatings that were installed as qualified, but have been subsequently classified as unqualified based on inspections are assumed to have failure distributions consistent with that reported in Reference 11. In general, this report concludes that epoxy topcoated systems fail as chips when exposed to design basis accident environments, while non-topcoated inorganic zinc primers fail in pigment size (i.e., 10 microns). For downstream effect evaluations, the size distribution of unqualified coatings was assumed to be that given in the Linear Mass Fraction column of Table I-1 of Reference 12.

***NRC Issue 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.

1. *Provide the methodology used to estimate quantity and composition of latent debris.*
2. *Provide the basis for assumptions used in the evaluation.*

3. *Provide results of the latent debris evaluation, including amount of latent debris types and physical data for latent debris as requested for other debris under c. above.*
4. *Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.*

<u>Response to Issue 3d1</u>:

Latent debris walkdowns were performed at Calvert Cliffs Units 1 and 2 in accordance with Reference 10, Section 3.5. Approximately 32 samples were taken of 10 different surface types. When multiple samples were taken of the same surface type the results were averaged. The debris weighed over the sampled area was then ratioed to the total surface area inside Containment for that type of debris. The total surface area was determined using plant drawings. This latent debris walkdown is being repeated in the Unit 1 containment during the Spring 2008 refueling outage. Approximately 60 samples are being taken. This data can be used to update the latent debris volumes.

<u>Response to Issue 3d2</u>:

Debris was assumed to be normally distributed for a given sample type. This assumption was supported by the walkdown observation that latent debris was uniform for a given surface type. Averaging the latent debris for surface types having multiple samples is consistent with the sampling approach taken to estimate the amount of latent debris inside Containment.

<u>Response to Issue 3d3</u>:

Latent debris includes dirt, dust, lint, fibers, etc., that are present inside the Calvert Cliffs Containments and could be transported to the ECCS sump screen during the post-LOCA recirculation phase of ECCS operation. This debris could be a contributor to head loss across the ECCS sump screen. In accordance with recommendations in Reference 13, latent debris samples were collected to estimate the actual mass of latent debris inside of Containment. A latent debris load of 20 lbs was computed. The latent debris was described as dust.

It is recognized that this value of latent debris is low compared to others in the industry. Therefore, this value has not been utilized yet in head loss or downstream wear evaluations. A confirmatory walkdown will be conducted in the 2008 refueling outage for Unit 1 to determine if this latent debris load is reasonable. Additional detail concerning the physical data of the latent debris will also be obtained.

<u>Response to Issue 3d4</u>:

Latent debris in the form of dust/fiber is accounted for in test and analysis by including it in the debris mix. Therefore, no specific sacrificial area needs to be allocated to it. Foreign material such as paper inadvertently left inside Containment can be accounted for by crediting the conservative sacrificial area allocated for stick-on labels (see Response to Issue 3b5 above).

<u>NRC Issue 3e</u>:

Debris Transport

The objective of the debris transport evaluation process 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 and methods used in the analysis that deviate from the approved guidance.*

3. *Identify any computational fluid dynamics codes used to compute debris transport fractions during recirculation and summarize the methodology, modeling assumptions, and results.*
4. *Provide a summary of, and supporting 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.*

Response to Issue 3e1:

Calvert Cliffs uses the transport fractions for fiber and particulate provided in Table 3-3 of Reference 4. For previously qualified coatings outside the zone of influence, credit is taken for the non-transportability of the coating chips at velocities less than 0.2 ft/sec as allowed by Reference 14.

Response to Issue 3e2:

There were no deviations from approved guidance (References 4 and 14) regarding debris transport.

Response to Issue 3e3:

No computational fluid dynamics codes were used by Calvert Cliffs.

Response to Issue 3e4:

Calvert Cliffs is installing debris interceptors in Unit 1 during the Spring 2008 refueling outage to shield a portion of the strainer surface area from debris. At present, no credit is taken in evaluations for these debris interceptors. If testing scheduled for spring 2008 indicates that the debris interceptors need to be credited in evaluations, then this determination will be communicated to the NRC in our final response on June 30, 2008.

Response to Issue 3e5:

Calvert Cliffs did not credit the settling of small debris fines in the transport calculations.

Response to Issue 3e6:

Table 3e6-1
Bounding Debris Quantity at ECCS Sump Screen for Calvert Cliffs

Debris Name	Quantity Generated (ft^3)	Transport Fraction	Quantity at Sump (ft^3)
Fibrous debris			
- Nukon	407.5	0.60	244.5
- Transco	477.18	0.60	286.3
- Temp-Mat	26.32	0.60	15.79
- Generic	111.40	1.00	111.40
- Mineral wool	6.12	1.00	6.12
		TOTAL	664.11
Transco reflective metal insulation debris	28.6	1.00	28.6
Qualified coatings	7.15 (Note 1)	1.00	7.15
Unqualified coatings	30.0	0.0624	1.87
Latent debris	4.29 (Note 1)	1.00	4.29

Note 1: Containment walkdowns during the spring 2008 refueling outage may allow us to reduce this value.

***NRC Issue 3f*:**

Head Loss and Vortexing

The objectives of the head loss and vortexing evaluations are 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. Provide bases for key assumptions.*
4. *Provide a summary of the methodology, assumptions, and results of prototypical head loss testing for the strainer, including chemical effects. Provide bases for key assumptions.*
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. *Describe significant margins and conservatisms used in the head loss and vortexing calculations.*
9. *Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the clean strainer head loss calculation.*
10. *Provide a summary of 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 net positive suction head (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, if so, provide a description of the scaling analysis used to justify near-field credit.*
13. *State whether temperature/viscosity was used to scale the results of the head loss tests to actual plant conditions. If scaling was used, provide the basis for concluding that boreholes or other differential-pressure induced effects did not affect the morphology of the test debris bed.*
14. *State whether containment accident pressure was credited in evaluating whether flashing would occur across the strainer surface, and if so, summarize the methodology used to determine the available containment pressure.*

<u>*Response to Issue 3f1*</u>:

Diagrams of the Calvert Cliffs ECCS and CS system for Units 1 and 2 are provided in Attachment (2) to the submittal.

<u>*Response to Issue 3f2*</u>:

Calculations for minimum containment flood level have demonstrated that, for a small break LOCA (SBLOCA) and a large break LOCA (LBLOCA), the ECCS strainers will be completely submerged at the time of ECCS switchover to the containment ECCS sump. The minimum calculated submergence level (level over the top of the strainer cassette), is as follows:

- SBLOCA – 1" (Note: this is applicable to break sizes smaller than 0.08 ft^2)
- LBLOCA – 7"

<u>*Response to Issue 3f3*</u>:

Calvert Cliffs has not completed vortex testing. The vortex testing will be completed and evaluated prior to our scheduled June 30, 2008 supplemental response.

<u>*Response to Issue 3f4*</u>:

Calvert Cliffs used the ECCS sump strainer supplier, CCI, to perform plant specific strainer head loss testing.

Two different test loop configurations were utilized for the Calvert Cliffs head loss testing, as follows:

1. Large Scale Loop Facility in Winterthur, Switzerland;
2. Multi Functional Test Loop (MFTL) at CCIs facility in Winterthur, Switzerland.

In each test one or more full-size strainer cartridges are placed in a test tank, and are subsequently loaded with the amount of debris computed to transport to this portion of the overall strainer. The volumetric flow rate is scaled so that the velocity through the strainer cartridges corresponds to that which would occur with the strainer installed in the plant during a LOCA.

Debris was introduced into the tank at the entrance to the strainer pockets, and approximately 5' away. Fiber debris is shredded, and diluted in water to minimize agglomeration of fines. Chemical precipitants are generated inside the test tank, by introducing solutions containing the elemental materials of calcium, silicon, and aluminum.

Large Scale Loop Facility:

The Large Scale testing loop contained a two-sided strainer array with three CCI strainer cartridges, per side, with 60 pockets placed in a pool that is filled with water (see Figure 3f4-1).

This testing provided further information into the expected head loss behavior of various types of debris.

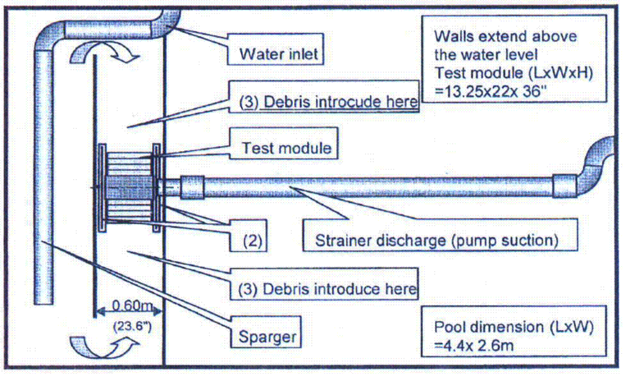


Figure 3f4-1
Outline of Large Scale Loop Facility

Multi Function Test Loop (MFTL):

The CCI MFTL is a closed recirculation loop as shown in Figure 3f4-2. The water recirculation in the loop occurs by means of a centrifugal pump with a flow rate capacity up to 125 m^3/h and a flow meter capacity of 80 m^3/h. The flow rate is adjustable by means of the frequency controlling of the rpm of the pump motor. Additionally the flow rate can be pre-adjusted by means of a valve in the downstream line. The water flow rate is measured using a KROHNE magnetic inductive flow meter. The temperature of the water is measured using a Ni-CrNi Thermocouple Type K.

