UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 7, 2022

Mr. Terry J. Brown
Site Vice President
Energy Harbor Nuclear Corp.
Mail Stop P-DB-3080
5501 North State Route 2
Oak Harbor, OH 43449-9760

SUBJECT: DAVIS-BESSE NUCLEAR POWER STATION, UNIT NO. 1 – CLOSEOUT OF GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (EPID-2017-LRC-0000)

Dear Mr. Brown:

The U.S. Nuclear Regulatory Commission (NRC) issued Generic Letter (GL) 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML042360586), dated September 13, 2004, requesting that licensees address the issues raised by Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR [Pressurized Water Reactor] Sump Performance."

As part of its response to GL 2004-02 provided by letter dated May 15, 2013 (ADAMS Accession No. ML13135A456), FirstEnergy Nuclear Operating Company [1] (FENOC or the licensee) stated that it will pursue Option 2 (deterministic) for the closure of GSI-191 and GL 2004-02 for Davis-Besse Nuclear Power Station, Unit No. 1 (Davis-Besse).

On July 23, 2019 (ADAMS Package Accession No. ML19203A303), GSI-191 was closed. The NRC determined that the technical issues identified in GSI-191 were now well understood and, therefore, GSI-191 could be closed. Prior to and in support of closing GSI-191, the NRC staff issued a technical evaluation report on in-vessel downstream effects (ADAMS Accession Nos. ML19178A252 and ML19073A044 (not publicly available, proprietary information)). Following the closure of GSI-191, the NRC staff also issued the review guidance for in-vessel downstream effects, "NRC Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses" (ADAMS Accession No. ML19228A011), to support review of the GL 2004-02 responses.

[1] By letter dated December 2,2019 (Accession No. ML19193A002), the Nuclear Regulatory Commission issued an Order approving the transfer of control of the Davis-Besse Nuclear Power Station, Unit No. 1; and the licensed spent fuel storage installation facility (ISFSI). Specifically, the Order approved a direct transfer of operating authority for the facility from FirstEnergy Nuclear Operating Company (FENOC) to Energy Harbor Nuclear Corp.; a direct transfer of ownership of the facility from FirstEnergy Nuclear Generation, LLC to Energy Harbor Nuclear Generation LLC; and an indirect transfer of ownership of the facility from FirstEnergy Corp. and FirstEnergy Solutions Corp. to Energy Harbor Corp.

The stated purpose of GL 2004-02 was focused on demonstrating compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46. Specifically, GL 2004-02 requested addressees to perform an evaluation of the emergency core cooling system (ECCS) and containment spray system (CSS) recirculation and, if necessary, take additional action to ensure system function considering the potential for debris to adversely affect long-term core cooling (LTCC). The NRC staff finds the information provided by the licensee demonstrates that debris will not inhibit the ECCS or CSS performance following a postulated loss-of-coolant accident. Therefore, the ability of the systems to perform their safety functions, to assure adequate LTCC following a design-basis accident, as required by 10 CFR 50.46, has been demonstrated.

Enclosed is the summary of the NRC staff's review. If you have any questions, please contact me at 301-415-1380 or via e-mail at Blake.Purnell@nrc.gov

Sincerely,

***/RA – R. Haskell for/***

Blake A. Purnell, Project Manager
Plant Licensing Branch III
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-356

Enclosure:
Staff Review re: Licensee Response to GL 2004-02

cc: Listserv

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

# U.S. NUCLEAR REGULATORY COMMISSION STAFF REVIEW OF THE DOCUMENTATION PROVIDED BY FIRSTENERGY NUCLEAR OPERATING COMPANY FOR DAVIS-BESSE NUCLEAR POWER STATION, UNIT NO. 1 DOCKET NO. 50-346 CONCERNING RESOLUTION OF GENERIC LETTER 2004-02 POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN-BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS

## 1.0 INTRODUCTION

A fundamental function of the emergency core cooling system (ECCS) is to recirculate water that has collected at the bottom of the containment through the reactor core following a break in the reactor coolant system (RCS) piping to ensure long-term removal of decay heat from the reactor fuel. Leaks from the RCS, hypothetical scenarios known as loss-of-coolant accidents (LOCAs), are part of every plant's design-basis. Hence, nuclear plants are designed and licensed with the expectation that they are able to remove reactor decay heat following a LOCA to prevent core damage. Long-term cooling following a LOCA is a basic safety function for nuclear reactors. The recirculation sump provides a water source to the ECCS in a pressurized-water reactor (PWR) once the primary water source has been depleted.

If a LOCA occurs, piping thermal insulation and other materials may be dislodged by the two-phase coolant jet emanating from the broken RCS pipe. This debris may transport, via flows coming from the RCS break or from the containment spray system (CSS), to the pool of water that collects at the bottom of containment following a LOCA. Once transported to the sump pool, the debris could be drawn towards the ECCS sump strainers, which are designed to prevent debris from entering the ECCS and the reactor core. If this debris were to clog the strainers and prevent coolant from entering the reactor core, containment cooling could be lost and result in core damage and containment failure.

It is also possible that some debris would pass through (termed "bypass") the sump strainer and lodge in the reactor core. This could result in reduced core cooling and potential core damage. If the ECCS strainer were to remain functional, even with core cooling reduced, containment cooling would be maintained and the containment function would not be adversely affected.

Findings from research and industry operating experience raised questions concerning the adequacy of PWR sump designs. Research findings demonstrated that, compared to other LOCAs, the amount of debris generated by a high-energy line break (HELB) could be greater. The debris from a HELB could also be finer (and thus more easily transportable) and could be comprised of certain combinations of debris (i.e., fibrous material plus particulate material) that

could result in a substantially greater flow restriction than an equivalent amount of either type of debris alone. These research findings prompted the U.S. Nuclear Regulatory Commission (NRC or Commission) to open Generic Safety Issue (GSI)-191, "Assessment of Debris Accumulation on PWR Sump Performance," in 1996. This resulted in new research for PWRs in the late 1990s.

GSI-191 focuses on reasonable assurance that the provisions of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.46(b)(5) are met. This deterministic rule requires maintaining long-term core cooling (LTCC) after initiation of the ECCS. The objective of GSI-191 is to ensure that post-accident debris blockage will not impede or prevent the operation of the ECCS and CSS in recirculation mode at PWRs during LOCAs or other HELB accidents for which sump recirculation is required. The NRC completed its review of GSI-191 in 2002 and documented the results in a parametric study that concluded that sump clogging at PWRs was a credible concern.

