FENOC

FirstEnergy Nuclear Operating Company

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

July 3, 2014
L-14-224

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 Request 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. 51

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 April 15, 2014 (ML14097A454), the Nuclear Regulatory Commission (NRC) requested additional information to complete its review of the License Renewal Application (LRA).

As communicated to the NRC License Renewal Project Manager by telephone on July 1, 2014, the date for submittal of the FENOC response to this request for additional information (RAI) was delayed. This delay was due to the additional time required for the final approval of the supporting cause investigation, and the time required to verify stakeholder communications and to obtain final letter approvals.

The Attachment provides the FENOC reply to the NRC request for additional information. The NRC request is shown in bold text followed by the FENOC response. The Enclosure provides Amendment No. 51 to the Davis-Besse LRA.

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 July 3, 2014.

Sincerely,

Thomas J. Summers
Director, Site Operations

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. 51 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

Section B.2.43

Question RAI B.2.43-4

Recent Plant-Specific Operating Experience-Shield Building Monitoring Program

Background:

In October 2011, during hydro-demolition operations to create a construction opening to support the scheduled reactor head replacement, FirstEnergy Nuclear Operating Company (FENOC or the applicant) discovered laminar cracking in the concrete of the shield building at Davis-Besse Nuclear Power Station (Davis-Besse). While investigating the extent of the cracking using the impulse response technique and confirmatory core bores, the applicant identified additional laminar cracking around the shield building. Although the root cause analysis determined that the initial laminar cracking was event driven (the blizzard of 1978), the staff was concerned that without an adequate aging management program (AMP) the cracks could grow and affect the safety function of the shield building during the period of extended operation. In response to the staff's concern, the applicant submitted a plant-specific AMP "Shield Building Monitoring Program" described in license renewal application (LRA) Sections A.1.43 and B.2.43 to address the cracking in the shield building. The Shield Building Monitoring Program is a prevention and condition-monitoring program that supplemented the Structures Monitoring Program (LRA Sections A.1.39 and B.2.39) for shield building concrete components exposed to an air-outdoor environment. The applicant proposed to apply a waterproof coating to the shield building and to monitor existing core bores for indications of changes in the cracking. The applicant also stated that rebar will be monitored for corrosion on an opportunistic basis when exposed. Following review of the Shield Building Monitoring Program, responses to several rounds of follow-up requests for additional information (RAIs), and an updated Shield Building Monitoring Program, the NRC staff found the updated Shield Building Monitoring Program to be acceptable, as documented in Section 3.0.3.3.9 in the NRC staff's September 3, 2013, Safety Evaluation Report related to the License Renewal of Davis-Besse Nuclear Power Station (ADAMS Accession No. ML13248A267).

Issue:

1) **The NRC staff understands that during a subsequent routine baseline inspection in August/September 2013, FENOC discovered several (about 15) cracks on the Davis-Besse shield building that were not identified previously. FENOC subsequently inspected and removed additional core samples and conducted further evaluations and testing to determine the root cause of the cracks and their apparent progression.**

2) **Further, the NRC staff understands that in the ongoing February 2014 refueling outage, during hydro-demolition activities for creation of a construction opening in the Davis-Besse shield building to support the scheduled steam generator replacement, FENOC learned that several (at least 26) sections of steel reinforcement (rebar) had been broken and/or cracked in the construction opening area. Each section was apparently broken very close to the mechanical splice coupling used to splice the rebar during the head replacement outage in 2011. Samples of the broken rebar were sent to a laboratory for examination and assessment.**

It is not clear to the NRC staff how this recent plant-specific operating experience will be incorporated, as applicable, into the Shield Building Monitoring Program and the Structures Monitoring Program AMPs credited for the shield building in the Davis-Besse LRA.

Request:

1. **Explain, with sufficient technical detail, any modifications or enhancements that will be made to the Shield Building Monitoring Program; the Structures Monitoring Program; or other applicable AMP to account for this recent plant-specific operating experience described as Issue items 1 and 2 above.**

2. **If FENOC determines that no modifications or enhancements to the Shield Building Monitoring Program; the Structures Monitoring Program; or other applicable AMP are necessary based on the operating experience described as Issue items 1 and 2, explain, with sufficient technical detail, the basis for that determination.**

RESPONSE RAI B.2.43-4

1. Due to the recent plant-specific operating experience described in the request, above, the minimum number of Shield Building monitoring bores currently managed under the FENOC Corrective Action Program is being changed to 23. Three monitoring bores will be used to aid in identifying changes in the limits of cracking in

areas with previously identified crack propagation. New core bores will be installed as required during each inspection cycle to bound crack limits. The frequency of internal visual inspection for the 23 monitoring bores is changed to annual inspections for a minimum of 4 years starting in 2015.