The test program did not intend to take credit for near field debris settling. The debris was introduced directly at the inlet surface of the strainer. The chemicals were introduced in the middle section of the loop. The volume of water in the test loop is approximately 1700 liters.

Very little debris settlement occurred in the MFTL testing. For the Calvert Cliffs testing a solid guiding plate was added in the loop near the discharge pipe. This plate created turbulent flow that kept the debris from settling during loop operation. The height of this wall in the tank was adjusted in order to ensure minimal settling occurred. Through the use of turbulent flow and vertical flow field near the surface of the strainer, much of the debris remained elevated during the entire loop operation and never settled on the strainer or floor (until flow in the test loop was shutdown).

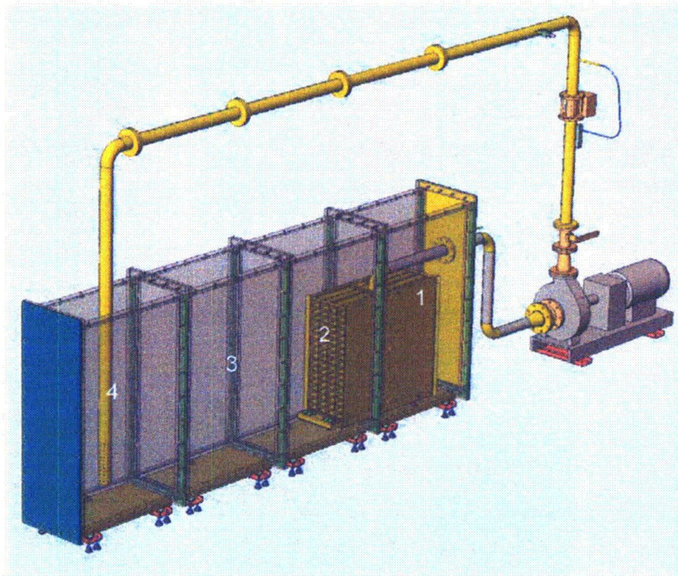


Figure 3f4-2
Outline of MFTL for Calvert Cliffs testing (4 modules shown)

The fibers used in the test had an as-fabricated density of 2.4 lb/ft^3, consistent with Reference 4, Section 3.5.2.3. The fibers were decomposed by first cutting with a leaf shredder, manually tearing the shredded fibers into smaller pieces and then soaking the pieces in a water bucket. A water jet was used to separate the fiber in the bucket after being shredded by the leaf shredder. The fibers used in the testing were produced by Transco.

Test Results

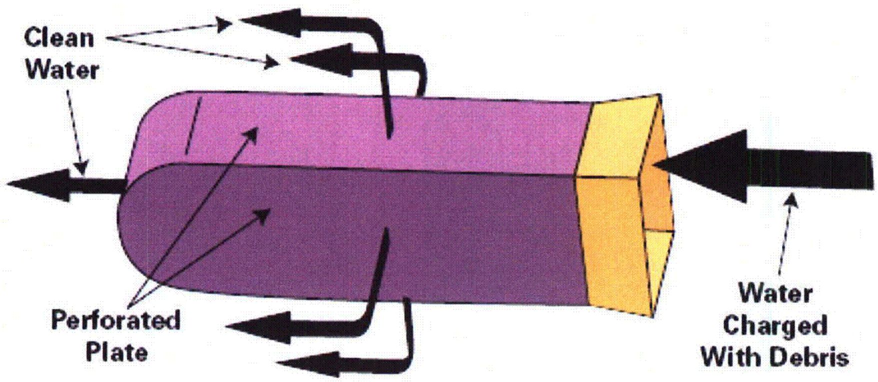
The latest-quality assured testing, conducted in November 2007, showed unacceptably high head losses. Calvert Cliffs has received an extension (Reference 3) to, among other things, conduct additional testing in the spring of 2008. These test results will be provided as part of our supplemental response due no later than June 30, 2008.

Response to Issue 3f5:

The pockets in CCIs strainer cassettes are designed to fill with debris with additional debris depositing on the outside of the strainer. The spacing of the strainer module rows between each other and with plant structures allows sufficient space for the debris to accumulate without interfering with the debris from another strainer row.

Response to Issue 3f6:

The strainer installed at Calvert Cliffs is CCI's pocket cassette type strainer. Figure 3f6-1 shows a representative pocket cassette strainer. During the November 2007 testing at CCIs Large Scale Loop Facility, attempts were made to generate a thin bed using Calvert Cliffs specific debris. The geometry of the pocket filtration surface is such that it was not possible to have a uniform fiber bed on the filtration surface. The measured head loss in this condition was on the order of 0.1".



CCI's horizontal cassette pocket with five flow paths

Figure 3f6-1
Pocket Cassette Strainer

During the scheduled spring 2008 testing, further attempts will be made to create a thin-bed in CCI MFTL. While a uniform thin-bed likely would not be achieved, it is currently envisioned to do a test where fiber is added incrementally until the entire filter surface is covered. This uneven fiber layer simulates the condition of minimum fiber bed thickness with the entire particulate load.

Response to Issue 3f7:

The acceptable maximum strainer head loss is based on ensuring adequate NPSH available to the pumps taking suction from the containment sump.

The minimum NPSH margin is approximately 2' (for the HPSI pump) based on static head to the ECCS pumps. The acceptable maximum strainer head loss for the replacement strainer was chosen to be 1' allowable margin. This strainer head loss will include both the tested head loss across the strainer filtration surface, and the analytically computed head loss in the strainer duct channels.

The strainer postulated maximum head loss due to the maximum quantity of debris that was calculated to reach the screens, including chemical effects will be determined by testing in the spring of 2008.

Response to Issue 3f8:

The key conservatism for the hydraulic analyses is the assumption that all small fines transport to the sump strainer. Testing at CCIs MFTL has shown significant quantities of settled small fines even in an agitated test pool. The low flow velocities in the Calvert Cliffs Containment account for the observed settling. We understand that other CCI customers did not observe this degree of settling because their flow rates were determined to be higher.

We will continue to pursue the issue (settling of fines) and believe that it must be resolved to allow us to complete testing. The fact that the strainer flow rate is so small that fines tend to settle, even at the inlet to the strainer, indicates a conservative overall design.

Response to Issue 3f9:

The clean strainer head loss across the filtration surface as measured in CCIs Large Scale Loop Facility was approximately zero.

The head loss in the axial flow channel between cartridges and in the radial duct are computed using formulas in Reference 15. Based on the computed Reynolds Number ($1.64x10^6$), flow formulas applicable to turbulent flow are used.

Influx flow from the side (i.e., through the cartridges) into the axial flow channel is considered. The friction drag coefficient is developed from the well-known Moody friction curves. A value of $\lambda = 0.025$ is used which is conservative for high Reynolds numbers. A relative roughness of 0.001 is used for the smooth stainless steel.

Head loss due to flow obstructions (i.e., seven stabilizer plates) and enlargements in the flow stream are considered using equations from Reference 15. The computed analytical head loss for the strainer interior is approximately 4.2".

Response to Issue 3f10:

A debris head loss analysis was performed by CCI during the sizing of the strainer using the equations from Reference 16.

The governing head loss analysis will consist of the analytically determined head loss of the strainer internals (see Response to Issue 3f10), and test results of the head loss across the debris bed on the filtration surface (See Response to Issue 3f4).

Response to Issue 3f11:

The ECCS sump screens are fully submerged under all accident scenarios that include ECCS recirculation. There is no vent above the water level.

Response to Issue 3f12:

The quality assured head loss testing with chemical effects conducted in November 2007 did not involve debris settling because a flow baffle plate was used to drive all debris to the strainer. Calvert Cliffs was concerned that this artificial means of driving the debris to the strainer was affecting the nature of the debris bed compaction, and thus providing a non-realistic head loss result. Non-quality assured testing conducted in January 2008 did not utilize this baffle plate, and a significant percentage of debris (both fiber and particulate) were observed to fall almost straight down from the introduction point, and not transport to the strainer. Other CCI customers utilized the exact same test loop without a baffle plate and did not have this degree of debris settling. The strainer vendor attributes the observed settling to the low approach velocities associated with our Containment layout. While we believe this demonstrates the overall conservativeness of our design, we also understand that the NRC has concerns about debris settling effects. Therefore, we will ensure future testing does not have some attribute that leads to debris settling that might not occur under actual accident conditions. Also, note that Calvert Cliffs does not use a computational fluid dynamics analysis to compute the amount of debris that transports to the strainer, but instead assumes the transport factions provided in Reference (10).

Response to Issue 3f13:

The test tank fluid temperature for head loss testing has been/will be approximately 15-20°C. The head loss results will be adjusted to 100°C (minimum available NPSH condition) by scaling the dynamic viscosity between these temperatures.

During previous testing, the borehole effect has been detected via sharp drops in head loss followed by gradual increases in head loss back to/near to the original peak head loss. This is believed to be an accurate representation of what will occur across the strainer filter surface during actual plant conditions. Calvert Cliffs will investigate the impact that a lower test temperature may have had on the propensity for boreholes to develop and will consider this during the final head loss testing.