GSI-191 concluded that debris clogging of sump strainers could lead to recirculation system ineffectiveness as a result of a loss of net positive suction head (NPSH) for the ECCS and CSS recirculation pumps. Resolution of GSI-191 involves two distinct but related safety concerns: (1) potential clogging of the sump strainers that results in ECCS and/or CSS pump failure; and (2) potential clogging of flow channels within the reactor vessel because of debris bypass of the sump strainer (in-vessel effects). Clogging at either the strainer or in-vessel channels can result in loss of the long-term cooling safety function.

After completing the technical assessment of GSI-191, the NRC issued Bulletin 03-01, "Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML031600259), on June 9, 2003. The Office of Nuclear Reactor Regulation (NRR) requested and obtained the review and endorsement of the bulletin from the Committee to Review Generic Requirements (CRGR) (ADAMS Accession No. ML031210035). As a result of the emergent issues discussed in Bulletin 03-01, the NRC staff requested an expedited response from PWR licensees on the status of their compliance of regulatory requirements concerning the ECCS and CSS recirculation functions based on a mechanistic analysis. The NRC staff asked licensees, who chose not to confirm regulatory compliance, to describe any interim compensatory measures that they had implemented or will implement to reduce risk until the analysis could be completed. All PWR licensees responded to Bulletin 03-01. The NRC staff reviewed all licensees' Bulletin 03-01 responses and found them acceptable.

In developing Bulletin 03-01, the NRC staff recognized that it might be necessary for licensees to undertake complex evaluations to determine whether regulatory compliance exists in light of the concerns identified in the bulletin and that the methodology needed to perform these evaluations was not currently available. As a result, that information was not requested in Bulletin 03-01 but licensees were informed that the NRC staff was preparing a Generic Letter (GL) that would request this information. GL 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design-basis Accidents at Pressurized-Water Reactors," dated September 13, 2004 (ADAMS Accession No. ML042360586), was the follow-on information request referenced in Bulletin 03-01. This document set the expectations for resolution of PWR sump performance issues identified in GSI-191, to ensure the reliability of the ECCS and CSS at PWRs. NRR requested and obtained the review and endorsement of the GL from the CRGR (ADAMS Accession No. ML040840034).

GL 2004-02 requested that addressees perform an evaluation of the ECCS and CSS recirculation functions in light of the information provided in the letter and, if appropriate, take additional actions to ensure system function. Additionally, addressees were requested to submit the information specified in GL 2004-02 to the NRC. The request was based on the identified potential susceptibility of PWR recirculation sump screens to debris blockage during design-basis accidents (DBAs) requiring recirculation operation of ECCS or CSS and on the potential for additional adverse effects due to debris blockage of flow paths necessary for ECCS and CSS recirculation and containment drainage. GL 2004-02 required addressees to provide the NRC a written response in accordance with 10 CFR 50.54(f), "Conditions of licenses".

By letter dated May 28, 2004 (ADAMS Accession No. ML041550661), the Nuclear Energy Institute (NEI) submitted a report describing a methodology for use by PWRs in the evaluation of containment sump performance. NEI requested that the NRC review the methodology. The methodology was intended to allow licensees to address and resolve GSI-191 issues in an expeditious manner through a process that starts with a conservative baseline evaluation. The baseline evaluation serves to guide the analyst and provide a method for quick identification and evaluation of design features and processes that significantly affect the potential for adverse containment sump blockage for a given plant design. The baseline evaluation also facilitates the evaluation of potential modifications that can enhance the capability of the design to address sump debris blockage concerns and uncertainties and supports resolution of GSI-191. The report offers additional guidance that can be used to modify the conservative baseline evaluation results through revision to analytical methods or through modification to the plant design or operation.

By letter dated December 6, 2004 (ADAMS Accession No. ML043280641), the NRC issued an evaluation of the NEI methodology. The NRC staff concluded that the methodology, as approved in accordance with the NRC staff safety evaluation (SE), provides an acceptable overall guidance methodology for the plant-specific evaluation of the ECCS or CSS sump performance following postulated DBAs.

In response to the NRC staff SE conclusions on NEI 04-07 "Pressurized Water Reactor Sump Performance Evaluation Methodology" (ADAMS Accession Nos. ML050550138 and ML050550156), the Pressurized Water Reactor Owners Group sponsored the development of the following Westinghouse Commercial Atomic Power (WCAP) Topical Reports:

- TR-WCAP-16406-P-A, "Evaluation of Downstream Sump Debris Effects in Support of GSI-191," Revision 1 (not publicly available), to address the effects of debris on piping systems and components (SE at ADAMS Accession No. ML073520295).

- TR-WCAP-16530-NP-A, "Evaluation of Post-accident Chemical Effects in Containment Sump Fluids to Support GSI-191," issued March 2008 (ADAMS Accession No. ML081150379), to provide a consistent approach for plants to evaluate the chemical effects that may occur post-accident in containment sump fluids (SE at ADAMS Accession No. ML073521072).

- TR-WCAP-16793-NP-A, "Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid," Revision 2 issued July 2013 (ADAMS Accession No. ML13239A114), to address the effects of debris on the reactor core (SE at ADAMS Accession No. ML13084A154).

The NRC staff reviewed the TRs and found them acceptable to use (as qualified by the limitations and conditions stated in the respective SEs). A more detailed evaluation of how the TRs were used by the licensee is contained in the evaluations below.

After the NRC staff evaluated licensee responses to GL 2004-02, the NRC staff found that there was a misunderstanding between the industry and the NRC on the level of detail necessary to respond to GL 2004-02. The NRC staff in concert with stakeholders developed a content guide for responding to requests for additional information (RAIs) concerning GL 2004-02. By letter dated August 15, 2007 (ADAMS Accession No. ML071060091), the NRC issued the content guide describing the necessary information to be submitted to allow the NRC staff to verify that each licensee's analyses, testing, and corrective actions associated with GL 2004-02 are adequate to demonstrate that the ECCS and CSS will perform their intended function following any DBA. By letter dated November 21, 2007 (ADAMS Accession No. ML073110389), the NRC issued a revised content guide.

The content guide described the following information needed to be submitted to the NRC:

- corrective actions for GL 2004-02,
- break selection,
- debris generation/zone of influence (ZOI) (excluding coatings),
- debris characteristics,
- latent debris,
- debris transport,
- head loss and vortexing,
- NPSH,
- coatings evaluation,
- debris source term,
- screen modification package,
- sump structural analysis,
- upstream effects,
- downstream effects – components and systems,
- downstream effects – fuel and vessel,
- chemical effects, and
- licensing basis

Based on the interactions with stakeholders and the results of the industry testing, the NRC staff in 2012, developed three options to resolve GSI-191. These options were documented and proposed to the Commission in SECY-12-0093, "Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance," dated July 9, 2012 (ADAMS Accession No. ML121320270). The options are summarized as follows:

- Option 1 would require licensees to demonstrate compliance with 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," through approved models and test methods. These will be low fiber plants with less than 15 grams of fiber per fuel assembly.

