FENOC
FirstEnergy Nuclear Operating Company

Davis-Besse Nuclear Power Station
5501 N. State Route 2
Oak Harbor, Ohio 43449

February 28, 2008
L-08-036

10CFR50.54(f)

ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Davis-Besse Nuclear Power Station, Unit No. 1
Docket No. 50-346, License No. NPF-3
Supplemental Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors" (TAC No. MC4681)

This letter provides supplemental information regarding the FirstEnergy Nuclear Operating Company (FENOC) response to Generic Letter 2004-02 (Reference 1) for the Davis-Besse Nuclear Power Station (DBNPS), previously provided in References 2, 3, and 4.

Attachment 1 of this submittal provides the DBNPS supplemental response to Generic Letter 2004-02. The Nuclear Regulatory Commission (NRC) Content Guide for Generic Letter 2004-02 Supplemental Response (Reference 6) was utilized in development of this submittal, and the Request for Additional Information (RAI) provided by the NRC (Reference 5) is also addressed within the applicable sections of this submittal.

Attachments 2 and 3 provide schematics of the Emergency Core Cooling System and Containment Spray System as referenced in the response to Review Area 3.f.1.

There are no regulatory commitments included in this letter. If there are any questions, or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at 330-761-6071.

I declare under penalty of perjury that the foregoing is true and correct. Executed on February 28, 2008.

Sincerely,

Clark A. Price

Clark A. Price

A116
NRR

Attachments:

1. Supplemental Response to Generic Letter 2004-02 for Davis-Besse Nuclear Power Station, Unit No. 1.
2. Emergency Core Cooling System Schematics.
3. Containment Spray System Schematic.

References:

1. NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004.
2. FENOC letter, "Davis-Besse Nuclear Power Station Response to NRC Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,'" dated March 4, 2005.
3. FENOC letter, "Response to Request for Additional Information on Generic Letter 2004-02," dated July 26, 2005.
4. FENOC letter, "Davis-Besse Nuclear Power Station Response to NRC Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,'" dated September 1, 2005.
5. NRC letter, "Davis-Besse Nuclear Power Station, Unit 1 – Request for Additional Information Re: Response to Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,'" dated February 9, 2006.
6. NRC letter, "Revised Content Guide for Generic Letter 2004-02 Supplemental Response," dated November 21, 2007.

cc: NRC Region III Administrator
NRC Resident Inspector
NRR Project Manager
Executive Director, Ohio Emergency Management Agency,
State of Ohio (NRC Liaison)
Utility Radiological Safety Board

1. Executive Summary:

The Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2004-02 on September 13, 2004 (Reference 11). It required specific responses from all Pressurized Water Reactor (PWR) licensees. The Davis-Besse Nuclear Power Station (DBNPS) responded to the GL in a letter dated March 4, 2005 (Serial 3128). Additional information was submitted to the NRC in a letter dated September 1, 2005 (Serial 3187). After reviewing the DBNPS response, the Staff issued a Request for Additional Information (RAI) in letter dated February 9, 2006.

The Nuclear Energy Institute (NEI) Sump Task Force and the PWR Owners Group initiated several projects to resolve issues identified as the body of knowledge on post-Loss of Coolant Accident (LOCA) emergency sump strainers developed. Due to the need for additional technical resolution, the Staff extended the required due date for the RAI response. Finally, a Content Guide for Generic Letter 2004-02 Supplemental Responses was issued by the NRC on August 15, 2007 (Reference 12). This guidance was revised by a NRC letter to NEI dated November 21, 2007 (Reference 8).

The information provided in this attachment addresses each of the specific Review Areas listed in the Revised Content Guide. In addition, where appropriate, a response to each question from the NRC's February 9, 2006 RAI has been appended to the relevant Review Area. The RAI number from the original NRC letter has been retained for easy identification of the item being answered.

The NRC also issued separate guidance on chemical effects in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (Reference 13). The response to Review Area 3.o of the Revised Content Guide includes the specific details from this guidance.

In evaluating each of the specific items listed in the Revised Content Guide and all the other guidance issued by the NRC, it has been determined that the DBNPS emergency sump strainer will fully support long term core cooling following all postulated Design Basis Accidents that require recirculation from the containment vessel emergency sump.

The DBNPS resolution of GL 2004-02 includes the installation of a significantly larger strainer within containment. The debris source term was also significantly reduced through removal of nearly all fibrous insulation and completely stripping and recoating the containment dome. Detailed analyses that used bounding limits for debris generation, transport and head loss effect were performed using the NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," and associated NRC Safety Evaluation Report (SER) methods, with permitted deviations. The basis for any deviation was established and is discussed in the appropriate sections. The methodology for determining the Net Positive Suction Head (NPSH) available was based on the analytical minimum value for water injected into the containment, and included consideration of system leakage throughout the mission time for long-term recirculation. The flow rates assumed in the NPSH analysis are greater than the actual flow rates that will exist in the plant. No credit for containment overpressure has been taken in the NPSH analyses. The impact of chemical precipitates that may form in the post-LOCA environment has been analyzed using the industry established methods. The effect of the chemicals on the NPSH margin has been analyzed and found acceptable.

The effect of debris bypassing the strainer on downstream components was evaluated. Modifications to the High Pressure Injection pumps and the cyclone separators for the Emergency Core Cooling System (ECCS) pump seals were required to ensure continued operation in the post-LOCA environment. In addition, cyclone separators were installed on the Containment Spray pump seal supply lines. The downstream effects of chemical precipitants on core cooling has been evaluated using industry developed methods and found to be acceptable.

Finally, controls and programs have been put in place to assure that the issues that resulted in GL 2004-02 do not cause the capability to establish and maintain long term core cooling to be challenged in the future. Controls on coatings, insulation, and signage have been established. Procedures have been instituted that require verification of strainer integrity and containment cleanliness prior to entering a mode of operation that requires emergency core cooling system operability. The design basis function of the strainer has been incorporated in the Updated Final Safety Analysis Report (UFSAR) in accordance with 10 CFR 50.71(e).

2. **FENOC/DBNPS Response**

The following supplemental responses are provided as specified in the Nuclear Regulatory Commission Content Guide for Generic Letter 2004-02 Supplemental Response. The NRC, in its letter to FENOC dated February 9, 2006, requested additional information relative to the Generic Letter 2004-02 response. The format for the response restates the content guide request followed by the specific FENOC response. If applicable, supplemental information relevant to the aforementioned request for additional information is presented within the applicable sections.

1. Overall Compliance:

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

GL 2004-02 Requested Information Item 2(a)
Confirmation that the ECCS and CSS recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this GL. 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.

FENOC Response to Review Area 1 (GL 2004-02 Item 2a):

DBNPS confirms that the ECCS and Containment Spray System (CSS) functions comply with the regulatory requirements listed in the Applicable Regulatory Requirements Section of GL 2004-02, including 10 CFR 50.46; 10CFR 50, Appendix A, General Design Criteria 35, 38, and 41; and 10CFR Part 100. Compliance is based on plant modifications and analyses described in detail below in the response labeled Requested Information Section 2 of GL 2004-02. The response provided follows the NRC guidance documented in the NRC letter to NEI, dated November 21, 2007.

The responses below describe the final configuration of the plant. This information has been incorporated into the DBNPS current design and licensing basis.

2. General Description of and Schedule for Corrective Actions:

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). (Note: All requests for extension should be submitted to the NRC as soon as the need becomes clear, preferably not later than October 1, 2007.)

GL 2004-02 Requested Information Item 2(b)
A general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this GL. 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.

FENOC Response to Review Area 2 (GL 2004-02 Item 2(b)):

A mechanistic evaluation of the Davis-Besse containment, ECCS, and CSS was performed. The evaluation included:

a) Containment walkdowns to identify and quantify debris sources,
b) Debris generation and transport analyses,
c) Quantification of latent debris inside containment,
d) Quantification of chemical effect sources and determination of generated debris,
e) Net Positive Suction Head margin analyses including debris sources and chemical effects,
f) Emergency sump strainer structural analyses, and,
g) Evaluation and testing for downstream effects,

Based on the evaluations and analyses, a new emergency sump strainer was designed and installed in Refuel Outage 13 (13RFO). All plant modifications necessary to establish compliance with the Applicable Regulatory Requirements section have been completed. Modifications completed include replacement of most fibrous insulation within containment, modification of the High Pressure Injection (HPI) pumps, and modification /installation of cyclone separators for the High Pressure Injection (HPI), Low Pressure Injection (LPI), and Containment Spray (CS) pumps. Detailed descriptions of methodologies used and the modifications completed are provided in this response to the Generic Letter Requested Information. The original detailed design has been updated to address technical developments that occurred following the original design effort for the strainer.

Programmatic changes have been implemented to maintain the design basis of the ECCS and CSS when they are required to be operable per DBNPS Technical Specifications. This includes establishing controls on the types of materials that can be taken into containment, requirements on what can be stored in containment, specification of coatings and insulation that can be used in containment, and verification that the design basis is met prior to declaring the systems operable.

Part of the DBNPS sump improvement effort during 13RFO included evaluation of downstream effects of debris-laden water. After evaluating the downstream systems and components, and identifying components of concern, a test program was initiated to develop resolutions. Testing was performed utilizing representative materials and component configurations to ensure realistic results were obtained. Based on the test results, several plant modifications were completed to ensure that systems would remain functional in the presence of debris-laden fluid. The modifications are described in the response to Review Area 3.j.

DBNPS participated in testing that demonstrates that the Zone of Influence modeled in the qualified coatings debris generation calculations is based on representative test results. The Zone of Influence model is described in the response to Review Area 3.b.1.

DBNPS has included the industry developed methodology for evaluation of chemical effects. Chemical effects are addressed in the responses to Review Area 3.o.

RAI 38
It appears that part of the September 2005 response to GL 2004-02 was not transmitted into ADAMS correctly. Information appears to be missing on the bottom of Page 8. Please provide the omitted information.

Response:
The document shown in ADAMS is complete. The question and answer were submitted as follows:

> **Request 2(d)(ii)**
> **The submerged area of the sump screen at this time and the percent of submergence of the sump screen (i.e., partial or full) at the time of switchover to sump recirculation.**
>
> Response 2(d)(ii)
> The total strainer surface area is calculated to be 1226 ft^2. This is made up of 394 ft^2 in the upper strainer structure and 832 ft^2 in the lower strainer structure.
>
> Both the upper and lower strainer structure are fully submerged at the time of switchover to sump recirculation for all scenarios.

In addition to the response provided in the September 2005 letter, Review Area responses 3.f.2, 3.f.8, and 3.j.1 contain information regarding the submerged section of the strainer during periods in addition to the aforementioned switchover. As indicated in these responses, the strainer remains completely submerged during its entire mission time.

3. Specific Information Regarding Methodology for Demonstrating Compliance

NRC Review Area 3.a:

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.**

FENOC Response to Review Area 3.a.1

Break selection consists of determining the size and location of the High Energy Line Breaks (HELB) that will produce debris and potentially challenge the performance of the recirculation sump screens. Since this break location is not known prior to the evaluation, the break selection process requires evaluating a number of break locations in order to identify the location that is likely to present the greatest challenge to post-accident sump performance. The debris inventory and the transport path are both considered when making this determination.

NEI 04-07 Section 3.3 recommends that a sufficient number of breaks in each high-pressure system that relies on recirculation be considered to ensure that the breaks that bound variations in debris generation by the size, quantity, and type of debris are identified. At a minimum, the following break locations are considered:

Break A: Breaks with the largest potential for debris
Break B: Large breaks with two or more different types of debris
Break C: Breaks in the most direct path to the sump
Break D: Large breaks with the largest potential particulate debris to fibrous insulation ratio by weight
Break E: Breaks that generate a "thin bed" - high particulate with 1/8" fiber bed

The insulation debris sources used in the Davis-Besse containment are limited to a large amount of Reflective Metal Insulation (RMI) and a very small amount of Nukon™. As a result of Davis-Besse plant specific parameters, the number of breaks to consider is simplified greatly. Breaks A, B, D and E can be combined to encompass RCS breaks with the largest potential for RMI and coatings debris, leaving two breaks to consider.

Break 1: Breaks with the largest potential for RMI and coatings debris generation. Break 1 was split into two subcases – East D-ring and West D-ring – for the debris transport calculation.
Break 2: Breaks in the most direct path to the sump.

In addition, Davis Besse has a unique strainer that extends into the in-core tunnel, creating the possibility that this portion of the strainer may be damaged by a reactor vessel nozzle break, reducing the available strainer surface area. Therefore, this break is analyzed separately.

Break 3: Reactor vessel nozzle breaks.

Only those line breaks that require recirculation from the sump need be evaluated. A review of the accident analysis and system descriptions has been performed to determine the scenarios that require the ECCS and containment spray pumps to take suction from the recirculation sump. This review has identified the high energy piping systems that are evaluated for a postulated HELB and associated debris generation.

Break location analyses identify the breaks that produce the maximum amount of debris and also the worst combination of debris with the possibility of being transported to the recirculation sump screens. From Section 3.3.4.1, Item 7 of the NEI 04-07 SER, piping under 2" diameter can be excluded when determining the limiting break conditions. The NEI 04-07 SER discusses a systematic approach to the break selection process where an initial location is selected at a convenient location and break locations are evaluated at 5-foot intervals in order to evaluate all break locations.

FENOC Response to Review Area 3.a.2

Secondary line breaks are not considered in the evaluation of the emergency sump strainer. These breaks do not cause the RCS pressure boundary to break. Long term cooling is provided by normal decay heat removal. In addition, these breaks do not result in actuation of containment spray. The peak Main Steam Line Break, which bounds all secondary system breaks, does not actuate Containment Spray. Consequently, while ECCS operation does occur to mitigate secondary line breaks, long term recirculation via the containment emergency sump strainer does not occur. Secondary line breaks may result in High Pressure Injection actuation. These breaks do not challenge reactor coolant system pressure boundary; therefore, no RCS inventory is lost into containment. Ultimately, the plant can be cooled down using Auxiliary Feedwater, and then transitioned to using normal decay heat removal. These modes of core cooling do not rely on recirculation from the containment emergency sump.

<u>FENOC Response to Review Area 3.a.3</u>

The basis for reaching the conclusion that the break size(s) and locations chosen present the greatest challenge to post-accident sump performance includes is as follows.

Case 1: RCS Hot leg Break in East D-Ring - this case provides the bounding break for breaks with the largest potential for debris, large breaks with two or more different types of debris, and large breaks with the largest potential particulate debris to fibrous insulation ratio by weight. The debris source terms for this case are provided in Table 3.b.4-1. The amount of debris generated by this break is greater than the debris generated by a hot leg break in the West D-ring. The hot leg represents the largest, most energetic HELB source, which creates the largest Zone of Influence. Therefore, it was not necessary to examine the effect of a cold leg break.

Case 2: Decay Heat or Letdown Line Break Outside the Secondary Shield Wall - this case provides the bounding break for breaks in the most direct path to the sump. Debris source terms for this case are provided in Table 3.b.4-2. The selection of these breaks was based on visual inspection which showed that these are the largest lines in the proximity of the emergency sump strainer.

Case 3: Reactor Vessel Nozzle Break - This case provides bounding debris loads for the unique condition when a nozzle break inside the reactor cavity may damage the portion of the strainer in the in-core tunnel, thus reducing the available surface area. Debris source terms for this case are provided in Table 3.b.4-3. Due to the potential for reduced strainer area, this case was retained for further evaluation.

NRC Review Area 3.b:

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

1. **Describe the methodology used to determine the ZOIs for generating debris. Identify which debris analyses used approved methodology default values. For debris with ZOIs not defined in the guidance report/SE, or if using other than default values, discuss method(s) used to determine ZOI and the basis for each.**
2. **Provide destruction ZOIs and the basis for the ZOIs for each applicable debris constituent.**
3. **Identify if destruction testing was conducted to determine ZOIs. If such testing has not been previously submitted to the USNRC 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.**

FENOC Response to Review Area 3.b.1:

The debris generation calculation defines the ZOI as the volume about the break in which the jet pressure is greater than or equal to the destruction damage pressure of the insulation, coatings, and other materials impacted by the break jet. The NEI 04-07 SER has concluded that modeling the double-ended guillotine (DEG) break ZOI as spherical and centered at the break site or location is an acceptable approach. The radius of the sphere is determined by the pipe diameter and the destruction pressures of the potential target insulation or debris material. The potentially important debris sources (insulation, coatings, etc.) within the ZOI were evaluated in accordance with the NEI-04-07, the NEI 04-07 SER, or the Westinghouse Technical Report, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified/Acceptable Coatings" (WCAP-16568-P) (Reference 9), shown in the Table below. The table below presents the debris sources, ZOI and method to determine the ZOI used in the analysis.

Table 3.b.1-1: Debris Material ZOI

Debris Source	ZOI (ft)	Basis
Diamond Power RMI with Standard Bands	28.6	NRC Approved Default Guidance
Transco RMI with Standard Bands	2.0	NRC Approved Default Guidance
Jacketed or Unjacketed NUKON™ with Standard Bands	17 L/D	NRC Approved Default Guidance
Qualified Coatings	5.5 L/D	WCAP-16568-P
Unqualified Coatings	100% failure	NRC Approved Default Guidance

Destruction testing performed for the ZOI of qualified coatings was conducted by Westinghouse at Wyle Laboratories. The testing and results are described in WCAP-16568-P. FENOC evaluated the test information and determined it was also applicable to the coatings applied at DBNPS. The test utilized surrogate coatings samples due to unavailability of materials originally used in plant construction. The coating vendors evaluated the surrogate samples and provided documentation to support applicability of the test to the qualified coatings used in plant construction. While the test results showed that ZOIs of 5 L/D or less could be demonstrated, FENOC selected a conservative value of 5.5 L/D for the qualified coatings ZOI.

<u>FENOC Response to Review Area 3.b.2:</u>

See response to 3.b.1.

<u>FENOC Response to Review Area 3.b.3:</u>

See response to 3.b.1.

FENOC Response to Review Area 3.b.4:

The quantity of each debris type generated for each of the three evaluated break locations is provided in the following tables:

Table 3.b.4-1
Break 1 Debris Generation Summary – Hot Leg Break East D-Ring

Debris Type	Small Fines	Large Pieces	Total Amount Destroyed
RMI	100,501 ft^2	33,500 ft^2	134,001 ft^2
NUKON™	3.6 ft^3	2.4 ft^3	6 ft^3
Qualified Coatings	1800 lbs	–	1800 lbs
Unqualified Coatings	2450 lbs	–	2450 lbs
Dirt/Dust Particulate	425 lbs	–	425 lbs
Latent Fiber	75 lbs	–	75 lbs
Tags, Labels, and Teflon Strainer Surface Area Reduction[1]	10 ft^2	–	10 ft^2

[1] Strainer surface area reduction is a direct surface area reduction and the 75% packing ratio discussed in the NEI 04-07 SER is not applied.

Table 3b.4-2

Break 2 Debris Generation Summary –
12" Decay Heat or 2 ½" Letdown Line Break Outside the Secondary Shield Wall

Debris Type	Small Fines	Large Pieces	Total Amount Destroyed
RMI	6,975 ft^2	2,325 ft^2	9,300 ft^2
NUKON™	3.6 ft^3	2.4 ft^3	6 ft^3
Qualified Coatings	1800 lb	–	1800 lb
Unqualified Coatings	2200 lb	–	2200 lb
Dirt/Dust Particulate	425 lbs	–	425 lbs
Latent Fiber	75 lbs	–	75 lbs
Tags, Labels and Teflon Strainer Surface Area Reduction[1]	10 ft^2	–	10 ft^2

[1] Strainer surface area reduction is a direct surface area reduction and the 75% packing ratio discussed in the NEI 04-07 SER is not applied.

Table 3b.4-3
Break 3 Debris Generation Summary – Hot Leg Nozzle Break inside Reactor Cavity

Debris Type	Small Fines	Large Pieces	Total Amount Destroyed
RMI	27,954 ft^2	9,318 ft^2	37,272 ft^2
NUKON™	0 ft^3	0 ft^3	0 ft^3
Qualified Coatings	158 lbs	–	158 lbs
Unqualified Coatings	2290 lbs	–	2290 lbs
Dirt/Dust Particulate	53.5 lbs	–	53.5 lbs
Latent Fiber	9.5 lbs	–	9.5 lbs
Tags, Labels and Teflon Strainer Surface Area Reduction[1]	10 ft^2	–	10 ft^2

[1] Strainer surface area reduction is a direct surface area reduction and the 75% packing ratio discussed in the NEI 04-07 SER is not applied.

Refer to Review Area 3.d for additional discussion on latent fiber quantities.