Response to Issue 3f14:

Containment accident pressure is not credited in evaluating whether flashing occurs across the strainer surface.

NRC Issue 3g:

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 loss-of-coolant accident (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. *Provide the basis for the required NPSH values, e.g., three percent head drop or other criterion.*
4. *Describe how friction and other flow losses are accounted for.*
5. *Describe the system response scenarios for LBLOCA and SBLOCAs.*
6. *Describe the operational status for each ECCS and CSS pump before and after the initiation of recirculation.*
7. *Describe the single failure assumptions relevant to pump operation and sump performance.*
8. *Describe how the containment sump water level is determined.*
9. *Provide assumptions that are included in the analysis to ensure a minimum (conservative) water level is used in determining NPSH margin.*
10. *Describe whether and how the following volumes have been accounted for in pool level calculations: empty spray pipe, water droplets, condensation and holdup on horizontal and vertical surfaces. If any are not accounted for, explain why.*
11. *Provide assumptions (and their bases) as to what equipment will displace water resulting in higher pool level.*
12. *Provide assumptions (and their bases) as to what water sources provide pool volume and how much volume is from each source.*
13. *If credit is taken for containment accident pressure in determining available NPSH, provide description of the calculation of containment accident pressure used in determining the available NPSH.*
14. *Provide assumptions made which minimize the containment accident pressure and maximize the sump water temperature.*

15. *Specify whether the containment accident pressure is set at the vapor pressure corresponding to the sump liquid temperature.*
16. *Provide the NPSH margin results for pumps taking suction from the sump in recirculation mode.*

Response to Issue 3g1:

The containment sump feeds both trains of the ECCS and CS system. When the ECCS switchover from the refueling water tank (RWT) to the sump is completed, the HPSI pump and the CS pump take suction from the sump. The maximum flow rate from the sump occurs when the HPSI and the CS pumps take suction from the sump.

Maximum HPSI pump flow rate = 1060 gpm (two pumps operating)
Maximum HPSI pump flow rate = 650 gpm (one pump operating)
Maximum CS pump flow rate = 1750-1800 gpm per pump, maximum two pumps operating

Strainer design flow = 5000 gpm

Maximum post-RAS sump temperature
= 194.8°F for cold leg break LBLOCA with two safety trains operating
= 208.8°F for cold leg break LBLOCA with one safety train operating
= 210.0°F for hot leg break LBLOCA with one safety train operating

Minimum Containment water level = 3'-7" (LBLOCA)
Minimum Containment water level = 3'-1" (LOCAs smaller than 0.08 ft^2)

Response to Issue 3g2:

The assumptions used for the above analysis are:

- HPSI flow rate is throttled as directed by procedure
- CS flow rate is that predicted by a hydraulic flow model where the containment spray flow rate is upgraded 10% above the vendor pump curve
- the diesel is assumed to be at 2% over-frequency

Response to Issue 3g3:

The NPSH values are provided on the vendor pump curve as a function of flow rate.

Original test data for the CS pumps was used to determine the NPSH. The CS pump was tested at decreasing NPSH available values at a given flow rate. The last data point taken during testing was that NPSH available value where a decease in total developed head was observed.

The NPSH required value was then established as the second to last tested NPSH available value (i.e., the lowest one for which no decrease in total developed head was detected).

Similar data on our HPSI pumps could not be recovered from plant history records. However, correspondence with the HPSI pump vendor (Sulzer) regarding testing they did for another client having an identical pump indicates that the NPSH required values on the pump curve are based on a 3% degradation in the pump total developed head.

Response to Issue 3g4:

Hydraulic friction losses in the strainer flow channels are accounted for as described in the Response to Issue 3f9. Hydraulic friction flow losses in the ECCS recirculation piping are computed by a KYPIPE hydraulic model of the ECCS piping. The NPSH available to the HPSI and containment spray pumps is obtained by subtracting these hydraulic friction losses from the static head differential between the containment water height and the pump suction elevation.

Response to Issue 3g5:

The ECCS consists of three HPSI pumps, two LPSI pumps, and four safety injection tanks (SITs). Each HPSI pump injects into one of two high pressure injection headers, both of which feed each cold leg. The LPSI pumps inject into a low pressure injection header that feeds each cold leg. Each SIT injects into a single cold leg. Two HPSI pumps and the LPSI pumps are automatically actuated by a safety injection actuation signal that is generated by either a low pressurizer pressure (<1725 psia) or a high containment pressure signal (>4.75 psig). The SITs automatically discharge when the RCS pressure decreases below the SIT pressure.

LBLOCA

The HPSI and LPSI pumps automatically start when the pressurizer pressure is less than or equal to 1725 psia, or containment pressure is greater than or equal to 4.75 psig. Actual HPSI pump flow to the core will not begin until the pressurizer pressure is approximately 1270 psia, and actual LPSI pump flow to the core will not begin until the pressurizer pressure is approximately 185 psia.

The CS pumps automatically start at a containment pressure of 4.75 psig. Flow to the containment environment is delayed only by the time required to fill the empty CS headers. Containment air coolers will also start to control the air temperature in Containment.

The SITs automatically discharge to the RCS at an RCS pressure between 200 – 250 psig.

All pumps take suction from the RWT. When the RWT is depleted a RAS is generated, and HPSI and CS pump suction transitions from the RWT to the containment sump. The LPSI pumps are automatically stopped when the RAS is generated.

High pressure safety injection pump flow is throttled post-RAS, and decreases as decay heat decreases. Containment spray flow continues until the containment atmosphere temperature is below 120°F or less.

SBLOCA

The same automatic actuations exist for a SBLOCA. However, for a SBLOCA where the pressurizer pressure remains high for an extended period of time, the Operators may take actions to secure the LPSI pumps to avoid running on mini-flow recirculation for an extended period of time. Also, for SBLOCAs the SITs may be isolated prior to these tanks injecting into the RCS.

Response to Issue 3g6:

Pump	Injection Phase	Recirculation Phase
HPSI	On	Throttled
LPSI	On	Off
CS	On	On

Response to Issue 3g7:

Sump performance is most challenged at high flow rates since this increases strainer head loss and increases debris transport to the strainer. It has been identified that the failure of a LPSI pump to stop on RAS, either automatically or manually, is a single failure that must be addressed. Calvert Cliffs will address this single failure and provide the required information in our supplemental response by June 30, 2008.

Response to Issue 3g8:

The containment sump water level assumes minimum inventory from the RWT drains to the RCS. Water lost due to fill up of the containment spray and other piping is considered. The RCS volume is not assumed to empty into the sump pool. Hold up of water in the refueling pool cavities is assumed to occur. Safety injection tank inventory is considered for LOCAs greater than 0.08 ft^2.

Response to Issue 3g9:

The conservatism of the minimum containment water level is maintained by minimizing the sources of water and by maximizing the volume of water entrapment. Some of the specific examples of water sources that are minimized are given below:

- Minimum RWT inventory
  - minimum initial RWT volume allowed by Technical Specifications
  - RAS occurs at earliest point in setpoint band
  - no water transfer from RWT post-RAS even though it is the preferred source for over one more minute
- RCS inventory assumed to remain in RCS (very conservative for a LBLOCA).
- The sump piping assumed empty up to sump valves.
- The current sump level calculation assumes the reactor cavity holds up water even though a 4" drain exists in this compartment.

Response to Issue 3g10:

The containment spray pipe and other selected pipes are assumed to be empty for the water level calculation.

The hold up of water on horizontal surfaces was investigated and it was found that a 1/16" film would account for approximately 450 gallons. This was considered to be bounded by the assumption that no RCS volume contributes to the sump pool volume.

The outer wall of Containment is not close enough to the spray nozzles for the containment spray to reach them. The surface areas of the other vertical surfaces that could be sprayed are not significant to affect the water level calculation.

Response to Issue 3g11:

In the sump water level calculation, the volume occupied by concrete pillars is considered in the displacement of water. No other equipment or structures in the sump pool are assumed to displace the water.

Response to Issue 3g12:

The following water sources are considered as contributors to the containment post-accident pool volume:

- RCS - The RCS inventory assumed to remain in RCS and does not contribute to the containment post-accident pool volume.
- RWT – It is assumed that the RWT provides 49,921 ft^3 of water that empties to the lower level of Containment. This assumes the RWT is at the minimum water level allowed by the low-level alarm setpoint (including uncertainty) at the start of the accident. It also assumes that RAS occurs at the highest value in the setpoint band, and furthermore that no water transfers from the sump after a RAS is reached even though the RWT will be discharging inventory to the RCS for over a minute after that time.
- Safety Injection Tanks – For LOCAs greater than 0.08 ft^2 in size it is assumed that the inventory from four SITs inject into the RCS. The minimum volume per SIT of 1113 ft^3, specified by Technical Specification 3.5.1, is assumed to inject into the core. Since only passive components separate the SITs from the RCS at the start of an accident the inventory from all four SITs is assumed to empty to the RCS.

Response to Issue 3g13:

Credit is not taken for containment accident pressure in determining the available NPSH.

Response to Issue 3g14:

Containment pressurization is not considered in our sump NPSH evaluations.