- Option 2 requires implementation of additional mitigating measures and allows additional time for licensees to resolve issues through further industry testing or use of a risk informed approach.

  - Option 2 Deterministic: Industry to perform more testing and analysis and submit the results for NRC review and approval (in-vessel only).

  - Option 2 Risk Informed: Use the South Texas Project pilot approach currently under review with NRR staff.

- Option 3 involves separating the regulatory treatment of the sump strainer and in-vessel effects.

The options allowed industry alternative approaches for resolving GSI-191. The Commission issued a Staff Requirement Memorandum on December 14, 2012 (ADAMS Accession No. ML12349A378), approving all three options for closure of GSI-191.

By letter dated May 15, 2013 (ADAMS Accession No. ML13135A456), FirstEnergy Nuclear Operating Company (FENOC or the licensee) stated that it will pursue Option 2 (deterministic) for the closure of GSI-191 and GL2004-02 for Davis-Besse Nuclear Power Station, Unit No. 1 (Davis-Besse).

On July 23, 2019 (ADAMS Package Accession No. ML19203A303), GSI-191 was closed. The NRC determined that the technical issues identified in GSI-191 were now well understood and, therefore, GSI-191 could be closed. Prior to and in support of closing the generic issue, NRR staff issued a technical evaluation report on in-vessel downstream effects (IVDEs) (ADAMS Accession Nos. ML19178A252 and ML19073A044 (non-public version)). Following the closure of the generic issue, NRR staff also issued review guidance for IVDEs to support review of the GL 2004-02 responses, NRC Staff Review Guidance for In-Vessel Downstream Effects Supporting Review of Generic Letter 2004-02 Responses" (ADAMS Accession No. ML19228A011).

The following is a list of documentation provided by the licensee in response to GL 2004-02. These references are used throughout this NRC staff review:

| RESPONSES TO GL 2004-02 | | |
|---|---|---|
| DOCUMENT DATE | ACCESSION NUMBER | DOCUMENT |
| March 4, 2005 | ML050670489 | Initial Response to GL |
| June 2, 2005 | ML051530197 | 1st NRC RAI |
| July 26, 2005 | ML052090194 | Licensee Response to RAI |
| September 1, 2005 | ML052490423 | Supplemental Information |
| February 9, 2006 | ML060380725 | 2nd NRC RAI |
| February 28, 2008 | ML080650368 | Licensee Response to RAI |
| July 10, 2008 | ML081780330 | NRC Partial Closure Letter |
| April 30, 2010 | ML101250217 | Supplemental Information |
| May 15, 2013 | ML13135A456 | Closure Option |
| March 29, 2021 | ML21088A344 | Final Response |

The NRC staff reviewed the information provided by the licensee in response to GL 2004-02 and all RAIs. The following is a summary of the NRC staff review.

## 2.0 GENERAL DESCRIPTION OF CORRECTIVE ACTIONS FOR THE RESOLUTION OF GL-2004-02

GL 2004-02, Requested Information Item 2(b), requested a general description of and implementation schedule for all corrective actions. The following is a list of corrective actions completed by the licensee at Davis-Besse in support of the resolution of GL 2004-02:

- Replaced original containment sump strainer with an available surface area of 50 square feet ($ft^2$), with new strainer using the Enercon top hat design, increasing the available surface area to 1,226 $ft^2$.

- Removed nearly all installed fibrous insulation from inside containment, thereby making Davis-Besse a low fiber plant.

- Restored containment coatings including the containment dome.

- Rebuilt air coolers using stainless steel coils.

- Established or enhanced programmatic controls on coatings, insulation, and signage and other materials including updated procedures for containment storage and signs, labels and tags. Equipment labels are now attached with stainless cables.

- Instituted procedures that require verification of strainer integrity and containment cleanliness prior to entering a mode of operation that requires emergency ECCS operability.

- Modified high pressure injection (HPI) pumps and the cyclone separators for the ECCS pumps seals to ensure continued operation in the post-LOCA environment. Installed cyclone separators on the CSS pump seal supply lines.

- Installed a trash rack over the refueling canal drain.

Based on the information provided by the licensee, the NRC staff considers this item closed for GL 2004-02.

## 3.0 BREAK SELECTION

The objective of the break selection process is to identify the break size and locations that present the greatest challenge to post accident sump performance. The term ZOI used in this summary refers to the zone representing the volume of space affected by the ruptured piping.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through May15, 2013.

The licensee selected three breaks for evaluation. The NRC staff initially determined that all aspects of the NEI 04-07 guidance for break selection were not followed. The process was simplified to pick three break locations based on engineering judgment. The most limiting break considered by the licensee was selected. The licensee stated that the selection resulted in

maximum reflective metal insulation (RMI) and coatings debris generation. The maximization of fibrous debris was not discussed in this section. The location of installed fibrous insulation was not identified and it was not clear that it was maximized in the break selection evaluation. As a low fiber plant, the maximization of fibrous debris may be an important factor in other portions of this evaluation, however, in its letter of May 15, 2013, the licensee stated that the total installed fiber amount in the plant is less than 0.75 lb (pound). This makes the question of break location insignificant for fiber.

After the initial review of the licensee's submittal and supplement information described above, the NRC staff determined that the licensee had addressed this area and that no additional information was needed, as documented in the July 10, 2008, partial closure letter (ADAMS Accession No. ML081780330). The determination that the area had been addressed adequately was made by the integrated review team (IRT). The IRT is a group of senior NRC staff convened to consider sump strainer issues that may not have been addressed using staff guidance but may be technically adequate by use of alternate methods or the consideration of other factors that result in significant conservatism. In this case, the IRT determined that because there is not a significant difference in debris generation based on location that the break location area had been adequately addressed. After the evaluation of the area was accepted by the IRT, the licensee revised its fibrous debris amount as discussed in the paragraph above.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the break selection evaluation for Davis-Besse is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02 for Davis-Besse.

## 4.0 DEBRIS GENERATION/ZONE OF INFLUENCE (EXCLUDING COATINGS)

The objective of the debris generation/ZOI evaluation is to determine the limiting amounts and combinations of debris that can occur from the postulated breaks in the RCS.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through May 15, 2013.

The licensee used the NEI 04-07 guidance report (GR) Section 4.2.2.1.1 ZOI refinement of debris-specific spherical ZOI as approved by the NRC staff SE on that document. The NEI GR along with the NRC staff SE is also called the GR/SE. The licensee used the GR/SE ZOI for Transco RMI, NUKON (jacketed or unjacketed with standard bands) and Diamond Power Mirror RMI with standard bands. The licensee indicated that all signs, placards, tags, tape, and similar miscellaneous materials were evaluated for becoming debris and unsuitable materials were replaced with those that would not generate transportable debris.

