UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION III
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May 28, 2015

Mr. Raymond Lieb
Site Vice President
FirstEnergy Nuclear Operating Co.
Davis-Besse Nuclear Power Station
5501 N. State Rte. 2, Mail Stop A–DB–3080
Oak Harbor, OH 43449-9760

SUBJECT: DAVIS-BESSE NUCLEAR POWER STATION - INSPECTION OF APPARENT CAUSE EVALUATION EFFORTS FOR PROPAGATION OF LAMINAR CRACKING IN REINFORCED CONCRETE SHIELD BUILDING AND CLOSURE OF UNRESOLVED ITEM INVOLVING SHIELD BUILDING LAMINAR CRACKING LICENSING BASIS - INSPECTION REPORT 05000346/2014008

Dear Mr. Lieb:

On April 15, 2015, the U.S. Nuclear Regulatory Commission (NRC) completed an inspection to evaluate your apparent cause evaluation efforts with respect to laminar crack propagation in the Davis-Besse reinforced concrete shield building, and to resolve a concern as to whether your acceptance of laminar cracking in the shield building required NRC review and approval. On March 27, 2015, (interim exit meeting), and on April 15, 2015, (final exit meeting), the NRC inspectors discussed the results of this inspection with you and members of your staff. Inspectors documented the results of this inspection in the enclosed inspection report.

This inspection was conducted as an inspection sample pursuant to NRC Inspection Procedure 71152, "Problem Identification and Resolution," under the Baseline Inspection Program. The inspection examined activities conducted under your license as they relate to safety and compliance with the Commission's rules and regulations, and with the conditions of your license. The inspectors reviewed selected records and interviewed personnel.

NRC inspectors documented one finding of very-low safety significance (Green) in this report. This finding involved a violation of NRC requirements. This violation was determined to be Severity Level IV under the traditional enforcement process. However, because of the very-low safety significance, and because the issue was entered into your Corrective Action Program, the NRC is treating the issue as a Non-Cited Violation (NCV) in accordance with Section 2.3.2, of the NRC Enforcement Policy.

If you contest the subject or severity of the NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001, with copies to the Regional Administrator, Region III; the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; and the NRC Resident Inspector at Davis-Besse Nuclear Power Station. In addition, if you disagree with the cross-cutting aspect assigned to any finding in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your disagreement, to the Regional Administrator, Region III, and the NRC Resident Inspector at Davis-Besse Nuclear Power Station.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 2.390, "Public Inspections, Exemptions, Requests for Withholding," of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC's Public Document Room or from the Publicly Available Records (PARS) component of the NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

David E. Hills, Chief
Engineering Branch 1
Division of Reactor Safety

Docket No. 50–346
License No. NPF–3

Enclosure:
Inspection Report 05000346/2014008;
w/Attachment: Supplemental Information

cc w/encl: Distribution via LISTSERV®

U.S. NUCLEAR REGULATORY COMMISSION

REGION III

Docket No:	50-346
License No:	NPF-3
Report No:	05000346/2014008
Licensee:	FirstEnergy Nuclear Operating Company (FENOC)
Facility:	Davis-Besse Nuclear Power Station
Location:	Oak Harbor, OH
Dates:	November 3, 2014, through April 15, 2015
Inspectors:	J. Neurauter, Senior Reactor Inspector, Lead T. Bilik, Senior Reactor Inspector
Approved by:	D. E. Hills, Chief Engineering Branch 1 Division of Reactor Safety

SUMMARY OF FINDINGS

Inspection Report 05000346/2014008; 11/03/2014 – 04/15/2015, Davis-Besse Nuclear Power Station; Inspection of Apparent Cause Evaluation Efforts for Propagation of Laminar Cracking in Reinforced Concrete Shield Building; Closure of Unresolved Item Regarding Whether the Licensee's Acceptance of Laminar Cracking in the Shield Building Required NRC Review and Approval.

This report covers a 5-month period of inspection by two U.S. Nuclear Regulatory Commission (NRC) regional inspectors. One Green finding was identified by the inspectors. The finding was also considered a Severity Level IV Non-Cited Violation (NCV) of NRC regulations. The significance of inspection findings is indicated by their color (i.e., greater than Green, Green, White, Yellow, or Red), and determined using Inspection Manual Chapter (IMC) 0609, "Significance Determination Process (SDP)," dated June 2, 2011. Cross-cutting aspects are determined using IMC 0310, "Aspects Within the Cross-Cutting Areas" effective date January 1, 2014. All violations of NRC requirements are dispositioned in accordance with the NRC's Enforcement Policy, dated July 9, 2013. The NRC's program for overseeing the safe operation of commercial nuclear power reactors is described in NUREG-1649, "Reactor Oversight Process" Revision 5, dated February 2014.

NRC-Identified and Self-Revealed Findings

Cornerstone: Barrier Integrity

Severity Level IV - Green. The inspectors identified a Severity Level IV NCV of Title 10, *Code of Federal Regulations* (CFR) Part 50.59(c)(2), and an associated finding of very-low safety significance for the licensee's failure to request and obtain a license amendment pursuant to 10 CFR 50.90. Specifically, the licensee's method of evaluation that accepted shield building laminar cracking represented a departure from the method of evaluation described in the Final Safety Analysis Report (as updated), and required prior NRC approval with respect to the design and licensing basis. The licensee entered this finding into its Corrective Action Program; the licensee's immediate corrective action determined that shield building remained operable and capable to perform its design safety functions; the licensee's planned corrective actions included revising 10 CFR 50.59 Evaluation 13-00918, and preparation of additional documents for inclusion in a license amendment request.

The finding was determined to be more than minor because the finding was associated with the Barrier Integrity cornerstone attribute of Design Control, and affected the cornerstone objective to provide reasonable assurance that physical design barriers protect the public from radionuclide releases caused by accidents or events. The inspectors evaluated the finding using IMC 0609, Appendix A, "The SDP for Findings At-Power." Using Exhibit 3, the inspectors determined that the finding screened as very-low safety significance because all the Reactor Containment screening questions for the Barrier Integrity Cornerstone were answered "No." Specifically, the inspectors concluded that the shield building remained capable of performing its design safety functions despite the identified laminar cracking. The associated violation was categorized as Severity Level IV because the issue was determined to be of very-low safety significance under the SDP. This finding had a cross-cutting aspect in the area of Human Performance, Conservative Bias, because the licensee did not take a conservative approach to decision making for evaluation of shield building laminar

cracking, particularly when information is incomplete or conditions are unusual. [H.14, Conservative Bias] (Section 4OA2.2)

Licensee-Identified Violations

No violations were identified.

REPORT DETAILS

SHIELD BUILDING DESCRIPTION

The containment system consists of three basic structures: a steel containment vessel (CV), a reinforced concrete shield building (SB), and the internal structures (Figure 1). The CV is a cylindrical steel pressure vessel which houses components and systems, including the reactor vessel and reactor coolant piping. The SB is a reinforced concrete structure that surrounds the CV, and has a cylindrical wall nominally 30 inches thick with vertical and horizontal reinforcement on both the inside and outside faces, and a shallow dome roof. An annular space is provided between the wall of the CV and the SB, and clearance is also provided between the CV and the dome of the SB. With the exception of the concrete under the CV, there are no structural ties between the CV and the SB above the foundation slab.

The cylindrical SB wall contains an inner and an outer rebar mat, each located approximately 3 inches into the concrete from their respective inner and outer wall surfaces. A rebar mat is a grid of reinforcing steel bars that adds strength to the concrete. In addition, the structure includes additional concrete elements (called shoulders) that extend out from the 2.5 foot thick wall to provide the appearance of eight evenly spaced, vertical cutouts (called flutes) in the outer wall surface (Figure 2). These shoulders (16 in toto) are a maximum thickness on each side of the flute (approximately 18 inches thick), and gradually blend into the 2.5 foot thick wall away from the flute. These shoulders are reinforced by additional rebar located below their concrete surfaces (Figure 3).

