FENOC
FirstEnergy Nuclear Operating Company

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

February 12, 2013
L-13-037

10 CFR 54

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 Number NPF-3
Reply to Requests for Additional Information for the Review of the Davis-Besse Nuclear Power Station, Unit No. 1, License Renewal Application (TAC No. ME4640) and License Renewal Application Amendment No. 38

By letter dated August 27, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML102450565), FirstEnergy Nuclear Operating Company (FENOC) submitted an application pursuant to Title 10 of the *Code of Federal Regulations*, Part 54 for renewal of Operating License NPF-3 for the Davis-Besse Nuclear Power Station, Unit No. 1 (Davis-Besse). By letter dated January 4, 2013 (ML12355A184), the Nuclear Regulatory Commission (NRC) requested additional information to complete its review of the License Renewal Application (LRA). During a telephone conference call on January 16, 2013, NRC Staff and FENOC discussed requests for additional information (RAIs) B.2.43-2a and B.2.43-3a, clarifying the request for RAI B.2.43-2a. During a telephone conference call on January 23, 2013, NRC Staff and FENOC discussed and clarified RAI B.2.43-3a. In lieu of responding to the RAIs as written, NRC Staff stated that FENOC should respond to RAIs B.2.43-2a and B.2.43-3a as clarified during the conference calls.

The Attachment provides the FENOC reply to the NRC requests for additional information. The NRC request is shown in bold text followed by the FENOC response. The Enclosure provides Amendment No. 38 to the Davis-Besse LRA.

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NRR

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Clifford I. Custer, Fleet License Renewal Project Manager, at 724-682-7139.

I declare under penalty of perjury that the foregoing is true and correct. Executed on February 12, 2013.

Sincerely,

David M. Imlay
Director, Site Performance Improvement

Attachment:
Reply to Requests for Additional Information for the Review of the Davis-Besse Nuclear Power Station, Unit No. 1 (Davis-Besse), License Renewal Application (LRA), Section B.2.43

Enclosure:
Amendment No. 38 to the Davis-Besse License Renewal Application

cc: NRC DLR Project Manager
NRC Region III Administrator

cc: w/o Attachment or Enclosure
NRC DLR Director
NRR DORL Project Manager
NRC Resident Inspector
Utility Radiological Safety Board

Question RAI B.2.43-2a

Background:

By letter dated November 20, 2012, the applicant responded to a request for additional information (RAI) regarding the proposed monitoring methods for the shield building (SB) cracking. The RAI response indicates that the proposed inspection sample size of 20 core bores will cover the three areas of cracking (flute shoulders, upper 20 ft of the building, and the steam line penetrations) and is adequate to identify any changes in the laminar cracking, without further impulse response testing during the period of extended operation.

Issue:

As part of evaluating the applicant's plan for monitoring the SB cracking with core bores, the staff needs to understand the technical basis for the size of the sample. For example, is the sample based purely on statistics or is it based on the long term effect of the concrete cracks on the ability of the reinforcement to carry design loads and the safety significance of the cracking. In an earlier RAI response, dated April 5, 2012, it was indicated that the structural impact of the cracking would be determined via testing. A summary description of the test results and discussion of how the test results demonstrate that the sample size is sufficient has not been provided.

Request:

Provide a discussion of the technical basis for the adequacy of the sample size. If the sample size was based on laboratory testing, provide a summary of the testing. Include an explanation of the testing completed as well as the results, and how this information relates to the structural capacity of the SB and supports the adequacy of the sample size.

Telephone Conference Call Summary:

The NRC Staff initiated a telephone conference call with FENOC on January 16, 2013, to discuss and clarify NRC follow-up RAIs B.2.43-2a and B.2.43-3a regarding the Davis-Besse Shield Building Monitoring Program. Following discussions, NRC Staff stated that, instead of addressing RAI B.2.43-2a as written, FENOC should respond to the RAI by providing summaries of the laboratory (i.e., university) testing performed and the results of the testing. The summary should address the

Shield Building reinforcing bar-concrete bond strength, the assumptions made in the structural operability calculations regarding bond strength, and how the testing performed supports those assumptions. A copy of laboratory reports is not needed by the NRC Staff.

RESPONSE RAI B.2.43-2a

Testing was performed at the University of Kansas and at Purdue University to assess the concrete-rebar bond strength of concrete with a laminar crack. Given the conservative nature of the test conditions used in these studies, it is concluded that the reinforcement in the Shield Building experiences little, if any reduction in strength and capacity due to the laminar cracking condition.