A 10 $ft^2$ (feet) strainer area reduction was assumed as adequate margin to account for any signs, placards, tags, tape, etc. that were missed in the potential debris reduction effort. The

licensee also indicated that most of the fibrous insulation had been removed from containment and that nearly all insulation in applicable GR or GR/SE ZOI was reflective metal and only a limited amount of NUKON remained.

NRC STAFF CONCLUSION:#

For the debris generation/ZOI review area, the licensee provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris generation/ZOI evaluation for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

## 5.0 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 strainer head loss.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through February 28, 2008.

The licensee based their debris characteristics on the GR/SE, and manufacturer data. The characteristics consisted of the various densities and the characteristic size of the fibers and particles. The licensee performed computational fluid dynamics (CFD) transport analyses but did not report the respective transport velocities used in the analysis and instead, stated that the analysis followed approved guidance. The licensee did not use the NUREG/CR-6224, "Parametric Study of the Potential for BWR [boiling-water reactor] ECCS Strainer Blockage Due to LOCA Generated Debris," dated October 1995 (ADAMS Accession No. ML083290498) correlation for head loss calculation so any associated head loss parameters are not relevant. Since a correlation was not used to estimate head loss the micro-level debris characteristics are not important for Davis Besse as discussed in the paragraph below, The licensee performed head loss calculations for the RMI debris but did not report the parameters used in that evaluation.

In general, specific surface areas for fibrous and particulate debris are used in the prediction of head loss with the NUREG/CR-6224 correlation. The licensee 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.

The licensee reported the bulk densities of materials that could become debris. These values were obtained from the NRC approved methodology or vendor specific information in the case of coatings.

The licensee's debris generation and transport analyses, used the debris characterization assumptions provided in the NRC approved guidance. The head loss analysis uses the results of the debris generation and transport analyses as a basis for the amount and characteristics of debris that reach the strainer. Based on these analyses the licensee determined that the amount of debris reaching the strainer could not cause significant head loss. Specifically, the size of particulates is consistent with staff guidance for coatings particulate and latent particulate. A two-size distribution is used for fibrous debris. The licensee stated that there are

no technical basis assumptions that deviate from NRC-approved guidance for any debris characterization.

NRC STAFF CONCLUSION:

For the debris characteristics review area, the licensee provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris characteristics evaluation for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

## 6.0 LATENT DEBRIS

The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris (e.g., miscellaneous fiber, dust, dirt) existing within the containment and its potential impact on sump screen head loss.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through May 15, 2013.

The licensee originally assumed an amount of latent debris sufficiently large (500 lb-mass (lbm)) as to eliminate any need to validate assumptions and methodology regarding latent debris loading and composition. The licensee later reduced the assumed amount due to reduced strainer surface area available for the case of RCS breaks inside the reactor vessel cavity. The ultimate amount of latent debris was determined via sampling.

The licensee developed a methodology to estimate the quantity of latent debris based upon the guidance provided in NEI 04-07, as modified by the NRC SE. Samples were taken from containment and the masses of debris that were collected were used to calculate the debris mass/unit area of surface. The total amount of latent debris available in containment was then determined by multiplying the debris mass/unit area by the appropriate surface area and summing all surfaces that were considered.

The debris characteristics were determined by adopting the Method-2 guidance provided in the NRC SE for characterizing the composition and density of the latent debris: 15 percent fiber, 85 percent particulate, dry bed bulk density of the latent fiber of 2.4 $lbm/ft^3$. The licensee determined that the total available latent debris in containment was 46 lbm. In its May 15, 2013, letter, the licensee noted that although it assumed 15 percent of the latent debris is fiber that the samples indicate that it is actually significantly less than this at 5.5 percent.

The licensee stated that the sacrificial screen area allotted to foreign materials and miscellaneous latent debris was 10 $ft^2$, based on the amount of unqualified tags and labels. No overlap was allowed.

After the initial review of the licensee's submittal and supplement information described above, the IRT determined that the licensee had addressed this area and that no additional information was needed, as documented in the July 10, 2008, partial closure letter. The IRT decision was based on the fact that the amount of latent debris in containment was determined using staff

accepted methods which had been confirmed by the staff reviewer for latent debris. After the IRT accepted the latent debris area evaluation the licensee revised its latent debris source term as described above.

NRC STAFF CONCLUSION:

For the latent debris review area, the licensee provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the latent debris evaluation for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

## 7.0 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.

NRC STAFF REVIEW:

Information related to the following was provided by the license in correspondence through February 28, 2008.

The licensee stated that its transport analysis considered the analytical steps of blowdown, washdown, pool fill up, and recirculation transport. A CFD analysis of pool flow patterns during recirculation was used to simulate transport during this phase. The licensee stated that erosion due to spray and break flows was analyzed but did not discuss erosion due to recirculation flow. The licensee combined the evaluations for each mode of transport into logic trees and combined the results to determine the transport for various breaks.

Ultimately the licensee assumed that all fine debris transports to the strainer. The only debris that is of concern for the strainer is fine debris. Because the amount of ZOI fiber is so small, erosion of that source is also insignificant. The licensee originally calculated debris amounts that arrive at its two separate strainers. However, with the acceptance of the significantly reduced debris source term and the assumption that all fine debris transports, the transport evaluation becomes relatively unimportant.

After the initial review of the licensee's submittal and supplement information described above, the NRC staff determined that the licensee had addressed this area and that no additional information was needed, as documented in the July 10, 2008, partial closure letter.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the debris transport has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris transport evaluation for Davis-Besse is acceptable. The NRC staff considers this area closed for GL 2004-02.

## 8.0 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.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through April 30, 2010.

The licensee's approach to the head loss and vortexing evaluation did not involve testing. The NRC staff finds that Davis-Besse is a low fiber plant based on its updated submittals and the IRT conclusions. The licensee determined that less fiber than that required to form a 1/8-inch bed was present in containment. However, the staff noted that the assumptions for debris generation in the initial submittal do not support the less than 1/8-inch bed assertion for some breaks. The staff determined that the assumptions used by the licensee are likely conservative. Separately, the licensee conducted a numerical evaluation of the head loss that could potentially be caused by RMI. The staff does not accept the RMI evaluation but considers RMI to be an insignificant contributor to head loss for the Davis-Besse strainer.

The licensee stated that clean strainer head loss was calculated to be very low at 0.06 pounds per square inch (psi). Vortex suppression was evaluated using the guidance in Appendix A, Table A-6 of Regulatory Guide 1.82, Revision 2, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," dated May 1996 (ADAMS Accession No. ML003740249). The licensee also stated that the strainer is submerged at all times that it is in service. The NRC found these responses acceptable.