The containment system was designed to provide protection for the public from radiological consequences of hypothetical accidents including a break of the largest reactor coolant piping. The CV provides primary means to contain the post-accident environment, and was designed to withstand and hold against accident pressure. The identified cracking did not involve the CV. The design basis of the SB provided: (1) environmental protection of the containment vessel; (2) for a controlled release of the annulus atmosphere during accidents; and (3) shielding from radiation sources within the SB. Specifically, the SB's function was to provide biological shielding, and in case radioactive leakage escapes from the CV during accident conditions, to allow the Emergency Ventilation System to draw suction from the annulus region and filter that leakage. In addition, the SB protects the CV from external environmental hazards such as tornado winds and tornado driven missiles. The SB must also function to withstand earthquakes.

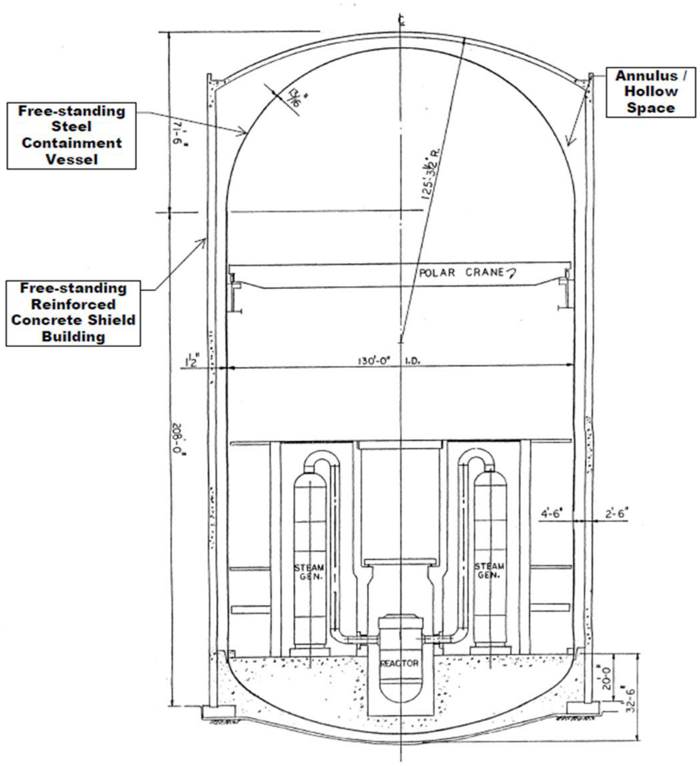

Figure 1: Simplified Davis-Besse Shield Building and Steel Containment Vessel

Figure 2: Davis-Besse Shield Building

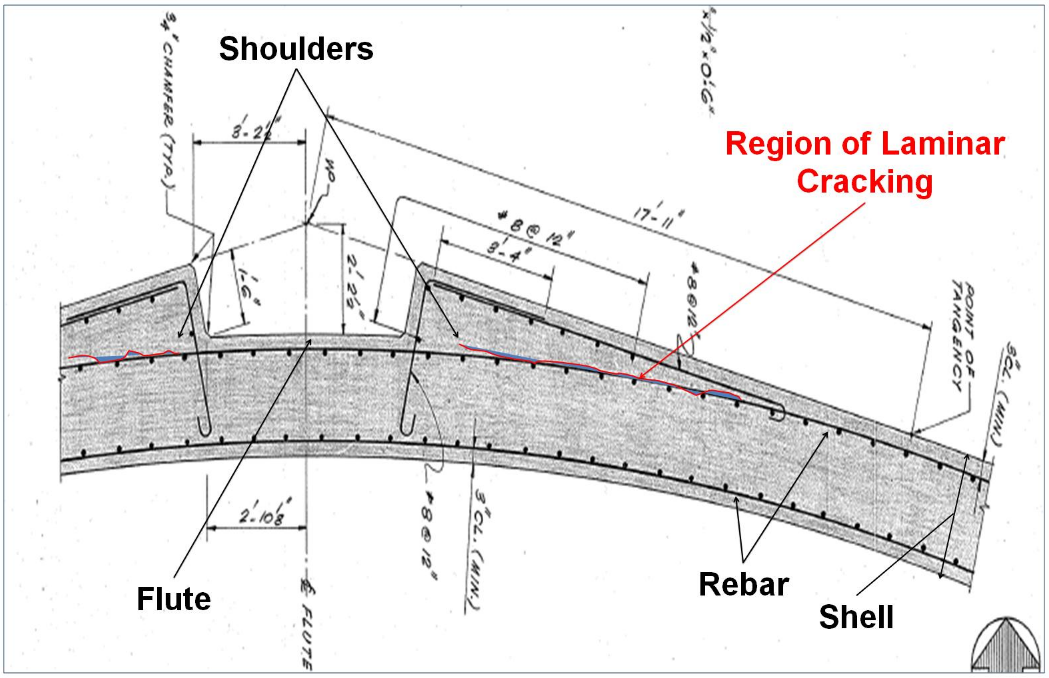

Figure 3: Flute and Shoulder Cross-Section

BACKGROUND AND OVERVIEW

During construction of the SB access opening to replace the reactor pressure vessel head in late 2011, the licensee discovered laminar subsurface cracking in the SB (Figure 3). Through Impulse Response testing and confirmatory core borings, the licensee bounded the extent of cracking as along the outer rebar mat in the SB flute shoulders, at the top of the SB near the junction with the roof, and at the SB main steam line penetrations. The licensee was able to demonstrate via rigorous and conservative structural calculations that the SB remained structurally adequate for the controlling load cases, and remained capable of performing its design safety functions. The licensee's analysis and associated NRC review regarding operability of the SB are discussed in NRC Inspection Report (IR) 05000346/2012007 (ADAMS Accession No. ML12128A443).

The licensee performed further evaluation, and outlined corrective actions (CAs) to SB degradation in its Root Cause Analysis Reports (RCRs) (ADAMS Accession Nos. ML120600056 and ML12142A053) in 2012. The associated NRC inspections and evaluations of the RCRs are discussed in NRC IR 05000346/2012009 (ADAMS Accession No. ML12173A023), and IR 05000346/2012010 (ADAMS Accession No. ML12276A342). As part of its evaluation of the laminar cracks, the licensee contracted Performance Improvement International, LLC (PII) to perform a comprehensive technical root cause assessment to identify the cause(s) of the laminar cracking. The licensee concluded that the reason for the SB laminar cracking was the geometric configuration of the thickened architectural flute shoulders and rebar arrangement coupled with a rare combination of severe environmental factors (i.e., significant moisture intrusion and low temperatures) associated with the blizzard of 1978. The design configuration did not include an exterior protective sealant on the SB which allowed moisture to migrate into the concrete, freeze, and expand. The resulting stress concentration and radial

stresses exceeded the tensile strength of the concrete and initiated the subsurface laminar cracking. The licensee RCRs attributed the root cause of the formation of laminar cracking to the design specification for construction of the SB that did not specify application of an exterior sealant from moisture, and the direct cause of the formation of laminar cracking to the integrated effect of moisture content, wind speed, temperature, and duration from the blizzard of 1978. The licensee CAs included the application of a water resistant coating onto the SB exterior wall in 2012 to prevent additional laminar crack initiation for conditions similar to the blizzard of 1978. The licensee also initiated long-term monitoring of the SB laminar cracking condition to substantiate that the cracks were stable: (1) verify no discernable change in crack width; and (2) confirm that no cracks have developed in previously un-cracked core bores.