The sump pool temperature calculation assumes a single failure resulting in the loss of both Containment air cooler trains. There is also no sump cooling as heat transfer to the containment basemat is not credited in the analysis. The analysis also neglects any cooling from the sump pool by means of evaporation. Finally, a containment pressure of 14.7 psia (as compared to 16.5 psia) is assumed along with 100% humidity. All these factors result in a conservative prediction of sump pool temperature.

Response to Issue 3g15:

For the NPSH evaluation, the vapor pressure corresponding to the sump temperature is used as the containment pressure during a LOCA.

Response to Issue 3g16:

Below is the minimum NPSH margin (NPSH Available minus NPSH Required):

Pump	**$NPSH_A$**	**$NPSH_R$**	**Margin**
HPSI	21.90 ft	19.5 ft	2.4 ft
CS	24.725 ft	21.5 ft	3.225 ft

The margins above do not include the head loss across the strainer filter or the head loss in the strainer.

NRC Issue 3h:

Coatings Evaluation

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

1. *Provide a summary of 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.*
4. *Provide bases for the choice of surrogates.*
5. *Describe and provide bases for coatings debris generation assumptions. For example, describe how the quantity of paint debris was determined based on zone of influence size for qualified and unqualified coatings.*
6. *Describe what debris characteristics were assumed, i.e., chips, particulate, size distribution and provide bases for the assumptions.*
7. *Describe any ongoing containment coating condition assessment program.*

Response to Issue 3h1:

A Bechtel construction specification was used to specify the coatings used during plant construction. It identifies the original primers used in Containment as Dimetcote No. 6 (also known as D6) and Mobilzinc 7. The original topcoats were Amercoat 66 and Mobil 89 Series.

Coatings that have been used at Calvert Cliffs since construction are identified in internal plant documents. These documents identify the primer, topcoat, and application standard to be used on the various surfaces inside Containment. A primer of Ameron D6 and a topcoat of Ameron 66 are the primary coatings referenced; however, Valspar 13F12 is used as a primer on some surfaces and Valspar 89 is used as the corresponding topcoat. Valspar 13F12 is the same as Mobilzinc 7 and Valspar 89 is the same as Mobil 89 Series.

New coatings are listed as Ameron 90, and Carboline 890. An additional update lists the metal primer as Carboline Carboguard 890, the concrete primer as Carboline Starglaze 2011S, and the topcoat as Carboline Carboguard 890.

Response to Issue 3h2:

All coatings in the zone of influence and all coatings of unknown pedigree (i.e., no proof it was ever qualified) are assumed to fail as 10 μm particles and transport to the sump. As discussed in Response to Issue 3c4 and Issue 3e1, for coatings that were installed as qualified, but subsequently found to be degraded per site inspection procedures, a portion of the coatings are assumed to fail as chips. Credit was then taken, as applicable, for the Reference 14 study that demonstrated paint chips will not transport in sump pool velocities less than 0.2 ft/sec.

Response to Issue 3h3:

The head loss testing used scaled quantities of coatings as part of the strainer debris load. Stone flour was used as a surrogate material for coatings that were assumed to fail as 10 μm particles. Actual paint chips made of Carboline Carboguard 890 were placed in the test tank during initial testing to assess the effect of these chips on the debris bed. Since these chips fell directly to the bottom of the tank even when introduced right at the face of the strainer, it was concluded that the Reference 14 coatings transport test data which showed the non-transportability of paint chips at velocities less than 0.2 ft/sec were applicable to our strainer installation. No further introduction of paint chips into the test was considered.

Response to Issue 3h4:

Stone flour was used because its size (average of 10 μm), and its high degree of transportability matched that of the coatings it represents.

Response to Issue 3h5:

Calvert Cliffs has followed the guidance from Reference 4 for determining the quantity of coating debris. Per Reference 4, Section 3.4.2.1:

- All coating (qualified and unqualified) in the zone of influence will fail,
- All qualified (design basis accident-qualified or acceptable) coating outside the zone of influence will remain intact,
- All unqualified coatings outside the zone of influence will fail.

From Reference 7, a zone of influence of 4.0 L/D was used for epoxy-based coatings, and a zone of influence of 5.0 L/D was used for un-topcoated inorganic zinc primer. All unqualified coatings (including degraded qualified coatings) were assumed to fail.

Response to Issue 3h6:

See the Response to Issue 3h2 above.

Response to Issue 3h7:

Calvert Cliffs conducts condition assessments of Service Level I coatings inside the Containment once each refueling cycle at a minimum. Generally, all of the accessible areas within the Containment are visually inspected. As localized areas of degraded coatings are identified, those areas are evaluated and scheduled for repair or replacement, as necessary. The periodic condition assessments, and the resulting repair/replacement activities, assure that the amount of Service Level I coatings that may be susceptible to detachment from the substrate during a LOCA event is minimized.

***NRC Issue 3i*:**

Debris Source Term

The objective of the debris source term section is to identify any significant design and operational measures taken to control or reduce the plant debris source term to prevent potential adverse effects on the ECCS and CSS recirculation functions.

1. *Provide the information requested in GL 04-02 Requested Information Item 2.(f) regarding programmatic controls taken to limit debris sources in containment.*

GL 2004-02 Requested Information Item 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, "A 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. In responding to GL 2004 Requested Information Item 2(f), provide the following:

2. *A summary of the containment housekeeping programmatic controls in place to control or reduce the latent debris burden. Specifically for RMI/low-fiber plants, provide a description of programmatic controls to maintain the latent debris fiber source term into the future to ensure assumptions and conclusions regarding inability to form a thin bed of fibrous debris remain valid.*
3. *A summary of the foreign material exclusion programmatic controls in place to control the introduction of foreign material into the containment.*
4. *A description of how permanent plant changes inside containment are programmatically controlled so as to not change the analytical assumptions and numerical inputs of the licensee analyses supporting the conclusion that the reactor plant remains in compliance with 10 CFR 50.46 and related regulatory requirements.*
5. *A description of how maintenance activities including associated temporary changes are assessed and managed in accordance with the Maintenance Rule, 10 CFR 50.65.*

If any of the following suggested design and operational refinements given in the guidance report (guidance report, Section 5) and SE (SE, Section 5.1) were used, summarize the application of the refinements.

6. *Recent or planned insulation change-outs in the containment which will reduce the debris burden at the sump strainers*
7. *Any actions taken to modify existing insulation (e.g., jacketing or banding) to reduce the debris burden at the sump strainers*
8. *Modifications to equipment or systems conducted to reduce the debris burden at the sump strainers*
9. *Actions taken to modify or improve the containment coatings program*

<u>*Response to Issues 3i1 and 3i2*</u>:

Several Calvert Cliffs' site procedures and practices are in place to insure containment cleanliness is maintained and that debris inside Containment is identified and minimized prior to power operations. Site procedures require that specific inspections be performed and documented for loose debris prior to containment closeout and an "intense" search be made of Containment prior to entering Mode 4 for sources of loose debris and corrective actions taken. Another site procedure assigns specific ownership responsibilities for plant areas including containment when accessible, and requires weekly cleanliness inspections and prompt actions to remediate. Calvert Cliffs has also developed a good practice of performing daily containment walk downs during refueling outages specifically for cleanliness issues and generating daily containment cleanliness key performance indicators which are tracked, reported on, and managed.

<u>*Response to Issue 3i3*</u>:

A Constellation Fleet procedure contains guidance specifically addressing foreign material exclusion (FME) concerns in areas like the containment, and the containment sumps. It classifies the containment sumps as a Special Foreign Materials Exclusion Area, and requires an FME project plan for any entry into the sumps. Foreign material exclusion project plans are prepared, reviewed, and approved. The requirements of this procedure are stringent with regard to standards but allow flexibility for adapting an FME project plan for any kind of maintenance evolution. This procedure also requires FME training for all personnel working in containment.

Response to Issue 3i4:

A Calvert Cliffs site procedure contains specific guidance in the impact screening process for analyzing the impact of changes that could affect thermal insulation and containment response to accidents. Another site procedure controls the requirements for research on the part of maintenance planners for maintenance which could introduce new debris sources into Containment. The procedure is being revised to require that for any maintenance activity that will install any materials in either Unit 1 or Unit 2 Containments expected to remain there during Mode 4 or higher operations, engineering reviews the installation details for impact on the containment sump strainer analyses and must approve the usage of these new materials.

Response to Issue 3i5:

A Calvert Cliffs site procedure establishes requirements for effective implementation of the Maintenance Rule program at the site. It describes approved methods to monitor, trend, establish and modify goals for system, structures and components. Additional site procedures for integrated work management and integrated risk management provide specific guidance on risk assessment and scheduling of maintenance and temporary changes.

Response to Issues 3i6 and 3i7:

For Unit 2, calcium-silicate insulation within 17 L/D of the RCS piping was banded on 3" centers to reduce the zone of influence to 3 L/D. Any calcium-silicate insulation within 3 L/D of the RCS piping was replaced on Unit 2 with fiberglass insulation. Walkdowns are occurring on Unit 1 during the Spring 2008 refueling outage and the calcium-silicate insulation found is being handled in the same manner.