After the initial review of the licensee's submittal and supplement information described above, the IRT determined that the licensee had addressed this area and that no additional information was needed, as documented in the July 10, 2008, partial closure letter. For this area, the IRT accepted that the amount of debris in containment could not form a filtering bed on the strainer. The IRT had previously accepted a reduced latent debris term and a very small fiber term from installed insulation. The IRT also found that there was no problematic insulation installed within any ZOI. Because the fibrous debris amount is so small and there are no problematic debris sources, the IRT found that there is reasonable assurance that significant head loss cannot occur.

In its April 30, 2010, letter, after the IRT documented its review, the licensee stated that it had increased its inorganic zinc coating source term based on updated review guidance on the ZOI for inorganic zinc coatings. Because a filtering bed does not form on the strainer, head loss across the strainer would not increase. The NRC staff agrees that if a filtering bed is not formed increasing the particulate coatings source term will not cause head loss to increase.

NRC STAFF CONCLUSION:

For the head loss and vortexing area, the licensee has provided information such that the NRC staff has reasonable assurance that the strainer head loss and potential for air ingestion has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the head loss and vortexing evaluation for Davis-Besse is acceptable. The NRC staff considers this area closed for GL 2004-02.

## 9.0 NET POSITIVE SUCTION HEAD

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

NRC STAFF REVIEW:

Information related to the following was provided by the license in correspondence through February 28, 2008.

The licensee presented a summary of its NPSH analyses. The licensee described the NPSH analysis methodology, generally standard industry practices and models used, and each of the information items specified in the generic letter content guidance document. The licensee presented details concerning the parameters, assumptions, and conservatisms that went into the NPSH and minimum flood level analyses.

The licensee identified the main components in the ECCS flow path post LOCA including the borated water storage tank (BWST), ECCS sump, low pressure injection (LPI) and CSS pumps, ECCS piping, RCS, and core flood tanks. The ECCS response to a LOCA was described from initiation to recirculation swap over to 30 days post LOCA. The methodology and data for determining NPSH available was taken in large part from the Crane Technical Paper 410. Fried and Idelchik's "Flow Resistance: A Guide for Design Engineers" [2] was used to determine form losses for some of the ECCS pump suction fittings, as well as the new strainer structure. The licensee listed and described assumptions and inputs, which were a combination of realistic and conservative conditions and values that are expected to yield a conservative result.

The licensee determined that LPI Pump 42-1 had the most limiting NPSH margin at 2.5 feet of water (before considering strainer/debris head loss).

Assumptions listed and described by the licensee are summarized below:

For determining minimum recirculation containment pool level:

- BWST water temperature assumed to be at 90 degrees-Fahrenheit (°F) and transfer to recirculation occurs assuming the minimum BWST level to minimize water mass transferred to containment.
- Containment volume from 545 ft. to 565 ft. elevations is relatively constant based on major structures.
- Any potential contribution from the makeup and purification system is ignored.
- The RCS break occurred at the highest point of the hot leg necessitating the most injected water to refill the RCS to make up for contraction (all RCS fluid is initially at 575 °F) and fill the pressurizer and no net contribution from the RCS to the containment pool.
- CSS train piping is empty and has to be filled when the system is started.
- Considered the mass of water suspended in containment atmosphere, condensation and spray water on surfaces above the pool not yet drained down to the pool, and the water puddled or held up above the pool including that entering and trapped in insulation jacketing.

[2] Referenced in Davis Besse Updated Final Safety Analysis Report, Chapter 6, Section 6.3.2.14, "Net Positive Suction Head Requirement" (pg. 6.3-11) (ADAMS Accession No. ML20302A292).

- Core flood tanks from minimum volume completely injected at 120 °F.

- ECCS system leakage outside containment is at the accident analysis assumed rate.

For determining NPSH available:

- Air ingestion into the LPI/CSS pump suction line does not occur. Strainers are submerged at minimum containment pool level and vortex suppressors are included in the strainer design.

- The maximum LPI pump flow is 4,100 gallons per minute (gpm) each limited by discharge valve stop position setting. A minimum recirculation flow line for each pump is set for 100 gpm, which gives the assumed LPI net pump flow of 8,000 gpm. The flow rate of 4,100 gpm is used for determining head loss in the pump 12-inch suction lines as the minimum recirculation flow passes through a portion.

- CSS pumps continue operating at their maximum flow of 1,500 gpm each after swap over to recirculation as the automatic flow control is assumed to fail to throttle the flows down to 1,300 gpm each.

- Suction piping reducer fittings are conservatively modeled as being shorter, more abrupt than actual.

- Most suction piping elbows are identified as long radius, those not so identified were assumed to be the same consistent with the original Bechtel NPSH calculation.

- Where same size piping appeared to be of different schedules, the smaller nominal inside diameter was assumed.

- Containment sump water temperature was assumed to be at 260 °F, greater than determined in the containment response in the accident analysis.

- No credit is taken for containment overpressure.

For determining NPSH required:

Decay heat removal (DHR)/LPI pump purchase specification required testing in accordance with American Society of Mechanical Engineers Power Test Code 8.2, 1965, which does not provide specific acceptance criteria for determining onset of cavitation. The containment spray pumps were required to be tested in accordance with the Hydraulic Institute Centrifugal Pump Test Standard, which stated that a head degradation of three percent is the usually accepted evidence of cavitation onset. Given no documentation that the Davis-Besse pump vendor NPSH required curves were determined by something other than the three percent standard, the NRC staff assumed that this was used. Also assumed was that the NPSH required was referenced to the pump centerline (horizontal).

The minimum NPSH margin of 2.5 ft. is adequate to ensure that the minimal debris head loss as accepted by the IRT, and clean strainer head losses, will not result in loss of pump NPSH.

NRC STAFF CONCLUSION:

For the NPSH area, the licensee has provided information such that the NRC staff has reasonable assurance that it has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the NPSH evaluation for Davis-Besse is acceptable. The NRC staff considers this area closed for GL 2004-02.

## 10.0 COATINGS EVALUATION

The objective of the coating's 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.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through April 30, 2010.

The licensee used a 5.5D ZOI based on WCAP-16568-P, "Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA-Qualified/Acceptable Coatings" (ADAMS Accession No. ML061990594 (non-public)). The licensee assumed 100 percent particulate for all generated coatings debris. The licensee stated that coating assessments are performed via visual inspection every outage. The licensee stated that damaged/degraded coatings are scheduled for repair or added to unqualified calculation.

After the initial review of the licensee's submittal and supplement information described above, the NRC staff determined that the licensee had addressed this area and that no additional information was needed, as documented in the July 10, 2008, partial closure letter.