During the evaluation of the Shield Building laminar cracking in 2011, FENOC performed calculations to document that the Shield Building remains capable of performing its safety functions despite the presence of laminar cracking. FENOC assumed in the evaluation calculations that there was no reinforcement capacity in cracked zones where the reinforcing bar included splices. The rationale for the assumption was that unspliced rebar spanning cracked zones retained capacity, while reinforcement capacity with rebar splices could not be quantified, and therefore was considered ineffective in the analysis. It was recognized at the time that follow-up laboratory testing was required to confirm assumptions regarding reinforcement capacity of spliced rebar.

FENOC sponsored independent testing programs at Purdue University and the University of Kansas to determine the effects of laminar cracking in the plane of and parallel with reinforcing bar splices (a condition similar to the Shield Building laminar cracking). The laboratory testing confirmed that the robust design and construction of the Shield Building allow the building to retain significant margin against design loads even with laminar cracking.

Both universities conducted testing programs to evaluate the effects of the laminar cracking using large scale rectangular section beams with size #11 tension reinforcement splices. The #11 reinforcement was chosen since it matches the size used in the construction of the Shield Building. Two adjacent splices at 6 inches on center spacing were used in all beams to simulate rebar interaction. The test specimen set-up at both universities was conservative since the Shield Building reinforcement splices are staggered, and not side-by-side, as constructed at both laboratory test facilities. Both testing programs used materials that were representative of the Shield Building materials with similar strengths. Concrete strengths of the samples were representative and conservative relative to the strength of the materials in the Shield Building. Select beams in both the Purdue and Kansas studies were subject to reload cycles. These beams were loaded to develop the crack (at calculated yield), unloaded, and the beams were reloaded to failure. The crack sizes developed exceeded the crack widths identified in the Shield Building.

Purdue University tested six samples with 120-inch splices and six samples with 79-inch splices. These splice lengths correspond to the splice lengths used in the Shield Building. Purdue used beam geometry in order to produce a preferential (laminar) crack at the location of reinforcement when loaded.

During testing, cracks developed and opened to widths exceeding 0.10 inches when approaching the maximum load. These crack widths well exceeded the Shield Building cracks identified and essentially covered the entire test span prior to failure.

Each of the beams tested demonstrated two fundamental properties:

1. Each beam developed yielding stress in the reinforcement after the development of laminar cracks, and

2. The load deflection curves for each beam exhibited classic ductile behavior with increasing deflection beyond the yield point.

These tests demonstrate that the reinforcement, and therefore the building as a system, retains its strength despite cracking, given the reinforcement was capable of developing yield stress. By exhibiting ductile behavior, the tests confirm that despite the laminar cracking condition, the building system can be expected to demonstrate the classically required deflection and surface cracking indications prior to failure.

The University of Kansas also used a large-scale rectangular beam section with #11 rebar splices as noted above; however, the main study beams were cast with a cold joint in the plane of the reinforcement for a length greater than the entire splice length. The University of Kansas tested 6 beams: 3 with 79-inch splices, and 3 with 120-inch splices. These splice lengths correspond to the splice lengths used in the Shield Building.

For the beams with the reload cycles, crack widths were at or greater than a width of 0.20 inches prior to unloading. This exceeds the crack widths identified in the Shield Building by a factor of approximately 2. These specimens developed capacities near and above yield despite the conservative testing conditions.

Given the conservative nature of the conditions used in the tests, it is the conclusion of the professors who conducted and evaluated the tests that the reinforcement in the Shield Building experiences little, if any, reduction in strength and capacity due to the laminar cracking condition. The studies also document that the structure retains its serviceability and ductile behavior. The university test findings provide additional confidence in structural adequacy above that already documented in the functionality calculations, and confirmed that the robust design and construction of the Shield Building allow the building to retain significant margin against design loads even with laminar cracking.

Question RAI B.2.43-3a

Background:

By letter dated November 20, 2012, the applicant responded to an RAI regarding the scope of the proposed Shield Building Monitoring Program. The RAI response notes that there were four conditions required to cause the SB laminar cracking and that the SB is the only plant structure that has all of these conditions. The response further states that the design features of all other concrete structures within the scope of license renewal prevent the occurrence of similar cracking, and this was verified via core bores and impulse response testing of an auxiliary building wall, which was a bounding location.