SB Laminar Crack Propagation

As noted in NRC IR 05000346/2013004 (ADAMS Accession No. ML13308A283), during SB monitoring inspections performed in August of 2013, licensee visual core examinations indicated that the SB laminar cracks may be propagating. The licensee initiated a condition report (CR) when changes in cracking were identified. In addition, the licensee initiated CR 2013-14097, “Shield Building Laminar Crack Extends,” dated September 11, 2013, to combine related CRs and address the concern. As a CA for CR 2013-14097, the licensee initiated a cause evaluation and contracted PII to perform a comprehensive technical cause assessment to identify the cause(s) of the crack propagation. The results were documented in the supporting vendor report, “Performance Improvement International - Root Cause Analysis: Laminar Crack Condition of the Davis-Besse Shield Building,” dated June 18, 2014. By letter dated July 8, 2014, the licensee’s Full Apparent Cause Evaluation (FACE) was sent to the NRC (ADAMS Accession No. ML14189A452).

SB Licensing Basis

As discussed in NRC IR 05000346/2012007 (ADAMS Accession No. ML12128A443), NRC inspectors in 2011/2012 reviewed the SB design and licensing basis with respect to laminar cracking in the cylindrical wall. The SB was designed, in-part, using rules and requirements from American Concrete Institute (ACI) 307-69, “Specification for the Design and Construction of Reinforced Concrete Chimneys.” This design standard specifies both inner face and outer face reinforcement for a cylindrical wall greater than 18 inches in thickness. The inspectors did not identify alternative design rules in ACI 307-69 that addresses laminar cracking in proximity to the outer face reinforcement mat. In addition, the SB design was checked by the Ultimate Strength Design Method in accordance with ACI 318-63, “Building Code Requirements for Reinforced Concrete.” The inspectors did not identify in ACI 318-63, or another industry design standard, design criteria that addressed concrete reinforcement effectiveness in proximity to laminar cracking. Hence, it appeared to the inspectors that the original design codes were no longer applicable to the current condition of the SB. Therefore, the inspectors questioned if laminar cracking in proximity to the outer face reinforcement was a condition not in conformance with the current design and licensing basis.

The licensee performed further evaluation and addressed the concern in the licensee’s RCRs (ADAMS Accession Nos. ML120600056 and ML12142A053). The associated NRC inspection and evaluation of the RCRs are discussed in NRC IR 05000346/2012009 (ADAMS Accession No. ML12173A023), and IR 05000346/2012010 (ADAMS Accession No. ML12276A342). The licensee’s RCRs concluded that the SB, with the laminar cracking in its cylindrical wall, was operable but non-conforming to the current design and licensing basis in regard to:

- The Davis-Besse Updated Safety Analysis Report (USAR) Section 3.8.2.2.5, and Design Criteria Manual Section II.H.2.5.1.5, specified the analysis methodologies used for the SB design. These documents stated that the SB wall was designed using, “Analysis of Spherical Shells” from Section III, of the 1968 Edition of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. In contrast, in the initial condition assessment of the laminar cracking, licensee calculations C-CSS-099.20-054, and C-CSS-099.20-056, used the “ANSYS” computer software to study the effect of the laminar cracks on the function of the SB.

- The USAR Section 3.8.2.2.6, and Design Criteria Manual Section II.H.2.5.1.5, defined the load combinations and allowed stresses for the SB design. Licensee calculation C-CSS-099.20-056, generated to address the laminar cracking, documented that the calculated stress for the tornado wind and differential pressure load exceeded the allowable stress value in the design and licensing basis, but was within the allowable limit using the alternative differential pressure design load of Regulatory Guide 1.76, “Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants,” Revision 1.

The licensee’s RCR specified Extent of Condition CA No. 1: Additional Examination of the Shield Building Exterior Wall. Specifically, an approved licensee vendor identified cracked and un-cracked areas of the SB using a screening method (Impulse Response testing), and a confirmatory method (core borings).

The licensee’s RCR specified Direct Cause CAs to re-establish the design and licensing basis for the SB:

- Direct Cause CA No. 1: Testing Program to Investigate the Steel Reinforcement Capacity Adjacent to Structural Discontinuities. Specifically, the licensee administered a testing program performed at Purdue University and the University of Kansas. The test procedure was developed and performed at the selected facilities to determine the effect of the structural discontinuities (i.e., laminar cracks) on adjacent steel reinforcement splices. This test program and the deliverable test report were reviewed and approved by the licensee.

- Direct Cause CA No. 2: Engineering Plan to Re-Establish the Design and Licensing Basis for Shield Building. Specifically, the licensee developed a plan for re-establishing SB conformance to the Davis-Besse design and licensing basis.

Upon the completion of the corrective action for inspection of the SB, the extent of laminar cracking would be more precisely established. Upon the completion of the corrective action for the Rebar Splice Testing Program, the capacity of the reinforcing steel splices adjacent to the laminar cracking would be known. The steps for re-establishing SB design and licensing bases conformance were to be finalized, and additional corrective actions were to be initiated, as required.

The licensee later consolidated these actions into and completed two CAs to re-establish the design and licensing basis of the SB with laminar cracking:

- CA-2011-03346-15; Complete Owner's Acceptance of the Design Basis Calculation, and the associated 10 CFR 50.59 documentation for the SB. The calculation incorporated test results that determined the extent of SB laminar cracking and the effect of laminar cracking on the structural capacity of reinforcing steel splices.

- CA-2011-03346-16; Complete Owner's Acceptance, approval and processing of USAR Change Notice for a new appendix to the USAR that reflects the current SB configuration inclusive of laminar cracking, university research test results, and design basis methodology.

In doing so, the licensee used the combination of testing and the calculation to re-establish the design and licensing basis of the SB with laminar cracking. Specifically, the licensee performed additional Impulse Response testing, and confirmatory core borings to more precisely establish the extent of the laminar cracking. The licensee also performed testing at selected university laboratories to determine a design capacity for rebar splices in laminar crack areas. Using these data as input, the licensee performed a complex evaluation/calculation to demonstrate the SB with laminar cracking had structural capacity to perform its design basis functions consistent with acceptance criteria specified in the design basis code referenced in the USAR. Finally, the licensee used the resulting information in a 10 CFR 50.59 evaluation, dated September 10, 2013, that concluded that the licensee's method of evaluation for acceptance of the SB laminar cracking did not require prior NRC approval.

The NRC completed an inspection (IR 05000346/2013009, dated May 12, 2014, [ADAMS Accession No. ML14132A259]) to evaluate the licensee's actions to address the design and licensing basis of the Davis-Besse SB with respect to the laminar cracking. The inspectors initiated unresolved item (URI) 05000346/2013009-01, "Methodology and Acceptance Criteria Utilized for Design and Licensing Basis of the Shield Building with Laminar Cracking," to provide further review and evaluation by the NRC staff to establish a position on whether the licensee's evaluation pursuant to 10 CFR 50.59 provided appropriate rationale to support its conclusion that acceptance of the laminar cracking in the SB with respect to the design and licensing basis did not require prior NRC approval. In particular, the inspectors questioned whether the licensee's analysis constituted a departure from the method of evaluation described in the USAR. By memorandum dated April 1, 2015, (ADAMS Accession No. ML15082A125), Subject: "Final Response to Task Interface Agreement 2015-11, Design and Licensing Basis Requirements for Davis-Besse Nuclear Power Station Shield Building with Reinforced Concrete Laminar Cracking," NRC Office of Nuclear Reactor Regulation (NRR) staff agreed that the licensee's use of the "ANSYS" Computer Program to evaluate SB laminar cracking was a departure from the method of evaluation which requires prior NRC approval under 10 CFR 50.59(c)(2)(viii).

4. OTHER ACTIVITIES

Cornerstone: Barrier Integrity

4OA2 Identification and Resolution of Problems (71152)

.1 Shield Building Laminar Crack Propagation Apparent Cause Evaluation

a. Inspection Scope

As part of CR 2013-14097, the licensee completed a FACE supported by vendor subject matter experts knowledgeable in concrete construction, design, examination, and modeling to review evidence associated with the discovery of the propagation of subsurface concrete laminar cracking. The licensee's apparent cause team was tasked with determining "how," "when," and "why" the concrete laminar crack propagation occurred in the SB wall. On July 8, 2014, the results of the licensee's FACE, and proposed CAs were submitted to the NRC: "FirstEnergy, Davis-Besse

Nuclear Power Station; FACE; Shield Building Laminar Crack Propagation; Condition Report 2013-14097 Dated September 11, 2013; Apparent Cause Evaluation Report, post-CARB" (ADAMS Accession No. ML14189A452).