For the Shield Building Monitoring Program, following acceptable results of the one-year interval inspections, the interval will be changed to a two-year interval in 2019 and a maximum four-year interval after the 2026 inspections. These inspection intervals will be evaluated for effectiveness by the Shield Building Monitoring Program. Should there be an identified change to the cause of the condition, significant change to the rate of crack growth, or a condition adverse to the bounding nature of the design basis documentation, modifications to the Shield Building Monitoring Program will be determined using the FENOC Corrective Action Program.

The four-year inspection interval is more stringent than the guidance in American Concrete Institute (ACI) Report ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures" Chapter 5, Section 5.3 and Chapter 6 for monitoring of a structural condition that has been discovered, evaluated and analyzed; which is a five-year interval.

LRA Sections A.1.43 and B.2.43, both titled, "Shield Building Monitoring Program," are revised to address the change in the core monitoring schedule. LRA Section B.2.43 is revised to include an operating experience (OE) summary of the conditions found in 2013 and summary results of the evaluation of the crack progression.

2. The Shield Building Monitoring Program is revised as described in item 1, above. Aging management programs related to other structures will not be revised because the conditions and geometry of other site structures are not susceptible to this type of cracking. The laminar cracking was eliminated from consideration in other buildings as previously described in the FENOC response to RAI B.2.43-3a by letter dated February 12, 2013 (ADAMS Accession No. ML13044A499).

   No revisions to any Aging Management Programs will be made as a result of the identification of steel reinforcement (rebar) that was broken or cracked in the Shield Building construction opening area in 2014. The failures of the rebar in the Shield Building temporary construction opening were determined to be the result of changes in rebar restraint, increase in rebar dowel length, decrease in temperature, and an increase in stress cycles from hydro-demolition trimming that collectively resulted in fatigue failure. Prior to restoration of the construction opening, all exposed rebar in the Shield Building construction opening that was not broken or cracked was examined through the use of ultrasonic examination, with magnetic

particle testing selectively used for surface examinations as needed. Rebar with indications of the fatigue failure mechanism was removed from the Shield Building. Given that the failure mechanism is understood and is the result of a single event, this rebar failure does not represent an aging management issue.

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-14-224

Amendment No. 51 to the
Davis-Besse License Renewal Application

License Renewal Application
Sections Affected

A.1.43

B.2.43

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
A.1.43	**Page A-25**	**4th Paragraph**

In response to NRC request for additional information (RAI) B.2.43-3, LRA Section A.1.43, "Shield Building Monitoring Program," the 4th paragraph, previously revised by FENOC letter dated November 20, 2012 (ML12331A125), is revised to read as follows:

The core bore visual inspections are performed on a representative sample of Shield Building Wall structural subcomponents by inspection of the internal surfaces of core bores. *The locations ~~of the core bores have been~~ for the inspections are chosen from the core bores that have been installed in the subcomponents of the Shield Building Wall, including new core bores installed as required to identify changes in the limits of cracking in areas with previously identified crack propagation. The representative sample size includes ~~20~~ a minimum of 23 core bore inspection locations in the subcomponent population (defined as Shield Building Wall subcomponents having the same material, environment, and aging effect combination). The ~~20~~ 23 core bore location distribution has been chosen to include core bore inspections in 8 of the 10 flute shoulders with a high prevalence of event-driven laminar cracking.* This distribution also covers shell sections above elevation 780 feet with 4 core bores (2 pairs), and each Main Steam Line penetration area with one core bore. *In addition, past evidence of crack propagation is considered in choosing future inspection locations.*

Affected LRA Section	LRA Page No.	Affected Paragraph and Sentence
B.2.43	**Page B-166**	**Detection of Aging Effects; Monitoring and Trending; Acceptance Criteria; and, Operating Experience**

In response to RAI B.2.43-3, LRA Section B.2.43, "Shield Building Monitoring Program," Program elements Detection of Aging Effects, Monitoring and Trending, Acceptance Criteria and Operating Experience, previously revised by FENOC letter dated November 20, 2012 (ML12331A125), are revised to read as follows:

- Detection of Aging Effects

  The Shield Building Monitoring Program provides for detection of aging effects prior to the loss of Shield Building intended functions. *The inspections, testing and analyses of the Shield Building concrete and rebar that was done to support the root cause evaluation report, "Concrete Crack within Shield Building Temporary Access Opening", and the follow-up report, "Shield Building Laminar Crack Propagation," ~~will~~ provide a baseline for future Shield Building Monitoring Program activities.*