Response to Issue 3i8:

Valve equipment tags are now made of materials that would sink in water and not transport to the containment sump. In addition, the tags will not delaminate in a post-accident environment. Calvert Cliffs is investigating re-coating the reactor coolant pump motors with qualified coatings to reduce the unqualified coating debris load (approximate surface area is 2000 ft^2 per Unit).

Response to Issue 3i9:

Calvert Cliffs has an existing coatings program that monitors and controls the quantities and types of coatings installed inside Containment. As noted in Reference 17 Calvert Cliffs has implemented controls for procurement, application, and maintenance of qualified coatings used inside Containment that are consistent with the licensing basis and regulatory requirements. This program conducts periodic condition assessments, typically each outage, to verify the adequacy of existing coatings and direct repair/replacement, as necessary. The quantity of unqualified coatings that are added inside Containment is tracked. This program is adequate in its current form to ensure coatings are properly controlled, and that future installations of unqualified coatings are quantified.

***NRC Issue 3j*:**

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.*

2. *Provide a list of any modifications, such as reroute of piping and other components, relocation of supports, addition of whip restraints and missile shields, etc., necessitated by the sump strainer modifications.*

<u>Response to Issue 3j1</u>:

In Calvert Cliffs Unit 2, a strainer of 6000 ft^2 filtration surface area (nominal) has been installed. This same strainer is being installed during the on-going Unit 1 refueling outage. The strainer is CCI's cassette pocket strainer design. The hole size through the filtration surface is 1/16". There are 33 strainer modules divided among three strainer rows. These modules are approximately 3' high. There are 324 pockets in 29 of the strainer modules, and 252 pockets in four of the strainer modules. The pocket dimensions are 70.4 mm x 70.4 mm in cross-section, and 200 mm deep. The strainer rows tie into a common duct which directs the flow to the existing containment sump. The containment sump is a concrete curb with a steel roof, and contains the inlet to both recirculation headers. See Figure 3j1-1.

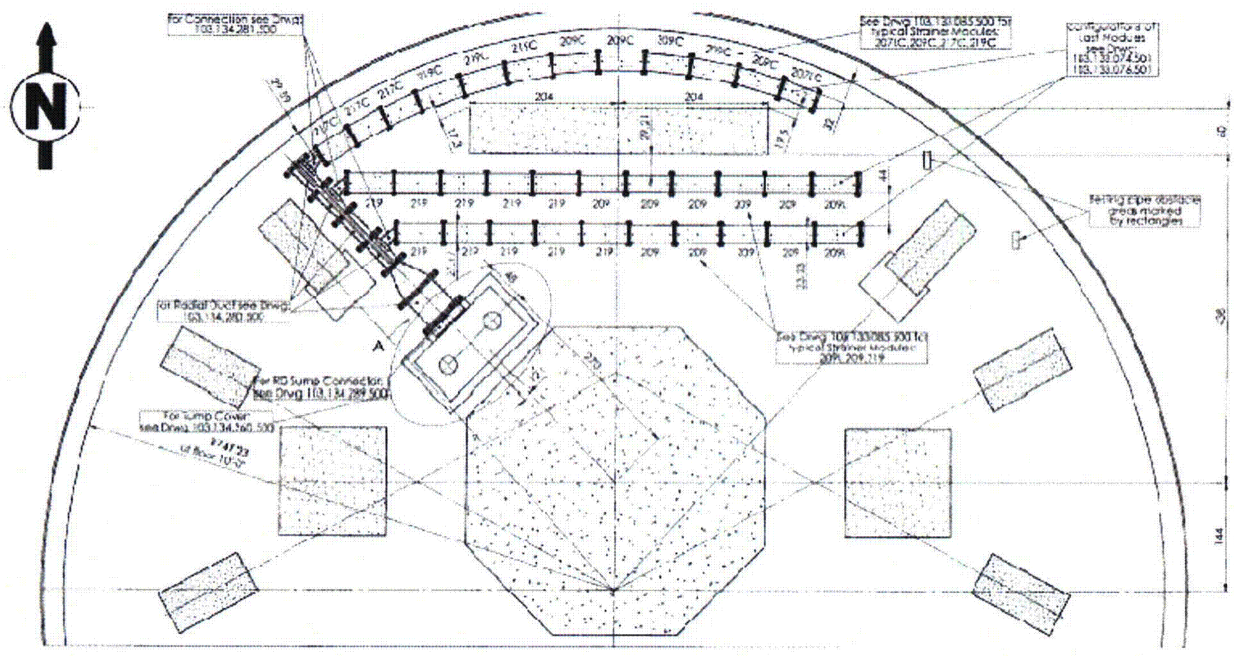


Figure 3j1-1
Strainer Arrangement

<u>Response to Issue 3j2</u>:

A 16" feedwater pipe support was modified on Unit 2 to allow clearance for one of the strainer rows. A cable tray support was also modified on Unit 2 to allow clearance for the radial duct. These modifications were not required on Unit 1. In addition, the 6" curb around the ECCS sump was notched to allow for installation of the common duct to the sump.

***<u>NRC Issue 3k</u>*:**

Sump Structural Analysis

The objective of the sump structural analysis section is to verify the structural adequacy of the sump strainer 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), that is, provide 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.*

1. *Summarize the design inputs, design codes, loads, and load combinations utilized for the sump strainer structural analysis.*
2. *Summarize the structural qualification results and design margins for the various components of the sump strainer structural assembly.*
3. *Summarize the evaluations performed for dynamic effects such as pipe whip, jet impingement, and missile impacts associated with high-energy line breaks (as applicable).*
4. *If a backflushing strategy is credited, provide a summary statement regarding the sump strainer structural analysis considering reverse flow.*

<u>*Response to Issue 3k1*</u>:

Classical and finite-element (ANSYS) methods were used to analyze the following parts of the strainer:

- Standard cartridges (cartridge depth 200 mm)
- Support structure and duct of a standard module
- Radial duct
- Sump cover

The strainers and their supports were analyzed to according to the rules of Reference 18 for Class 2 components. These rules were chosen to provide a recognized standard for structural analyses, however, the strainer components are non-American Society of Mechanical Engineers code items, Seismic Category 1.

The standard module analysis assumes an 18 cartridge design which envelopes the smaller 14 cartridge design.

The design codes used for the sump structural strainer analysis are References 19 and 20.

<u>Design Inputs</u>

Total weight of modules (2 support structures, duct, cover plate, and cartridges)
18 Cartridge Module 906.9 lbm (411.37 kg)
14 Cartridge Module 767.9 lbm (348.30 kg)

Total debris mass transported to sump = 10,782.81 lbm (4891 kg)
(Note: this is an enveloping value used for structural analyses only)

Conservative differential pressure = 2.103 psi (.0145 MPa) at 220°F (104.4°C)
Standard differential pressure = 1.949 psi (.01334 MPa) at 212°F (100.0°C)

Operating Basis Earthquake
Maximum Horizontal Acceleration ≈ 1.96 g at ≈ 5 Hz
Maximum Vertical Acceleration ≈ 0.59 g at ≈ 10 Hz

Safe-Shutdown Earthquake
Maximum Horizontal Acceleration ≈ 2.73 g at ≈ 5 Hz
Maximum Vertical Acceleration ≈ 1.11 g at ≈ 10 Hz

Additional load from shielding blankets = 885.91 lbf (3940.76 N)

Summary of Design Load Combinations

The load combinations are summarized in Table 3k1-1 below.

In addition to these loads a sloshing load was computed and included to account for the impact of water sloshing in the sump pool.

Table 3k1-1
Load Combinations and Acceptance Criteria Used in ECCS Sump Screen Verification

#	Load Combination Type	Temperature (°F)	Temperature (°C)
1	W(pool dry)	280	137.8
2	W+OBE(pool dry)	280	137.8
3	W+SSE(pool dry)	280	137.8
4	W+OBE(pool filled)	280	137.8
5	W+SSE(pool filled)	280	137.8
6	W+WD+OBE(pool filled)+ΔPD	70(220)	21(104.4)
7	W+WD+SSE(pool filled)+ΔPD	70(220)	21(104.4)
8	W+AddL	70	21

Variables:

W	weight of strainers & supporting structures
WD	weight of debris
ΔPD	pressure differential
OBE	operating basis earthquake
SSE	safe-shutdown earthquake
AddL	additional load caused by radiation shielding blankets

Response to Issue 3k2:

The ECCS sump strainer structure consists of two separate structures: the floor structures, and the sump pit structures.

The floor structures consist of the strainer modules themselves which provide the filtration surface area, and a radial duct which channels the flow from the three rows of strainer modules to the sump pit. The radial duct consists of six segments each approximately 4' long. There are 29 strainer modules that are approximately 5' long, and four strainer modules that are approximately 4' long. Each of these strainer modules/radial duct segments are anchored to the concrete floor via an anchor plate at each end. There are four anchor bolts (½" Hilti bolts at 3½" minimum embedment torqued to 40 ft-lbs) on each anchor plate. A retaining structure is mounted on top of each anchor plate. This retaining structure provides the mounting frame for the radial duct segments and the interior duct of the strainer modules. The various connections are made using M12, M16, and M20 bolting hardware. The retaining structures are attached to the anchor plates using two M30 bolts. The strainer cassettes (filter surface) attach to the strainer interior duct, and are covered with a deck plate.