From November 3, 2014, to March 27, 2015, the inspectors performed an inspection of the licensee's causal analysis for the identified SB laminar crack propagation as discussed below to determine:

- If the licensee's apparent cause evaluation efforts for crack growth were adequate;
- If the licensee reached a reasonable conclusion as to cause of laminar crack growth based on the evidence;
- If the laminar crack propagation and licensee identified causes invalidated conclusions related to SB laminar cracking causes documented in the licensee's 2012 RCRs (ADAMS Accession Nos. ML120600056 and ML12142A053); and
- If the SB remained capable to perform its design safety functions with identified laminar crack propagation.

The activities conducted by the inspectors included:

- Review of the FACE, the supporting vendor report (Performance Improvement International-Root Cause Analysis: Laminar Crack Condition of the Davis-Besse Shield Building; dated June 18, 2014), CRs, and the SB related drawings for Impulse Response testing results,
- Review of the licensee's cause analysis process and approach,
- Review of the inputs and assumptions for the licensee's vendor analysis and modeling applied in support of (or to refute) the potential SB failure modes,
- Interviews of licensee and supporting vendor staff and review of additional information provided, and
- Review of the licensee's basis to reasonably conclude that the SB remained capable of performing its design safety functions.

The inspectors did not review the adequacy of the licensee's crack growth CAs, because the review of related actions was currently or would be conducted through other regulatory processes. In particular:

- Licensee CAs for the crack growth included revision to the SB Aging Management Program (AMP), "Shield Building Monitoring Program (SBMP)" (ADAMS Accession No. ML14189A452). The NRC staff review and evaluation of the SBMP AMP will be documented as part of another regulatory process (i.e., license renewal). The NRC's license renewal review included SBMP acceptance criteria with respect to the extent of crack growth (ADAMS Accession Nos. ML14353A425 and ML15028A540).

- As noted in Section 4OA2.2, of this inspection report, the NRC inspectors concluded that the licensee's acceptance of the laminar cracking in the SB with respect to the design and licensing basis required prior NRC review and approval for the current license and took enforcement action accordingly. The inspectors expected that NRC review and approval, including whether other actions were necessary with respect to the design and licensing basis, would be conducted pursuant to provisions in 10 CFR 50.90.

Documents reviewed are listed in the Attachment to this report.

The inspectors' review of this issue constituted a single follow-up inspection sample for in-depth review as defined in Inspection Procedure 71152-05.

b. Detailed Inspection Activities

b.1 Licensee Full Apparent Cause Evaluation and Vendor Root Cause Analysis Report Evaluation and Conclusions

As a part of the investigation, the licensee researched industry resources for similar symptoms of laminar crack propagation. The licensee concluded that there have been no similar issues with design specifications, coatings, or design interfaces to indicate a generic problem. There have been no similar previously identified events with concrete laminar crack propagation at Davis-Besse or within the FirstEnergy Nuclear Operating Company (FENOC).

The licensee contracted PII to perform a comprehensive technical cause assessment to identify the cause(s) of the unexpected crack propagation. The PII investigation considered the time period from September 2011 to September 2013, and corresponding conditions necessary for crack propagation. As part of its investigation, PII utilized analytical and/or testing methodologies, field observation data, laboratory testing, test results, and computer analytical modeling to validate conclusions. Results from the PII report, "Root Cause Analysis: Laminar Crack Condition of the Davis-Besse Shield Building," were incorporated into the licensee's FACE.

The evaluation considered 17 failure modes as potential candidates to explain the newly observed crack propagation condition. Since there was previous laminar cracking adjacent to the recently identified cracks, failure modes were developed on the basis that the observed cracks were either new cracks, pre-existing laminar cracks that were propagating (or had propagated), or a combination of both. The 17 failure modes were grouped into six major categories: Excess Water (Modes 6, 7, 11, 13, 14, 15, 16, and 17), Thermal Stresses (Modes 2, 10, and 12), Drilled Open Bores (Modes 1, 4, and 9), Materials (Modes 8 and 13), Building Settlement (Mode 3), and Crack Misidentification (Mode 5). Each failure mode was evaluated during the apparent cause investigation.

Based on the evidence for the causes of laminar crack propagation, the licensee concluded:

- Apparent Cause: Ice-Wedging (failure Mode 16). Ice-wedging occurs when water accumulates in a cracked section of concrete and expands by a volume of nine percent upon freezing. The force exerted by the ice-wedge on the adjacent concrete faces causes existing cracks to propagate. Supporting evidence included: tested core sample revealed very-high moisture content, water analysis

revealed water transport within the concrete, and distinct step crack propagation was identified in core sample S5-666.0-9.5. The ice-wedge laboratory tests determined three conditions are required for ice-wedging to occur: pre-existing laminar cracks, water accumulation at the laminar crack location, and freezing temperatures at the laminar crack location.

Laminar crack propagation in steps due to ice-wedging is different than original laminar crack initiation. The licensee RCRs for the original laminar cracking attributed the direct cause of the cracking to the integrated effect of moisture content, wind speed, temperature, and duration from the blizzard of 1978, a one-time event. Those RCRs identified the following conditions as necessary to initiate a new laminar cracking:

- The exposed unsealed concrete surface of the Shield Building allows moisture penetration.
- A significant amount of water is diffused into the concrete (minimum of 93 percent of pore voids filled with water).
- The environmental temperature is well below freezing point of water for a long period of time so that the temperature near the outer mat rebar behind the shoulders (about 3-18 inches deep into the Shield Building) could drop below the freezing point.
- The design of flute-shoulders which caused discontinuity in the structure and the lack of radial reinforcing steel in the shoulder areas to resist radial stresses.
- Tensile strength of the concrete is lower than the radial stresses produced in some areas near the outer rebar mat.

Initiation of new laminar cracking was not a potential failure mode because the amount of water discovered recently in the bores was much smaller than the nearly saturated amount needed to create tensile strain high enough to cause initial damage to the structure. The relatively small amounts of water located in the bores did not provide the level of moisture (minimum of 93 percent pore saturation) needed for the formation of new cracks.

- Contributing Cause: Application of SB exterior coating. The coating effectively prevented water from entering SB but also prevented water inside the SB wall from exiting the SB.
    - When the temperature inside the annulus region is higher than the temperature at the SB exterior surface, the temperature gradient will cause moisture vapor inside the SB wall to migrate towards the exterior wall. If moisture inside the SB wall had condensed into water at the existing (formed during the blizzard of 1978) laminar cracks, the cracks would have likely propagated. However, core samples taken from the SB in 2011 did not exhibit step fracture in laminar crack areas associated with crack propagation. Therefore, moisture likely permeated though the wall into the outside atmosphere and dissipated sufficiently within the SB

wall such that laminar crack propagation did not occur prior to the application of the exterior coating.

  - After the coating was applied, the moisture could no longer permeate through the wall into the outside atmosphere causing the relative moisture content to increase near the exterior surface, and thus providing the opportunity for water to accumulate at the existing laminar crack locations. Temperature variations at the exterior wall resulted in temperature fluctuation at the laminar crack and crack step propagation due to water freeze-thaw cycles.

  - The FACE implied that the moisture will dissipate over time due to absorption and disbursement such that laminar crack propagation due to ice-wedging will no longer occur.

  In summary, the application of the exterior sealant prevented the formation of new laminar cracks as intended, but created conditions that allowed for the propagation of the existing laminar cracking.