FENOC Response to Review Area 3.b.5:

The total surface area of all signs, placards, tags, tape, and similar miscellaneous materials in containment included in the quantity of debris generated is 10 ft^2. All placards, tags, and tape were evaluated for becoming potential debris sources. Where unsuitable materials were identified, they were replaced with material that would not generate debris. Thus, the 10 ft^2 reduction is additional margin that accounts for any non-qualified materials that may have been missed during the replacement effort.

RAI 1
Identify the name and bounding quantity of each insulation material generated by a large-break loss-of-coolant accident (LBLOCA). Include the amount of these materials transported to the containment pool. State any assumptions used to provide this response.

Response:
The type and amount of insulation debris generated by a LBLOCA that is transported to the containment pool are in Response to 3.b.4. The breaks analyzed are:

Case 1: RCS Hot leg Break in East D-Ring - this case provides the bounding break for breaks with the largest potential for debris, large breaks with two or more different types of debris and large breaks with the largest potential particulate debris to fibrous insulation ratio by weight. Debris source terms for this case are provided in Table 3.b.4-1.
Case 2: Decay Heat or Letdown Line Break Outside the Secondary Shield Wall - this case provides the bounding break for breaks in the most direct path to the sump. Debris source terms for this case are provided in Table 3.b.4-2.
Case 3: Reactor Vessel Nozzle Break - This case provides bounding debris loads for the unique condition when a nozzle break inside the reactor cavity may damage a portion of the strainer in the incore tunnel, thus reducing the available surface area. Debris source terms for this case are provided in Table 3.b.4-3.

Assumptions used including the ZOI, are described in the Response to 3.b.1

NRC Review Area 3.c:

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 USNRC-approved guidance.**

FENOC Response to Review Area 3.c.1 and 3.c.2:

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 3.c.1-1: Debris sources and material properties

Debris Source	**Bulk Density**	**Material Density**	**Characteristic Size**	**Basis**
INSULATION/FIBER				
NUKON™	2.4 lb/ft^3	175 lb/ft^3	7 micron	SER, NUREG-6224
Latent Fiber	2.4 lb/ft^3	175 lb/ft^3	7 micron	SER, NUREG-6224
LATENT PARTICULATES				
Dirt/Dust	N/A	169 lb/ft^3	17.3 micron	SER
QUALIFIED COATINGS				
Nu-Klad 110AA	N/A	121.5 lb/ft^3	10 micron	NEI-04-07/ SER/Manufacturer
Amercoat 66	N/A	126.5 lb/ft^3	10 micron	NEI-04-07/ SER/Manufacturer
Amercoat 90	N/A	126.5 lb/ft^3	10 micron	NEI-04-07/ SER/Manufacturer
K&L No 6129	N/A	69.9 lb/ft^3	10 micron	NEI-04-07/ SER/Manufacturer

Debris Source	Bulk Density	Material Density	Characteristic Size	Basis
QUALIFIED COATINGS (Cont.)				
K&L No 5000	N/A	94.6 lb/ft^3	10 micron	NEI-04-07/ SER/Manufacturer
UNQUALIFIED COATINGS				
Epoxy	N/A	94 lb/ft^3	10 micron	NEI-04-07
Alkyd	N/A	98 lb/ft^3	10 micron	NEI-04-07
Inorganic Zinc (IOZ) Primer	N/A	457 lb/ft^3	10 micron	NEI-04-07

FENOC Response to Review Area 3.c.3:

In general, specific surface areas for fibrous and particulate debris are used in the prediction of head loss with the NUREG/CR-6224 (Reference 4) correlation. FENOC has determined that the NUREG/CR-6224 correlation is not directly applicable to the Davis-Besse debris bed mixture, and has not used the NUREG/CR-6224 correlation to determine the debris bed head loss. Therefore, this item is not applicable.

FENOC Response to Review Area 3.c.4:

The Davis-Besse debris generation, transport and head loss analyses have used the debris characterization assumptions provided in the NRC approved guidance. Specifically, the size of particulates is consistent with 10 micron for coatings particulate and the recommended size distribution for latent particulate. A two size distribution is utilized for fibrous debris.

<u>NRC Review Area 3.d:</u>

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>FENOC Response to Review Area 3.d.1:</u>

The amount of latent debris was initially assumed to be a sufficiently large quantity to eliminate the need to validate assumptions regarding latent debris loading and composition. As analyses were completed it was determined that a plant specific quantification of latent debris was necessary due to the reduced strainer surface area available for RCS breaks inside the reactor vessel cavity. The remaining cases continued to utilize the initial assumption of 500 lbs of latent debris for conservatism.

A sampling procedure was developed and samples were taken from containment in December 2007 based on the guidance provided in NEI-04-07, as modified by the NRC SER. The sampling material was weighed before and after sample collection. The net weight change was noted. The surface area of the sample point was calculated based on the field measurements. A calculation that determined the amount of surface area of each sample type was prepared. The total amount of latent debris was then determined in a separate calculation by multiplying the latent debris loading per square foot by the applicable surface area.

<u>FENOC Response to Review Area 3.d.2:</u>

The acceptance criterion for the acceptable amount of latent debris was based on the assumption that the composition of latent debris is 15% fiber by weight. The remainder of the latent debris is assumed to be particulate. This is based on Appendix VII of the NEI-04-07 SER. Additional samples of containment latent debris were taken and analyzed for fiber content to validate this assumption. It was determined that the 15% fiber by weight assumption bounds all characterization samples. It was also assumed that the density of the latent fiber as it arrives at the strainer is 2.4 lb/ft^3. This assumption is based on Appendix VII of the NEI-04-07 SER.

FENOC Response to Review Area 3d.3:

The calculation of latent debris determined that the latent debris loading in containment is 46 lbs. Of this, 15%, or 6.9 lbs. is fiber, based on the assumption described above.

FENOC Response to Review Area 3.d.4:

The amount of sacrificial strainer surface area is 10 ft^2, consistent with the assumed amount of unqualified tags and labels. No overlap is assumed.

The NRC, in its letter to FENOC dated February 9, 2006 (Reference 10), requested additional information relative to Generic Letter 2004-02. Additional information is presented for the following RAIs pertaining to latent debris at DBNPS. The format for the response first includes the request itself and is then followed by the specific FENOC response.

RAI 31
Your submittal indicated that you had taken samples for latent debris in your containment, and that these were evaluated in an Enercon report DBE004-RPT-004 (ACT 03-0426). This report was not provided, please submit this report.

Response:
During preparation of the Enercon Report DBE004-RPT-004, no specific samples were taken. Samples were taken recently in December 2007 to determine latent debris. The sampling procedure and associated calculations are discussed above in the response to Review Area 3.d.1. Since latent debris samples were not included in the report, a copy of the report is not submitted with this correspondence.

RAI 32
Your submittal did not provide details regarding the characterization of latent debris found in your containment as outlined in the NRC SE. Please provide these details.

Response:
See the response to Review Area 3.d.2 and 3.d.3.

RAI 42
Please state the quantity of latent fiber assumed in the evaluation.

Response:
The response to Review Area 3.d.3 contains the necessary information.

NRC Review Area 3.e:

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.**

FENOC Response to Review Area 3.e.1:

Debris transport is the estimation of the fraction of debris generated that is transported from debris sources (break location) to the sump screen. Debris generation/transportation was calculated in two (2) analyses. The results from the Debris Generation Calculation are used to identify debris types and quantities resulting from HELB LOCA scenarios. These results are inputs to the Debris Transportation Calculation.

The four major debris transport modes, as defined in final Debris Transportation Calculation, are:

1. Blowdown transport - the vertical and horizontal transport of debris to all areas of containment by the break jet.
2. Washdown transport - the vertical (downward) transport of debris by the containment sprays and break flow.
3. Pool fill-up transport - the transport of debris by break and containment spray flows from the Borated Water Storage Tank (BWST) to regions that may be active or inactive during recirculation.
4. Recirculation transport - the horizontal transport of debris from the active portions of the recirculation pool to the sump screen by the flow through the ECCS.

The methodology used in the debris transportation analysis is based on the NEI 04-07 for refined analyses, as modified by the NRC's SER, as well as the refined methodologies suggested by the SER in Appendices III, IV, and VI. The specific effect of each transport mode was analyzed for each debris type generated, and a logic tree was developed to determine the total transport to the sump screen. The purpose of this approach is to break a complicated transport problem down into specific smaller problems that can be more easily analyzed.

The basic methodology used for the Davis-Besse transport analysis is described below:

1. Based on many of the containment building drawings, a three-dimensional model was built using Computer Aided Drafting (CAD) software.
2. A review was made of the drawings and CAD model to determine transport flow paths. Potential upstream blockage points including screens, fences, grating, drains, etc. that could lead to water holdup were addressed.
3. Debris types and size distributions were gathered from the debris generation calculation for each postulated break location.
4. The fraction of debris blown into upper containment was determined based on the relative volumes of upper and lower containment.
5. The quantity of debris washed down by spray flow was conservatively determined.
6. The quantity of debris transported to inactive areas or directly to the sump screen was calculated based on the volume of the inactive and sump cavities proportional to the water volume at the time these cavities are filled.
7. Using conservative assumptions, the location of each type / size of debris at the beginning of recirculation was determined.
8. A Computational Fluid Dynamics (CFD) model was developed to simulate the flow patterns that would occur during recirculation.
9. A graphical determination of the transport fraction of each type of debris was made using the velocity and Turbulent Kinetic Energy (TKE) profiles from the CFD model output, along with the determined initial distribution of debris.
10. The recirculation transport fractions from the CFD analysis were gathered to input into the logic trees.
11. The quantity of debris that could experience erosion due to the break flow or spray flow was determined.
12. The overall transport fraction for each type of debris was determined by combining each of the previous steps in logic trees.

<u>FENOC Response to Review Area 3.e.2:</u>

There are no assumptions or methods that deviate from the approved guidance in the areas of debris transport. There is no specific guidance in the areas of refined transport analyses provided by the NRC. The NRC has audited several of the debris transport analyses performed by Alion Science & Technology during the Generic Safety Issue(GSI)-191 plant audits and provided feedback on the methods employed. The Davis-Besse analysis is consistent with those analyses previously audited by the NRC in support of GSI-191.

FENOC Response to Review Area 3.e.3:

The CFD calculation for recirculation flow in the Davis-Besse containment pool was performed using Flow-3D Version 9.0, Windows installation, using an Alion Corporation modified subroutine. Flow-3D is a commercially available general-purpose computer code for modeling the dynamic behavior of liquids and gasses influenced by a wide variety of physical processes. The program is based on the fundamental laws of mass, momentum, and energy conservation. It has been constructed for the treatment of time-dependent multi-dimensional problems, and is applicable to most flow processes. Flow-3D is configuration-controlled under Alion's QA program, which contains a varied collection of exacting test problems. Version 9.0 (with the modified subroutine) has been validated and verified under the Alion QA program.

The CFD model was developed to simulate the flow patterns that would occur during recirculation.

a. The mesh in the CFD model was nodalized to sufficiently resolve the features of the CAD model, but still keep the cell count low enough for the simulation to run in a reasonable amount of time.
b. The boundary conditions for the CFD model were set based on the configuration of Davis-Besse during the recirculation phase.
c. The containment spray flow was included in the CFD calculation with the appropriate flow rate and kinetic energy to accurately model the effects on the containment pool.
d. At the postulated LOCA break location, a mass source was added to the model to introduce the appropriate flow rate and kinetic energy associated with the break flow.
e. Negative mass sources were added at the upper and lower strainer locations with a total flow rate equal to the sum of the break flow and spray flow.
f. An appropriate turbulence model was selected for the CFD calculations.
g. After running the CFD calculations, the mean kinetic energy was checked to verify that the model had been run long enough to reach steady-state conditions.
h. Transport metrics were determined based on relevant tests and calculations for each significant debris type present in the Davis-Besse containment building.
i. The results are provided in the response to Review Area 3.e.6.

FENOC Response to Review Area 3.e.4:

No credit was taken in the revised transport analysis for debris interceptors.

FENOC Response to Review Area 3.e.5:

Fine debris was allowed to settle per Stokes Law. However, the Turbulent Kinetic Energy was found to exceed the level required to keep the fine debris in suspension. Therefore, 100% of the fine debris in the active pool was transported to the strainer.

FENOC Response to Review Area 3.e.6:

The debris types, sizes, transport fractions and quantities are given in the tables below.

Table 3.e.6-1: East D-ring Hot Leg Break (Break 1 East) –Upper Strainer

Debris Type	Debris Size	Debris Transport Fraction (%)	Debris Quantity at Sump
RMI	Small Pieces	16	16080.16 ft^2
	Large Pieces	0	0 ft^2
NUKON®	Fines	27	0.97 ft^3
	Large Pieces	2*	0.05 ft^3
Qualified Coatings	Fines	27	486 lbm
Unqualified Coatings	Fines	32	784 lbm
Dirt/Dust	Fines	3	12.75 lbm
Latent Fiber	Fines	3	2.25 lbm

* Transport of Large Pieces reflects erosion

Table 3.e.6-2: East D-ring Hot Leg Break (Break 1 East) – Lower Strainer

Debris Type	Debris Size	Debris Transport Fraction (%)	Debris Quantity at Sump
RMI	Small Pieces	0	0 ft^2
	Large Pieces	0	0 ft^2
NUKON®	Fines	71	2.56 ft^3
	Large Pieces	5*	0.12 ft^3
Qualified Coatings	Fines	71	1278.0 lbm
Unqualified Coatings	Fines	68	1666.0 lbm
Dirt/Dust	Fines	83	352.75 lbm
Latent Fiber	Fines	83	62.25 lbm

* Transport of Large Pieces reflects erosion

Table 3.e.6-3: West D-ring Hot Leg Break (Break 1 West) – Upper Strainer

Debris Type	Debris Size	Debris Transport Fraction (%)	Debris Quantity at Sump
RMI	Small Pieces	29	2022.75 ft^2
	Large Pieces	0	0 ft^2
NUKON®	Fines	27	0.97 ft^3
	Large Pieces	2*	0.05 ft^3
Qualified Coatings	Fines	27	486 lbm
Unqualified Coatings	Fines	32	704 lbm
Dirt/Dust	Fines	3	12.75 lbm
Latent Fiber	Fines	3	2.25 lbm

*Transport of Large Pieces reflects erosion

Table 3.e.6-4: West D-ring Hot Leg Break (Break 1 West) – Lower Strainer

Debris Type	Debris Size	Debris Transport Fraction (%)	Debris Quantity at Sump
RMI	Small Pieces	0	0 ft^2
	Large Pieces	0	0 ft^2
NUKON®	Fines	71	2.56 ft^3
	Large Pieces	5*	0.12 ft^3
Qualified Coatings	Fines	71	1278.0 lbm
Unqualified Coatings	Fines	68	1496.0 lbm
Dirt/Dust	Fines	83	352.75 lbm
Latent Fiber	Fines	83	62.25 lbm

* Transport of Large Pieces reflects erosion

Break 2 (Letdown line break) debris transport fractions are bounded by the Break 1 (Hot Leg break) East loadings, so no specific debris transport analysis was performed for that Break case.

Table 3.e.6-5: Nozzle Break in Reactor Cavity (Break 3) - Upper Strainer Only

Debris Type	**Debris Size**	**Debris Transport Fraction (%)**	**Debris Quantity at Sump**
RMI	Small Pieces	0	0 ft^2
	Large Pieces	0	0 ft^2
NUKON®	Fines	100	0 ft^3
	Large Pieces	10*	0 ft^3
Qualified Coatings	Fines	100	158.0 lbm
Unqualified Coatings	Fines	100	2290.0 lbm
Dirt/Dust	Fines	100	53.5 lbm
Latent Fiber	Fines	100	9.5 lbm

* Transport of Large Pieces reflects erosion

Since the unqualified coating particulate was all assumed to reach the active recirculation pool, and would transport 100%, the overall transport fraction to the upper strainer would be 32% and the overall transport fraction to the lower strainer would be 68% (for Breaks 1 and 2). For Break 3, the overall transport to the upper strainer would be 100%. The unqualified coating chips, however, would not transport to either the upper or lower strainers, giving an overall transport fraction of 0%. This is because the turbulent kinetic energy is not high enough to keep the chips suspended.

RAI 39
The September 2005 response to GL 2004-02 stated that debris interceptors were credited in the debris transport analysis. The NRC staff requests that you describe how credit was applied for the debris interceptors, and state the final debris transport fractions derived for the types of debris considered in the evaluation.

Response:
The debris interceptors were originally credited, but are no longer credited in the calculations. The response to Review Area 3.e.4 above contains additional information.

RAI 45
The September 2005 GL response stated that FirstEnergy Nuclear Operating Company (FENOC) performed computational fluid dynamics (CFD) analysis to calculate debris transport. Please explain how you used CFD results to determine the amount of debris that transports to the sump screen.

Response:
The responses to Review Areas 3.e.1 and 3.e.3 above contains additional information.

NRC Review Area 3.f:

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.**

FENOC Response to Review Area 3.f.1:

a) UFSAR Figures 6.3-2A and 6.3-6 for schematics of the Emergency Core Cooling System are provided in Attachment 2.

b) UFSAR Figure 6.3-1 for a schematic of the Containment Spray System is provided in Attachment 3.

FENOC Response to Review Area 3.f.2:

The minimum submergence of the strainer is not dependent on the size of the LOCA. The amount of water delivered to containment is dependent on the break location and the amount of water assumed transferred from the BWST. For all breaks considered, the minimum water level in containment at the time of establishing long term recirculation is 566.88 feet International Great Lakes Datum (IGLD). Once containment has cooled down to 90°F, the level remains at 566.88 feet IGLD. This is a result of enough water vapor condensing from the atmosphere to compensate for the shrinkage due to cool down. The water level 30 days after the LOCA drops to a minimum value of 566.67 IGLD is due to leakage outside of containment. The maximum height of the strainer is 566.58 feet IGLD. This ensures that the strainer remains submerged at all times.

FENOC Response to Review Area 3.f.3:

A plant specific vortexing analysis was not completed for Davis-Besse. The design of the strainer complies with the specifications for vortex suppression contained in Regulatory Guide 1.82, Revision 2, Appendix A, Table A-6. The Regulatory Guide guidance was based on NUREG/CR-2761, "Results of Vortex Suppressor Tests, Single Outlet Sump Tests and Miscellaneous Sensitivity Tests."

FENOC Response to Review Area 3.f.4:

Specific Davis-Besse head loss testing has not been performed. Davis-Besse has removed essentially all fiber from containment, and thus the limiting fiber loads are generated through latent fiber. A walkdown and analysis performed in December 2007 documented that the latent debris loads were significantly less than the required latent debris loads necessary to develop a fiber bed of 1/8" for the postulated break locations. Analyses have concluded that the strainer will have clean screen area at these low latent fiber loads, and thus the debris head loss essentially consists of clean screen head loss plus RMI head loss.

FENOC Response to Review Area 3.f.5:

The sump strainer head loss calculation documents the performance of the replacement sump screen for design debris loads. Davis-Besse debris loads consist of fibrous insulation, particulate, RMI, coatings, and latent debris. While the RMI will occupy a substantial amount of interstitial volume, it will not impede the transport of the small amounts of fiber to the screen. The average debris bed thickness based on the maximum fibrous debris load is less than 0.125 inches. At this debris bed thickness, the screen remains fully effective.

FENOC Response to Review Area 3.f.6:

The Davis-Besse strainer is built in two sections, the upper and lower strainer. For LOCAs that occur in the D-rings, both strainer areas are available. The amount of fiber that reaches the upper strainer surface amounts to a fiber bed thickness of 0.06 inches on the upper strainer. This thickness was based on complete failure of all installed fibrous insulation and 75 lbs of latent fiber in containment. The Davis-Besse containment was determined to only have 46 lbs of latent debris, which represents 6.9 lbs of fiber, assuming latent debris is 15% by weight of latent debris. Thus the actual fiber bed would be well below the 1/8 inch thick bed typically assumed for creating the thin bed effect.

The strainer has no specific design features for resisting formation of a thin bed. However, the debris generation within containment is controlled to prevent development of a thin bed. For breaks in the reactor vessel cavity, a fiber load of 9.5 lb will result in a fiber bed of 1/8 inch. This is greater than the actual amount present in containment. This also does not credit the flow area of the lower strainer. The lower strainer may be damaged by debris generated by the HELB. There is additional strainer area into the upper strainer where flow from the lower strainer normally enters. This strainer area is not included in the analyzed flow area for the thin bed effect. This provides a reserve strainer area that will not experience development of a thin bed. If the lower strainer remains intact, there is a large amount of additional strainer area available to avoid thin bed effects.

FENOC Response to Review Area 3.f.7:

The strainer design differential pressure was originally based upon the minimum NPSH margin for the ECCS pumps of 3.4 feet, when operating LPI/Decay Heat (DH), Train 2. The maximum head loss in the strainer cannot exceed this available margin during ECCS operation. Since 3.4 feet of water is approximately 1.5 psi, 5 psi was conservatively used as a design differential pressure. This means that the strainer will fail at a differential pressure of above 5 psi, but the maximum expected pressure is 1.5 psi.