The sump pit structure consists of cover plates, and support beams fixed on and about a concrete curb which covers the sump pit. Two pairs of mounting brackets are anchored to the concrete curb using four anchor bolts (½" Hilti bolts at 3½" minimum embedment torqued to 40 ft-lbs) on each bracket. A pair of posts is also anchored to the sump pit floor in a similar fashion. A 140 mm x 140 mm I-beam is fastened to these mounting brackets/mounting posts (one on each end). A series of 12 plates (0.59" thick) are laid on top of the I-beams, and are located in place by a set of locating pins fixed to the I-beams.

Ratios of design stress and corresponding allowable stress for various components of the ECCS sump strainer structural assembly are given below. The figures illustrate the component analyzed.

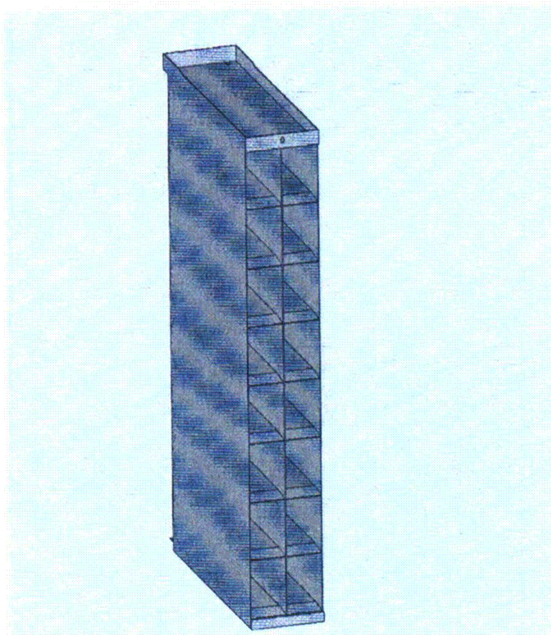


Figure 3k2-1
Cartridges

Table 3k2-1
Cartridges

Ratio	Calculated MPa	Allowable MPa	Stress Location and Type
0.436	133.92	306.9	Sidewall global + local bending stress
0.024	2.90	122.76	Sidewall connection to coverplate shear stress
0.014	2.79	204.6	Sidewall connection to coverplate tension
0.270	45.5	168.5	Upper cover plate bearing stress
0.117	14.32	122.76	Upper cover plate shear stress
0.402	123.3	306.9	Upper cover plate bending stress
0.427	72.0	168.5	Lower cover plate bearing stress
0.322	108.93	338.03	Cartridge pocket bending stress
0.131	1.63	12.41	Cartridge pocket compression stress
0.008	0.93	122.76	Cartridge pocket shear stress

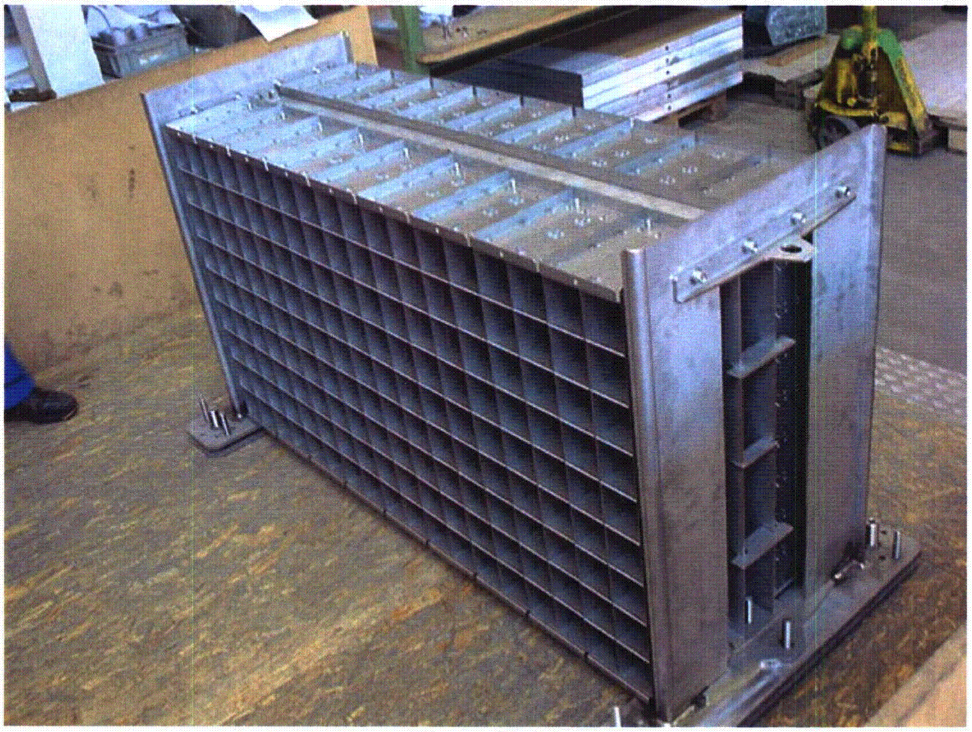


Figure 3k2-2
Standard Strainer Module

Table 3k2-2
Standard Module Support Structure

Ratio	Calculated MPa	Allowable MPa	Stress Location and Type
0.556	64	115.1	Maximum principle stress intensity – Load 1
0.759	196.6	259	Maximum principle stress intensity – Load 7
0.913	157.56	172.65	Maximum principle stress intensity – Load 8
0.116	30	259	Welded joints
0.023	6.56	279.77	M16 leveling screws compression stress
0.045	12.65	279.77	M20 leveling screws compression stress
0.426	101.9	239.04	M16 bolt membrane & bending stress
0.058	5.24	89.82	M16 bolt shear stress
0.013	1.21	92.68	M20 screws shear stress
0.005	1.2	246.64	M12 head screws normal stress – Load 7
0.005	0.48	92.68	M12 head screws shear stress – Load 7
0.349	20.9	59.88	Pin Ø 12/M8 screws shear stress
0.038	9.8	259.0	Closure plate of the duct bending
0.042	64.2 lbf	1515 lbf	Loads on anchorage – normal
0.030	92.55 lbf	3040 lbf	Loads on anchorage – shear

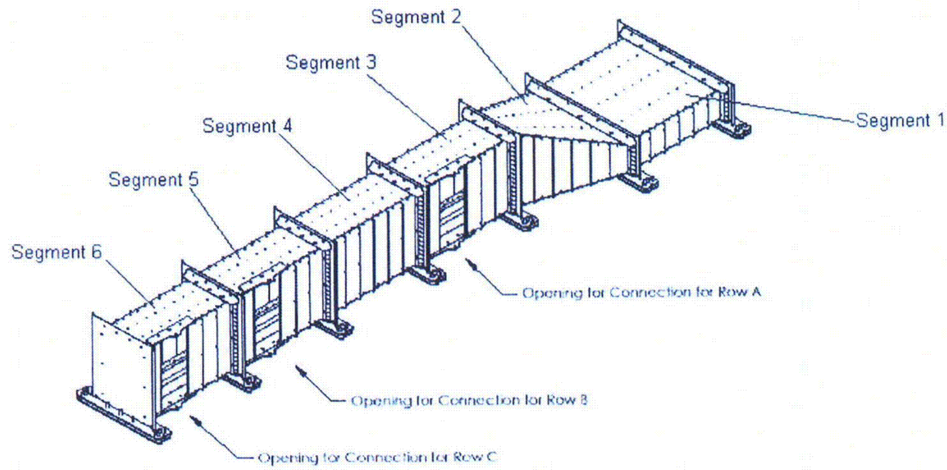


Figure 3k2-3
Radial Duct

Table 3k2-3
Radial Duct

Ratio	Calculated MPa	Allowable MPa	Stress Location and Type
0.002	0.18	82.74	Global bending of duct shear stress – Load 8
0.003	0.7	206.85	Global & local bending of cover plate – Load 8
0.007	0.434	61.03	Sidewalls compression stress – Load 8
0.002	0.21	122.76	Global bending of duct shear stress – Load 7
0.003	0.43	124.11	Loads in horizontal directions shear stress – Load 7
0.003	0.67	306.9	Global bending due to Weight & Earthquakes - Load 7
0.024	7.25	306.9	Local & global bending of cover plate – Load 7
0.004	0.36	101.1	Membrane stress in compression – Load 7
0.013	0.815	61.03	Axial compression of the sidewalls – Load 7
0.270	82.75	306.9	Global & local bending sidewalls – Load 7
0.009	0.71	76.86	Inner duct walls – Load 7

Table 3k2-4
Analysis of Retaining Structure of Radial Duct Segment 4

Ratio	Allowable MPa	Calculated MPa	Stress Location and Type
0.002	239.04	0.7	Support plate w/anchorage M30/M16 tension
0.185	89.82	16.6	Support plate w/anchorage M30/M16 shear stress
0.019	92.68	1.77	Connection duct to retaining structure shear stress
0.012	246.64	3.0	Cylinder head screw M12 normal stress
0.024	92.68	2.2	Cylinder head screw M12 shear stress
0.360	259	93.14	Support legs membrane bending stress
0.018	103.6	1.83	Support legs shear stress
0.027	259	7.1	Closure plate of the duct bending stress
0.008	1515 lbf	12.51 lbf	Anchor plate w/4 Hilti Kwik Bolts 111 tension
0.096	3040 lbf	292.5 lbf	Anchor plate w/4 Hilti Kwik Bolts 111 shear