- The causes for the SB laminar cracking determined in the 2012 RCRs remained valid. Specifically:

  - The 2012 RCRs attributed the root cause of the SB laminar cracking to the design specification for construction of the SB that did not specify application of an exterior sealant from moisture. Although the subsequent application of the SB exterior coating was determined to be a contributing cause for laminar crack propagation, evidence presented in the evaluation for failure mode 6 (Cumulative Water Damage from Coating the Structure in 2012) concluded that excess water in the SB can cause freeze-thaw damage and microcracks, but not initiate laminar cracks. Therefore, the root cause for original SB laminar cracking had not been invalidated.

  - The 2012 RCRs attributed the direct cause of the SB laminar cracking to the integrated effect of moisture content, wind speed, temperature, and duration from the blizzard of 1978. Prior to coating the SB in 2012, water was discovered in bores. However, no evidence of laminar crack propagation was identified in 2011 SB core samples. Therefore, the direct cause of SB laminar cracking was not invalidated.

The crack growth rate due to ice wedging was evaluated by the licensee's contractor:

- Based on results from ice-wedging laboratory experiments, PII measured crack growth between 0.4 inches and 0.7 inches per freeze-thaw cycle at a 53 degrees Fahrenheit per hour freezing rate. Similar crack growth test results between 0.3 inches and 0.6 inches per freeze-thaw cycle were measured at a 20 degrees Fahrenheit per hour freezing rate. The overall numerical average of ice-wedge propagation was 0.49 inches per freeze-thaw cycle. The licensee extracted a new SB core that was in proximity to identified laminar crack growth. Laboratory examination of core S5.666.0-9.5 measured step fractures approximately 0.60 inches in length that is close to step fracture lengths measured in laboratory experiments.

- The PII report calculated a maximum crack propagation growth rate at bore S5-666-10 of 10.25 inches per year and 9.0 inches per year at bore S7-666-9 as bounding values. As recognized in the report, Impulse Response data can only be used qualitatively as a relative crack indicator with limited accuracy. That is, the actual rate is less due to the fact that the Impulse Response data showed cracks were present beyond the bore hole.

- To determine transient temperatures throughout the SB, PII developed a finite element thermal transient model to understand the SB response to ambient temperature conditions. The thermal analyses incorporated meteorological data collected at the Davis-Besse site from September 2011 to Septermber 2013. The thermal transient model was used to predict the number of freeze-thaw cycles at various SB bore locations and calculate an average crack growth rate. Based on the thermal model:

    - A total of 18 freeze-thaw cycles were predicted at bore S5-666-10 translating into a total crack growth of 10.8 inches over the 2-year period, or 5.4 inches per year. The estimated total growth using impulse response data was 10.25 inches per year.

    - A total of 16 freeze-thaw cycles were predicted at bore S7-666-9 translating into a total crack growth of 9.6 inches over the 2-year period, or 4.8 inches per year. The estimated total growth using impulse response data was 9.0 inches per year.

b.2 Inspection Observations

NRC Inspectors' Conclusions Regarding Full Apparent Cause Evaluation

The inspectors concluded that the licensee's apparent cause evaluation efforts for crack growth were adequate. The licensee's evaluation had been conducted via an established, methodical, and valid process and by qualified personnel. Specifically, the inspectors confirmed that the licensee's evaluation was performed, and documented in accordance with guidance described in licensee procedure NOP-LP-2001, "Corrective Action Program," business practice NOBP-LP-2011, "FENOC Cause Analysis," and reference material NORM-LP-2003, "Analytical Methods Guidebook." The extent of failure modes considered and evaluated by the licensee was comprehensive. The inspectors reviewed the adequacy of each failure mode evaluation with respect to evidence presented that either supported or refuted the failure mode, technical justifications, and conclusions with respect to laminar crack propagation causal factors. Each failure mode was adequately refuted or supported by consideration of evidence: laboratory tests and examinations, state-of-the-art Finite Element Analyses, and other data.

The inspectors concluded that the licensee reached a reasonable conclusion as to cause of laminar crack growth based on the evidence. The inspectors reviewed the results of laboratory ice-wedge testing that established the three necessary conditions for crack propagation to occur and determined that the fracture propagated in steps between 0.3 and 0.7 inches per freeze-thaw cycle; testing that revealed high-moisture content in the core sample; testing that demonstrated water transport within concrete; and computer evaluation of meteorological data that predicted freeze-thaw cycles had occurred at laminar crack propagation locations during the winter of 2011 and 2012, and

the winter of 2012 and 2013. In addition, the inspectors reviewed testing performed on core sample S5-666.0-9.5 that confirmed actual step fracture had occurred consistent with laboratory ice-wedge tests. The inspectors concluded the evidence reasonably supported laminar crack propagation due to ice-wedging.

The inspectors concluded that the occurrence of laminar crack propagation and its associated cause due to ice wedging did not invalidate conclusions related to SB laminar crack causes documented in the licensee's 2012 RCRs. In particular, core samples taken in 2011 indicated the fracture occurred from a single event (the cores did not exhibit evidence of step fracture consistent with crack propagation).

The inspectors used guidance from IMC 0612, Appendix B, to conclude that the licensee's application of the exterior coating was not a performance deficiency. Specifically, the inspectors determined that it was not reasonable for the licensee to foresee ice-wedging at laminar cracks due to the coating. In particular:

- The licensee's application of the SB coating to prevent the initiation of laminar cracking by eliminating future water intrusion from wind driven rain and prevent additional laminar crack initiation for conditions similar to the blizzard of 1978 was a reasonable corrective action;

- Licensee review of plant and industry experience did not identify any plant having similar laminar cracks; the laminar cracking of the SB is unique with respect to reinforced concrete;

- As part of PII's assessment for the ice-wedging failure mode, ice-wedging was a known phenomenon in geological sciences through observations of rock cracking, but not known or studied as related to concrete cracking;

- Although the presence of moisture is inherent in concrete structures, there was no evidence of laminar crack propagation in 2011 SB core samples; and

- The original SB design standards, ACI 307-69 and ACI 318-63, did not require a coating to prevent water intrusion. The licensee applied the coating to the SB in 2012 in accordance with subsequent industry standards and specifications.

Further, the inspectors did not identify a violation of Plant Technical Specifications because the SB remained operable and capable to perform its design safety functions during plant operation as noted below.

The inspectors did not believe that the licensee had provided sufficient evidence to support its contention that the amount of free water in the SB wall would eventually diminish due to absorption and disbursement, and hence crack growth would cease. In particular, the inspectors noted that the FACE did not perform a technical evaluation or provide other justification to quantify the time required for sufficient moisture dissipation. The possibility of continued crack growth is being and will continue to be monitored by the SB long-term monitoring program. This observation on the licensee's cause evaluation did not constitute a performance deficiency or finding because the recommended corrective actions in the FACE focus on monitoring the crack propagation condition to address the causes, and not on mitigating the causes; therefore, the statement could be removed without adversely affecting the conclusions or corrective actions in the apparent cause evaluation.

Shield Building Operability

In 2011, NRC inspectors evaluated and agreed with the licensee's conclusion regarding SB operability, the building could still perform its design safety functions despite the laminar cracking as documented in NRC IR 05000346/2012007 (ADAMS Accession No. ML12128A443). Upon the subsequent identification of crack growth, SB operability was addressed again in NRC IR 05000346/2013004, and IR 05000346/2013009 (ADAMS Accession Nos. ML13308A283 and ML14132A259, respectively). In particular, the inspectors continued to believe that the SB laminar cracking condition remained bounded by the licensee's 2011 operability evaluation and the SB remained capable of performing its design safety functions despite the identified crack growth. SB operability was addressed again in NRC IR 05000346/2013010 (ADAMS Accession No. ML14204A317) with respect to concrete voiding that was not adequately repaired following the SB construction opening restoration in 2011. Damaged rebar embedded in the concrete, discussed in that same IR, was not an operability issue, because it was damaged during the hydro-demolition activities to cut an opening in the SB wall for steam generator replacement and was repaired before the plant restarted from that same outage.