FENOC Response to Review Area 3.f.8:

The following margins and conservatisms exist in determining the head loss calculation:
1. The containment water level calculations contained conservatisms described in the response to Review Area 3.g.2.
2. Conservative friction factors used for piping and components in determining the system losses.
3. The ZOI used was greater than that recommended by NEI 04-07.
4. The amount of fiber present in the latent debris was conservatively assumed to be 15%.
5. Maximum system flowrates were used in determining NPSH.
6. It is assured that conditions to maintain the strainer fully submerged exist throughout mission time of the strainer.

The strainer design configuration was based on NRC sponsored testing, so no vortexing calculations were done.

FENOC Response to Review Area 3.f.9:

The methodology for determining the head loss across the clean strainer is as follows:

Flow models are constructed of the upper and lower strainers. A single-tube model is constructed for the upper strainer, because the flow is parallel. The lower strainer model consists of several parts – the Horizontal Tubes in the basement, the Lower Collector, the Inclined Tubes, the Upper Collector, and structures inside the sump.

This calculation determines the dynamic head loss of the large strainer based on an iteratively determined clean strainer flow split between the upper and lower strainers. Then the head loss is determined for an assumed maximum flow rate of 11,000 gpm (total of Containment Spray and LPI) through each section of the strainer (Upper and Lower), separately. These calculations are performed using standard methods. Bernoulli's Equation is used for incompressible flow along with the First Law of Thermodynamics. Head loss coefficients, friction factors, fluid properties, and perforated plate pressure drops are taken from references to the calculation.

The assumptions and inputs associated with the clean strainer head loss are:
1. Steady, incompressible flow is assumed. By definition, the system is water-solid and single phase.
2. The water on the containment floor is assumed to be 120°F, constant. This is at the lower end of the calculated post-LOCA containment sump temperatures, which is for head loss determination since the water viscosity is at its highest.

3. Credit is taken for the grating installed inside the perforated plate in accordance with Table A-6 of Regulatory Guide (RG) 1.82, Rev 2. This vortex suppression design has been shown to reduce air ingestion to zero during testing at Alden Research Laboratories. Therefore, air ingestion into the LPI pump suction lines is assumed to be zero.
4. A roughness of 0.010-inch is assumed for the inside surfaces of the stainless steel perforated plate, which effectively forms the wall of the suction tubes. The sensitivity of the head loss of the tube roughness is small, to be confirmed by a sensitivity analysis in this regard.
5. Intake flow through the perforated plate is assumed to be uniform. The basis for this is described in detail in the calculation.
6. The strainer is assumed to be clean and unfouled. This is confirmed by a containment emergency sump visual inspection each refueling outage.
7. It is assumed that the containment pressure is 14.7 psia.
8. Head loss calculations for individual sections of the strainer assume that all the flow that is going to enter that section over its length has already entered upstream. This is a conservative assumption as it increases the velocity and the losses of the fluid throughout the individual strainer internal structures.
9. Loss coefficients for miter joints are taken from the table on page A-29 in the Crane Manual. In the case that a modeled miter joint does not match one of the angles in the table, the closest angle on the conservative side (larger) is used.
10. In the upper collector, when flows are modeled as joining at the Incline Tube exits, it is likely that the two combining flows will have different pressures at the joining point. In this case, the lower of the two pressures is chosen for the new combined flow at the joining point.

Summarizing the results of the calculation:
1. The head loss across the strainer was found to be in a clean condition. It is concluded that the upper section of the large passive strainer is capable of passing all required ECCS flow (11,000 gpm for a large LOCA) with minimal pressure drop, approximately 0.06 psi.
2. For use in determining a loss coefficient for the upper and lower strainers, individually, the following pressure loss values may be conservatively applied:
    a. Pressure loss at 11,000 gpm through upper strainer equals 0.06 psi
    b. Pressure loss at 11,000 gpm through lower strainer equals 1.01 psi
3. It is concluded that the pressure drop across the perforated plate will be negligible due to the low approach velocities and suction flows.

FENOC Response to Review Area 3.f.10:

Methodology
The debris types identified in the Davis-Besse containment to be addressed by this calculation include:

- RMI
- Fibrous Debris
  - Fibrous Insulation Products (NUKON™)
  - Fibrous Latent Debris
- Particulate Debris
  - Failed Coatings
  - Particulate Latent Debris (Dirt/Dust)
- Chemical Precipitation Debris

Head Loss for RMI:
The head loss for a RMI debris bed on the sump screen surface depends mainly on the accumulation at the sump screen and the type and size distribution of RMI debris. The key parameter needed to evaluate RMI head loss is the surface area of the foils of RMI deposited on the screen. The Davis-Besse analysis uses relationships contained in the NEI-04-07 SER to determine the head loss from RMI that may collect at the strainer.

Head Loss for Fibrous Debris with Particulate, including Chemical Precipitation Debris:
The SER states that a minimum thickness in which a uniform thin-bed could form that could subsequently filter sufficient particulate debris is 1/8". Therefore, it can be conservatively assumed that for debris mixtures with an equivalent bed thickness less than 1/8" will not sufficiently filter particulate debris and thus will not produce an appreciable head loss. From this assumption it can be reasonably inferred that clean screen area will exist to allow particulates and chemical precipitates to pass through without causing a noticeable head loss. For strainer qualification purposes, the fibrous/particulate/chemical debris bed head loss would be zero in this case.

Results:
For debris load conditions in which clean screen area is assured (i.e., debris bed thickness is less than 1/8"), the total strainer head loss is the sum of the RMI head loss and the clean strainer head loss values. For the various analyzed breaks the following results are obtained:

Break 1/Break 2 – Upper strainer: Total Debris Head Loss = 0.1684 ft water
Break 3 – Upper strainer: Total Debris Head Loss = 0.15 ft water.

FENOC Response to Review Area 3.f.11:

The sump is not partially submerged or vented. The containment sump screen is a vertical strainer design located within the existing sump pit and in-core tunnel and is designed to assure full submergence at the minimum calculated recirculation pool water level.

The strainer is a passive design, and has been designed to withstand applicable structural loads, including seismic and head loss. A trash rack has been provided for the upper strainer to preclude the introduction of large debris that might cover a portion of the strainer surface.

The design calculations assume that a hot leg nozzle break in the reactor cavity (Break 3) will compromise the lower strainer integrity. The upper strainer integrity has been assured for this break by placing strainer media over the opening into the emergency sump from the lower strainer assembly.

FENOC Response to Review Area 3.f.12:

The analyses do not include near-field settlement. Near field effects pertain to a testing phenomenon, and no plant specific testing was performed.

FENOC Response to Review Area 3.f.13:

Analyses have concluded that the strainer will have clean screen area, and thus the debris head loss essentially consists of clean screen head loss plus RMI head loss. Head losses have been determined at the lowest postulated pool temperatures to maximize viscosity, and no scaling of head losses to early event higher temperatures is necessary.

FENOC Response to Review Area 3.f.14:

Davis-Besse analyses have shown the screen to have clean screen area, and thus the debris head loss essentially consists of clean screen head loss plus RMI head loss. Under these conditions, no flashing across the debris bed is postulated, and containment pressure has not been credited. The head loss across the strainer and debris bed was shown to be 0.1684 ft-water, or 2 inches of water. At the time of recirculation, there is sufficient elevation head to maintain the water subcooled as it goes across the debris bed. The concern is only at the top of the strainer, and in addition to the water above the strainer, from design drawings, the top ½" is not perforated. Therefore, containment accident pressure was not credited in evaluating strainer flashing.

RAI 37
You stated that the primary debris sources are reflective metallic insulation (RMI) insulation and coatings, and that the debris is both particulate and chips. Please provide the debris size distribution assumptions applied in the head loss analyses and discuss the technical basis for the distributions assumed.

Response:

The debris physical properties are listed in Tables RAI 37-1 and RAI 37-2, below. The values are based on the NEI 04-07 SER Table 3-3.

Table RAI 37-1: Debris physical properties

Debris Type	Small Fines	Large Pieces	Material Bulk Density	Particulate/Individual Fiber Density
RMI	<4"	>4"	-	-
NUKON	<4"	>4"	2.4 lb/ft^3	175 lb/ft^3
Qualified Coatings	10μm	-	-	Varies by coating
Unqualified Coatings	10 μm	-	-	Varies by coating
Dirt/Dust particulate	17.3 μm	-	-	169 lb/ft^3
Latent Fiber	7 μm	-	2.4 lb/ft^3	175 lb/ft^3

The debris size distribution for the insulation and coating materials is as follows:

Table RAI 37-2: Debris size distribution

Debris Type	% Small Fines	% Large Pieces
Diamond Power RMI with Standard Bands	75%	25%
Transco RMI with Standard Bands	75%	25%
Unjacketed and Jacketed NUKON with Standard Bands	60%	40%
Qualified Coating Systems	100%	0%

RAI 43

The NUREG/CR-6224 correlation was used to calculate the head loss across the Davis-Besse strainer. This correlation was designed and validated essentially to model debris beds where a fibrous layer filters out particulate debris. However, as the GL response stated, it might not be likely for a 1/8" fiber layer to form on the Davis-Besse strainer because the quantity of fibrous material inside containment has been strictly reduced and controlled. Thus, for a bed composed mainly of coating debris and RMI, it is not clear to the staff why the NUREG/CR-6224 correlation is appropriate. Please provide justification that the NUREG/CR-6224 correlation provides conservative head loss results for the low-fiber debris beds that have been analyzed as forming at Davis-Besse.

Response:
The specific surface areas for fibrous and particulate debris are used in the prediction of head loss with the NUREG/CR-6224 correlation. The NUREG/CR-6224 correlation was used in the initial design of the strainer. The design analyses have been updated after the issuance of the NEI-04-07 and NEI-04-07 SER. As a result of the update, FENOC has determined that the NUREG/CR-6224 correlation is not directly applicable to the Davis-Besse debris bed mixture, and has not used the NUREG/CR-6224 correlation to determine the debris bed head loss. Therefore, this item is no longer applicable.

NRC Review Area 3.g:

Net Positive Suction Head (NPSH)

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a 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.**

FENOC Response to Review Area 3.g.1

The flow through each of the LPI pumps is assumed to be 4100 gallons per minute (gpm), of which 100 gpm is minimum recirculation flow. The remainder of the flow is entering the pumps from the containment emergency sump strainer.

The CS Pumps are assumed to be pumping 1500 gpm, all of which is entering through the strainer. The CS pump minimum flow path is back to the BWST, and is normally isolated. When recirculating coolant from the sump following a LOCA, the CS system does not have a minimum flow path since pump cooling is provided by mixing with the ECCS water in the containment pool. Flow is assured because the pump discharge head is well above the maximum containment vessel pressure. The CS pump discharge valve is automatically throttled to reduce flow to 1300 gpm; however, no credit is taken for this action in the emergency sump strainer NPSH evaluation.

The total flow therefore entering through the containment emergency sump strainer is 11,000 gpm. The NPSH is evaluated at 260°F, which exceeds the maximum sump temperature predicted following transfer to the recirculation mode.

The water level in containment is evaluated at 229°F and at 90°F. It is also calculated 30 days after the LOCA, considering the maximum allowable ECCS leakage outside containment with no operator action to replenish the water level. The water level is at 566.88 feet IGLD when the systems are transferred to sump recirculation. It is also at this elevation when sump temperature has been reduced to 90°F. Following 30 days of recirculation with no operator action to replenish water, the level could decrease to 566.67 feet IGLD. The top of the strainer is located at 566.58 feet IGLD. The NPSH margin calculation includes these water level considerations when determining the NPSH margin.

FENOC Response to Review Area 3.g.2

The following assumptions were used in determining the Net Positive Suction Head margin:

1. It is assumed that the NPSH requirements on the LPI and CS pump curves are referenced to the pump centerlines.
2. Based on Table A-6 of RG 1.82, Rev. 2, air ingestion into the LPI pump suction lines is assumed to be zero.
3. Pressure losses inside the sump due to vortex suppressors, etc., are determined in the head loss calculations for the new strainer.
4. The head loss through the flange connecting the suction piping to the LPI and CS pumps is assumed to be negligible.

5. Approximately 100 gpm of the LPI pump flow is re-circulated back to the pump inlet. In order to meet a minimum flow requirement to the RCS when the LPI pumps draw a suction from the BWST, the stop position of the discharge valves DH14A and 14B are set such that the maximum LPI pump flow is 4100 gpm when aligned to the sump (i.e., 4000 gpm sump suction pipe flow). Therefore, a pump flow rate of 4100 gpm and a sump suction pipe flow rate of 4000 gpm will be used in this calculation. A flow rate of 4100 gpm is used in the 12-inch suction piping because the 100 gpm of re-circulated flow travels through a good portion of the 12-inch piping.
6. The head loss from the 18"x14" eccentric reducers was conservatively modeled as a sudden contraction. The head loss from the 14"x18" eccentric expander was conservatively modeled as a sudden enlargement. Treating the eccentric reducers as a sudden contraction and the eccentric expanders as a sudden enlargement results in a conservative resistance coefficient, because in reality the pipe inside diameter transition in these fittings is gradual.
7. To allow for an area in which the 18" x 12" reducers can be welded to the suction piping, it was assumed that the concentric reducers neck down linearly over a 9-inch span. The total length of the 18" x 12" reducers is 15-inches.
8. To allow for an area in which the 10" x 8" reducers can be welded to the suction piping, it was assumed that the concentric reducers neck down linearly over a 3-inch span. The total length of the 10" x 8" reducer is 7-inches.
9. Most of the 90° elbows are identified as long radius elbows (i.e. r/d = 1.5) on the LPI and CS Isometric Drawing. It is assumed that all of the 90° elbows are long radius. This is consistent with the original Bechtel NPSH calculation.
10. It was conservatively assumed that the all of the 8" piping in the CS suction (Line Number 8"-HCB-3) is schedule 40. In reality, some of the 8" piping is Schedule 10s. Since the schedule 40 piping has an inside diameter that is less than the inside diameter for schedule 10S, the velocity through the piping is higher. This results in a conservative head loss.
11. It is assumed that the containment sump temperature is constant at 260°F. This exceeds the maximum sump temperature determined in containment analyses for the design-basis, 14.14-ft^2 hot leg break. It also exceeds the peak sump temperature reported in UFSAR Section 15.4.6.5.
12. Consistent with the DBNPS licensing basis, the vapor pressure of the sump water is assumed to be equal to the containment atmosphere pressure.

The following assumptions were used in determining the post-LOCA containment water level:

1. The containment volume from 545' to 565' elevation has a relatively constant cross section.
2. Water from the BWST and Reactor Coolant System (RCS) have the same physical characteristics as regular water. The boric acid in solution with the water has no measurable impact on the thermal and physical characteristics over the concentrations and temperatures of interest.
3. For the minimum water level, at least 360,000 gallons of water has injected into containment at swapover, there is no bypass leakage or other flow paths that will divert water from reaching the containment, containment atmosphere, RCS, etc.
4. For the purpose of the water level calculation, the minimum flooding level is defined as the point at which suction is transferred to the sump. To ensure that the minimum flood depth is determined, the flood depth for each case when the long term containment, RCS, and sump temperature reaches 90°F is calculated. There is no specific basis for using 90°F. It was selected as a conservative long term post-LOCA condition.
5. All water on the containment floor remains subcooled or at saturation
6. The volume of trisodium phosphate (TSP) and the TSP baskets are small compared to the amount of water present in CTMT and thus, will be ignored for the minimum flood depth cases (a conservative assumption).
7. In-core guide tubes are small and shall be ignored for this calculation for the minimum flood depth cases (a conservative assumption).
8. The volume of water from the Makeup and Purification System is small and will be ignored. This is conservative for the minimum level.
9. For the most limiting break that results in the lowest flooding level, the break is assumed to be located high such that part of the injected BWST water is used to fill up the RCS system due to shrinkage since the pressurizer will still retain RCS Inventory. Therefore, there is no contribution from the RCS to flood the containment floor.

The assumptions made in predicting the sump water temperature are made to support predicting the maximum containment pressure and temperature. Since the containment atmosphere becomes a saturated environment, maximizing the vapor pressure and temperature also maximizes the liquid temperature.

<u>FENOC Response to Review Area 3.g.3</u>

The purchase specification for the Decay Heat Removal (DHR) Pumps required testing to be performed in accordance with American Society of Mechanical Engineers (ASME) Power Test Code (PTC) 8.2, 1965. The PTC 8.2 standard does not provide any specific acceptance criteria for determination of onset of cavitation.

The CS pumps required the testing to be conducted in accordance with the Standards of the Hydraulic Institute. The Hydraulic Institute Centrifugal Pump Test Standards state that a head degradation of 3 percent is usually accepted as evidence that cavitation is present. While no specific documentation that the three percent standard was used for testing the Davis-Besse pumps, it is reasonable to assume that this was the standard applied in developing the pump Net Positive Suction Head Required (NPSHr) curves. No documentation that indicated a change of NPSHr curves from the original curve supplied with the pump was identified.

FENOC Response to Review Area 3.g.4

Friction losses in the ECCS and CSS are calculated based on the flows in each pipe section, except as noted in assumption six of the NPSH margin analysis, described in Review Area 3.g.2, above. The form losses are taken from Crane Technical Paper 410, except for the fittings at the sump suction. The form losses for those fittings and for the strainer structure are based on information from Fried and Idelchick's Flow Resistance: A Guide for Design Engineers.

FENOC Response to Review Area 3.g.5

The response of the ECC system is not highly dependent on the size of the loss of coolant accident. In general, SBLOCAs are less severe than LBLOCAs for several reasons. First, SBLOCAs will result in a smaller ZOI, with resulting lower debris generation. With less debris generated, the amount of debris transported to the strainer would be reduced. Since the RCS pressure will also remain elevated for SBLOCAs, the flow through the strainer will be reduced. The lower flow causes the debris transport to be further reduced. The pressure drop through the strainer and the ECC and CS systems will be lower. Also, the NPSHr to support the lower flows will be reduced. This would all contribute to higher margins.

There is a potential that the HPI pumps will continue to operate due to a SBLOCA. However, the HPI pumps do not draw water directly from the emergency sump. They are fed from the LPI pumps during the recirculation phase. Since the total flow through the LPI pump is controlled to ensure that the system operation is bounded by the analyses, the inclusion of HPI flow does not alter the analyzed scenario. The NPSH margin will be preserved by controlling the LPI flow.

After any break, water would be supplied from the BWST. Therefore, the water level in containment is only a function of when the Safety Features Actuation System Level 5 permissive is reached. The containment water level analysis evaluated several break locations. The limiting break was at the top of the Hot leg U-bend. The maximum amount of water is retained in the RCS if the break is small and at the very top of the pipe. If the break is large, more water from the RCS volume is spilled into containment.

CS is automatically actuated in LBLOCAs based on containment pressure. However, since Operators might manually start spray flow, the existing strainer design always includes CS flow and is bounding.

FENOC Response to Review Area 3.g.6

All ECCS and CS pumps will be in standby status during normal plant operation. Should a LOCA occur, automatic startup of the pumps is provided by the Safety Features Actuation System, as described in the UFSAR Chapter 6.3. At startup, all the pumps are fed from the BWST. The LPI flow will be limited by the setting of LPI Cooler discharge throttle valve, DH14A(B). The minimum setting for that valve is based on ensuring minimum flow, as assumed in the LOCA analysis, is met. The maximum opening of DH14A(B) is based on ensuring that with the system on recirculation, the maximum analyzed flow through the strainer is not exceeded. The CS system is allowed to run without throttling when fed from the BWST. When switched to the recirculation mode, the discharge of the pumps is automatically throttled to 1300 gpm. The strainer analyses assume that this system continues to provide flow at 1500 gpm per pump to provide margin for the results.

Transfer to the recirculation mode of operation is only permitted once the minimum amount of water has been transferred from the BWST. This permissive is part of the Safety Features Actuation System. Actual transfer is performed by plant operators. This ensures that the minimum water level used in the analyses exists within containment.

FENOC Response to Review Area 3.g.7

Single failure analysis considerations would generally result in the loss of one train of ECCS or CSS. A single train of each system is capable of providing full mitigation of all LOCAs. A reduction in the amount of water being pumped will result in lower flow in containment and through the strainer. This results in less pressure drop in each of the systems. The total amount of flow is bounded by the analyses that assume all trains are operating at maximum flow.

If the amount of water injected into the RCS/containment does not exceed the amount used in the analyses, there could be an adverse effect. The SFAS permissive that controls when the change to recirculation is permitted is single failure proof in that it has four level sensor channels that are combined in a coincidence matrix to ensure that the plant performance bounds the analyses.