Table 3k2-5
Analysis of the Duct Structure of Radial Duct Segment 1

Ratio	Allowable MPa	Calculated MPa	Stress Location and Type
0.002	82.74	0.18	Global bending of duct shear stress
0.002	206.85	0.35	Global & local bending of cover plate
0.004	114.56	0.449	Sidewalls compression stress
0.001	122.76	0.17	Global bending of duct shear stress
0.001	124.11	0.13	Loads in horizontal directions shear stress
0.001	306.9	0.4	Global bending due to Weight & Earthquakes
0.084	306.9	25.87	Global and local bending of cover plate
0.017	15.78	0.27	Membrane stress in compression
0.014	141.2	1.96	Axial compression of the sidewalls
0.046	306.9	14.2	Global & local bending sidewalls
0.735	11.15	8.2	Inner duct walls

Table 3k2-6
Analysis of Retaining Structure of Radial Duct Segment 1

Ratio	Allowable MPa	Calculated MPa	Stress Location and Type
0.138	89.82	12.4	Support plate w/anchorage M30/M16 shear
0.014	92.68	1.32	Connection duct to retaining structure shear
0.012	246.64	2.95	Cylinder screw M12 normal stress
0.023	92.68	2.16	Cylinder screw M12 shear stress
0.116	259	30.0	Support legs membrane bending stress
0.013	103.6	1.37	Support legs shear stress
0.072	3040 lbf	218.8 lbf	Anchor plate w/4 Hilti Kwik Bolts 111 shear stress

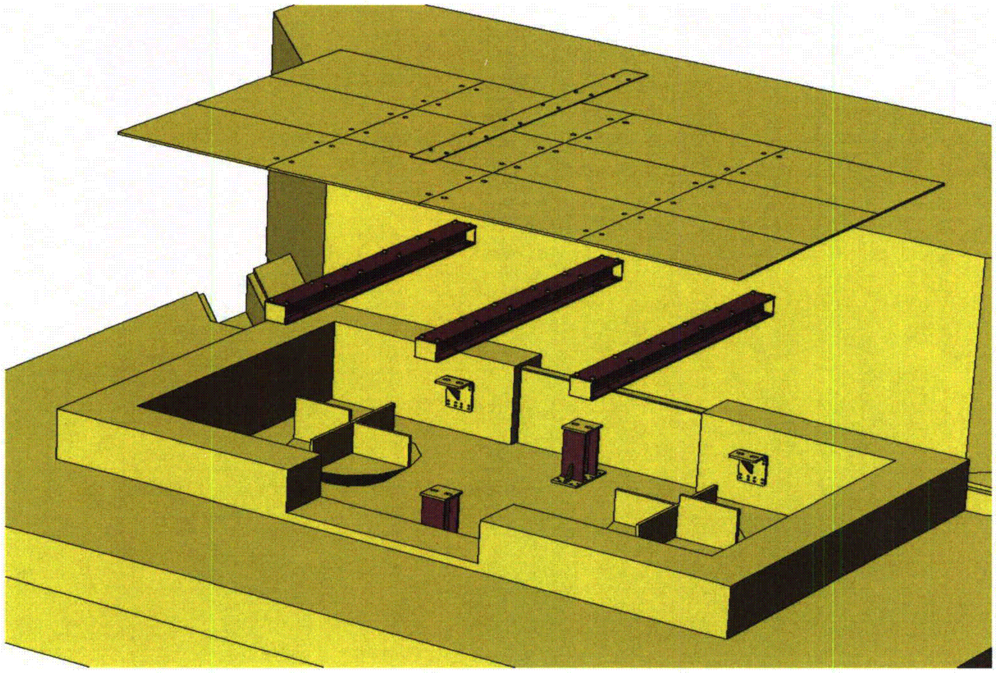


Figure 3k2-7
Sump Cover

Table 3k2-7
Sump Cover

Ratio	Allowable	Calculated	Stress Location and Type
0.406	0.0380 MPa	0.0154 MPa	Grating bearing bar size load
0.154	197.7 MPa	30.5 MPa	Stresses in support beam I-HEB140
0.480	9065.4 N	4352.5 N	Bolted support shear load per bolt
0.603	6740 N	4069 N	Tension per bolt
0.121	296.6 MPa	35.8 MPa	Cover plate bending stress
0.141	155.8 MPa	21.9 MPa	I-beams (IPB140) bending stress
0.32	177.1 MPa	5.71 MPa	Support columns bending stress
0.018	177.1 MPa	3.27 MPa	Support columns compression stress

Response to Issue 3k3:

Calvert Cliffs has approval to use leak-before-break methodology so that the dynamic effects of a LOCA do not need to be considered in the design of structures and components. Emergency Core Cooling System sump recirculation is not required for breaks in other piping systems.

Response to Issue 3k4:

The Calvert Cliffs ECCS sump strainer design does not incorporate a backflushing strategy.

***NRC Issue 3l*:**

Upstream Effects

The objective of the upstream effects assessment is to evaluate the flowpaths upstream of the containment sump for holdup of inventory which could reduce flow to and possibly starve the sump. Therefore, provide a summary of the upstream effects evaluation including the information requested in GL 2004-02, *"Requested Information," Item 2(d)(iv) including 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.*

1. *Summarize the evaluation of the flow paths from the postulated break locations and containment spray washdown 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.*

Response to Issue 311:

The lower level of Containment is open and contains no compartment or choke point which could prevent water from flowing to the sump.

The two refueling pool compartments have the potential to fill with water from the CS system because the drain to these compartments is a 1" drain which is not sufficient to prevent a back-up of water in these compartments. Once these compartments fill up to the level of the refueling pool seal ring, water could fall into the reactor cavity, and potentially be trapped there.

The reactor cavity region has a 4" drain that drains to the sump pool. The current sump pool water level height calculation assumes this drain is blocked, and the computed water holdup in the reactor cavity region is 3,792 ft^3. The cavity is inspected for debris during each refueling outage, and the only insulation inside this compartment is reflective metal insulation, so a break at the one of the RCS nozzles to the reactor vessel is not believed to be able to result in debris that could block this drain.

The containment water level calculation assumes all of these compartments are filled with water thereby reducing the predicted sump water height.

Response to Issue 312:

A drain cover is placed on the 1" drain line of the refueling pool compartment, but even if this drain does not clog, as mentioned in Response to Issue 311, this size drain line is insufficient to prevent this compartment from filling up with water. The reactor cavity area is periodically inspected for debris, and the 4" drain line is of sufficient size to drain the water from the refueling pool cavity to the sump pool.

The only debris that could be generated in the refueling pool is reflective metal insulation which would not likely block the 4" drain in the event of a break near a reactor vessel nozzle. However, at this time no inspection of this region is performed for personnel dose reasons. Therefore, this drain is assumed to be blocked.

Response to Issue 313:

There are no curbs of sufficient dimension to impact water flow to the sump. The design of the debris interceptors in Unit 1 allow water flow over the top of the debris interceptors.

Response to Issue 314:

See the Response to Issue 311 above.

NRC Issue 3m:

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. If approved methods were used (e.g., WCAP-16406-P), briefly summarize the application of the methods. The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the ECCS 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 ECCS 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 ECCS 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 ECCS 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.

3m1. If NRC-approved methods were used (e.g., WCAP-16406-P with accompanying NRC SE) briefly summarize the application of the methods. Indicate where the approved methods were not used or exceptions were taken, and summarize the evaluation of those areas.

3m2. Provide a summary and conclusions of downstream evaluations.

3m3. Provide a summary of design or operational changes made as a result of downstream evaluations.

Response to Issue 3m1:

Reference 12 is used to evaluate the downstream components for the effects of plugging/corrosion. All particulate (10 μm) debris is assumed to transport through the system, and not deplete over 30 days. The amount of fiber bypass is in accordance with Reference 12 with the appropriate prototypical testing done to establish the strainer bypass fraction. The amount of fiber that transports through the system is computed to deplete with time in accordance with this WCAP.

Valves, pumps, heat exchanger tubes, orifices, containment spray nozzles are being evaluated for plugging/erosion based on the concentrations and maximum particle size as determined by the Reference 12 methodology.

Response to Issue 3m2:

Testing of the HPSI pump cyclone separator, and HPSI and CS pump mechanical seals are scheduled for March 2008 at Wyle Labs. Debris loads for the downstream analytical evaluations are being revised based on the reductions in conservatisms required by the high strainer head losses with chemical precipitants. A summary of the results and conclusions for our downstream evaluations will be provided in our supplemental response no later than June 30, 2008.

The sump strainer opening consists of 1/16" diameter holes. A post-installation examination inspects for gaps at all strainer interfaces/joints. The acceptance criteria is no gap greater than 1/32" can remain. These small openings will ensure no large particles enter the downstream recirculation piping.

Response to Issue 3m3:

No design or operational changes are anticipated as a result of our downstream effects evaluations. If any changes are identified based on testing in March 2008, they will be reported in our supplemental response no later than June 30, 2008.