During this inspection, the inspectors reviewed additional evidence that pertained to SB operability considering the potential for laminar crack propagation. Specifically, the licensee's 2011 operability evaluation calculations used very conservative assumptions with respect to the extent of cracking in the SB, and did not credit rebar/concrete bonding in the areas of cracking. The licensee had subsequently performed testing at selected universities to measure the structural capacity of rebar splices within laminar crack areas, and additional Impulse Response testing at accessible SB wall areas to more precisely determine the extent of laminar cracking. Using these data, the licensee completed calculation C-CSS-099.20-063; "Shield Building Design Calculation," Revision 0. The inspectors reviewed this calculation and concluded that it provided additional safety margin to augment the existing determination that the SB continued to be capable of performing its design safety functions despite the identified crack growth due to ice wedging.

c. Findings

No findings were identified.

.2 Shield Building Licensing Basis Review

(Closed): Unresolved Item 05000346/2013009-01; "Methodology and Acceptance Criteria Utilized for Design and Licensing Basis of the Shield Building with Laminar Cracking"

a. Inspection Scope

As discussed in the Background and Overview section of this report, by memorandum dated April 1, 2015, (ADAMS Accession No. ML15082A125), Subject: "Final Response to Task Interface Agreement 2014-11, Design and Licensing Basis Requirements for Davis-Besse Nuclear Power Station Shield Building with Reinforced Concrete Laminar Cracking," NRR staff agreed that the licensee's use of the "ANSYS" Computer Program to evaluate SB laminar cracking was a departure from the ~~a~~ method of evaluation which requires prior NRC approval under 10 CFR 50.59(c)(2)(viii). The inspectors reviewed

the memorandum, discussed its conclusion and rationale with both NRR and licensee staff, used the information provided to resolve URI 05000346/2013009-01 identified in NRC IR 05000346/2013009 (ADAMS Accession No. ML14132A259), and evaluated appropriate enforcement actions. The inspectors also used, in part, Nuclear Energy Institute (NEI) 96-07, "Guidelines for 10 CFR 50.59 Implementation," Revision 1, in reaching conclusions. The NEI document was endorsed by the NRC in Regulatory Guide 1.187, "Guidance for Implementation of 10 CFR 50.59, Changes, Tests, and Experiments," dated November 2000.

b. Findings

Introduction: The inspectors identified a Severity Level IV NCV of 10 CFR 50.59(c)(2), and an associated finding of very-low safety significance (Green) for the licensee's failure to request and obtain a license amendment pursuant to 10 CFR 50.90. Specifically, the licensee's method of evaluation that accepted SB laminar cracking represented a departure from the method of evaluation described in the Final Safety Analysis Report (FSAR) (as updated), and required prior NRC review and approval with respect to the design and licensing basis.

Description: As the licensee's original licensing basis methodology "Analysis of Spherical Shells" from Section III, of the 1968 Edition of the ASME Boiler and Pressure Vessel Code used to confirm that the SB design met applicable design basis code acceptance criteria did not consider laminar cracking in the structure, the licensee instead used computer software "ANSYS" to model the SB and calculate concrete and rebar stress for design basis loading conditions. The licensee used additional Impulse Response testing and confirmatory core boring data to more precisely establish the extent of SB laminar cracking. The licensee also performed testing at selected university laboratories to determine rebar splice design capacity in laminar crack areas. Using these data as input, the licensee performed an evaluation, calculation C-CSS-099.20-063, Revision 0, "Shield Building Design Calculation," to demonstrate the SB with laminar cracking had sufficient structural capacity to perform its design basis functions consistent with acceptance criteria specified in the design basis code, ACI 318-63, and standard ACI 307-69, referenced in the USAR. In 10 CFR 50.59 Evaluation 13-00918, the licensee reviewed calculation C-CSS-099.20-063 with respect to 10 CFR 50.59 requirements using NEI 96-07 as guidance.

Licensee Evaluation 13-00918 concluded that its use of the "ANSYS" Computer Program did not involve a departure from the method of evaluation described in the USAR, because the use of "ANSYS" was considered "approved by the NRC for the intended application." Specifically, the licensee compared its use of "ANSYS" for analytical evaluation of the SB with a similar application of "ANSYS" reviewed by the NRC, and documented in an NRC memorandum dated December 15, 2011, Subject: U.S EPR Design Certification Application – Safety Evaluation with Open Items for Portions of Chapter 3, "Design of Structures, Components, Equipment and Systems" (ADAMS Accession Nos. ML092860252 and ML113081431). The licensee's design calculation concluded that the calculation methodologies were consistent with the original design basis code; ACI Standard 318-63; "Building Code Requirements for Reinforced Concrete"; the SB met all design requirements specified in the USAR; and the SB will perform its USAR design functions. The licensee further concluded that a license amendment was not required prior to implementation of the change.

The inspectors noted that 10 CFR 50.59(c)(2) requires that a licensee obtain a license amendment pursuant to 10 CFR 50.90 prior to implementing a proposed change, if the change meets any of eight criteria specified in that regulation. One of these criteria is specified in 10 CFR 50.59(c)(2)(viii) as "result in a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design basis or in the safety analysis." The inspectors also noted that NEI 96-07, Section 4.3.8, "Does the Activity Result in a Departure from a Method of Evaluation Described in the UFSAR Used in Establishing the Design Bases or in the Safety Analyses?," in providing detailed guidance on evaluating changes against that specific criterion, states "In general, licensees can make changes to elements of a methodology without first obtaining a license amendment if the results are essentially the same as, or more conservative than, previous results. Similarly, licensees can also use different methods without first obtaining a license amendment if those methods have been approved by the NRC for the intended application." Further, Section 4.3.8.2, in discussing changing from one method of evaluation to another, states that "A new method is approved by the NRC for intended application if it is approved for the type of analysis being conducted, and applicable terms, conditions, and limitations for its use are satisfied." Further, licensees are specifically allowed to "apply methods that have been reviewed and approved by the NRC, or that have been otherwise accepted as part of another plant's licensing basis, without prior NRC approval." That section also provides detailed guidance for determining whether "a particular application of a different method is technically appropriate for the intended application, within the bounds of what has been found acceptable to the NRC, and does not require prior NRC approval."

However, the inspectors determined that the licensee had not properly applied provisions in NEI 96-07 that allow for alternate "NRC approved" methodologies in concluding that a change in the facility is not a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design basis or in the safety analysis. Specifically:

- The inspectors agreed that the "ANSYS" software was capable of accurately modeling the laminar cracking as opposed to the original licensing basis methodology. However, the inspectors determined that the licensee did not use an appropriate reference on which to base its conclusion, under provisions of NEI 96-07, that "ANSYS" was considered "approved by the NRC for the intended application." Specifically, the referenced Safety Evaluation Report (SER) was issued pursuant to an interim phase of the U.S. EPR design certification review process, and hence was not considered a final, issued SER.

- In that the licensee's referenced NRC-approved application did not involve modeling of laminar cracking in the structure, the inspectors concluded that the licensee's methodology was not "within the bounds of what has been found acceptable to the NRC." NEI 96-07 specifies that it is incumbent upon the users of a new methodology to ensure they have a thorough understanding of the methodology in terms of its existing application and conditions/limitations on its use and should document in the 10 CFR 50.59 evaluations the basis for determining it is approved for use in the intended application. In particular, the inspectors determined that the SB laminar cracking, given its uniqueness in the nuclear industry, was not sufficiently similar to the referenced NRC-approved application to consider the licensee's methodology as NRC-approved or otherwise applied appropriately.

While the licensee might be able to revise Licensee Evaluation 13-00918, to reference a different valid “NRC-approved application” with respect to structural analysis using “ANSYS”, the inspectors did not believe the licensee would likely be able to identify an existing “NRC-approved application” that included modeling and design analyses of an existing structure with laminar cracking, which is the intended application in this case.