The strainer is a passive device so single failure criteria does not apply in the short term. In the long term, no single failure mechanisms for passive devices (e.g., seal or packing leaks) are applicable.

FENOC Response to Review Area 3.g.8

Containment post-LOCA water level is determined by first determining the volume occupied by structures on Elevation 565 ft and the cavity volumes inside containment. Then, the sources of water contributing to the flooding level, and the potential ways that this water can be diverted from reaching the sump are defined. General assumptions are then discussed, which leads to the identification of limiting cases. These are evaluated and compared to determine to the worst-case sump level. Limiting assumptions were made and conclusions drawn to calculate conservative minimum and maximum flood depths. The maximum ECCS leakage over 30 days is taken into account in the final minimum flood depth.

FENOC Response to Review Area 3.g.9

A minimum conservative post-LOCA water level is determined using the following assumptions:

1. For the minimum water level, no more than 360,000 gallons of water has injected into containment at swapover. This accounts for instrument uncertainty, and the minimum allowable water level by Technical Specifications. No water is credited during the transfer to the emergency sump.

2. To ensure that the minimum flood depth is determined, the flood depth for each case when the long term containment, RCS, and sump temperature reaches 90°F is calculated. This temperature was selected as a conservative long term post-LOCA condition. Calculation results show little sensitivity to temperatures. A slightly lower containment flood depth may result when everything in containment cools down to 90°F because the sump water expansion will be lower than the point at which suction is transferred to the sump.

3. For the most limiting break that results in the lowest flooding level, the break is assumed to be located high such that part of the injected BWST water is used to fill up the RCS system due to shrinkage. Additional volume is used to fill the pressurizer since it remains intact. Consequently, there is no contribution from the RCS to the containment flood level.

4. Maximum ECCS leakage over 30 days is considered in the minimum containment water level.

FENOC Response to Review Area 3.g.10

The following conditions could reduce the water contribution to the containment sump. These conditions are taken into account in determining the minimum water level in the containment post-LOCA: empty spray pipe, water droplets, condensation and holdup on horizontal and vertical surfaces.

The filling of one train of empty CS piping is taken into account to determine the amount of BWST water that is diverted away from reaching the sump when the Lo-Lo level is reached at the BWST (i.e., when transfer takes place to have the ECCS pumps taking suction from the sump). Only the portion of the piping downstream of the outboard containment isolation valves is included.

Condensation held up on various surfaces inside the containment is considered for the minimum flood depth cases. A water film layer or drops condensed out on surfaces are also taken into account.

On surfaces that are limited heat sinks, (e.g., piping and equipment that does not interface with the outside environment), the surface temperature will approach an equilibrium temperature with the containment atmosphere and will be left with a non-flowing film of water coating the surface. Other surfaces that provide large heat sinks, (e.g., the containment walls) that can transfer heat to the environment, will experience a continuous flow of condensation resulting from natural convection from the pool to the atmosphere.

The containment building and penetrations is the only surface area that is considered a large heat sink since the heat transmitted to the containment surface via condensation can be transferred to the environment. The other surfaces located inside the containment building cannot transmit heat to the environment; therefore, these surfaces will reach the internal containment air temperature preventing further condensation. Both can be modeled using equations derived for laminar flow on a vertical plate.

The equation for the film thickness is based on the assumption that the flowing film is laminar. The flow down a vertical wall will be laminar with ripples up to a Reynolds Number of approximately 1000 to 2000. If the Reynolds Number exceeds 1000 to 2000, a turbulent flow regime exists. The Reynolds Number for the flow down the steel containment vessel ranges from 0 (at the top) to approximately 3000 at the bottom. As flow starts to ripple, part of the flow will separate from the steel containment vessel wall. The droplets that separate from the containment wall will fall to the bottom of containment at a faster rate than if the flow had not separated from the wall. Therefore, using the equation above with the assumption of laminar flow is conservative for this water level calculation. Water droplets in the atmosphere and water on surfaces are due to CSS actuation.

The surface area for the containment walls and penetrations is rounded up; the value is well defined, so no additional margin of error is included in this portion of the condensation estimation. The non-flowing film area is determined by subtracting the containment surface area from the total condensation surface area.

Puddling, pooling, (i.e., some water may be perched on various horizontal surfaces or trapped inside equipment foundations, curbed areas, insulation jacketing, etc.) is taken into account.

FENOC Response to Review Area 3.g.11

The volume of trisodium phosphate (TSP) and the TSP baskets are small compared to the amount of water present in containment and thus, will be ignored for the minimum flood depth cases (a conservative assumption). Evaluations show that the volume occupied by miscellaneous equipment, such as fire carts and equipment storage containers, is small and have a negligible effect on the water level inside containment. The miscellaneous equipment stored on elevation 565' will not be included in the minimum level calculation.

FENOC Response to Review Area 3.g.12

Table 3.g.12-1 shows the water volumes for the minimum water level in containment:

Table 3.g.12-1: Minimum Water Volumes in Containment

Description	**Volume in ft^3**	**Comments**
Water contributions to the sump (+)		
BWST Contents, corrected from 90°F	50,346	360,000 gallons (min)
Core Flood Tanks, corrected from 120°F	2,162	Entire volume injected
RCS Inventory, corrected from 575°F	0	Conservative assumption
Makeup Tank, corrected from 90°F	0	Conservative assumption
Volume of water in PZR, corrected from 575°F	0	Conservative assumption
Additional water due to blowdown	0	Conservative assumption

Description	Volume in ft^3	Comments
Subtotal of contributions to the sump	52,507	
Water diverted away from sump (-)	6,383	
Water that will end up at the sump	46,125	

FENOC Response to Review Area 3.g.13

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

FENOC Response to Review Area 3.g.14

Credit is not taken for containment accident pressure in determining available NPSH, therefore, minimizing the containment accident pressure is not necessary.

The assumptions made in predicting the sump water temperature are made to support predicting the maximum containment pressure and temperature. Since the containment atmosphere becomes a saturated environment, maximizing the vapor pressure and temperature also maximizes the liquid temperature.

The containment analysis uses bounding inputs to determine a maximum containment pressure, and therefore, a maximum containment sump water temperature.

The major characteristics/assumptions of the containment response analysis are:

- Initial power level of 1.02 of 2966 MWt.
- UHS temperatures modeled as a function of time with initial temperature of 90.0°F.
- Initial average containment vessel air temperature of 90°F and 120.0°F.
- Initial BWST water temperature of 90.0°F
- Initial containment vessel pressure of 15.3 psia that includes the Tech Spec allowed pressure range.
- RELAP5/MOD2-B&W mass & energy release data which incorporated the appropriate assumptions to maximize the release.
- Single train operation of plant systems except for Core Flooding Tanks (both tanks modeled)
- Decay power and sensible heat generation models.
- No heat loss from the containment vessel to the annulus.

- Heat transfer coefficient between sump water and containment vessel vapor set to zero.
- Fraction of heat sink condensate that is allowed to revaporize set to zero.
- The maximum allowable coating thickness was modeled for each heat sink.
- Air / steam leakage from the containment vessel (e.g., through penetrations) is assumed to be zero.

Mass and Energy Release Data:
LBLOCA mass and energy release analyses were performed in support of the power uprate at Davis-Besse. The analyses utilized a power level of 102 percent of 2966 MWt. The RELAP5/MOD2-B&W code was used to perform the entire blowdown and refill portions of the transient.

The sump is in thermal equilibrium with the containment vessel atmosphere. If the average temperature of the sump becomes greater than the saturation temperature corresponding to the total containment vessel pressure, boiling will occur in the sump. Thus, the highest achievable sump temperature is equal to the saturation temperature corresponding to the total containment vessel pressure.

Several input assumptions were incorporated to maximize the M&E, such that, they could be utilized for the containment vessel's peak pressure analysis. These assumptions included:

- 0% steam generator tube plugging
- maximum initial pressurizer level,
- minimum Emergency Core Cooling System flowrates,
- LOOP and pumps powered with a 2-min RCP trip delay, and,
- Consideration of nitrogen entering the RCS via emptying of the Core Flood Tanks (CFTs).

<u>FENOC Response to Review Area 3.g.15</u>

The containment accident pressure analysis is separate from the ECCS and CSS NPSH analysis. Consistent with the DBNPS licensing basis, the vapor pressure of the sump water is assumed to be equal to the containment atmosphere pressure.

<u>FENOC Response to Review Area 3.g.16</u>

The NPSH margins calculated exclude the head loss across the sump screen, inside the sump, across the anti-vortex device and across the debris buildup on the sump screen. LPI Pump 42-1 has the most limiting NPSH margin (2.5 feet). This represents the maximum head loss that the debris and the strainer could have before the NPSH available is equal to NPSH required.

The actual head loss of the debris and the strainer is calculated to be 0.17 feet of water (ft-H_2O) at the maximum LPI and CS flow rates. This is less than the limiting NPSH Margin of 2.5 ft-H_2O. Therefore, adequate NPSH margin is provided to the LPI and CS Pumps with the installed sump strainer at the time of swapover to recirculation.

The reduced containment water level due to 30 days of ECCS leakage was also determined. The containment water level would be 0.21 feet lower than the level at the start of recirculation. This reduces the available NPSH. The head loss would then be 0.17 ft-H_2O due to debris plus 0.21 ft-H_2O due to lower level equaling 0.38 ft-H_2O. This results in 2.1 ft-H_2O of the NPSH margin remaining. Therefore, adequate NPSH margin is provided to the LPI and CS pumps with the installed strainer after 30 days of ECCS leakage.

RAI 7

For a LBLOCA, provide the time until ECCS external recirculation initiation and the associated pool temperature and pool volume. Provide estimated pool temperature and pool volume 24 hours after a LBLOCA. Identify the assumptions used for these estimates.

Response:

The Davis-Besse Updated Safety Analysis Report provides a time to recirculation for a LBLOCA of 40 minutes using a single train of ECCS and CS for the Maximum Hypothetical Accident analysis which makes assumptions to maximize the dose consequences of the accident. A time of approximately 30 minutes is calculated by assuming a maximum flow from the BWST in both trains of the ECC and CS systems. This also assumes the minimum volume of water is injected from the BWST.

The containment pool temperature is conservatively calculated to be approximately 251°F at start of recirculation (4500 seconds or 75 minutes). The temperature has dropped to approximately 210 °F by 86,400 seconds (24 hours). This analysis has assumed only one train of ECCS and CS in service, which causes the delay in establishing recirculation. However, this maximizes the pool temperatures.

The minimum pool elevation is 1.88 feet above the 565 foot elevation of containment at the time of switchover to recirculation. The analysis assumes the minimum amount of water spills from the RCS, and the minimum amount is injected from the CFTs and BWST. Hold up of water in piping systems and on wall surfaces is included, as well as accounting for the steam that would exist in containment. No miscellaneous volumes in the pool were included. Davis-Besse does not have a specific calculation of pool height at 24 hours post-LOCA. However, the pool height was evaluated when sump temperature has cooled to 90°F, which occurs well after 24 hours. The pool height at that time was also found to be 1.88 feet above the 565 foot elevation of containment. This occurs because the density increase is offset by a lower mass of water in the steam volume of the containment.

NRC Review Area 3.h:

Coatings Evaluation

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

1. **Provide 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 ZOI 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.**

FENOC Response to Review Area 3.h.1:

The qualified coatings systems are in Table 3.h.1-1, the coatings analyzed are a part of the response to Review Area 3.c.1:

Table 3.h.1-1: Qualified Coatings systems

Coating	Dry Density (lb/ft^3)
Amercoat 90	126.5
Amercoat 66	126.5
Nu-Klad 1100AA	121.5
Dimetcote 6	185.5
Carbozinc 11 SG	223.6
K&L No. 6129	69.9
K&L No. 5000	94.6

The following summarizes the high heat silicone aluminum coatings:

Table 3.h.1-2: High Heat Silicone Aluminum Coatings

Coating	Dry Density (lb/ft^3)
Coverdale Hi-Heat Silicone Aluminum	88.3
Ameron Amercoat 878	101.5
Sherwin-Williams TT-P-28G MOD High Heat Aluminum	82.4

The following is a summary of the unqualified coatings:

Table 3.h.1-3: Unqualified Coatings

Coating Type	Reported Surface Area (ft^2)	Surface Area +20% (ft^2)	Area Density (lb/ft^2)	Mass (lbs)
Powder	149	179	0.094	17
Alkyd	4515	5418	0.049	265
Epoxy Two Coat	1765	2118	0.094	199
Epoxy One Coat (IOZ primer and Epoxy Top Coat)	8899	10679	0.161	1719
Total				2200

FENOC Response to Review Area 3.h.2:

The following assumptions and justifications apply to post-LOCA paint debris transport analysis:

- It was assumed that the settling velocity of paint particulate can be calculated using Stokes' Law. This is a reasonable assumption since particulate debris is generally spherical and would settle slowly (within the applicability of Stokes' Law).
- It was conservatively assumed that all debris blown upward would be subsequently washed back down by the Containment Spray flow. The fraction of debris washed down to various locations was determined based on the spray flow split determined based on the geometry of the Davis-Besse containment and the Containment Spray system.
- With the exception of debris washed directly to the sump screen or to inactive areas, it was assumed that the fine paint debris that is not blown to upper containment would be uniformly distributed in the recirculation pool at the beginning of recirculation. This is a reasonable assumption, since the initial shallow flow at the beginning of pool fill-up would carry the fine debris to all regions of the pool.
- During pool fill-up, it was assumed that a fraction of the paint debris would be transported to inactive areas, as well as some debris directly to the sump screen as the sump cavity fills with water. These fractions were determined based on the ratio of the cavity volumes to the pool volume at the point when the cavities are filled.
- It was assumed that the unqualified coatings in lower containment would enter the recirculation pool in the vicinity of the locations where they are applied. This is a reasonable assumption since unqualified coatings outside the ZOI would

break down gradually, and would be likely to fail after recirculation has been initiated.

- All unqualified coatings, and qualified coatings within the postulated ZOI that fail, were assumed to fail as particulate in the debris generation analysis for Davis-Besse. The recirculation transport fraction from the upper levels of containment to the pool for particulate debris was assumed to be 100%. The unqualified were also analyzed to fail as chips, however, they would not transport to either the upper or lower strainers, giving an overall transport fraction of 0%. This is because the turbulent kinetic energy is not high enough to keep the chips suspended.
- Please see the response to 3.e.6 for transport to the sump, and the response to 3.e.5 for the basis.

<u>FENOC Response to Review Area 3.h.3:</u>

Davis-Besse has removed essentially all fiber from containment, and thus the limiting fiber loads are generated through latent fiber. A walkdown performed in December 2007 documented that the latent debris loads were significantly less than the latent debris loads necessary to develop a fiber bed of 1/8" for the postulated break locations. Davis-Besse analyses have shown the screen to have clean screen area at these low latent fiber loads, and thus the debris head loss essentially consists of clean screen head loss plus RMI head loss. Specific Davis-Besse head loss testing has not been performed.

<u>FENOC Response to Review Area 3.h.4:</u>

See Response to Review Area 3.h.3 above

<u>FENOC Response to Review Area 3.h.5:</u>

The following assumptions were applied to paint debris generation calculations.

- It is assumed that all coatings within the ZOI fail as a result of impingement.
- It is assumed that the ZOI for qualified coatings is 5.5D. The SER evaluation of NEI-04-07 Section 3.4.2.1 recommends the use of a 10D ZOI unless site specific coatings destruction information is available. Westinghouse has performed jet impingement testing for coatings similar to those used in the Davis-Besse containment. The test results and conclusions are presented in WCAP-16568-P. The WCAP recommends the use of a 4D ZOI for qualified coatings, therefore the assumed 5.5D ZOI is considered conservative.
- Qualified paint outside the ZOI is assumed to not fail during a design basis accident.
- It is further assumed that the impingement-destroyed coatings fail as 10 μm particles. NEI 04-07 provides appropriate justification for this assumption.

- It is assumed that unqualified coatings not covered by intact insulation will fail as a result of post accident environmental conditions. This maximizes the amount of available paint debris and is conservative.
- It is assumed that all qualified IOZ primers used in containment has a dry density of 457 lb/ft^3 as recommended by NEI-04-07 Table 3-3 for generic IOZ. Davis-Besse IOZ coatings systems have been determined to have a significantly lower density.
- IOZ dry film thickness is assumed to be 3 mils based upon the NEI-04-07 recommended thickness for typical IOZ coatings.
- It is assumed that the applied thickness of the uncovered unqualified coatings (both alkyds and epoxy) is 6 mils per coat. This is consistent with the average thickness of typical vendor coatings and is double the thickness recommended in NEI 04-07, for coatings outside the 10D ZOI.
- The density for the high heat aluminum coating is derived from similar coating materials on the market today.

FENOC Response to Review Area 3.h.6:

Since Davis-Besse is a low fiber plant where there may not be enough fiber to form a thin-bed, the transport for the unqualified coatings was analyzed assuming that the coatings fail as chips as well as particulate. The chip thickness will be assumed to be equal to the original applied thickness, and the chip length will be conservatively taken as the smallest chip size which would not pass through the holes in the strainer (3/16 inch). The debris generation calculation shows that unqualified coatings fail as 10 micron particulate/fines. This is consistent with NEI 04-07 guidance.

FENOC Response to Review Area 3.h.7:

Coatings are inspected each refueling outage to assess the coating material condition to determine degraded areas which may create additional debris generation. The amount of coatings that are not in a qualified condition (i.e., degraded or unqualified) is tracked and compared to the analyzed limit, and is dispositioned per the FENOC Corrective Action Program.

RAI 25
Describe how your coatings assessment was used to identify degraded qualified/acceptable coatings and determine the amount of debris that will result from these coatings. This should include how the assessment technique(s) demonstrates that qualified/acceptable coatings remain in compliance with plant licensing requirements for design-basis accident (DBA) performance. If current examination techniques cannot demonstrate the coatings' ability to meet plant licensing requirements for DBA performance, licensees should describe an augmented testing and inspection program that

provides assurance that the qualified/acceptable coatings continue to meet DBA performance requirements. Alternatively, assume all containment coatings fail and describe the potential for this debris to transport to the sump.

Response:
During the 13th refueling outage an extensive inspection of protective coatings applied to structures and components located in the containment was performed. This inspection identified degraded coatings which had been originally qualified and coating material for which no DBA qualification documentation could be located. From the results of this inspection, significant recoating work was performed and all remaining non-qualified coating material was documented in a non-DBA qualified inventory.

Each refueling outage, a coating condition assessment inspection is performed to address the overall health of the protective coating material applied in containment. The coating condition assessment inspection is performed to the guidance of an engineering procedure. The inspections are performed by qualified personnel and are visual inspections to determine soundness of the coating material. Coating material which is found degraded is identified in the FENOC Corrective Action program, and is quantified and added to the non-DBA qualified coating inventory. This material is dispositioned and scheduled for rework during the refueling or subsequent refueling outages.

A coatings assessment and inspection is done in accordance with a site procedure, Containment Protective Coatings Condition Assessment Inspections. The degraded or non-qualified coatings are tracked in a calculation. This calculation is an input to the Debris Generation calculation, which determines the amount of debris generated, based on if the coating is qualified or if it is degraded or nonqualified.

Additional information is presented in the response to 3.b and 3.h.7.

RAI 30
The NRC staff's safety evaluation (SE) addresses two distinct scenarios for formation of a fiber bed on the sump screen surface. For a thin bed case, the SE states that all coatings debris should be treated as particulate and assumes 100% transport to the sump screen. For the case in which no thin bed is formed, the staff's SE states that the coatings debris should be sized based on plant-specific analyses for debris generated from within the ZOI and from outside the ZOI, or that a default chip size equivalent to the area of the sump screen openings should be used (Section 3.4.3.6). Describe how your coatings debris characteristics are modeled to account for your plant-specific fiber bed (i.e. thin bed or no thin bed). If your analysis considers both a thin bed and a non-thin bed case, discuss the coatings debris characteristics assumed for each case. If your analysis deviates from the coatings debris characteristics described in the staff-approved methodology, provide justification to support your assumptions.

Response
Since Davis-Besse is a low fiber plant with insufficient fiber to form a thin-bed, the transport for the unqualified coatings was analyzed assuming that the coatings fail as chips as well as particulate. The chip thickness will be assumed to be equal to the original applied thickness, and the chip length will be conservatively taken as the smallest chip size which would not pass through the holes in the strainer (3/16 inch). The debris generation calculation shows that unqualified coatings fail as 10 micron particulate/fines.

<u>NRC Review Area 3.i:</u>

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.

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

<u>GL 2004-02 Requested Information Item 2(f)</u>

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:

1. **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.**
2. **A summary of the foreign material exclusion programmatic controls in place to control the introduction of foreign material into the containment.**
3. **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.**

4. **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.