In its April 30, 2010, letter, the licensee stated that it had reviewed updated guidance on the ZOI for inorganic zinc coatings. The licensee stated that the quantity of coatings generated would increase due to the ZOI size increase. However, because a filtering bed does not form on the strainer, head loss across the strainer would not increase. The NRC staff agrees that if a filtering bed is not formed increasing the particulate coatings source term will not cause head loss to increase.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the coatings evaluation for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

## 11.0 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.

NRC STAFF REVIEW:

Information related to the following was provided by the license in correspondence through April 30, 2010.

The licensee stated that the debris source term was significantly reduced through removal of nearly all fibrous insulation and completely stripping and recoating the containment dome. The licensee 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 inch 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.

The licensee did not identify a plan to continue to perform containment latent debris surveys in the future. The licensee provided a description of its work controls program and the programmatic measures taken to control potential debris in containment. Given that Davis-Besse is now an all-RMI plant, the NRC staff does not consider the lack of future surveys significant.

The licensee altered several of the design specifications to identify materials that are acceptable for use in containment, particularly coatings and insulation. Prior to start up from a refueling outage, the licensee conducts an inspection of containment and all unauthorized materials are removed or dispositioned via the Corrective Action Program. Materials stored in containment are assessed for 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 CSS operability, foreign material exclusion controls are required for 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. The licensee requires cleanup of all significant latent debris found during inspections. Operations, Radiological Protection, and Engineering personnel perform the containment inspections. The licensee holds pre-job briefs to ensure personnel understand the purpose of the inspection. The Design Engineering Manager is responsible for containment conformance to the approved configuration. The licensee implemented procedures to confirm that the ECCS strainer is in conformance with the design requirements to ensure operability. 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 are declared operable, controls are established to preserve their integrity and conformance to the design basis.

The licensee uses the work control process and the Maintenance Rule program to identify potential risks to the ECCS strainers and associated systems. Operations and Engineering evaluate the impact of maintenance activities, including temporary changes, for potential effect on operability of systems as a part of the work planning process. If a work activity can 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, the effect on plant risk is evaluated and accounted for in the planning and implementation of the activity.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the debris source term evaluation for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

## 12.0 SCREEN MODIFICATION PACKAGE

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

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through February 28, 2008.

The licensee provided the revised content guide specified information. The description provided a basic understanding of the new sump strainers location, configuration, and construction details, and identified associated modifications necessitated by the sump/strainer modification.

The licensee provided a description of the major features of the new sump strainers. They are Enercon Top Hat design with two concentric 10-guage plates formed into cylinders and perforated with 3/16-inch diameter holes on 5/16 inch centers. Twenty-seven of the top hat assemblies are mounted vertically in the existing emergency sump, located in the annulus area outside the secondary shield wall or D-rings, where they extend partially above the containment floor, although fully submerged for all LOCAs, and are referred to as the upper strainer with about 400 $ft^2$ of surface area. All horizontal surfaces of this upper strainer are solid plate and the strainer is surrounded by trash racks. An additional 10 top hat assemblies are mounted horizontally above the incore thimble tubes in the bottom of the incore tunnel. Three stacked tubes, made of perforated plate similar to the top hat construction, run up the incore tunnel and connect these lower 10 assemblies to the emergency sump. These 10 top hat assemblies and the connecting tubes are referred to as the lower strainer, add about 800 $ft^2$ of surface area, and are separated from the upper strainer by perforated plate divider that has the same hole size as the strainer perforated plate (internal strainer). The lower strainer is protected only by its structural frame and is postulated to fail for an RCS loop nozzle break at the vessel reducing the strainer surface back to the internal divider/strainer plate leaving the 400 $ft^2$ of the upper strainer intact and effective. The strainers and trash racks are constructed of stainless-steel materials.

The licensee also provided a basic description of the associated modifications to remove/relocate interferences and protect the new sump strainers. The licensee installed a piece of perforated plate with 3/16-inch holes at the grating for the drain from the emergency sump to the normal sump to prevent debris from entering the emergency sump from the normal sump. The drain grating is welded to the drainpipe. The licensee made a cutout in the wall separating the emergency sump from the incore tunnel to allow for water from the lower strainer to enter the emergency sump. The tail pipe from the containment drain header relief valve was shortened and a support for that line altered. The licensee also modified a piping support/restraint for the decay heat cooldown line relief valve tail pipe. The licensee installed a

jet impingement shield to protect the upper strainer from a break of high energy piping. The licensee relocated the emergency sump access and level sensors. The licensee replaced the original vortex breaker in the emergency sump with a grating beneath the 27 top hats of the upper strainer and at the new sump penetration from the lower strainer.

NRC STAFF CONCLUSION:

For the screen modification package review area, the licensee provided screen location, configuration, and construction information such that the NRC staff has confidence in the design of the strainer. Therefore, the NRC staff concludes that the screen modification package information provided for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

13.0 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.

NRC STAFF REVIEW:

Information related to the following was provided by the license in correspondence through February 28, 2008.

The major recirculation sump components which the licensee analyzed for structural adequacy included the emergency sump strainer, incore tunnel strainer, HELB jet deflector, emergency sump trash rack, and the containment periphery and refueling canal trash racks. Limiting components analyzed within the major components for structural integrity included all corresponding structural members, welds, anchor bolts, grating, and bolted connections. The licensee's summary indicated that the components continue to meet the allowable stress requirements of the American Institute of Steel Construction (AISC) Manual of Steel Construction, 8$^{th}$ Edition, which is the design code used in the qualification of the recirculation sump structures.

The licensee stated that the sump strainer structures were modeled in GT STRUDL using dynamic analysis methods. The trash rack was also modeled in GT STRUDL but used static analysis methods. The licensee indicated that a jet deflector had been installed to protect the upper sump strainer structure from the effects of a HELB resulting from the possible rupture of a terminal end of the RCS pressure boundary piping. The jet deflector and other miscellaneous components (e.g., baseplates) were evaluated using standard hand calculations. Each of these evaluations was performed to demonstrate code compliance with the AISC Manual of Steel Construction, 8$^{th}$ Edition. The interaction coefficients for all the components were less than 1.0.

The various components were analyzed using the normal, upset, and faulted loading combinations. The deadweight loads used in each combination were based on each component's material and corresponding density. The seismic loads used in the analyses were taken from the plant's design basis seismic floor response spectra at the closest elevations to sump strainer. The licensee used a two percent damping value in the analyses for an Operating Basis Earthquake and Safe Shutdown Earthquake (SSE); the SSE loads are used for this analysis. The SSE loads used in the analyses also included stresses due to hydrodynamic loading resulting from a seismic event. The licensee assumed the differential pressure loading

used for the strainer external surfaces was a uniform 5 psi. For the trash racks, a 0.5 psi uniform loading was used in the analyses, which encompassed the combined deadweight and seismic loads.