***NRC Issue 3n*:**

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 (WCAP-16793), as modified by NRC staff comments on that document. Briefly summarize the application of the methods. Indicate where the WCAP methods were not used or exceptions were taken, and summarize the evaluation of those areas.*

Response to Issue 3n1:

Nuclear Regulatory Commission approval of the industry generic guidance (Reference 21) has recently been received. Calvert Cliffs intends to complete the required evaluations prior to the June 30, 2008 supplemental submittal.

***NRC Issue 3o*:**

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.*
2. *Content guidance for chemical effects is provided in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML072600372).*

Response to Issue 3o1:

Debris and other containment sources which could contribute to the formation of chemical precipitants in the sump pool were evaluated using the methodology of Reference (22). The results of this evaluation showed the elemental amounts of calcium (Ca), silicon (Si), and aluminum (Al) expected to be released into the sump pool as well as the expected quantities of precipitates: $Ca_3(PO_4)_2$, $NaAlSi_3O_8$, ALOOH

Head loss testing with chemical precipitants was originally conducted in November 2007, and extremely high head losses were encountered. Inputs to the evaluation which supported this test were based on accurate sources. However, actions are being evaluated that would reduce these sources or mitigate their effect. For instance, the quantity of aluminum inside containment was taken from the Updated Final Safety Analysis Report as 13,000 ft^2. A subsequent review (to be confirmed by walkdown during the 2008 refueling outage) shows that this value can be reduced by approximately 90% if aluminum scaffolding is removed from Containment. Calvert Cliffs believes the chemical precipitant load on the strainer can ultimately be reduced to ¼ of that which was tested in November 2007. Testing to be conducted in the spring of 2008 will validate this assumption. Additional information concerning the testing results will be supplied in our supplemental response no later than June 30, 2008.

NRC Issue 3p:

Licensing Basis

The objective of the licensing basis 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. That is, provide 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. 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.

Response to Issue 3p:

The Calvert Cliffs licensing basis will be updated in accordance with the requirements of 10 CFR 50.71 to reflect the results of the analyses and the modifications performed to demonstrate compliance with the regulatory requirements. There are no currently identified licensing actions or exemption requests needed to support changes to the plant-licensing basis as a result of the GSI-191 improvements.

REFERENCES:

(1) Letter from Mr. J. A. Spina (CCNPP) to Document Control Desk (NRC), dated December 10, 2007, Request for Extension for Completion of Activities Related to Generic Letter 2004-02

(2) Letter from Mr. J. A. Spina (CCNPP) to Document Control Desk (NRC), dated December 20, 2007, Request for Additional Information – Request for Extension for Completion of Activities Related to Generic Letter 2004-02

(3) Letter from Mr. D. V. Pickett (NRC) to Mr. J. A. Spina (CCNPP), Dated December 27, 2007, Extension for Completion of Activities Related to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors"

(4) Letter from Ms. S. C. Black (NRC) to Mr. A. R. Pietrangelo (NEI), dated December 6, 2004, Pressurized Water Reactor Containment Sump Evaluation Methodology

(5) WCAP-16710-P, Revision 0, dated October 2007, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON Insulation at Wolf Creek and Callaway Nuclear Operating Plants"

(6) WCAP-16720-P, Revision 0, dated March 2007, "Jet Impingement Testing to Determine the Zones of Influence for Diablo Canyon Power Plant"

(7) WCAP-16568-P, Revision 0, dated June 2006, "Jet Impingement Testing to Determine the Zones of Influence (ZOIs) for DBA-Qualified/Acceptable Coatings"

(8) SL-009195, Revision 0, dated November 9 2007, "Wyle Jet Impingement Testing Data Evaluation"

(9) NUREG/CR-6808, dated February 2003, "Knowledge Base for the Effect of Debris on Pressurized Water Reactor Emergency Core Cooling Sump Performance"

(10) NEI 04-07, Revision 0, December 2004, "Pressurized Water Reactor Sump Performance Evaluation Methodology"

(11) Keeler & Long PPG Report No. 06-0413

(12) WCAP-16406-P, Revision 1, dated August 2007, Evaluation of Downstream Debris Effects in Support of GSI-191

(13) NEI 02-01, April 2002, "Condition Assessment Guidelines: Debris Sources Inside PWR Containments"

(14) NUREG/CR-6916, dated December 2006, "Hydraulic Transport of Coating Debris"

(15) I.E. Idlechik, "Flow Resistance, a Design Guide for Engineers"

(16) NUREG/CR-6224, dated April 2005, "Correlation and Deaeration Software Package"

(17) Letter from Mr. C. H. Cruse (CCNPP) to Document Control Desk (NRC), dated November 13, 1998, Response to Generic Letter 98-04, "Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident Because of Deficiencies and Foreign Material in Containment"

(18) ASME Section III, Subsection NF, "Supports"

(19) ASME B&PVC Section III, Division I, Subsection N, "Supports," 2004 Edition including 2005 Addenda

(20) ASME B&PVC Section II, Part D, "Properties," 2004 Edition including 2005 Addenda

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

(22) WCAP-16530-NP, Revision 0, dated February 2006, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Supports GSI-191"

ATTACHMENT (2)

ECCS and CS SYSTEM FIGURES

FIGURE 6-1 SAFETY INJECTION AND CONTAINMENT SPRAY – UNIT 1

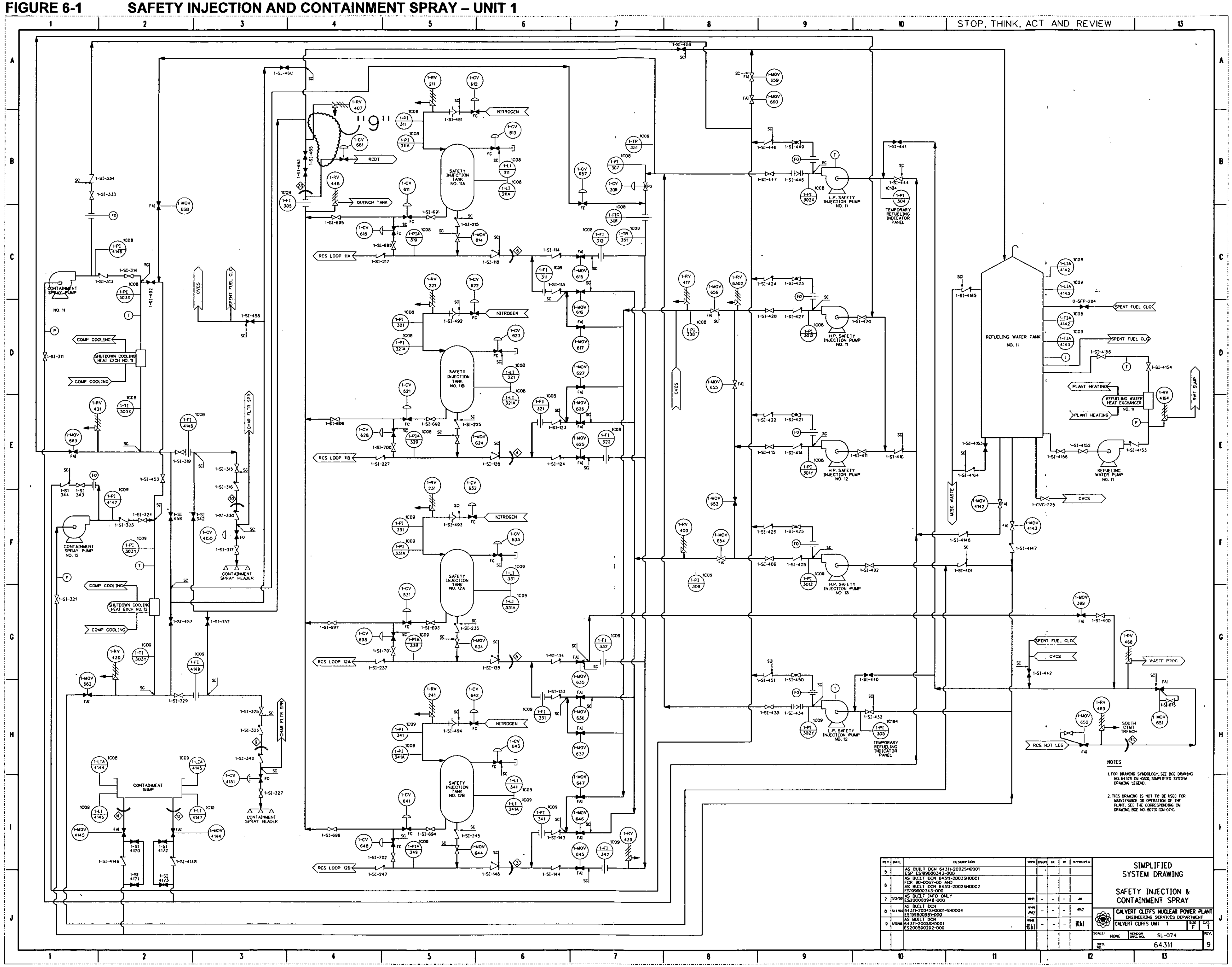


FIGURE 6-10 SAFETY INJECTION AND CONTAINMENT SPRAY – UNIT 2