Issue:

1. **The staff believes that testing to verify cracking did not occur in other structures should be conducted on a structure comparable to the SB. It is not clear to the staff why the auxiliary building is considered a comparable structure to the SB, since the wall that was tested was coated while the SB was uncoated. A comparable structure should have as many characteristics that match the SB as possible (e.g., similar rebar density, similar wall thickness, similar environmental exposure, lack of coating).**

2. **In past RAI responses, the applicant has explained that some other structures within the scope of license renewal have exterior coatings; however, they are not relied upon to prevent sub-surface laminar cracking. In addition the coatings are not included in the scope of license renewal.**

Request:

1. **Explain why the auxiliary building is comparable to the SB, or identify other comparable structures and provide technical justification for why testing is unnecessary on those structures or how it will be verified that cracking has not occurred in those structures. The response should identify any uncoated structures within the scope of license renewal.**

2. **Identify which coatings are included in the scope of license renewal and the acceptance criteria that will be used for those coatings. Provide technical justification for excluding the coatings that are not within license renewal.**

Telephone Conference Call Summary:

The NRC Staff initiated telephone conference calls with FENOC on January 16 and 23, 2013, to discuss and clarify NRC follow-up RAIs B.2.43-2a and B.2.43-3a regarding the Davis-Besse Shield Building Monitoring Program. Following

discussions, NRC Staff stated that, instead of addressing RAI B.2.43-3a as written, FENOC should respond to the following requests.

1. **For Request #1, NRC Staff stated that the discussion is not about aging mechanisms. Rather, more detail is needed to justify why the other structures within the scope of license renewal are not susceptible to the same laminar cracking phenomenon as the Shield Building.**

2. **For Request #2, NRC Staff stated that the wording of FENOC license renewal future commitments made regarding the use of American Concrete Institute (ACI) Report 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," for the inspection of coatings was inconsistent.**

RESPONSE RAI B.2.43-3a

1. Structures other than the Shield Building do not have the same configuration as the Shield Building and are not susceptible to the same laminar cracking phenomenon. The Root Cause Analysis Report for the Shield Building laminar cracking condition identified that all four of the following design configuration and meteorological conditions were required for Shield Building laminar cracking to occur:

   - a stress concentration associated with the Shield Building flute shoulder configuration,
   - reinforcing bar arrangement,
   - significant moisture intrusion, and
   - low temperatures.

   Elimination of any one of the four conditions in the root cause will prevent a laminar cracking condition from occurring.

   The root cause also concluded that the blizzard of 1978 was the event that initiated the Shield Building laminar cracking, and that there is no active aging mechanism present. The Shield Building is the only Davis-Besse structure constructed that includes the design configuration required for the development of laminar cracking; no other site structures within the scope of license renewal include the design configuration geometry required for the laminar cracking to occur. The inherent stress concentration created due to the reinforcing bar geometry behind the thickest concrete section of the Shield Building flute shoulder, when combined with the expansive stress developed by entrained moisture as it froze, allowed for the cracking to initiate.

   Other uncoated site structures within the scope of license renewal do not have the design configuration geometry required to initiate laminar cracking. With respect to

moisture intrusion, a review of other site structures within the scope of license renewal reveals ancillary concrete surfaces that are in scope but not coated (e.g., Borated Water Storage Tank Foundation). The identified uncoated surfaces are flat walls, slabs or cylindrical foundation piers. These uncoated surfaces do not have the design configuration geometry required to create the inherent stress concentration necessary to initiate laminar cracking, whereas the Shield Building design incorporated a protruding shoulder geometry and a cylindrical shell.

To confirm that uncoated structures without the flute shoulder design configuration geometry are not susceptible to laminar cracking, FENOC performed additional impulse-response testing and core boring on the Shield Building shell between the flute shoulders during the summer of 2012. This testing and the follow-up core bore inspections confirmed that cracking did not initiate in the shell portions of the uncoated Shield Building at any elevation.

The area of the Auxiliary Building that was investigated (coated area, with high density reinforcement) did not have evidence of laminar cracking. Investigation of this area also supports the root cause findings that high density reinforcement is only a contributing cause. When reviewed in combination with the Shield Building shell (uncoated surfaces, with low and high density reinforcement), and Shield Building shoulders (uncoated surfaces with low density reinforcement) this comparison concludes the flute shoulder geometry is the design configuration required to initiate cracking. No other structures on-site have the shoulder geometry similar to the Shield Building. Therefore no additional investigation is warranted.

2. License Renewal Application Section B.2.39, "Structures Monitoring Program," and Table A-1, "Davis-Besse License Renewal Commitments," Commitment 20, are revised to clarify that inspections of external structural concrete coatings for structures within the scope of license renewal will be performed in accordance with ACI 349.3R. Concrete coatings exposed to outside air are inspected as required by the Shield Building Monitoring Program and the Structures Monitoring Program. FENOC will perform the inspections of coatings in accordance with the quantitative acceptance criteria for coatings in Chapter 5, Sections 5.1.4 and 5.2.4, of ACI Report 349.3R.