  Periodic visual inspections will be performed in accordance with an implementing procedure by inspectors qualified as described in Chapter 7 of ACI Report 349.3R. The visual inspections will be performed on a representative sample of Shield Building Wall structural subcomponents by inspection of the internal surfaces of core bores. *The locations of the ~~core bores have been~~ inspections will be chosen from the core bores that have been installed in the subcomponents of the Shield Building Wall, including new core bores installed as required to identify changes in the limits of cracking in areas with previously identified crack propagation. The representative sample size includes ~~20~~ 23 core bore inspection locations in the subcomponent population (defined as Shield Building Wall subcomponents having the same material, environment, and aging effect combination). A minimum of 10 of the core bores at inspection locations are currently uncracked; however, they are adjacent to areas of known cracking. This strategic location, and selection of core bores provides FENOC with the ability to monitor for crack propagation. The ~~20~~ 23 core bore location distribution has been chosen to include core bore inspections in 8 of the 10 flute shoulders with a high prevalence of event-driven laminar cracking.* This distribution also covers shell sections above elevation 780 feet with 4 core bores (2 pairs), and each Main Steam Line penetration area with one core

bore. *In addition, past evidence of crack propagation will be considered in choosing future inspection locations.* Visual inspections will be supplemented by other established nondestructive examination (NDE) techniques and testing, as appropriate.

The initial frequency of visual inspection of core bores and core bore samples will be based on the results of inspections conducted before the period of extended operation. ~~*If no aging effects were identified by these visual inspections, then visual inspections will continue to be conducted at least once every two years during the period of extended operation.*~~ *The first inspection conducted during the period of extended operation is scheduled for 2017 and the next inspection is scheduled for* ~~*2019*~~ *2018. If no aging effects are identified by the* ~~*two-year*~~ *one-year interval visual inspections (defined as no discernable change in crack width or the confirmation that no visible cracks have developed in core bores that previously had no visible cracks), then the frequency of visual inspections may be changed to at least once every* ~~*five*~~ *two years through 2026. If no aging effects are identified by the two-year interval visual inspections, then the frequency of visual inspections may be changed to at least once every four years.* Any evidence of degradation will be documented and evaluated through the FENOC Corrective Action Program. *The evaluation will include a determination of the need for any required change to the inspection schedule or parameters that need to be inspected.*

The exterior concrete coatings of the Shield Building Wall, Shield Building Dome, and Shield Building Emergency Air Lock walls, will be inspected at least once every five years in accordance with the implementing procedure. The coatings inspectors will be qualified as described in Chapter 7 of ACI Report 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures." The frequency of the coatings inspections may be adjusted based on observed coating conditions, any required reapplication of a coating, or on the recommendations of a coating manufacturer.

- Monitoring and Trending

The Shield Building Monitoring Program will include a baseline inspection, followed by periodic inspections. Visual inspections will be performed in accordance with the implementing procedure by personnel qualified as described in Chapter 7 of ACI Report 349.3R. *The representative sample size includes* ~~*20*~~ *a minimum of 23 core bore inspection locations in the Shield Building Wall subcomponent population having the same material, environment, and aging effect combination. A minimum of 10 of the core bores at inspection locations are currently uncracked; however, they are adjacent to areas of known cracking. This strategic location, and selection of*

core bores provides FENOC with the ability to monitor for crack propagation. The ~~20~~ 23 core bore location distribution has been chosen to include core bore inspections in 8 of the 10 flute shoulders with a high prevalence of event-driven laminar cracking. This distribution also covers shell sections above elevation 780 feet with 4 core bores (2 pairs), and each Main Steam Line penetration area with one core bore. *In addition, past evidence of crack propagation will be considered in choosing inspection locations.* Inspection findings will be documented and evaluated by assigned engineering personnel such that the results can be trended. Inspection findings that do not meet acceptance criteria will be evaluated and tracked using the FENOC Corrective Action Program.

- Acceptance Criteria

  Indications of relevant conditions of degradation detected during the inspections will be evaluated and compared to pre-determined acceptance criteria. The acceptance criteria will be defined to ensure that the need for corrective actions is identified before loss of structure or component intended functions. If the acceptance criteria are not met, then the indications or conditions will be evaluated under the FENOC Corrective Action Program.

  Engineering evaluation by qualified personnel will be used for disposition of inspection findings that do not meet the acceptance criteria.

  For core bore inspections, unacceptable inspection findings will include any indication of new cracking or a "discernable change" in previously identified cracks. Any indication of new cracking is defined as a visual inspection finding that visible cracks have developed in core bores that previously had no visible cracks. A discernable change in a previously identified crack is defined as a visual inspection finding that there has been a discernable change in general appearance or in crack width as identified by crack comparator measurement. *Conditions to be evaluated following each inspection cycle for determination of "acceptable results" include conformance with the plant design and licensing basis, as well as with previously determined crack propagation rates. Comparison with previously determined propagation rates will be to identify any potential changes in the driving force of the condition.*

  The acceptance criteria for any identified loss of material or change of material properties will be as described in Chapter 5 of ACI Report 349.3R.