With regards to HELBs, the licensee indicated that no evaluation was required for the upper sump strainer. Justification is provided for this based on the aforementioned installation of a jet deflector to deter the effects of a possible rupture of a terminal end of the RCS pressure boundary piping near the upper sump strainer. As noted above, the licensee performed an evaluation to justify the structural adequacy of the jet deflector. The licensee also indicated that for the scenario involving a reactor cavity nozzle break, the lower strainer is assumed to sustain damage and possibly be rendered inoperable due to this postulated HELB. The licensee indicated that no HELB evaluation was performed for this portion of the sump strainer because the postulated damage is accounted for in the head loss analyses. In addition, no jet deflectors or other protective features were installed for the lower strainer.

The licensee indicated that a backflushing strategy was not credited in the analysis, negating the need for an evaluation of reverse flow through the strainer.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the sump structural analysis evaluation for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

## 14.0 UPSTREAM EFFECTS

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

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through February 28, 2008.

The licensee's upstream effects assessment included an evaluation of the flow paths upstream of the containment sump to assess holdup of inventory. The evaluation was performed to ensure ECCS or CSS flows would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return flow paths. The licensee took into account phenomena that could reduce the water inventory in the containment sump during the evaluation of the minimum water level in the containment, post-LOCA. The licensee identified the sources of water and the contribution of each source to the water level in containment. The licensee conservatively assumed that no water from the RCS contributed to the containment sump inventory.

The licensee's only potential upstream blockage points in the pool are 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 credible. Another potential upstream blockage point is the six-inch refueling canal drain. Any sprays draining through the refueling canal must flow through this drain, which discharges in the reactor cavity. To preclude the drain from clogging with debris, a trash rack was 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 six-inch drain.

The licensee studied the various flow paths for water to reach the emergency sump 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 pass water to the lower levels.

NRC STAFF CONCLUSION:

For this review area, the licensee has provided information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the upstream effects evaluation for Davis-Besse is acceptable. The NRC staff considers this item closed for GL 2004-02.

## 15.0 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.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through February 28, 2008.

The licensee provided a summary description of the methods used to evaluate the downstream effects of debris that bypass the ECCS sump strainers. The licensee did not follow the methods of WCAP-16406-P, “Evaluation of Downstream Sump Debris Effects in Support of GSI-191,” Revision 1. The licensee stated that the downstream effects were addressed as part of the 13 refueling outage recovery effort which preceded the WCAP. Because WCAP-16406-P was not cited as the guide for performing the downstream analysis, the staff initially proposed to request additional information to assess the adequacy of the licensee’s evaluation. It was later determined that Davis-Besse participated in an effort for the NRC and industry to develop a methodology to evaluate downstream effects on components. Although the methodology used was not strictly in accordance with the approved staff guidance, the licensee performed the analyses described below.

The licensee stated that an initial evaluation of all downstream systems and components was completed as a part of the GSI-191 resolution project. The evaluation studied all piping, pumps, valves, decay heat coolers, flow elements, and orifices in the major flow paths of HPI, LPI, CSS, and boron precipitation control systems. The evaluation identified that the HPI pump bearings and several pumps’ seals could be affected by debris. In response, the licensee initiated a test program to more definitively assess the impact of the post-LOCA environment on the equipment. Based on the observations in these tests, the licensee concluded that the amount of fiber in containment had to be reduced, and subsequently eliminated nearly all fibrous

insulation in the containment building prior to plant restart from 13 RFO. The cyclone separators for the HPI pumps were modified to conform to the as-tested configuration and cyclone separators were added to the CSS pump seal water cooling lines.

The licensee stated that with these modifications in place LOCA generated debris is judged not to represent a threat to the system operation following a LOCA.

After the initial review of the licensee's submittal and supplement information described above, the NRC staff determined that the licensee had addressed this area and that no additional information was needed, as documented in the July 10, 2008, partial closure letter.

NRC STAFF CONCLUSION:

For the ex-vessel downstream effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the licensee's evaluation of this area is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

16.0 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 LTCC.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through March 29, 2021.

The licensee stated that it applied the NEI clean plant criteria which uses a fiber penetration (bypass) fractions of 45 percent. The licensee used a debris transport fraction of 100 percent instead of the 75 percent from guidance, as applied to in-vessel effects. The use of 100 percent transport is conservative. The licensee calculated the in-vessel fiber load as 10.9 grams per fuel assembly (g/FA), which is below the WCAP-17788-P, Revision 1 "Comprehensive Analysis and Test Program for GSI-191 Closure" (ADAMS Package Accession No. ML20010F181) acceptance criterion.

The licensee stated that because Davis-Besse is a Babcock & Wilcox (B&W) plant and is less susceptible to an inhibition of LTCC due to in-vessel debris effects, it only confirmed that the maximum combined amount of fiber that may arrive at the core inlet and heated core for the worst-case hot leg break scenario is less than the WCAP-17788 in-vessel fibrous debris acceptance criterion.

The licensee stated that it uses Framatome's fuel design Mark-B-HTP FAs [fuel assemblies] and that the proprietary total in-vessel fibrous debris limit in WCAP-17788 applies to Davis-Besse. The licensee stated that the mass of fibrous debris is the limit for dirt loading in containment with 15 percent assumed to be fiber. The licensee confirmed that the maximum combined amount of fiber that may arrive at the core inlet and heated core for a hot leg break and the core inlet fiber amount is less than the WCAP-17788 limit.

The licensee stated that the earliest possible sump switchover time is 40 minutes. The injection phase is assumed to terminate at 40 minutes, the minimum time at which the water from the borated water storage tank could be exhausted.

Based on comparison of the key chemical precipitation parameters and values for Davis-Besse with the WCAP-17788, Table 3.n.9.1, the licensee determined that test group 42 was representative of Davis-Besse and the predicted chemical precipitation timing is greater than 24 hours.

The licensee stated that establishing long term boron dilution is a time critical action that is performed within 4 hours when required. This is less than the predicted chemical precipitation time of > 24 hours.

The licensee stated that since Davis-Besse is a B&W plant, $t_{block}$ [3] is 20 minutes. The licensee confirmed that chemical effects occur after 24 hours which is greater than the applicable $t_{block}$ of 20 minutes.

The licensee stated that the Davis-Bessie rated thermal power of 2,817 mega-watts (MWt) is less than the WCAP-17788 applicable analyzed thermal power of 2,827 MWt and is therefore bounded by the WCAP alternate flow path analysis.