Further, as documented in NUREG-0136, “SER related to operation of Davis-Besse Nuclear Power Station, Unit 1,” dated December 1976, the NRC reviewed and accepted ACI 318-63 code provisions that were used in the Davis-Besse safety analysis as its basis for approval of the SB design. The licensee believed its analysis demonstrated the ACI design standard remained valid and that the SB design remained consistent with the standard despite the laminar cracking. However, since the ACI standard did not anticipate or contain provisions to govern evaluation of laminar cracking, the inspectors concluded that the design standard may no longer be applicable/valid, at least in-part, for the current condition.

The licensee’s design change to accept the laminar cracking in the SB involved changing from the method(s) described in the UFSAR to another method. The licensee changed from the method described in UFSAR Section 3.8.2.2, ASME Code, Section III, 1968, Articles 1-2 and 1-3, and UFSAR Section 3.7.2.1, seismic method of analysis, which the licensee’s 10 CFR 50.59 evaluation states were done using hand calculations. The licensee performed select new SB analyses using another method, “ANSYS”, a three-dimensional finite element model which was necessary to more accurately represent the SB sections with laminar cracking. Title 10 CFR 50.59(a)(1) defines a change, in part, as a modification to the facility that affects an evaluation that demonstrates that an intended design function will be accomplished. The licensee’s acceptance of the SB laminar cracking was a change because it affected the evaluation used to demonstrate the SB had structural capacity to perform its design safety functions to protect the containment building from missiles and loadings resulting from external events (e.g., earthquakes and tornados) and to provide an additional preventative barrier to the release of radiation or contamination in the event of accident conditions. Title 10 CFR 50.59(a)(2) defines, in part, a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design bases or in the safety analyses as changing from a method described in the FSAR to another method unless that method has been approved by the NRC for the intended application. Hence, the change also resulted in a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design bases as defined in 10 CFR 50.59(a)(2) because it involved changing from a method described in the FSAR, specifically ASME Code hand calculations, to another method, “ANSYS”, a three-dimensional finite element model, and the new method of evaluation had not been approved by the NRC for the intended application (modeling laminar cracking in a reinforced concrete structure.)

In summary, the inspectors determined that the conditions for the Davis-Besse SB were satisfied for requiring a license amendment prior to implementation. Specifically, the inspectors identified that the licensee’s acceptance of the SB laminar cracking was a change and the use of the “ANSYS” Computer Program to evaluate SB laminar cracking resulted in a departure from a method of evaluation which required prior NRC approval per 10 CFR 50.59(c)(2).

The inspectors noted that this conclusion does not imply that the SB is unsafe because of the laminar cracking or that the licensee's technical rationale for accepting the laminar cracking was insufficient. In particular, as explained in Section 4OA2.1.b.2 of this inspection report, the inspectors concluded that the SB remains capable of performing its design safety functions. However, this matter is a regulatory concern with respect to adherence to related regulatory processes that preserve the NRC's decision making responsibility and authority and the ability to provide independent review and oversight.

On April 10, 2015, the licensee initiated CR 2015-05014, "NRC Response to Task Interface Agreement 2014-11: Design and Licensing Basis for Shield Building." The licensee's immediate CA determined that SB remained operable and capable to perform its design safety functions. The licensee's planned CAs included revising 10 CFR 50.59 Evaluation 13-00918, and preparation of additional documents for inclusion in a license amendment request.

Analysis: The inspectors determined that the licensee's use of the "ANSYS" Computer Program to evaluate and accept the SB laminar cracking was a departure from a method of evaluation described in the FSAR (as updated) and the associated failure to obtain a license amendment pursuant to 10 CFR 50.59 (c)(2) was a performance deficiency. The inspectors determined the performance deficiency was more than minor because the finding was associated with the Barrier Integrity cornerstone attribute of Design Control, and affected the cornerstone objective to provide reasonable assurance that physical design barriers protect the public from radionuclide releases caused by accidents or events. Specifically, the design safety functions of the SB provide for: environmental protection of the containment vessel, controlled release of the annulus atmosphere during accidents, and shielding from radiation sources within the SB.

The inspectors determined the finding could be evaluated using the SDP in accordance with IMC 0609, "SDP." Using Attachment 0609.04, "Initial Characterization of Findings," Table 2, the inspectors determined that the finding affected the Barrier Integrity cornerstone attribute of Design Control, and affected the cornerstone objective to provide reasonable assurance that physical design barriers protect the public from radionuclide releases caused by accidents or events. As a result, the inspectors evaluated the finding using Appendix A, "The SDP for Findings At-Power," Exhibit 3, "Barrier Integrity Screening Questions." The inspectors answered "No" to both questions in Exhibit 3.B for Reactor Containment. Specifically, the inspectors concluded that the SB remained capable of performing its design safety functions despite the identified laminar cracking. Therefore, the finding screened by the SDP as having very-low safety significance (i.e., Green finding).

Violations of 10 CFR 50.59 are also dispositioned using the traditional enforcement process because they are considered to be violations that potentially impede or impact the regulatory process. This violation is associated with a finding that has been evaluated by the SDP, and communicated with an SDP color reflective of the safety impact of the deficient licensee performance. The SDP, however, does not specifically consider the regulatory process impact. Thus, although related to a common regulatory concern, it is necessary to address the violation and finding using different processes to correctly reflect both the regulatory importance of the violation and the safety significance of the associated finding.

In accordance with Section 6.1.d, of the NRC Enforcement Policy this violation is categorized as Severity Level IV because the resulting changes were evaluated by the SDP as having very-low safety significance (i.e., Green finding).

The inspectors determined that the associated finding had a cross-cutting aspect in the area of Human Performance, Conservative Bias, where individuals use decision making practices that emphasize prudent choices over those that are simply allowable. Specifically, the licensee did not take a conservative approach to decision making for evaluation of SB laminar cracking, particularly when information is incomplete or conditions are unusual. [H.14, Conservative Bias]

Enforcement: Title 10 CFR 50.59(c)(2) states, in part, that "a licensee shall obtain a license amendment pursuant to § 50.90 prior to implementing a proposed change, test, or experiment if the change, test, or experiment would result in in a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design bases or in the safety analyses."

Contrary to the above, on September 10, 2013, the licensee's acceptance of the SB laminar cracking via 10 CFR 50.59 Evaluation 13-00918, "Shield Building Design Calculation," Revision 0, was a change that resulted in a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design basis and safety analyses, and the licensee did not obtain a license amendment pursuant to 10 CFR 50.90. Specifically, the licensee departed from the method described in USAR Sections 3.8.2.2, and 3.7.2.1, by using "ANSYS", a three-dimensional finite element model versus ASME Code hand calculations to demonstrate that the SB had structural capacity to perform its design safety functions despite the laminar cracking, and that method had not been approved by the NRC for the intended application (modeling laminar cracking in a reinforced concrete structure.)

This violation is being treated as an NCV, consistent with Section 2.3.2, of the Enforcement Policy because it was a Severity Level IV violation and was entered into the licensee's Corrective Action Program as CR-2015-05014. The licensee's immediate CA determined that SB remained operable and capable to perform its design safety functions. The licensee's planned CAs included revising 10 CFR 50.59 Evaluation 13-00918, and preparation of additional documents for inclusion in a license amendment request. [NCV 05000346/2014008-01, Departure from Method of Evaluation Required Prior NRC Approval under 10 CFR 50.59 (c)(2)]

4OA6 Management Meetings

.1 Final Exit Meeting Summary

On April 15, 2015, the inspectors presented the inspection results to the Site Vice President, Mr. Raymond Lieb, and other members of the licensee staff by teleconference related to closure of URI 05000346/2013009-01. The licensee acknowledged the issues presented. The inspectors confirmed that none of the potential report input discussed was considered proprietary. Proprietary information given to inspectors as part of inspection activities will be destroyed using an approved method of destruction for sensitive material.