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

FENOC Response to Review Area 3.i.1:

The latent debris loading of containment is controlled in several ways. Key to the overall success is an understanding for the need to maintain a high degree of cleanliness. When the new sump strainer design was implemented, site personnel were informed of the reason for the change and how they play a role in plant safety through their work. Several of the design specifications were then altered to identify what materials are acceptable for use in containment, particularly coatings and insulation. Controls on what material can be stored or used in containment when the sump supports operability of the ECC and CS systems were put in place. Prior to starting the plant up from a refueling outage, an inventory of containment is conducted and all unauthorized materials removed or dispositioned via the FENOC Corrective Action program. The documentation requirements for stored materials in containment include assessment of impact on debris generation, inventory holdup, and chemical interaction.

Coatings in particular are inspected each outage to assess changes in condition that might cause additional debris generation. The amount of coatings that are not in a qualified condition (i.e., degraded or unqualified) is tracked and compared to the analyzed limit.

During periods when the sump must support ECCS and CS operability, Foreign Material Exclusion controls are enacted on containment. The type and amount of material taken into containment is identified and tracked until removed.

The containment is inspected prior to plant startup to ensure all potential debris items have been removed. If significant latent debris is noted, clean up is required. Operations, Radiological Protection, and Engineering personnel participation in the inspection is required. Pre-job briefs are held to ensure personnel understand the purpose of the inspection. Responsibility for containment conformance to approved configuration is assigned to the Design Engineering Manager.

Procedures to confirm that the plant is in conformance with the design basis prior to declaring the systems operable were upgraded or established. The procedures address the cleanliness inside the emergency sump boundary, the integrity of the sump boundary, the status of trash racks and jet shields, and the cleanliness of containment outside the emergency sump boundary. Once the containment and emergency sump have been declared operable, controls are established to preserve their integrity and conformance to the design basis.

To ensure that personnel understand the importance that cleanliness contributes to design basis compliance, training was conducted. The training raised awareness of the emergency sump issue and informed personnel of actions they can take to assist in addressing the issue.

FENOC Response to Review Area 3.i.2:

Once the design basis of the emergency sump strainer and downstream components was finalized, it was necessary to establish or refine programs that would protect this design basis. Specifications that control the types of coatings that may be used in containment were upgraded. There are also requirements for a Design Engineer to evaluate new coatings and maintenance of an unqualified coatings inventory. Coating limitations are specified in design documents to ensure compliance. Similarly, the types of materials that can be stored in containment are procedurally inventoried and controlled. The application of tags, labels, and signs in containment is controlled procedurally to ensure that they don't contribute to the design debris load. The types of insulation that can be used in containment were restricted in the applicable Design Specification to ensure that no unacceptable additional fiber loading or calcium silicate is introduced to containment.

During periods when the sump must support ECCS and CS operability, Foreign Material Exclusion controls are enacted on containment. The amount of material taken into containment is identified and tracked until removed.

Procedures to confirm that the plant is in conformance with the design basis prior to declaring the systems operable were upgraded or established. The procedures address the cleanliness inside the emergency sump boundary, the integrity of the sump boundary, the status of trash racks and jet shields, and the cleanliness of containment outside the emergency sump boundary. Once the containment and emergency sump have been declared operable, controls are established to preserve their integrity and conformance to the design basis.

To ensure that personnel understand the importance that cleanliness contributes to design basis compliance, training was conducted. The training raised awareness of the emergency sump issue and informed personnel of actions they can take to assist in addressing the issue.

FENOC Response to Review Area 3.i.3:

The types of materials that can be stored in containment are procedurally inventoried and controlled. The application of tags, labels, and signs in containment is controlled procedurally to ensure that they don't contribute to the design debris load.

The types of insulation that can be used in containment were restricted in the applicable Design Specification to ensure that no unacceptable additional fiber loading or calcium silicate is introduced to containment. The type of coatings that can be used in containment is restricted in the applicable Design Specification to ensure that unacceptable coatings are not introduced into containment.

The design process has controls which require changes that require the use of materials (e.g., insulation, plastic, paint, etc.) in areas such as containment that could result in clogging of sumps and Emergency Core Cooling System suction strainers to be evaluated by Design Engineering.

FENOC Response to Review Area 3.i.4:

The function of the Decay Heat /LPI System, as described in the Maintenance Rule Program Manual, includes the capability to provide recirculation from the emergency sump for long term decay heat removal. This is a risk significant function. Performance criteria are established for the system, both for system availability and reliability. Conditions that may not conform to the design basis are entered into the Corrective Action Program. This causes the condition to be assessed for impact on operability and functionality. The Maintenance Rule Program then reviews and tracks the issue.

The impact of other maintenance activities, including temporary changes, is evaluated for potential effect on operability of systems by Operations and Engineering as a part of the work planning process. If a work activity would affect the capability of the strainer, whether due to the potential for greater than design debris generation or the potential to compromise strainer integrity, while DHR/LPI operability is required, it would cause plant risk to be unacceptably high. This is in part due to the single sump strainer for both trains of DHR/LPI configuration that was licensed for Davis-Besse. In this case the activity would be performed in accordance with risk management guidelines.

The sump screen also supports CS and HPI functions. The above discussion also is appropriate for these systems.

FENOC Response to Review Area 3.i.5:

Davis-Besse has removed essentially all fiber from containment, and thus the limiting fiber loads are generated through latent fiber. A walkdown performed in December, 2007 documented that the latent debris loads were significantly less than the required latent debris loads necessary to develop a fiber bed of 1/8" for the postulated break locations. Analyses have concluded that the strainer will have clean screen area at these low latent fiber loads, and thus the debris head loss essentially consists of clean screen head loss plus RMI head loss. The head loss across the strainer is less than the NPSH margin of the most limiting ECCS pump or CS pump.

FENOC Response to Review Area 3.i.6:

No actions are being taken to modify the existing RMI in the plant. No further reductions in the fibrous insulation in containment are planned.

FENOC Response to Review Area 3.i.7:

Although they are not credited in the analyses, debris interceptors were installed in containment to reduce the debris burden at the sump strainers. Also, see the response to Review Area 3.h.7.

FENOC Response to Review Area 3.i.8:

Once the design basis of the emergency sump strainer and downstream components was finalized, it was necessary to establish or refine programs that would protect this design basis. Design specifications that control the application of coatings in containment were upgraded and an unqualified coatings inventory was established. Limitations on coatings have been identified in design documents to ensure compliance.

RAI 35
You stated that the debris generation analysis was based on NEDO-32686, Rev. 0 (BWR URG). Please discuss the evaluations performed to verify that the methodology applied in the debris generation analyses is at least as conservative as the Nuclear Energy Institute (NEI) guidance report "Pressurized Water Reactor Sump Performance Evaluation Methodology," NEI 04-07, and the NRC staff's SE of this guidance.

Response:
Davis-Besse has re-analyzed the emergency sump strainer design consistent with NEI 04-07 and the NRC SER. Where deviations are allowed, bases for the deviation have been provided. The results were then processed to arrive at a revised final Net Positive Suction Head margin. Therefore, the information provided in the September 1, 2005 response to GL 2004-02 has been superseded. The current design information for debris generation is discussed in the responses to Review Areas 3.b, 3.c, 3.d, and 3.i.

NRC Review Area 3.j:

Screen Modification Package

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

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

FENOC Response to Review Area 3.j.1:

The emergency sump is designed to provide sufficient flow at minimal head loss to the Emergency Core Cooling System (ECCS) and the Containment Spray System (CS) following a Loss of Coolant Accident (LOCA).The emergency sump strainer is a passive device required to maintain Net Positive Suction Head (NPSH) margin under conservatively determined debris loading conditions following a large pipe rupture inside containment.

The new strainer has the following key features:

1. The replacement strainers have cylindrical tubes (called top hats) rolled from perforated stainless steel (SS) plate. The perforated plate is 10-gauge plate perforated with 3/16 inch round holes on 5/16 inch centers resulting in 32% open area. To maximize the available vertical surface area, 27 tophats are installed as a cluster of cylinders above the sump, and will consist of a cylinder within a cylinder construction. The tophats are mounted to the sump via a structural frame attached to the inside walls of the existing sump (called the upper strainer). The upper strainer contributes approximately 400 square feet of surface area.

2. The original construction vortex suppressor was replaced with grating located beneath the tophats and at the penetration through the sump wall (the connection to the incore strainer).

3. The strainer is designed to be fully submerged following all postulated LOCAs. All horizontal surfaces of the upper strainer are constructed of solid plate.

4. The tophat structure is completely surrounded by trash racks. The trash racks are installed to collect large debris, such as RMI, to minimize the debris loading on the strainer surfaces.

5. To protect the emergency sump from back flow of particles through the sump floor drain, a piece of perforated plate with 3/16" diameter holes is installed at the floor

drain grating within the emergency sump, and the floor drain grating is welded to the drain pipe.

6. Strainer sections are added in the Incore Tunnel area (called the lower strainer), and connected to the emergency sump by perforated pipes and a new cut-out through the sump wall. The connecting pipes and collector boxes are perforated to maximize strainer surface area. The incore strainer adds approximately 800 square feet of surface area.

7. Strainer sections are stacked and routed down the stairs to the area above the incore tubes between the pressure relief damper and the first incore instrument seismic support plate. The strainer tubes routed down the stairs are stacked vertically three high.

8. A group of ten strainer sections are installed over the incore tubes between the pressure relief damper and the first incore instrument seismic support plate. The lower 10 strainer tubes are connected to the strainer tubes running down the stairs via a collector box mounted on the edge of the incore tunnel stairway.

9. Hold-up trash racks are installed at various locations on the 565' containment floor. These racks are installed to impede the progress of large debris, such as RMI sections, from challenging the trash racks surrounding the strainer.

10. A small trash rack is installed over the 6" refueling canal to reactor cavity drain line open flange. This trash rack is installed to assure that debris does not block flow out of this line and adversely affect the post-LOCA water level in containment.

11. Trash racks are not installed on the incore tunnel strainer. Since the strainer tubes are mounted at elevated positions within the incore tunnel, protection from large debris is accomplished via elevation. Large debris settles to the lower elevations so trash racks are not required.

12. All large gaps (greater than 3/16 inch) in the strainer at locations such as pipe penetrations, along edges of the strainer, and at attachments to the concrete are eliminated by installing either perforated plates or solid plates/structural members.

13. The tail pipe for the containment drain header relief valve (RC754) is shortened 2 inches, by this modification, to accommodate upper strainer installation. The piping support for the RC754 tail pipe is also modified.

14. The piping support/restraint for the decay heat cool down line relief valve (DH4849) tail pipe is modified.

15. The new strainer is manufactured from stainless steel perforated plate and stainless steel support members and is corrosion resistant.

16. A jet impingement shield is installed to protect the upper strainer from the jet spray caused by potential failure of the Class 1 piping upstream of the RCS to decay heat isolation bypass valve (DH-21).

FENOC Response to Review Area 3.j.2:

Other modifications completed to support the strainer upgrade include:

1. Replaced most fibrous insulation with Reflective Metal Insulation.
2. Installed a jet deflector as part of the emergency sump modification.
3. Relocated the sump access ladder and the emergency sump water level equipment to remove interferences with strainer assembly
4. Opened a hole through the sump wall to permit lower strainer feed.
5. Removed/ replaced equipment tags, signs and labels with qualified materials.
6. Cleaned all floor drains and associated drain piping in containment to assure no volume holdup
7. Installed refuel canal drain line debris screen
8. Installed trash racks at points around containment.

RAI 34
Your response to GL 2004-02 question (d)(viii) indicated that an active strainer design will not be used, but does not mention any consideration of any other active approaches (i.e., backflushing). Was an active approach considered as a potential strategy or backup for addressing any issues?

Response:
No active methods are being used, nor were any considered beyond the conceptual design stage. No provision exists for cleaning the debris from the strainer. The strainer is sized such that the debris bed that will form will not cause sufficient pressure drop as to reduce the Net Positive Suction Head (NPSH) available at the ECCS and CS pump suctions to less than the NPSH required.

RAI 36
The Davis-Besse analyses and sump modification were completed prior to issuance of the NEI guidance (NEI 04-07) and the staff's SE of that guidance. As such, Davis-Besse applied different analytical methods. Please discuss plans you have to identify and evaluate the impacts of the differences between the NEI/SE and the Davis-Besse methodologies.

Response:
FENOC has re-analyzed the emergency sump strainer design consistent with NEI 04-07 and the NRC SER. Where deviations are allowed and have been taken; supporting bases have been provided. Details are provided in response to Review Area 3.j.

RAI 40
Are there any vents or other penetrations through the strainer control surfaces which connect the volume internal to the strainer to the containment atmosphere above the containment minimum water level? In this case, dependent upon the containment pool height and strainer and sump geometries, the presence of the vent line or penetration could prevent a water seal over the entire strainer surface from ever forming; or else this seal could be lost once the head loss across the debris bed exceeds a certain criterion, such as the submergence depth of the vent line or penetration. According to Appendix A to Regulatory Guide 1.82, Revision 3, without a water seal across the entire strainer surface, the strainer should not be considered to be "fully submerged." Therefore, if applicable, explain what sump strainer failure criteria are being applied for the "vented sump" scenario described above.

Response:
There are no vents or penetrations through the strainer surface that connect the internal volume of the sump to the containment atmosphere. The upper surface of the strainer is completely submerged at the conservatively calculated minimum water height. There are piping and conduit penetrations through the strainer surface, but each of these are closed so that a path between the atmosphere and the inner sump volume is not formed.

RAI 44
What size are the holes in the divider plate between the upper and lower strainers? What analysis has been performed to demonstrate that debris could not pass through the lower strainer and create blockage at the divider plate, thereby concentrating debris mainly upon the upper section of the strainer?

Response:
The holes in the divider plate are 3/16 inch diameter on 1/4 inch centers. The

material is 12 gage stainless steel. The remainder of the strainer media is 10 gage stainless steel perforated with 3/16 inch diameter holes on 5/16 inch staggered spacing. Therefore the debris removal by the divider plate is the same size as the rest of the strainer. The analyses which assumed that the lower strainer failed non-mechanistically assumed that the divider plate was completely blocked, so that all flow had to enter the sump through the upper strainer. The debris loading was assumed to occur only on the upper strainer.

The holes in the divider plate are the same size as the holes in the rest of the strainer. If the lower strainer remains intact, the debris that passes through it can also pass through the divider plate, so that no accumulation should occur on the divider plate in this case. Therefore, the debris distributions assumed in the analyses are appropriate.

NRC Review Area 3.k:

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).

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

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.**

FENOC Response to Review Area 3.k

The upper portion of the DBNPS sump strainer is surrounded by a protective stainless steel cage made of stainless steel deck grating, which keeps large pieces of debris from impacting the upper strainer media. Additionally, large pieces of debris are removed from the flow stream by debris interceptors located around the containment periphery. The entire upper sump strainer structure is protected from LOCA generated missiles and large pieces of debris by a concrete floor, ceiling, and walls. One terminal end of the RCS is located within this protected area. If that pipe were to rupture, the jet would have impinged on the trash racks and strainer media of the upper sump. Consequently, a jet blast deflector shield was installed between the source pipe and the strainer. This will deflect the blast upwards so that it does not impact the strainer.

The lower strainer had the potential to be damaged by missiles generated by a rupture of the RCS piping at the nozzles entering the Reactor Vessel. The intensity of this break was so large that structural integrity of the lower strainer structure could not be assured. However, the total amount of debris generated in containment by a break in this area is lower than the debris generated by a rupture in a containment D-ring. The lower strainer was assumed to fail due to missiles, so an additional strainer cage was added where the lower strainer feeds into the sump through the wall between the sump and the in-core tunnel stairway. Analyses were then performed to determine the pressure drop associated with the debris loading created by this scenario, with the reduced strainer surface area and reduced debris load. The results showed that the debris pressure drop would be less than the pressure drop determined for the break in the D-ring scenario. The additional strainer cage is recessed into the sump structure so that debris cannot impact it during the blowdown of the RCS.

The structure of the sump strainer and the trash racks has a design basis that includes all static and dynamic hydraulic loads that it could experience. This includes the pressure drop across the debris bed due to flow through the strainer. The flow assumed in the analysis exceeds the maximum flow expected during recirculation so that the pressure drop is conservative. The analysis shows that the strainer and trash racks are capable of withstanding all loads that could be placed upon it.

<u>FENOC Response to Review Area 3.k.1:</u>

The strainer supporting structures were modeled in GTSTRUDL using dynamic analysis methods. The trash rack was modeled in GTSTRUDL using static analysis methods. The jet deflector was evaluated utilizing standard structural hand calculations. Deadweight, thermal, seismic, and differential pressure loads were considered as appropriate for the structure. Evaluations of miscellaneous components (baseplates, etc) were performed utilizing standard structural hand calculations.

<u>Design Inputs/Loads</u>
The following are the design inputs and loads used in the qualification of the structures:

<u>Material Properties</u>:
The strainer is constructed of type 304 Stainless Steel (SS) and 316 SS. Appropriate allowables are assumed for individual parts in the analyses. Stainless steel fasteners (bolts, studs, anchors) are incorporated into the design and analyses are performed with appropriate allowables.

The jet deflector is constructed of carbon steel plate and members. The jet deflector design used carbon steel expansion anchors.

Concrete Strength
A concrete strength of 4000 psi is used in the evaluation of concrete anchors, except for the jet deflector which used 6000 psi concrete.

Deadweight: Weight, densities, etc.

Stainless steel weights are based on a density of 0.29 lbs/cu-in.

Carbon steel weights (for jet deflector) are based on a density of 0.28 lbs/cu in.

Design Temperature and Thermal Expansion:
Thermal expansion of the structure @ 270 degrees F is considered. Generally, thermal releases in the form of bolted/slotted connections are employed in the design to minimize the impact of thermal stresses.

The jet shield deflector considered the design temperature of the pipe, 650°F.

Differential Pressure Loading:
5 psi on all strainer external surfaces.

Seismic:
- Seismic inertia load requirements are taken from the applicable Davis-Besse design basis seismic floor response spectra.
- 2% damping value is used for Operating Basis Earthquake (OBE) & Safe Shutdown Earthquake (SSE).
- Response spectra for the plant elevations closest to the strainer structure elevation are utilized in the analyses.
- SSE loads are utilized in the calculations.

High Energy Line Breaks (HELB)
The upper strainer is not impacted by a HELB due to the installation of a jet deflector (see response below), therefore no evaluation is required and has not been considered as a design load for the strainer and trash rack structures. A separate evaluation was performed to qualify the jet deflector.

For the Reactor Cavity Nozzle Break, the lower strainer is assumed to be damaged or rendered inoperable by the break. Head loss analyses are performed utilizing these assumptions. No jet deflectors were designed or installed for protection of the lower strainer.

Design Codes
The American Institute of Steel Construction (AISC) Manual of Steel Construction, 8th Edition is the representative design code used in the qualification of the structures. Individual references to other appropriate standards and codes may be found in the specific qualification calculations.

Loads, Load Combinations, and Allowables
Static loads such as deadweight, thermal, etc are combined using algebraic summation. The following load combinations are evaluated for the strainer structure:

Normal
Dead Weight + Differential Pressure + Buoyancy

Upset
Dead Weight + Differential Pressure + Buoyancy + OBE inertia (SSE values used for OBE), including hydrodynamic mass

Faulted
Dead Weight + Seismic (SSE) including hydrodynamic mass + Differential Pressure + Buoyancy (negligible)

A 0.5 psi uniform loading has been applied to the trash rack, which envelopes the combined dead weight and seismic loads.

Dead load, differential pressure, and seismic load are combined algebraically to obtain worst-case results.

Members are evaluated for the application of faulted loads based on normal allowables unless noted otherwise. Member stresses and weld stresses shall be less than the allowable specified in AISC Manual of Steel Construction, 8th Edition.

Expansion anchors were evaluated using their normal allowable loads with no increases for the seismic or accident loading cases.

FENOC Response to Review Area 3.k.2:

Given the loading combinations and inputs described above, qualifications for all of these structures were found to have applied loads within allowable limits. These structures are capable of withstanding the required design differential pressure loads (where applicable), deadweight loads, seismic loads (including hydrodynamic loads), and thermal loads at design temperatures of 270°F, and 650°F for the jet shield deflector.

The controlling Interaction Coefficients (ICs) are the design margins for the components. The following information provides a summary of the controlling ICs (the ratio of actual stress/load to allowable stress/load, i.e., design margin) for the major sump components.