   See the Enclosure to this letter for the revision to the Davis-Besse LRA.

Enclosure

Davis-Besse Nuclear Power Station, Unit No. 1 (Davis-Besse)

Letter L-13-037

Amendment No. 38 to the
Davis-Besse License Renewal Application

License Renewal Application
Sections Affected

Table A-1

Section B.2.39

The Enclosure identifies the change to the License Renewal Application (LRA) by Affected LRA Section, LRA Page No., and Affected Paragraph and Sentence. The count for the affected paragraph, sentence, bullet, etc. starts at the beginning of the affected Section or at the top of the affected page, as appropriate. Below each section the reason for the change is identified, and the sentence affected is printed in *italics* with deleted text ~~*lined-out*~~ and added text *underlined*.

Affected LRA Section	LRA Page No.	Affected Paragraph and Sentence
Table A-1	**Page A-67**	**Commitment No. 20**

In response to RAI B.2.43-3a regarding inspection of structural coatings, license renewal future Commitment 20 in LRA Table A-1, "Davis-Besse License Renewal Commitments," is revised to include clearer reference to an industry standard document, as follows:

Table A-1
Davis-Besse License Renewal Commitments

Item Number	Commitment	Implementation Schedule	Source	Related LRA Section No./ Comments
20	Enhance the Structures Monitoring Program to: • Add sufficient acceptance criteria and critical parameters to trigger an increased level of inspection and initiation of corrective action. *Indicate that ACI 349.3R provides acceptable guidelines which will be considered in developing acceptance criteria for concrete structural elements, steel liners, joints, ~~coatings,~~ and waterproofing membranes. The acceptance criteria for visual inspection of coatings on in-scope concrete structures will be in accordance with ACI 349.3R.* Plant specific quantitative degradation limits, similar to the three-tier hierarchy acceptance criteria from Chapter 5 of ACI 349.3R, will be developed and added to the inspection procedure. The Structures Monitoring Program procedure will also be enhanced to reflect the "Periodic Evaluation" criteria defined in chapter 3.3 of ACI 349.3R. The Structures Monitoring Program procedure	Prior to April 22, 2017	LRA and *FENOC Letters L-11-153, L-11-237, L-11-292, L-11-317, L-12-455, and L-13-037*	A.1.39 B.2.39 *Responses to NRC RAIs B.2.39-4, B.2.39-5, B.2.39-6 and B.2.39-7 from NRC Letter dated April 5, 2011, B.2.39-11 and*

Table A-1
Davis-Besse License Renewal Commitments

Item Number	Commitment	Implementation Schedule	Source	Related LRA Section No./ Comments
	will include the "prioritization process" to develop a representative sample of areas to inspect in accordance with ACI 349.3R.			*3.5.2.3.12-4 from NRC Letter dated July 21, 2011, Supplemental RAI B.2.39-11 from telecon held with the NRC on September 13, 2011, Supplemental RAI OIN-380 from Region III IP-71002 Inspection, RAI B.2.4-1a from NRC Letter dated November 14, 2012, and, RAI B.2.43-3a from*

Table A-1
Davis-Besse License Renewal Commitments

Item Number	Commitment	Implementation Schedule	Source	Related LRA Section No./ Comments
				NRC Letter dated January 4, 2013

Affected LRA Section	LRA Page No.	Affected Paragraph and Sentence
B.2.39	**Pages B-154 thru B-160**	**Enhancements**

In response to RAI B.2.43-3a regarding inspection of structure coatings, LRA Section B.2.39, "Structures Monitoring Program," subsection titled "Enhancements – Acceptance Criteria," is revised to include clearer reference to an industry standard document, to read as follows:

Enhancements

- **Acceptance Criteria**

  The program procedure will be enhanced by adding sufficient acceptance criteria and critical parameters to trigger an increased level of inspection and initiation of corrective action. *Indicate that ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," provides acceptable guidelines which will be considered in developing acceptance criteria for concrete structural elements, steel liners, joints, ~~coatings,~~ and waterproofing membranes. The acceptance criteria for visual inspection of coatings on in-scope concrete structures will be in accordance with ACI 349.3R.* Plant specific quantitative degradation limits, similar to the three-tier hierarchy acceptance criteria from Chapter 5 of ACI 349.3R, will be developed and added to the inspection procedure. The Structures Monitoring Program procedure will also be enhanced to reflect the "Periodic Evaluation" criteria defined in chapter 3.3 of ACI 349.3R. The Structures Monitoring Program procedure will include the "prioritization process" to develop a representative sample of areas to inspect in accordance with ACI 349.3R.