.2 Interim Exit Meeting Summary

On March 27, 2015, the inspectors presented the inspection results to the Site Vice President, Mr. Raymond Lieb, and other members of the licensee staff by teleconference related to laminar crack propagation in the Davis-Besse reinforced concrete shield building. The licensee acknowledged the issues presented. The inspectors confirmed that none of the potential report input discussed was considered proprietary. Proprietary information given to inspectors as part of inspection activities will be destroyed using an approved method of destruction for sensitive material.

ATTACHMENT: SUPPLEMENTAL INFORMATION

SUPPLEMENTAL INFORMATION

KEY POINTS OF CONTACT

Licensee

R. Lieb, Site Vice President
D. Blakely, Supervisor, Site Engineering
B. Boles, Director, Site Operations
K. Browning, Root Cause Evaluator
K. Byrd, Director, Site Engineering
T. Henry, Engineer, Design Engineering
J. Hook, Manager, Design Engineering
T. Lentz, Manager, Fleet Licensing
P. McCloskey, Manager, Regulatory Compliance
J. Sturdavant, Regulatory Compliance
G. Wolf, Supervisor, Regulatory Compliance

U.S. Nuclear Regulatory Commission

D. Kimble, Senior Resident Inspector

LIST OF ITEMS OPENED, CLOSED, AND DISCUSSED

Opened

05000346/2014008-01	NCV	Departure from Method of Evaluation Required Prior NRC Approval Under 10 CFR 50.59 (c)(2) (Section 4OA2.2)

Closed

05000346/2013009-01	URI	Methodology and Acceptance Criteria Utilized for Design and Licensing Basis of the Shield Building with Laminar Cracking (Section 4OA2.2)
05000346/2014008-01	NCV	Departure from Method of Evaluation Required Prior NRC Approval Under 10 CFR 50.59 (c)(2) (Section 4OA2.2)

Discussed

None

LIST OF DOCUMENTS REVIEWED

The following is a list of documents reviewed during the inspection. Inclusion on this list does not imply that the NRC inspectors reviewed the documents in their entirety, but rather, that selected sections of portions of the documents were evaluated as part of the overall inspection effort. Inclusion of a document on this list does not imply NRC acceptance of the document or any part of it, unless this is stated in the body of the inspection report.

Shield Building Laminar Crack Propagation (71152)

- Calculation C-CSS-099.20-063; Shield Building Design Calculation; Revision 0
- Davis-Besse CR-2011-03346; Root Cause Analysis Report: Concrete Crack within Shield Building Temporary Access Opening; Revision 1 dated May 08, 2012 (ADAMS Accession No. ML12142A053)
- Davis-Besse CR-2013-14097; Shield Building Laminar Crack Extends; initiated September 11, 2013
- FENOC Drawing C-111A; Davis-Besse: Shield Building Exterior Developed Elevation; Revision 5
- FENOC Drawing C-111B; Davis-Besse: Shield Building Exterior Developed Elevation; Revision 1
- FENOC Drawing C-111B, Sheet 1; Davis-Besse: Shield Building Continued Data for Core Bore Inspections; Revision 0
- Letter from CTL Group to FENOC (J. Hook); Subject Impulse Response (IR) Retesting, Shield Building Wall at the Davis-Besse Nuclear Plant; dated October 16, 2013
- Letter from Morgan, Lewis & Bockius LLP to NRC ASLB; Re: Notification of Documents Related to the Davis-Besse Shield Building; dated July 8, 2014 (ADAMS Accession No. ML14189A452)
- Letter L-12-205 from FENOC to NRC Region III; Subject: Davis-Besse Nuclear Power Station, Unit No. 1, Submittal of Revision 1 of Shield Building Root Cause Evaluation; dated May 16, 2012 (ADAMS Accession No. ML12142A053
- NRC Letter L-14-354 to FENOC; Subject: Request for Additional Information for the Review of the Davis-Besse Nuclear Power Station License Renewal Application (TAC No. ME4640); dated December 28, 2014 (ADAMS Accession No. ML14353A425)
- Letter L-15-037 from FENOC to NRC; Subject: 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. 54; dated January 28, 2015 (ADAMS Accession No. ML15028A540)
- EN-DP-01511; Inspection Procedure: Design Guidelines for Maintenance Rule Evaluation of Structures; Revision 03
- NOP-LP-2001; Nuclear Operating Procedure: Corrective Action Program; Revision 35
- NOBP-LP-2011; Nuclear Operating Business Practice: FENOC Cause Analysis; Revision 16
- NORM-LP-2003; Nuclear Operating Reference Material: Analytical Methods Guidebook; Revision 05
- Performance Improvement International Report; Root Cause Analysis: Laminar Crack Condition of the Davis-Besse Shield Building; dated June 18, 2014

Closure of Unresolved Item 05000346/2013009-01 (71152)

- 10 CFR 50.59 Screen No. 13-00918; Shield Building Design Calculation; Revision 0 dated September 10, 2013

- 10 CFR 50.59 Evaluation No. 13-00918; Shield Building Design Calculation; Revision 0; dated September 10, 2013
- Calculation C-CSS-099.20-063; Shield Building Design Calculation; Revision 0
- NRC Memorandum, NRR (M. Gavrilas) to Region III (M. Shuaibi); Subject: Final Response to Task Interface Agreement 2014-11, Design and Licensing Basis Requirements for Davis-Besse Nuclear Power Station Shield Building with Reinforced Concrete Laminar Cracking; dated April 1, 2015 (ADAMS Accession No. ML15082A125)

Corrective Action Program Documents (CRs) Issued During Inspection

- CR 2015-05014; NRC Response to Task Interface Agreement 2014-11: Design and Licensing Basis for Shield Building; initiated April 10, 2015

LIST OF ACRONYMS USED

ADAMS	Agencywide Document Access and Management System
ACI	American Concrete Institute
AMP	Aging Management Program
ASME	American Society of Mechanical Engineers
CA	Corrective Action
CFR	*Code of Federal Regulations*
CR	Condition Report
CV	Containment Vessel
FACE	Full Apparent Cause Evaluation
FENOC	FirstEnergy Nuclear Operating Company
FSAR	Final Safety Analysis Report
IMC	Inspection Manual Chapter
IR	Inspection Report
NCV	Non-Cited Violation
NEI	Nuclear Energy Institute
NRC	U.S. Nuclear Regulatory Commission
NRR	NRC Office of Nuclear Reactor Regulation
PARS	Publicly Available Records System
PII	Performance Improvement International, LLC
RCR	Root Cause Analysis Report
SB	Shield Building
SBMP	Shield Building Monitoring Program
SDP	Significance Determination Process
URI	Unresolved Item
UFSAR	Updated Final Safety Analysis Report
USAR	Updated Safety Analysis Report
§	Section

If you contest the subject or severity of the NCV, you should provide a response within 30 days of the date of this inspection report, with the basis for your denial, to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555-0001, with copies to the Regional Administrator, Region III; the Director, Office of Enforcement, U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001; and the NRC Resident Inspector at Davis-Besse Nuclear Power Station. In addition, if you disagree with the cross-cutting aspect assigned to any finding in this report, you should provide a response within 30 days of the date of this inspection report, with the basis for your disagreement, to the Regional Administrator, Region III, and the NRC Resident Inspector at Davis-Besse Nuclear Power Station.

In accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) 2.390, "Public Inspections, Exemptions, Requests for Withholding," of the NRC's "Rules of Practice," a copy of this letter, its enclosure, and your response (if any) will be available electronically for public inspection in the NRC's Public Document Room or from the Publicly Available Records (PARS) component of the NRC's Agencywide Documents Access and Management System (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

David E. Hills, Chief
Engineering Branch 1
Division of Reactor Safety

Docket No. 50–346
License No. NPF–3

Enclosure:
Inspection Report 05000346/2014008;
w/Attachment: Supplemental Information

cc w/encl: Distribution via LISTSERV®

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