Emergency Sump Strainer
The controlling ICs are:
Structural Members IC_{MAX} = 0.92
Welds IC_{MAX} = 0.93
Anchor Bolts IC_{MAX} = 0.99, conservative in that nominal strength of the concrete and straight line interaction for the anchor bolts were considered.
Bolted Connections IC_{MAX} = 0.84
Perforated Tube Factor of $Safety_{BUCKLING}$ = 23 – for differential pressure

Incore Tunnel Strainer
The controlling ICs are:
Structural Members IC_{MAX} = 0.95
Welds IC_{MAX} = 0.90
Anchor Bolts IC_{MAX} = 0.91
Bolts IC_{MAX} = 0.50
Perforated Tube Factor of $Safety_{BUCKLING}$ = 3.78 – for differential pressure

HELB Jet Deflector
The controlling ICs are:
These values are conservative due to the simplified manual analysis techniques used for this structure.
Structural Members IC_{MAX} = 0.98
Welds IC_{MAX} = 0.73
Anchor Bolts IC_{MAX} = 0.93

Emergency Sump Trash Rack
The controlling ICs are:
Structural Members IC_{MAX} = 0.81
Grating IC_{MAX} = 0.43 (72/168)
Welds IC_{MAX} = 0.94
Anchor Bolts IC_{MAX} = 0.81

Containment Periphery & Refueling Canal Trash Racks
The controlling ICs are:
These values are conservative due to the simplified manual analysis techniques used for this structure.
Structural Members IC_{MAX} = 0.99
Welds IC_{MAX} = 0.82
Anchor Bolts IC_{MAX} = 0.93

FENOC Response to Review Area 3.k.3:

The upper strainer was determined to be in the zone of influence of a HELB for Decay Heat System piping. Break location DR640 at the inlet to the RCS to decay heat isolation bypass valve (DH21) was determined to be the only applicable break, with the upper strainer being shielded from all other breaks by concrete structures. A jet deflector was designed and installed to protect the upper strainer from this identified break. The deflector was designed to meet the required jet thrust loading, which bounds all normal structural design loads. This structure is qualified in Calculation C-CSS-49.01-026. For the Reactor Cavity Nozzle Break, the lower strainer is assumed to be damaged or rendered inoperable by the break. Head loss analyses are performed utilizing these assumptions. No jet deflectors were designed or installed for protection of the lower strainer.

FENOC Response to Review Area 3.k.4:

A backflushing strategy is not credited.

NRC Review Area 3.I.

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.

Provide a summary of the upstream effects evaluation including the information requested in GL 2004-02, Requested Information Item 2(d)(iv).

GL 2004-02 Requested Information Item 2(d)(iv)
The basis for concluding that the water inventory required to ensure adequate ECCS or CSS recirculation would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return 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.**

FENOC Response to Review Area 3.I.1:

The only potential upstream blockage points in the pool would be the trash rack gates. Given the spacing of the bars on these trash rack gates, and the fact that most of the debris in containment is RMI, full blockage of any of these gates is not considered to be a concern.

Another potential upstream blockage point is the 6-inch refueling canal drain. Any sprays draining through the refueling canal must flow through this drain, which discharges in the reactor cavity. If this drain were to become clogged with debris, a large amount of water would be held up in the refueling canal. In order to preclude the drain from clogging with debris, a trash rack has been designed and installed for the refueling canal drain. The spacing between the trash rack grating bars is sized such that any small pieces of debris that pass through the trash rack would also readily pass through the 6-inch drain.

FENOC Response to Review Area 3.I.2:

See response to Review Area 3.I.1.

FENOC Response to Review Area 3.I.3:

The various flow paths for water to reach the emergency sump were studied to assure that all the water in containment is available to the post-accident pool. The horizontal platforms within the D-rings are constructed of open grating that allows water to flow to the bottom floor of the containment (565 ft. elevation). This is the level that pours into the sump. Outside the D-rings, the solid floors are separated from the wall of the containment vessel by a ring of deck grating around much of the circumference of the building. This allows water to drain down to the 565 ft. elevation. There are also drains in the floors that will also pass water to the lower levels. Water falling into the refueling canal will drain from the deep end of the canal to the normal containment sump. The normal sump will be filled and adding to the containment post-LOCA pool through grating that forms its lid. The drain line from the deep end is protected by a trash rack (a box made of deck grating) that will prevent material that could plug the line from entering. Material that can move past the trash rack cage will fit through the drain pipe and will be transported to the normal sump. It is prevented from entering the emergency sump by the installed strainer.

The normal sump has a pipe connecting it to the emergency sump to permit draining of water to the normal sump, should any occur in the emergency sump during power operation. The floor drain entrance to this pipe inside the emergency sump has strainer media welded over it to prevent entry of debris into the sump. This line is not relied upon to feed the emergency sump, so its blockage would be inconsequential to the recirculation function.

No credit is taken for debris interceptors, although they are installed in containment. Debris interceptors have been installed at several points on the periphery of the 565 foot elevation of containment, perpendicular to the ECCS flow. The debris interceptors in the main flow path have three distinct regions. They have a solid base plate, six inches tall. Above that, a smaller grate size (4 in. by 1-3/16 in.) is installed in the section of the interceptor that would be submerged post-LOCA to remove debris from the flow path. The grating opens up to a larger mesh (3-9/16in. by 4 in.) above the approximate minimum submergence level. The height of the gate is above the maximum containment flood level. This configuration aids in removing debris sliding on the floor, or moving in the flow stream below the surface while providing a nearly unimpeded path near the surface of the water. This will allow water to move past the debris interceptor regardless of how much debris accumulates at its lower sections. Debris interceptors made of grating are also installed where the recirculating fluid passes under the fuel transfer tubes. This adds additional large debris removal capacity while ensuring a flow path is maintained.

The CFD model takes into account some lifting of sunken debris over a curb. Curbs have the potential to interrupt the movement of sunken debris along a floor. Ramps of debris can, however, build up in front of a curb allowing debris to climb up over the curb more easily. Some data exists for the magnitude of velocity required to lift various types of debris over a curb. However, there is no test data to show what the debris ramp angle would be. The steeper the angle, the less material comprising the debris pile. Regarding this, the commonly reported angle of repose for a pile of loose material is 34°. This would be the upper limit on how steep a ramp formed of debris fragments could be; at least in regions where the pool flow direction is mixed (i.e., due to cross flow or swirling eddies, etc.). (Note that if flow approaches a curb directly and the velocity is high enough, it is possible to form debris ramps with a steeper angle.) The conservative assumption then, with respect to the amount of debris captured at curbs where the flow direction is mixed, is that debris ramps formed against curbs or trash racks have an angle of 34°.

FENOC Response to Review Area 3.I.4:

See the response to Review Areas 3.I.1 and 3.I.3.

RAI 24

The Davis-Besse GL 2004-02 response (page 10 of Attachment 2) indicates scaffolding boxes have drain and vent holes that are smaller than the holes of the strainer media so that any debris generated by chemical reaction will remain within the box. The NRC staff does not understand why corrosion product or dissolved ions from the scaffolding would remain in the scaffolding box. Please clarify this statement.

Response:
The surface area of the scaffolding inside the boxes is inventoried in a design basis calculation; the scaffolding is all made of galvanized steel. This surface area was an input to the chemical effects analysis. Per WCAP-16530-NP, "Evaluation of Post Accident Chemical Effects in Containment Sump Fluids to Support GSI-191," (Reference 6), Section 6.2.2, Galvanized Steel, the zinc releases were relatively small and can be ignored in chemical effects precipitation modeling.

RAI 46

It was not clear to the NRC staff from the September 2005 GL response whether FENOC accounted for possible erosion of large debris pieces from containment spray and sump pool recirculation flows. If you did, please explain how you modeled erosion. If not, please justify.

Response:
In the debris transport calculation, erosion was modeled. Some types of insulation debris could erode when subjected to the continuing forces of break or spray flows and pool turbulence. If the debris breaks down into smaller pieces, it would transport more easily and cause a larger head loss across the sump strainer. Stainless steel RMI is assumed not to break down into smaller pieces following the initial generation at the beginning of the LOCA. The Nukon small fines were conservatively treated as individual fibers, which would not be subject to further erosion. This leaves the large pieces of Nukon fiberglass.

A 1% erosion factor was applied for large piece fibrous debris held up in upper containment. This is consistent with the approach taken for the pilot plant in the NEI 04-07 SER (Appendix VI). The SER points out substantial uncertainties associated with the erosion testing. Since the test data showed in general that the erosion consisted primarily of small, loosely attached pieces of fiber breaking off from larger pieces, it is considered reasonable to assume that erosion would taper off after 24 hours. To be conservative, however, the 24 hour erosion was rounded up to 10%. This erosion fraction was applied for large pieces of fiberglass in the containment pool. Note that the fines generated due to erosion were assumed to transport proportionally to the two strainers based on the flow split (i.e., 32% of 10% to the upper strainer and 68% of 10% to the lower strainer).

NRC Review Area 3.m:

Downstream effects - Components and Systems
The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the containment sump screen on the function of the ECCS and CSS in terms of potential wear of components and blockage of flow streams. Provide the information requested in GL 04-02 Requested Information Item 2.(d)(v) and 2.(d)(vi) regarding blockage, plugging, and wear at restrictions and close tolerance locations in the ECCS and CSS downstream of the sump.

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

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

1. **If 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.**
2. **Provide a summary and conclusions of downstream evaluations.**
3. **Provide a summary of design or operational changes made as a result of downstream evaluations.**

FENOC Response to Review Area 3.m

An evaluation of all downstream systems and components was completed as a part of the Generic Safety Issue 191 resolution project. Enercon Report DBE004-RPT-004 (ACT 03-0426), "Assessment of Debris Size Acceptance on ECCS Components" determined that the cyclone separators that provide clean water to the Low Pressure Injection pump seals and the Containment Spray pump seals as well as the High Pressure Injection pump internal passages could be adversely impacted by debris. It was found that outside of the identified items, adequate flow through the fuel, the ECCS and the CSS would be maintained so that the core cooling and containment cooling functions would be accomplished.

The evaluation performed in the report concluded the following:

1. All piping, valves, Decay Heat Coolers, flow elements, and restriction orifices in the major flow paths of LPI, HPI, CS and Boron Precipitation Control Systems are of a larger size than the material that passes through the emergency sump strainer. LOCA generated debris is judged to not represent a threat to the system operation in a LOCA.
2. Evaluation of LPI pumps determined that the LPI/DHR pumps would be capable of maintaining their function with solids of up to a 1" diameter passing through the pumps, as per discussion with the pump vendor. LOCA generated debris is judged to not represent a threat to the performance of the LPI system.
3. Due to potential clearance concern associated with the HPI hydrostatic bearing, the debris passing through the emergency sump strainer has the potential to damage the pump bearing. Failure of HPI pump bearing will prevent the pump from performing its safety function. With the exception of the HPI pumps, LOCA generated debris is judged to not represent a threat to the performance of the HPI system
4. Strainer sizing is decoupled from the HPI pump hydrostatic bearing issue and the LPI/HPI mechanical seal issues.
5. There are no debris concerns associated with the CS pumps. LOCA generated debris is judged to not represent a threat to the performance of the CS system.
6. LOCA generated debris is judged to not represent a threat to the performance of the Boron Precipitation Control.

Based on the findings of the Enercon Report, significant effort to demonstrate the capability of the affected components was undertaken. A test program that modeled the anticipated debris loading quantities and characteristics of the post-LOCA fluid was initiated to assess the impact of the environment on the equipment. Based on the results, it was determined that the amount of fiber in containment has to be strictly controlled. Modifications to eliminate nearly all fibrous insulation were initiated and completed prior to plant restart from 13RFO. The remaining amounts, which are unlikely to be dislodged by LOCA blow down, were none-the-less retained in the test fluid modeling and applicable analyses.

Based on the results of the testing, the cyclone separators and the High Pressure Injection pumps were modified to match the final, successful as-tested configuration. In addition, cyclone separators were added to the CS pump seal water cooling lines. This test program ensures that the design basis of the containment matches the design basis of the downstream components. This work was completed prior to the restart from 13RFO. No further work is outstanding with respect to debris laden fluid effect on downstream components.

The basis for concluding that there are no adverse gaps in the strainer is that the cleanliness and integrity of the emergency sump is verified each refueling outage. This inspection includes verifying that no abnormal holes or gaps exist. The mesh spacing in the sump screen is accounted for in the pressure drop calculation. It has also been determined that the debris that is allowed to pass through the holes would not produce any adverse downstream effects.

Prior to declaring the ECCS and CSS operable following an outage, close inspection of the sump and strainer are required. Internal cleanliness is confirmed via accesses into the structures of the sump and strainer. Detailed surface and structural inspection is required. It is verified that gaps are below the acceptance criterion. Inspectors are required to have knowledge of the sump's design and construction. The inspection is required by the DBNPS "Containment Emergency Sump Visual Inspection" procedure.

RAI 33

You indicated that you would be evaluating downstream effects in accordance with WCAP 16406-P. The NRC is currently involved in discussions with the Westinghouse Owner's Group (WOG) to address questions/concerns regarding this WCAP on a generic basis, and some of these discussions may resolve issues related to your particular station. The following issues have the potential for generic resolution; however, if a generic resolution cannot be obtained; plant-specific resolution will be required. As such, formal RAIs will not be issued on these topics at this time, but may be needed in the future. It is expected that your final evaluation response will specifically address those portions of the WCAP used, their applicability, and exceptions taken to the WCAP. For your information, topics under ongoing discussion include:

a. Wear rates of pump-wetted materials and the effect of wear on component operation
b. Settling of debris in low flow areas downstream of the strainer or credit for filtering leading to a change in fluid composition
c. Volume of debris injected into the reactor vessel and core region
d. Debris types and properties
e. Contribution of in-vessel velocity profile to the formation of a debris bed or clog
f. Fluid and metal component temperature impact
g. Gravitational and temperature gradients
h. Debris and boron precipitation effects
i. ECCS injection paths
j. Core bypass design features
k. Radiation and chemical considerations
l. Debris adhesion to solid surfaces
m. Thermodynamic properties of coolant

Response:
Davis-Besse cannot identify where in the GL 2004-02 response reference was made evaluating downstream effects in accordance with WCAP 16406-P, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," (Reference 1). Downstream effects were evaluated and addressed as a part of the 13RFO recovery effort. Specific testing and plant modifications, as described in Section 3.m above, were undertaken to address this issue.

NRC Review Area 3.n

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 USNRC 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.**

FENOC Response to Review Area 3.n.1:

WCAP 16793-NP, "Evaluation of Long Term Core Cooling Associated With Sump Debris Effects," (Reference 7), Section 7 states that assurance of long term core cooling is demonstrated by satisfying five statements. The first four statements are generically met by all PWRs, the fifth requirement is to either demonstrate that the sample calculation bounds plant-specific chemistry or complete a plant specific calculation using the method in the WCAP.

The WCAP requirements are met because the sample calculation bounds plant-specific chemistry. An assessment of the WCAP was done to determine the applicability to Davis-Besse. The sample calculation was shown to be applicable. In interpreting the results, the data in WCAP-16793 was conservatively extrapolated (using data in the WCAP) to find the final fuel temperatures for the fuel rod diameter used at Davis-Besse. The extrapolation was small, and it was determined that the acceptance criteria of 800°F was met.

NRC Review Area 3.o

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. ML0726007425).**

The following additional guidance was excerpted from Enclosure 3, Section 3 of the NRC to NEI letter dated September 27, 2007.

(1) Sufficient 'Clean' Strainer Area
i. Those licensees performing a simplified chemical effects analysis should justify the use of this simplified approach by providing the amount of debris determined to reach the strainer, the amount of bare strainer area and how it was determined, and any additional information that is needed to show why a more detailed chemical effects analysis is not needed.

(2) Debris Bed Formation
i. Licensees should discuss why the debris from the break location selected for plant-specific head loss testing with chemical precipitate yields the maximum head loss. For example, plant X has break location 1 that would produce maximum head loss *without consideration of chemical effects*. However, break location 2, with chemical effects considered, produces greater head loss than break location 1. Therefore, the debris for head loss testing with chemical effects was based on break location 2.

(3) Plant Specific Materials and Buffers
i. Licensees should provide their assumptions (and basis for the assumptions) used to determine chemical effects loading: pH range, temperature profile, duration of containment spray, and materials expected to contribute to chemical effects.

(4) Approach to Determine Chemical Source Term (Decision Point)

i. Licensees should identify the vendor who performed plant-specific chemical effects testing.

(5) *Separate Effects Decision (Decision Point)*
No additional GL 2004-02 guidance regarding this topic was provided in the NRC to NEI letter dated September 27, 2007.

(6) *AECL* [Atomic Energy of Canada Limited] *Model*
i. Since the NRC USNRC is not currently aware of the testing approach, the NRC USNRC expects licensees using it to provide a detailed discussion of the chemical effects evaluation process along with head loss test results.
ii. Licensees should provide the chemical identities and amounts of predicted plant-specific precipitates.

(7) *WCAP Base Model*
i. For licensees proceeding from block 7 to diamond 10 in the Figure 1 flow chart [in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425)], justify any deviations from the WCAP base model spreadsheet (i.e., any plant specific refinements) and describe how any exceptions to the base model spreadsheet affected the amount of chemical precipitate predicted.
ii. List the type (e.g., AlOOH) and amount of predicted plant-specific precipitates.

(8) *WCAP Refinements*
No additional GL 2004-02 guidance regarding this topic was provided in the NRC to NEI letter dated September 27, 2007.

(9) *Solubility of Phosphates, Silicates and Al Alloys*
i. Licensees should clearly identify any refinements (plant-specific inputs) to the base WCAP-16530 model and justify why the plant-specific refinement is valid.
ii. For crediting inhibition of aluminum that is not submerged, licensees should provide the substantiation for the following: (1) the threshold concentration of silica or phosphate needed to passivate aluminum, (2) the time needed to reach a phosphate or silicate level in the pool that would result in aluminum passivation, and (3) the amount of containment spray time (following the achieved threshold of chemicals) before aluminum that is sprayed is assumed to be passivated.
iii. For any attempts to credit solubility (including performing integrated testing), licensees should provide the technical basis that supports

extrapolating solubility test data to plant-specific conditions. In addition, licensees should indicate why the overall chemical effects evaluation remains conservative when crediting solubility given that small amount of chemical precipitate can produce significant increases in head loss.

iv. Licensees should list the type (e.g., AlOOH) and amount of predicted plant specific precipitates.

(10) Precipitate Generation (Decision Point)

No additional GL 2004-02 guidance regarding this topic was provided in the NRC to NEI letter dated September 27, 2007.

(11) Chemical Injection into the Loop

i. Licensees should provide the one-hour settled volume (e.g., 80 ml of 100 ml solution remained cloudy) for precipitate prepared with the same sequence as with the plant-specific, in-situ chemical injection.

ii. For plant-specific testing, the licensee should provide the amount of injected chemicals (e.g., aluminum), the percentage that precipitates, and the percentage that remains dissolved during testing.

iii. Licensees should indicate the amount of precipitate that was added to the test for the head loss of record (i.e., 100 percent 140 percent).

(12) Pre-Mix in Tank

i. Licensees should discuss any exceptions taken to the procedure recommended for surrogate precipitate formation in WCAP-16530.

(13) Technical Approach to Debris Transport (Decision Point)

No additional GL 2004-02 guidance regarding this topic was provided in the NRC to NEI letter dated September 27, 2007.

(14) Integrated Head Loss Test with Near-Field Settlement Credit

i. Licensees should provide the one-hour or two-hour precipitate settlement values measured within 24 hours of head loss testing.

ii. Licensees should provide a best estimate of the amount of surrogate chemical debris that settles away from the strainer during the test.

(15) Head Loss Testing Without Near Field Settlement Credit

i. Licensees should provide an estimate of the amount of debris and precipitate that remains on the tank/flume floor at the conclusion of the test and justify why the settlement is acceptable.

ii. Licensees should provide the one-hour or two-hour precipitate settlement values measured and the timing of the measurement relative to the start of head loss testing (e.g., within 24 hours).

(16) Test Termination Criteria

i. Provide the test termination criteria.

(17) Data Analysis

i. Licensees should provide a copy of the pressure drop curve(s) as a function of time for the testing of record.

ii. Licensees should explain any extrapolation methods used for data analysis.

(18) Integral Generation (Alion)

No additional GL 2004-02 guidance regarding this topic was provided in the NRC to NEI letter dated September 27, 2007.

(19) Tank Scaling / Bed Formation

No additional GL 2004-02 guidance regarding this topic was provided in the NRC to NEI letter dated September 27, 2007.

(20) Tank Transport

No additional GL 2004-02 guidance regarding this topic was provided in the NRC to NEI letter dated September 27, 2007.

(21) 30-Day Integrated Head Loss Test

i. Licensees should provide the plant-specific test conditions and the basis for why these test conditions and test results provide for a conservative chemical effects evaluation.

ii. Licensees should provide a copy of the pressure drop curve(s) as a function of time for the testing of record.

(22) Data Analysis Bump Up Factor

i. Licensees should provide the details and the technical basis that show why the bump-up factor from the particular debris bed in the test is appropriate for application to other debris beds.