The licensee stated that since the barrel/baffle design for all B&W plants is the same and the barrel/baffle flow resistances shown in WCAP-17788 represents all B&W plants, the alternate flow path (AFP) value for Davis-Besse aligns with the analyzed value.

The licensee stated that the WCAP-17788 sump recirculation rate of 8.5 gpm/FA (1,504.5 gpm based on 8.5 gpm x 177 FA) bounds all B&W plants. The Davis-Besse minimum ECCS recirculation flow is 19.8 gpm/FA.

The NRC staff was unsure that the calculated core inlet fiber amount included consideration of the small amount of fiber (0.73 lb.) installed in the plant. The NRC staff confirmed that consideration of this fiber amount increases the total inlet fiber load by about 1 g/FA using the licensee's methodology. The calculated fiber amounts are very low and would not cause blockage sufficient to result in a loss of LTCC even if no auxiliary feed pumps were available. The NRC staff reviewed the Test Group 42 data in Volume 5 of WCAP-17788-P and confirmed: (1) that the test conditions were representative of the Davis-Besse projected post-LOCA conditions, and (2) that the tests showed no precipitation was detected during the 24-hour test duration. Therefore, since $t_{block}$ and long-term boron dilution occur before chemical precipitation, AFPs are available before chemical effects could contribute to a complete blockage of the core inlet. The licensee demonstrated that the key parameters for the plant are bounded or equal to those accepted by staff guidance.

NRC STAFF CONCLUSIONS:

For the in-vessel downstream effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has

[3] $t_{block}$ is the time at which the fuel inlet can become fully blocked and core cooling will continue with coolant flow via alternate flow paths.

been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the licensee's evaluation of this area is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

## 17.0 CHEMICAL EFFECTS

The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on strainer head loss and core cooling. Chemical effects in the reactor vessel were evaluated in Section 16.0 above.

NRC STAFF REVIEW:

Information related to the following was provided by the licensee in correspondence through March 29, 2021.

Davis-Besse used the WCAP-16530-NP base chemical model to determine the plant-specific chemical precipitate load. However, the licensee determined that testing with chemical effects was not required due to the very low amounts of fiber in containment.

The licensee's chemical effects conclusions are based on analysis alone and rely on too little fibrous material in the plant to form a filtering debris bed on the sump strainer. Specific Davis-Besse head loss testing with chemical precipitate has not been performed. As indicated by the licensee: "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." FENOC letter dated February 28, 2008 stated that after the replacement of fibrous piping insulation with RMI, the remaining fibrous insulation totals approximately 0.9 $ft^3$. The licensee assumed an additional 5 $ft^3$ of fiber in their plant specific analysis to provide margin. Considering the very low fiber levels, the 1,226 $ft^2$ sump strainer, and the non-uniform flow Enercon top-hat strainer design, the staff finds the Davis-Besse analysis acceptable since there is not enough fiber to filter chemical precipitates and cause strainer blockage.

Based on the information described above the NRC staff determined that the licensee has addressed this area and that no additional information was needed. This is consistent with the staff's documented position in the July 10, 2008, partial closure letter.

NRC STAFF CONCLUSION:

For the chemical effects review area, the licensee has provided sufficient information such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC staff concludes that the licensee's evaluation of this area is acceptable. Based on the information provided by the licensee, the NRC staff considers this area closed for GL 2004-02.

## 18.0 LICENSING BASIS

The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the changes associated with GL 2004-02. The NRC staff review is based on documentation provided by the licensee through March 29, 2021.

The licensee stated it has incorporated the design basis of the modified emergency sump strainer into the plant's current licensing basis. The licensee also stated that it revised the

updated final safety analysis report to include this information. The licensee stated that no additional licensing actions or exemption requests are needed to support the resolution of the emergency sump strainer blockage issues.

The licensee indicated other modifications that were made to the plant including replacement of most fibrous insulation within containment, modification of the HPI pumps, and modification/installation of cyclone separators for the HPI, LPI, and CSS pumps. The licensee stated that the original detailed design of these systems has been updated.

NRC STAFF CONCLUSION:

For this review area the licensee has provided information, such that the NRC staff has reasonable assurance that the subject review area has been addressed conservatively or prototypically. Therefore, the NRC considers this item closed for GL 2004-02.

## 19.0 CONCLUSION

The NRC staff has performed a thorough review of the licensee's responses and RAI supplements to GL 2004-02. The NRC staff conclusions are documented above. Based on the above evaluations the NRC staff finds the licensee has provided adequate information as requested by GL 2004-02.

The stated purpose of GL 2004-02 was focused on demonstrating compliance with 10 CFR 50.46. Specifically, the GL requested addressees to perform an evaluation of the ECCS and CSS recirculation and, if necessary, take additional action to ensure system function in light of the potential for debris to adversely affect LTCC. The NRC staff finds the information provided by the licensee demonstrates that debris will not inhibit the ECCS or CSS performance following a postulated LOCA. Furthermore, the NRC staff have concluded that the ability of the systems to perform their safety functions, to assure adequate LTCC following a design-basis accident, as required by 10 CFR 50.46, has been demonstrated. Therefore, the NRC staff concludes the licensee's responses to GL 2004-02 are adequate and considers GL 2004-02 closed for Davis-Besse.

SUBJECT: DAVIS-BESSE NUCLEAR POWER STATION, UNIT NO. 1 – CLOSEOUT OF GENERIC LETTER 2004-02, "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION DURING DESIGN BASIS ACCIDENTS AT PRESSURIZED-WATER REACTORS" (EPID-2017-LRC-0000) DATED JANUARY 7, 2022

DISTRIBUTION:
PUBLIC
PM File Copy
RidsACRS_MailCTR Resource
RidsRgn3MailCenter Resource
RidsNrrDorlLpl3 Resource
RidsNrrLASRohrer Resource
RidsNrrPMDavis-Besse Resource
RidsNrrDssStsb Resource
RidsNrrDroIoeb Resource
RidsNrrDnrlNcsg Resource
SSmith, NRR
ARussell, NRR
PKlein, NRR

**ADAMS Accession No.: ML21277A012**

| OFFICE | NRR/DORL/LPL3/PM | NRR/DORL/LPL3/LA | NRR/DSS/STSB/BC(A) |
|---|---|---|---|
| NAME | BPurnell (RHaskell for) | SRohrer | NJordan |
| DATE | 10/4/2021 | 10/7/2021 | 9/26/2021 |
| OFFICE | NRR/DNRL/NCSG | NRR/DORL/LPL3/BC | NRR/DORL/LPL3/PM |
| NAME | SBloom | NSalgado (RKuntz for) | BPurnell (RHaskell for) |
| DATE | 10/5/2021 | 1/7/2022 | 1/7/2022 |

**OFFICIAL RECORD COPY**