  The acceptance criteria for rebar corrosion found during visual inspections will be that there is no evidence of corrosion indicated by loose, flaky rust or reinforcement section loss. Given the inherent variability of reinforcement

cross section, and the encompassing concrete, no measurement technique is employed.

The acceptance criteria for Shield Building Wall, Shield Building Dome and Shield Building Emergency Air Lock Enclosure wall coatings will be based on the ability of the coatings to continue to be effective. The acceptance criteria will include the quantitative acceptance criteria for coatings in Chapter 5, Sections 5.1.4 and 5.2.4, of ACI Report 349.3R.

- Operating Experience

Review of Davis-Besse operating experience identified degradation of the Shield Building concrete wall (above grade) due to internal laminar cracking. The degradation had not been identified by the existing maintenance rule structural inspections which are based on visual inspection of the external surfaces of structures. Although the laminar cracking degradation of the concrete for the Shield Building was not caused by an aging mechanism, it is prudent to establish a plant-specific Aging Management Program to include monitoring methods to identify aging effects that may occur in the future. The Shield Building Monitoring Program is designed to identify and evaluate potential aging effects within the Shield Building walls. The program is also designed to identify and evaluate any loss of preventive action effectiveness of the exterior Shield Building concrete coatings, which were applied in 2012.

Industry operating experience regarding similar structures was evaluated for applicability at Davis-Besse. The only other similar instance of concrete delamination discovery was associated with creating a temporary access opening in the post-tensioned containment structure at Crystal River Unit 3. The root cause of the Crystal River containment concrete delamination was the design of the structure, in combination with the type of concrete used, and the acts of detensioning and opening the containment structure. As part of the root cause analysis of the Davis-Besse Shield Building laminar cracking, FENOC concluded that the subject Crystal River operating experience was not applicable to the Davis-Besse Shield Building.

The existing long-term corrective actions for Shield Building laminar cracking include inspections of the Shield Building concrete, rebar and coatings. *The results of those activities ~~may provide~~ has provided operating experience relevant to the Shield Building Monitoring Program.*

Inspections of 12 core bores were completed in 2013 under the "Design Guidelines for Maintenance Rule Evaluation of Structures" Procedure EN-DP-01511. During that cycle of inspections, a crack was observed in one of the core bores. This finding, upon a review of records, was determined to

be a pre-existing crack given that the extracted concrete core was cracked at the location identified. Given this finding, the inspection population was increased, eventually leading to inspection of all available core bores. This re-inspection identified a total of 7 core bores with similar conditions that were determined to be pre-existing. This re-inspection also identified 8 conditions where the laminar cracking conditions were determined to have undergone a discernable change.

The cracking propagation was determined to be a result of ice-wedging (freezing water at a pre-existing crack leading edge). This condition requires water, freezing temperatures and pre-existing cracks. Because the Shield Building has been coated it contains a finite amount of water. It is not practical to remove the water in an accelerated manner given the cumulative magnitude of leading crack edges and transportability of water. It is also not practical to remove the existing cracks or prevent freezing temperatures. The rate of cracking propagation is estimated at 0.4 to 0.7 inches per freezing cycle based on laboratory simulation. By application of the evaluation criteria hierarchy of ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," Figure 5.1, the condition was acceptable through evaluation. The condition was not passive; however, it was bounded by design basis documentation. The Shield Building Monitoring Program was changed to ensure conformance with the design requirements and to maintain the USAR functions.

The Shield Building laminar cracking condition has been evaluated with respect to the design basis functions of the Shield Building. The condition is documented in FENOC Calculation C-CSS-099.20-063, as supported by Bechtel Report, "Effect of Laminar Cracks on Splice Capacity of No. 11 Bars based on Testing Conducted at Purdue University and University of Kansas for Davis-Besse Shield Building," that the Shield Building "... meets all design requirements specified in USAR and will perform its USAR described design functions." This analysis bounds the identified changes in the laminar cracking condition from the conditions identified in 2011.

Referencing the Evaluation criteria hierarchy of ACI 349.3R, Figure 5.1, the 2013 condition was determined to be acceptable through evaluation. The condition was not passive; however, it was bounded by design basis documentation. The condition will therefore be subjected to increased monitoring to ensure conformance with the design requirements and USAR functions.

The elements that comprise the Shield Building Monitoring Program inspections will be consistent with industry practice. Industry and plant-specific operating experience will be considered in the implementation

of this program. As additional operating experience is obtained, lessons learned will be incorporated, as appropriate.