<u>FENOC Response to Review Area 3.o.1</u>:

Chemical precipitates that form in the post-LOCA containment environment combined with debris do not result in an unacceptable head loss. Head loss due to chemical precipitates and debris is demonstrated by analysis. As a result of having less than a thin bed, clean screen area is expected given the low amounts of fiber generated by the analyzed breaks at Davis-Besse. Review Area 3.n provides information regarding chemical effects on core cooling.

FENOC Response to Review Area 3.o.2.(1).i

Davis-Besse has limited amounts of fibrous insulation postulated to be destroyed in a design basis accident. As a result of having less than a thin bed, clean screen area is expected in all postulated breaks. Thus, while a chemical effects analysis was performed, it did not influence the overall results of the strainer head loss analysis because, when less than a thin bed exists, the chemical products do not contribute to head loss.

FENOC Response to Review Area 3.o.2.(2).i

Enercon and Alion Science and Technology performed plant-specific chemical effects and head loss analyses. No specific chemical effects testing was performed based upon the presence of clean screen area due to the low fiber loads at Davis-Besse.

The fiber loading was examined for the analyzed breaks. The limiting break for chemical effects analysis is the reactor vessel cavity break (Break 3). This results from the potential for debris from the break to compromise the integrity of the lower strainer assembly.

For Breaks 1 and 2 (East and West D-Ring breaks), it is assumed that 6 ft^3 of low density fiberglass insulation, such as Nukon, is destroyed. All fibrous piping insulation in containment has been removed or replaced with RMI with the exception of three locations:

1) There is 0.36 ft^3 located on and in the Reactor Vessel Head Continuous Vent Line (CVL) guard pipe at the Control Rod Drive Mechanism (CRDM) nozzle flange connection because of available space restriction for use of RMI.
2) There is a 0.22 ft^3 segment on the CVL at the top of the reactor head service structure to provide electrical cable protection.
3) There is 0.307 ft^3 contained within the East D-Ring wall penetration for the CVL.

With the entire upper and lower strainer area available, the resulting fiber bed is very thin and clean strainer area is expected. These locations total approximately 1 ft^3 of Nukon insulation. The analysis provides at least 5 ft^3 of low density fiberglass insulation margin to account for any undocumented sources that may be identified.

In the case of the Reactor Vessel cavity break, the only fiber to reach the strainer is the latent fiber within containment. The insulation on the CVL was changed to RMI except for 0.887 ft^3 of Nukon, as noted above. That insulation is located within the Service Structure above the Reactor Vessel Head and in the D-Ring wall where the line penetrates to reach the 2A Steam Generator. These areas are shielded from the blowdown of the reactor cavity break by the installed permanent cavity seal plate. The seal plate protects the insulation from blowdown forces so it will not become dislodged. The Service Structure prevents CS from washing the insulation from the Reactor Vessel Head region and the installed caps on the D-ring wall penetration prevent sprays from washing that insulation out. Therefore, for the Reactor Vessel cavity break (break 3) it is assumed that the only source of fiber to the emergency sump strainer is the latent fiber found within containment. Based on sampling of latent debris, it was determined that this amount of fiber available will not result in a complete loss of clean strainer area.

It is assumed that the presence of clean screen area will allow the chemical precipitates that are expected to form during a LOCA to pass through without causing a noticeable head loss. Based upon data presented in the WCAP-16530-NP, the chemical precipitates are gelatinous and incapable of developing any shear strength and therefore pass through the open holes in the perforated plate.

While the reactor vessel cavity break challenges the clean strainer area, the overall head loss margin is associated with the breaks in the D-rings, since greater amount of RMI debris arrive at the strainer, Therefore, the worst case head loss (break 1/break 2 upper strainer) was used to determine head loss margin.

FENOC Response to Review Area 3.o.2.(3).i

The pH range and temperature profile evaluated for chemical effects is as follows:

Table 3.o.2.(3)-1: pH range and temperature profile for chemical effects analysis

Time (sec)	min	hr	days	Sump pH	Sump Temp. (°F)	Sump Mixed 1=Yes	Steam or Spray pH	Containment Temp. (°F)
6	0	0	0	4.28	242.2	0	4.5	241.7
30	0.5	0	0	4.28	248.6	0	4.5	256.7
60	1.o	0	0	4.28	252.9	0	4.5	254.3
120	2	0	0	4.28	253.9	0	4.5	249.5
180	3	0	0	4.28	254.8	0	4.5	246.8
200	3	0	0	4.28	255	0	4.5	246
400	7	0	0	6.76	254.6	0	4.5	241
600	10	0	0	7.18	254.6	0	4.5	238.3
800	13	0	0	7.4	254.4	0	4.5	237.1
1000	17	0	0	7.54	254.1	0	4.5	236.5
1100	18	0	0	7.56	254	0	4.5	236.3
1500	25	0	0	7.67	253.7	0	4.5	235.8
1750	29	0	0	7.7	253.5	0	4.5	235.3
2000	33	1	0	7.73	253.3	0	4.5	234.8
3000	50	1	0	8.04	252.5	0	4.5	232.3
4500	75	1	0	8.04	250.9	0	8.042	226.7
6000	100	2	0	8.04	251.5	0	8.042	229.4
7500	125	2	0	8.04	252.2	0	8.042	229.9
8600	143	2	0	8.04	252.6	0	8.042	229.6
10500	175	3	0	8.04	253.1	0	8.042	228.7
11500	192	3	0	8.04	253.1	0	8.042	227.5
13000	217	4	0	8.04	253	0	8.042	226.4
14500	242	4	0	8.04	252.7	0	8.042	225.1
50000	833	14	1	8.04	226.8	0	8.042	192.6
90000	1500	25	1	8.04	205.6	0	8.042	177.4
150000	2500	42	2	8.04	189.1	0	8.042	165
221000	3683	61	3	8.04	179.1	0	8.042	159
300000	5000	83	3	8.04	171.7	0	8.042	153.1
400000	6667	111	5	8.04	162.3	0	8.042	146.6
900000	15000	250	10	8.04	142.5	0	8.042	130.8
1300000	21667	361	15	8.04	138	0	8.042	128.2
1720000	28667	478	20	8.04	134.6	0	8.042	124.6
2200000	36667	611	25	8.04	130.7	0	8.042	123.1
2600000	43333	722	30	8.04	127.5	0	8.042	119.7

The values for sump temperature are from the design basis calculation on the Containment Vessel Analysis. The values for pH are derived from a design basis calculation written by AREVA on post-LOCA pH analysis.

The following materials were evaluated for chemical effects:

Table 3.o.2.(3)-2: Materials evaluated for chemical effects

Class	Material	Amount
Coolant	Sump Pool Volume (ft3)	84685
Metallic Aluminum	Aluminum Submerged (sq ft)	87
	Aluminum Submerged (lbm)	615.3
	Aluminum Not-Submerged (sq ft)	7199
	Aluminum Not-Submerged (lbm)	6810.8
Calcium Silicate	CalSil Insulation(ft3)	0
	Asbestos Insulation (ft3)	0
	Kaylo Insulation (ft3)	0
	Unibestos Insulation (ft3)	0
E-glass	Fiberglass Insulation (ft3)	0
	NUKON (ft3)	6
	Temp-Mat (ft3)	0
	Thermal Wrap (ft3)	0
Silica Powder	Microtherm (ft3)	0
	Min-K (ft3)	0
Mineral Wool	Min-Wool (ft3)	0
	Rock Wool (ft3)	0
Aluminum Silicate	Cerablanket (ft3)	0
	FiberFrax Durablanket (ft3)	0
	Kaowool (ft3)	0
	Mat-Ceramic (ft3)	0
	Mineral Fiber (ft3)	0
	PAROC Mineral Wool (ft3)	0
Concrete	Concrete (ft2)	1300
Interam	Interam (ft3)	0

The buffer used is trisodium phosphate. The materials were taken from a design basis calculation on the inventory of materials in containment.

Containment Spray is assumed to continue for the full 30- day duration of a LOCA scenario.

FENOC Response to Review Area 3.o.2.(4).i

Enercon and Alion Science and Technology performed plant-specific chemical effects and head loss analyses. No specific chemical effects testing was performed based upon the presence of clean screen area due to the low fiber loads at Davis-Besse.

FENOC Response to Review Area 3.o.2.(5).i

Davis-Besse plant specific chemical effects head loss was determined by analysis based upon the presence of clean screen area due to the low fiber loads as discussed in 3.o.2.2 above. Plant-specific head loss results are documented in an approved calculation. Plant specific quantities of precipitates expected to be generated were developed using methods presented in WCAP-16530-NP and WCAP-16785-NP.

FENOC Response to Review Area 3.o.2.(6).i

The AECL model was not used for DBNPS.

FENOC Response to Review Area 3.o.2.(6).ii

The AECL model was not used for DBNPS.

FENOC Response to Review Area 3.o.2.(7).i

This item is not applicable to Davis-Besse.

FENOC Response to Review Area 3.o.2.(7).ii

The following precipitates and quantities are predicted for the plant.

Table 3.o.2.(7)-1: Chemical Precipitates

Chemical Precipitate Batch Quantities - Plant		
Sodium Aluminum Silicate $NaAlSi_3O_8$	**Aluminum Oxyhydroxide** AlOOH	**Calcium Phosphate** $Ca_3(PO_4)_2$
lbm	**lbm**	**lbm**
14.8	419.8	1.4

FENOC Response to Review Area 3.o.2.(8)

No specific WCAP refinements were used for the Davis-Besse analyses.

FENOC Response to Review Area 3.o.2.(9).i

No changes to the base WCAP-16530 model were made, therefore this item is not applicable to Davis-Besse.

FENOC Response to Review Area 3.o.2.(9).ii

Davis-Besse did not credit inhibition of aluminum or silica in chemical effects analyses.

FENOC Response to Review Area 3.o.2.(9).iii

WCAP methods as noted and justified above were used. No additional efforts were made to account for the effects of solubility at Davis-Besse

FENOC Response to Review Area 3.o.2.(9).iv

See response to 3.o.2.7.ii above for the quantity and type of precipitates.

FENOC Response to Review Area 3.o.2.(10).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(11).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(11).ii

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(11).iii

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(12).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(13).i

The debris transport analysis does not include near-field settlement. Near field effects pertain to a testing phenomenon, no plant specific testing was performed.

FENOC Response to Review Area 3.o.2.(14).i

This is not applicable to Davis-Besse since near field settlement was not included in analyses.

FENOC Response to Review Area 3.o.2.(14).ii

This is not applicable to Davis-Besse since near field settlement was not included in analyses.

FENOC Response to Review Area 3.o.2.(15).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(15).ii

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(16).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(17).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis. No head loss testing was performed since clean strainer area is expected in all break scenarios.

FENOC Response to Review Area 3.o.2.(17).ii

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(18).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(18).ii

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(19).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(19).ii

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(20).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis.

FENOC Response to Review Area 3.o.2.(21).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis. No head loss testing was performed since clean strainer area is expected in all break scenarios.

FENOC Response to Review Area 3.o.2.(21).ii

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis. No head loss testing was performed since clean strainer area is expected in all break scenarios.

FENOC Response to Review Area 3.o.2.(22).i

No plant specific testing was performed. The WCAP-16530 testing and methodology was applied to the chemical effects analysis. No head loss testing was performed since clean strainer area is expected in all break scenarios.

RAI 2

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

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

(b) in the containment spray zone following a LOCA:

- **aluminum**
- **zinc (from galvanized steel and from inorganic zinc coatings)**
- **copper**
- **carbon steel not coated**
- **uncoated concrete**

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

Response:

a) The highest submergence in the containment after an accident is the 570' elevation.
b) The areas listed as surface area above 570' are the areas exposed to spray.

The following is a summary of materials in containment:

Table RAI 2-1: Materials in Containment

Material	**Surface Area (ft^2) below 570'**	**Surface Area (ft^2) above 570'**	**Total Surface Area (ft^2)**
Galvanized Steel	3,782	108,083	123,051 *
Aluminum	79	1,136	1,215
Copper	79	5,852	5,931
Uncoated Concrete	1,050	250	1,300
Uncoated Carbon Steel	171	178	349

* The total surface area for galvanized steel includes a 10% multiplier for zinc coatings

The table shown below is from Table 3-1 from the ICET #2 Data report.

Table RAI 2-2, ICET#2 Data Report

Material	Ratio (ft^2/ft^3)	Percentage of Material Submerged (%)	Percentage of Material Unsubmerged (%)
Zinc	8.0	5	95
Aluminum	3.5	5	95
Copper	6.0	25	75
Uncoated Concrete	0.045	34	66
Uncoated Carbon Steel	0.15	34	66

The ratios from ICET #2 are scaled up to Davis-Besse to show the allowable amounts of materials:

1. To obtain the Davis-Besse total allowable amount of materials, the ratios from ICET #2 are multiplied by the minimum water level in containment.
   The minimum water volume in containment post-LOCA is 46,060 ft^3.
2. The result of this is the Davis-Besse allowable total.
3. Then, the total is multiplied by the percentage of material submerged, to obtain the Davis-Besse allowable submerged.

4. Then, the Davis-Besse allowable total is multiplied by the percentage of material unsubmerged to obtain the Davis-Besse allowable unsubmerged value.

Table RAI 2-3: ICET #2 data ratios with allowable material quantities.

Material	Ratio (ft^2/ft^3)	Davis-Besse Allowable Submerged	Davis-Besse Allowable Unsubmerged	Davis-Besse Allowable Total
Zinc	8	18,424	350,056	368,480
Aluminum	3.5	8,061	153,150	161,210
Copper	6	69,090	207,270	276,360
Uncoated Concrete	0.045	705	1,368	2,073
Uncoated Carbon Steel	0.15	2,349	4,560	6,909

The ICET #2 Davis-Besse Allowable Total bounds all Davis-Besse actual materials, with the exception of submerged uncoated concrete. Although the submerged uncoated concrete is not bounded by the ICET #2 analysis, the chemical effects analysis is relatively insensitive to uncoated concrete in a trisodium phosphate environment.

A calculation was performed on chemical effects that determined the plant specific amounts of chemical products. Reference the response to 3.o.

RAI 3
Identify the amount (surface area) and material (e.g., aluminum) for any scaffolding stored in containment. Indicate the amount, if any, that would be submerged in the containment pool following a LOCA. Clarify if scaffolding material was included in the response to Question 2.

Response:
The surface area of the scaffolding inside the boxes is inventoried in a design basis calculation; the scaffolding is all made of galvanized steel. This surface area was an input to the chemical effects analysis. Per WCAP-16530-NP Section 6.2.2, Galvanized Steel, the zinc releases were relatively small and can be ignored in chemical effects precipitation modeling.

RAI 4
Provide the type and amount of any metallic paints or non-stainless steel insulation jacketing (not included in the response to Question 2) that would be either submerged or subjected to containment spray.

Response
All insulation jacketing utilized in the Davis-Besse containment is constructed of stainless steel.

In determining chemical effects, the total unsubmerged aluminum, which includes metallic paints, is 7199 ft^2. The submerged aluminum analyzed was 87 ft^2 (which corresponds to 79ft^2 discussed in RAI 2 with 10% additional margin).

RAI 5
Provide the expected containment pool pH during the emergency core cooling system (ECCS) recirculation mission time following a LOCA at the beginning of the fuel cycle and at the end of the fuel cycle. Identify any key assumptions.

Response:
The minimum post-LOCA pH, once dissolution of the trisodium phosphate (TSP) is complete, is 7.06. Calculations have determined that the TSP neutralization of the boric acid occurs rapidly as containment floods, so that the pH will be approaching the stated value by the time recirculation begins. This pH analysis assumes the maximum amount of borated water is released to the containment sump and that the initial boric acid concentration in the RCS is well above the beginning of cycle concentration and all other water sources are at the maximum allowable concentrations. The amount of neutralizing TSP is at the minimum allowable and not all the TSP present in containment is included, thereby yielding conservative results.

The maximum pH post-LOCA, once dissolution of the TSP is complete is 8.22. This analysis assumes that the RCS is at 0 ppmB, corresponding to end of cycle conditions. The amount of borated water released to containment is minimized, the boric acid concentration in water supplies is at minimum value, and the amount of TSP is maximized.

Table 3.o.2.(3)-1 provides the pH range and temperature profile for the chemical effects analysis.

RAI 6

For the ICET environment that is the most similar to your plant conditions, compare the expected containment pool conditions to the ICET conditions for the following items: boron concentration, buffering agent concentration, and pH. Identify any other significant differences between the ICET environment and the expected plant-specific environment.

Response:

The Integrated Chemical Effects Test (ICET) environment most similar to the Davis-Besse post-LOCA environment is ICET #2. The ICET #2 environment consisted of boric acid buffered with trisodium phosphate, with amounts of hydrochloric acid and lithium hydroxide added. The only insulation present was fiberglass material. In contrast, the ICET #3 environment consisted of a similar environment, but with insulation samples comprised of 80% calcium silicate and 20% fiberglass. Davis-Besse does not have calcium silicate insulation that would be part of the post-LOCA debris mix, since it is outside the break's Zone of Influence and it is protected from chemical spray wetting. Hence, the Davis-Besse environment will be compared to the ICE-Test #2 environment:

Table RAI 6-1 – Comparison of ICET with Davis-Besse

	ICET-2 Run 1	ICET-2 Run 2	Davis-Besse (min pH analysis)	Davis-Besse (max pH analysis)
Boric acid (ppm)	2800		2835.99	2600
TSP (mols/l)	as needed for pH of 7	as needed for pH of 7	0.00595	0.036635
pH	7.0	7.0	7.063	8.222

RAI 8

Discuss your overall strategy to evaluate potential chemical effects including demonstrating that, with chemical effects considered; there is sufficient net positive suction head (NPSH) margin available during the ECCS mission time. Provide an estimated date with milestones for the completion of all chemical effects evaluations.

Response:

Davis-Besse evaluated chemical product generation using guidance from WCAP-16530. A calculation was done to determine the NPSH in the ECCS system. From the NPSH analysis, it was determined that clean screen area will exist that will allow the chemical precipitates that are expected to form during a LOCA to pass through without causing a noticeable head loss. Based upon data presented in the WCAP-16530-NP, the chemical precipitates are gelatinous and incapable of developing any shear strength and therefore pass through the open holes in the perforated plate.

RAI 9
Identify, if applicable, any plans to remove certain materials from the containment building and/or to make a change from the existing chemicals that buffer containment pool pH following a LOCA.

Response:
Due to identified downstream effects, Davis-Besse removed the majority of installed fibrous insulation from containment. This work was complete prior to plant restart from the 13th Refueling Outage. Presently, no plans exist to remove other materials from containment. Controls are in place on the amount of galvanized metal and aluminum used in containment to ensure the chemical effects analysis remains valid. Presently, no plans exist to change the chemical buffer.

RAI 10
If bench-top testing is being used to inform plant specific head loss testing, indicate how the bench-top test parameters (e.g., buffering agent concentrations, pH, materials, etc.) compare to your plant conditions. Describe your plans for addressing uncertainties related to head loss from chemical effects including, but not limited to, use of chemical surrogates, scaling of sample size and test durations. Discuss how it will be determined that allowances made for chemical effects are conservative.

Response:
Bench top testing, as planned and executed by the PWR Owner's Group, is a part of the strategy for assessing the effect of chemicals on the emergency sump strainer design. The test report for bench top testing was published in February 2006 in WCAP-16530-NP. FENOC has determined that this report is applicable to the Davis-Besse plant.

FENOC performed a conservative calculation which inventoried material in containment. This calculation was used as an input to the chemical effects analysis. The chemical effects analysis was performed in accordance with WCAP-16530-NP. These chemical products were evaluated for their effect on head loss. The chemical products calculation assumed that the presence of clean screen area will allow the chemical precipitates that are expected to form during a LOCA to pass through without causing a noticeable head loss. Based upon data presented in the WCAP-16530-NP, the chemical precipitates are gelatinous and incapable of developing any shear strength and therefore pass through the open holes in the perforated plate. Therefore, the impact on head loss due to chemical products is assumed to be negligible.

RAI 11

Provide a detailed description of any testing that has been or will be performed as part of a plant-specific chemical effects assessment. Identify the vendor, if applicable, that will be performing the testing. Identify the environment (e.g., borated water at pH 9, deionized water, tap water) and test temperature for any plant-specific head loss or transport tests. Discuss how any differences between these test environments and your plant containment pool conditions could affect the behavior of chemical surrogates. Discuss the criteria that will be used to demonstrate that chemical surrogates produced for testing (e.g., head loss, flume) behave in a similar manner physically and chemically as in the ICET environment and plant containment pool environment.

Response:
Enercon and Alion Science and Technology performed plant-specific chemical effects and head loss analyses. No specific chemical effects testing was performed based upon the presence of clean screen area due to the low fiber loads at Davis-Besse. Additional details are documented in the response to Review Area 3.o.

RAI 12
For your plant-specific environment, provide the maximum projected head loss resulting from chemical effects (a) within the first day following a LOCA, and (b) during the entire ECCS recirculation mission time. If the response to this question will be based on testing that is either planned or in progress, provide an estimated date for providing this information to the NRC.

Response:
The chemical effects analysis was performed in accordance with WCAP-16530-NP. These chemical products were evaluated for their effect on head loss. The chemical products calculation assumed that the presence of clean screen area will allow the chemical precipitates that are expected to form during a LOCA to pass through without causing a noticeable head loss. Based upon data presented in the WCAP-16530-NP, the chemical precipitates are gelatinous and incapable of developing any shear strength and therefore pass through the open holes in the perforated plate. Therefore, no additional head loss occurs due to the formation of chemical precipitates.

RAI 14
Given the results from the ICET #3 tests (Agencywide Document Access and Management System (ADAMS) Accession No. ML053040533) and NRC-sponsored head loss tests (Information Notice 2005-26 and Supplement 1), estimate the concentration of dissolved calcium that would exist in your containment pool from all containment sources (e.g., concrete and materials such as calcium silicate, Marinite™, mineral wool, kaylo) following a LBLOCA and discuss any ramifications related to the evaluation of chemical effects and

downstream effects.

Response:
The sources of calcium identified in the chemical effects analysis are only from concrete. Davis-Besse's containment does not have calcium silicate exposed to LOCA blowdown or Containment Spray, and does not have any mineral wool, or any other calcium insulation sources installed. The chemical effects analysis determined that 1.4 lbs of calcium phosphate was generated in containment post-LOCA. This amount is assumed to pass through the clean strainer with a negligible effect on head loss.

RAI 41
The September 2005 response to GL 2004-02 discussed the potential of scaffolding in vented boxes to contribute to chemical effects. The conclusion is that no problem exists, mainly because the boxes' vent holes are smaller than the holes in the strainer. The staff does not consider this conclusion to be complete, inasmuch as the accumulation of debris upon the strainer might reduce the effective flow holes through the strainer to a dimension that is smaller than the flow holes in the scaffolding boxes. While the GL response notes that, due to the small quantity of fibrous debris sources at Davis-Besse, the formation of a classical 1/8" thin bed of fibrous debris might not be likely in most scenarios (e.g., assuming both the upper and lower modules are available), the possibility remains that sparser fiber beds could be sufficient to filter out chemical precipitants (i.e., chemical precipitants would not necessarily be of the same dimensions or have the same adhesion characteristics as the fine particulate used to arrive at the 1/8" thin bed thickness). In addition, chemical species might leave the box in one form or size (e.g., as a dissolved ion), interact with other chemical species in the pool-at-large and then take on a different form or size prior to accumulating upon the strainer surface. The staff requests additional information concerning these two scenarios which do not seem to have been adequately addressed by the analysis provided in the GL response.

Response:
Because the materials in the scaffold storage boxes could contribute to the chemical effects debris generation to some degree, the entire amount of galvanized material was included in the chemical effects inventory and chemical effects debris generation calculations. Per WCAP-16530-NP, Section 6.2.2, Galvanized Steel, the zinc releases were relatively small and can be ignored in chemical effects precipitation modeling.

The strainer head loss analysis determined that the amount of fiber within containment would stay below the 1/8 inch thick value typically associated with the thin bed effect for the most limiting break. The thin bed effect thickness is based on

NUREG/CR 6224, which was based on testing performed with a flat plate and uniformly distributed fiber. The strainer at Davis-Besse is a much more complex shape. This is likely to result in non-uniform deposition of fiber and result in clean strainer area. The head loss will therefore be the clean strainer head loss with the RMI head loss. Therefore, while the thin bed effect might not occur at the thickness of 1/8 inch, the clean area of the strainer will assure adequate flow through the strainer occurs.

<u>NRC Review Area 3.p:</u>

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 <u>Requested Information</u> Item 2(e) regarding changes to the plant licensing basis. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10 CFR 50.59 evaluation for the change to the licensing basis.

> ***<u>GL 2004-02 Requested Information Item 2(e)</u>***
> ***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 GL. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included.***

<u>FENOC Response to Review Area 3.p:</u>

The design basis of the modified emergency sump strainer has been incorporated into the plant's current licensing basis. The Davis-Besse Updated Final Safety Analysis Report has been revised to include this information as part of the modification implementation process.

No additional licensing actions or exemption requests are needed to support the resolution of the emergency sump strainer blockage issues, as noted in the response to Review Area 2.

3. List of Acronyms Used

AECL Atomic Energy of Canada Limited
AlOOH Aluminum Oxyhydroxide
AISC American Institute of Steel Construction
ASME American Society of Mechanical Engineers
BWR Boiling Water Reactor
BWST Borated Water Storage Tank
CAD Computer Aided Drafting
CFD Computational Fluid Dynamics
CFR Code of Federal Regulations
CFT Core Flood Tank
CRDM Control Rod Drive Mechanism
CS Containment Spray
CSS Containment Spray System
CVL Continuous Vent Line
DBA Design Basis Accident
DBNPS Davis-Besse Nuclear Power Station
DEG Double Ended Guillotine
DH Decay Heat
DHR Decay Heat Removal
ECCS Emergency Core Cooling System
FENOC FirstEnergy Nuclear Operating Company
GL Generic Letter
GSI Generic Safety Issue
HELB High Energy Line Break
HPI High Pressure Injection
ICET Integrated Chemical Effects Test
IC Interaction Coefficient
IGLD International Great Lakes Datum
IOZ Inorganic Zinc
LBLOCA Large Break LOCA
LOCA Loss -of-Coolant Accident
LPI Low Pressure Injection
NEDO Boiling Water Reactor Owners Group Topical Report, General Electric
NEI Nuclear Energy Institute
NPSH Net Positive Suction Head
NPSHr Net Positive Suction Head Required
NRC Nuclear Regulatory Commission
OBE Operating Basis Earthquake
PTC Power Test Code
PWR Pressurized Water Reactor
PZR Pressurizer
QA Quality Assurance
RAI Request for Additional Information
RCP Reactor Coolant Pumps
RCS Reactor Coolant System
RFO Refueling Outage
RG Regulatory Guide
RMI Reflective Metal Insulation
SBLOCA Small Break LOCA
SE Safety Evaluation
SER Safety Evaluation Report (specifically SER to NEI 04-07)
SSE Safe Shutdown Earthquake
TKE Turbulent Kinetic Energy
TSP Trisodium Phosphate
UFSAR Updated Final Safety Analysis Report
URG Utility Resolution Guidance
USNRC United States Nuclear Regulatory Commission
WCAP Westinghouse Technical Report
WOG Westinghouse Owners Group
ZOI Zone-of-Influence

4. References

1. WCAP-16406-P, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," Revision 1

2. Davis Besse Updated Final Safety Analysis Report

3. NEI 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology," Revision 0 with the associated Safety Evaluation Report

4. NUREG/CR-6224, "Parametric Study of the Potential for BWR ECCS Strainer Blockage. Due to LOCA-Generated Debris," Revision 0

5. USNRC Safety Evaluation Report to the Boiling Water Reactor Owners' Group Utility Resolution Guidance, NEDO-32686, Revision 0

6. WCAP-16530-NP, "Evaluation of Post Accident Chemical Effects in Containment Sump Fluids to Support GSI-191," Revision 0

7. WCAP-16793-NP, "Evaluation of Long Term Core Cooling Associated With Sump Debris Effects," Revision 0

8. NRC letter to NEI dated November 21, 2007, "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," (ADAMS Accession No. ML073110389)

9. WCAP-16568-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified/Acceptable Coatings," Revision 0, June 2006.

10. NRC letter to DBNPS – RAI's dated February 9, 2006 (Log No 6399)

11. NRC Generic Letter 2004-02 dated September 13, 2004, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors," (ADAMS Accession No. ML042360586)

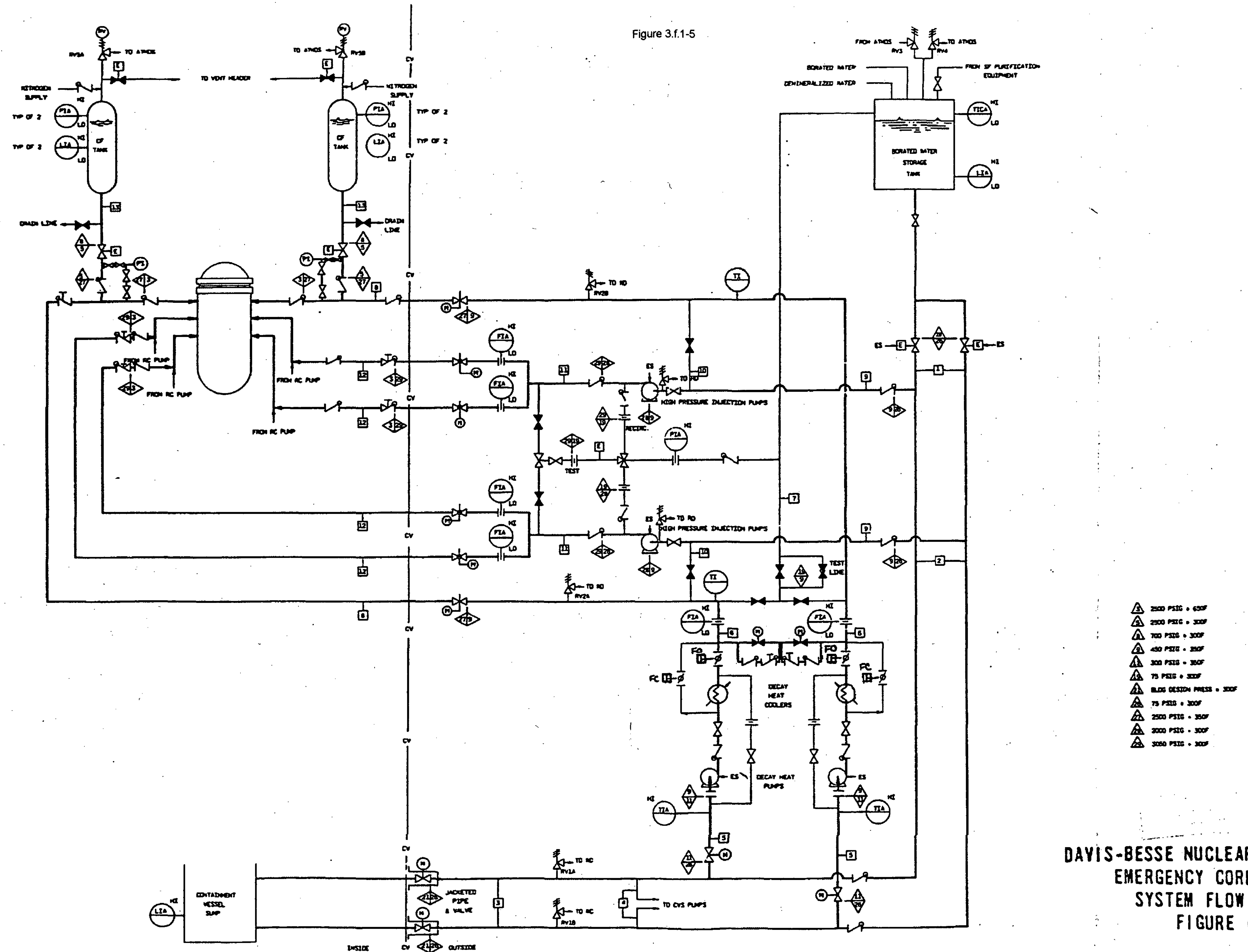
12. NRC letter to NEI dated August 15, 2007, "Content Guide For Generic Letter 2004-02 Supplemental Responses," (ADAMS Accession No. ML071060091)

13. NRC letter to NEI dated September 27, 2007, "Draft Guidance for Review of Final Licensee Responses to Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized Water Reactors,'" (ADAMS Accession No. ML072600372)

ATTACHMENT 2
L-08-036

Emergency Core Cooling System Schematics
Page 1 of 3

Figure 3.f.1-5



DAVIS-BESSE NUCLEAR POWER STATION
EMERGENCY CORE COOLING
SYSTEM FLOW DIAGRAM
FIGURE 6.3-6

REVISION 9
JULY 1989

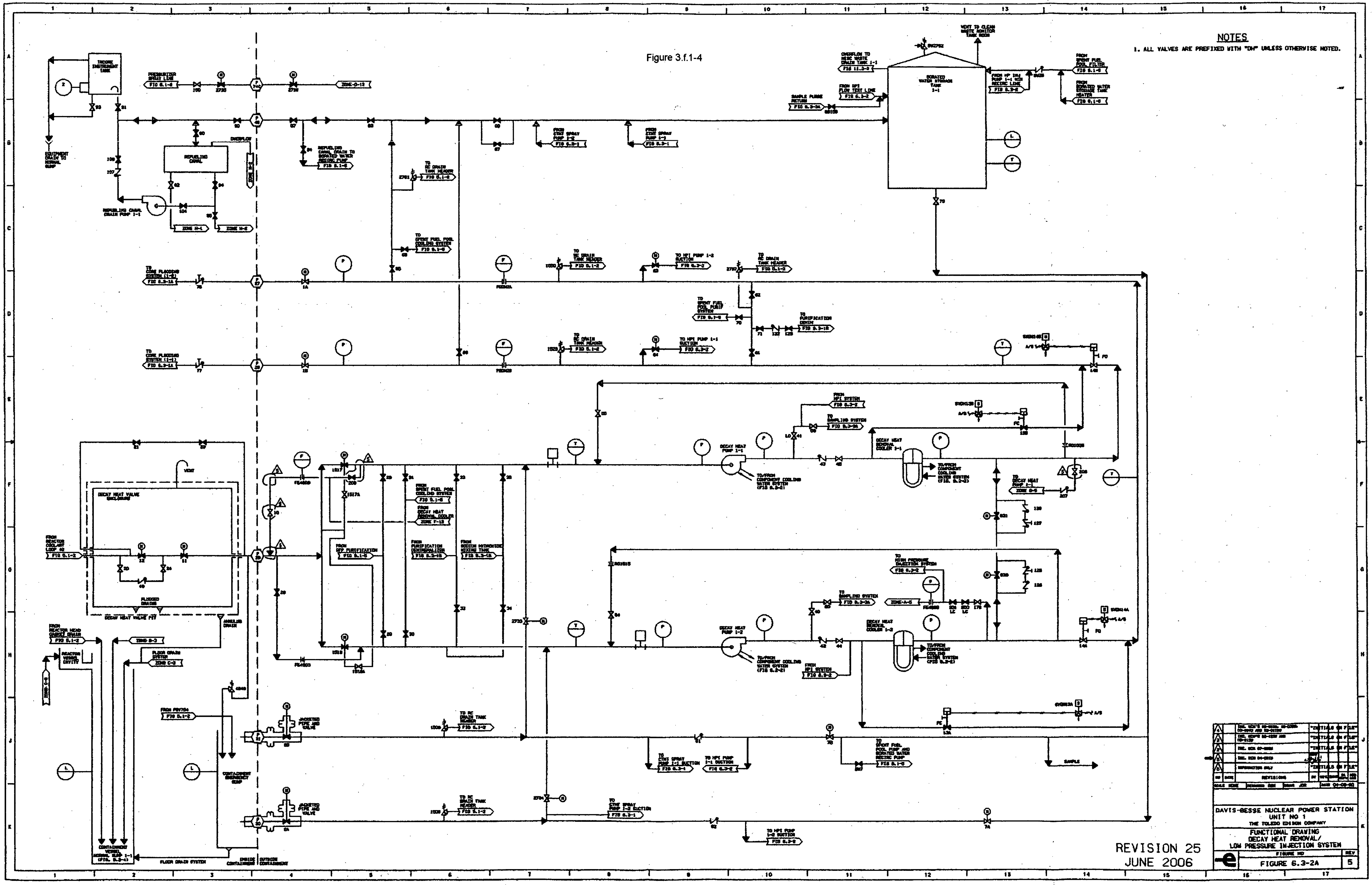


Figure 3.f.1-4
NOTES
1. ALL VALVES ARE PREFIXED WITH "DH" UNLESS OTHERWISE NOTED.
REVISION 25
JUNE 2006
DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO 1
THE TOLEDO EDISON COMPANY
FUNCTIONAL DRAWING
DECAY HEAT REMOVAL/
LOW PRESSURE INJECTION SYSTEM
FIGURE 6.3-2A
5

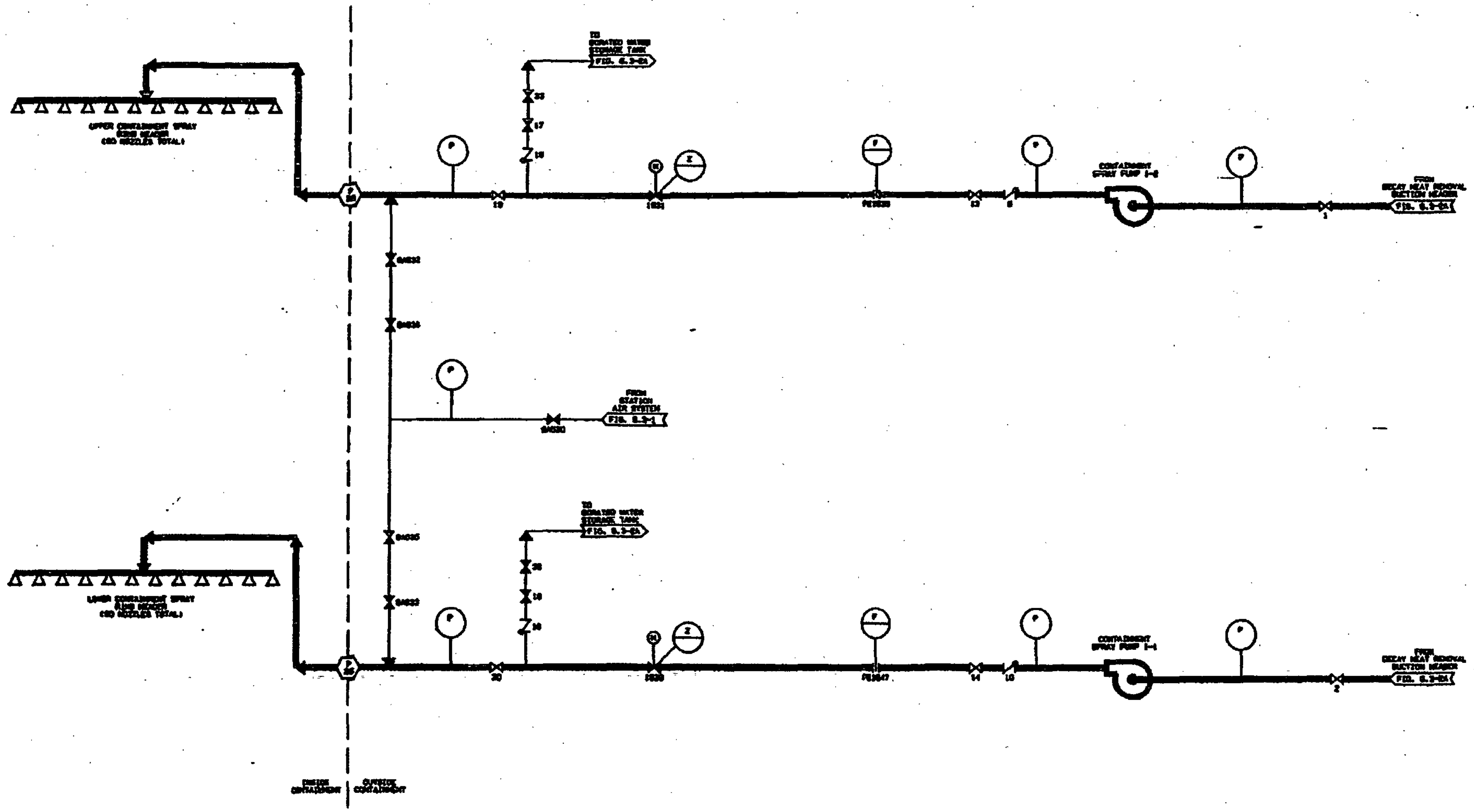
ATTACHMENT 3
L-08-036

Containment Spray System Schematic
Page 1 of 2

NOTES

1. ALL VALVES ARE PREFIXED WITH "CS" UNLESS OTHERWISE NOTED.

Figure 3.f.1-1



REVISION 14
JULY 1991

APPROVED FOR OPERATION

SCALE NONE

DAVIS-BESSE NUCLEAR POWER STATION
UNIT NO 1
THE TOLEDO EDISON COMPANY

FUNCTIONAL DRAWING
CONTAINMENT SPRAY SYSTEM

FIGURE NO	REV
FIGURE 6.3-1	0