April 1, 2015

MEMORANDUM TO: Mohammed A. Shuaibi, Deputy Director
Division of Reactor Safety
Region III

FROM: Mirela Gavrilas, Deputy Director ***/RA/***
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

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

By memorandum dated December 2, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14336A671), the U.S. Nuclear Regulatory Commission (NRC) Region III Office requested technical assistance from the Office of Nuclear Reactor Regulation (NRR) to determine regulatory requirements to support NRC review of the licensee's design and licensing basis evaluation for the reinforced concrete shield building with identified laminar cracking at the Davis-Besse Nuclear Power Station (DBNPS). This concern was identified during an inspection and was documented as an Unresolved Item (URI) 05000346/2013009-01, Methodology and Acceptance Criteria Utilized for Design and Licensing Basis of the Shield Building with Laminar Cracking (Reference 8) dated May 12, 2014. Specifically, Region III requested NRR address the following question related to shield building laminar cracking identified in proximity to the outer rebar mat at the Davis-Besse Nuclear Power Station:

1. Is there sufficient information/basis for NRC staff to conclude that acceptance of the shield building laminar cracking with respect to design and licensing basis results in a departure from a method of evaluation described in the final safety analysis report (as updated) within the context of 10 CFR 50.59(c)(2)(viii), or meets any of the other 10 CFR 50.59(c)(2) criteria, and hence requires prior NRC approval? Why or why not?

In conducting its review of the licensee's current design and licensing basis within the context of 10 CFR 50.59(c)(2), NRR staff have determined that there is sufficient information/basis for NRC staff to conclude that acceptance of the shield building laminar cracking with respect to design and licensing basis results is a departure from a method of evaluation. The basis for this position can be found in Section 3.0 of the enclosure.

Enclosure:
Task Interface Agreement

CONTACT: Holly D. Cruz, NRR/DPR
(301) 415-1053

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TASK INTERFACE AGREEMENT 2014-11

DESIGN AND LICENSING BASIS REQUIREMENTS FOR DAVIS-BESSE NUCLEAR POWER STATION SHIELD BUILDING WITH REINFORCED CONCRETE LAMINAR CRACKING

1.0 INTRODUCTION

By memorandum dated December 2, 2014 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14336A671), the U.S. Nuclear Regulatory Commission (NRC) Region III Office requested technical assistance from the Office of Nuclear Reactor Regulation (NRR) to determine regulatory requirements to support NRC review of the licensee's design and licensing basis evaluation for the reinforced concrete shield building with identified laminar cracking at the Davis-Besse Nuclear Power Station (DBNPS). This concern was identified during an inspection and was documented as an Unresolved Item (URI) 05000346/2013009-01, Methodology and Acceptance Criteria Utilized for Design and Licensing Basis of the Shield Building with Laminar Cracking (Reference 8) dated May 12, 2014. Specifically, the inspectors questioned if there was sufficient information/basis for NRC staff to conclude that acceptance of the shield building laminar cracking with respect to design and licensing basis results is a departure from a method of evaluation described in the Final Safety Analysis Report (FSAR) (as updated) within the context of 10 CFR 50.59(c)(2)(viii), or meets any of the other 10 CFR 50.59(c)(2) criteria, and hence requires prior NRC approval.

2.0 BACKGROUND

The NRC Region III inspectors, with assistance from NRR technical specialists, reviewed licensee actions following the identification of laminar cracking at the shield building (SB) outer cylindrical wall steel reinforcement (rebar). Inspection activities were documented in Inspection Report 05000346/2012007 (Reference 1). Of particular note:

- On December 2, 2011, the NRC technical review team concluded that the licensee provided reasonable assurance that the SB had sufficient structural capacity to perform its design functions if subjected to a postulated design basis earthquake, tornado wind, or tornado generated missiles. In the operability determination evaluation, the licensee conservatively did not credit rebar strength for lap splices enveloped by laminar cracks because it could not quantify rebar lap splice to concrete bond strength in the presence of a laminar crack.

- The inspectors reviewed the SB current design and licensing bases to determine if the operability evaluations were in conformance with the current design and licensing bases. As part of the review of SB laminar cracking, the inspectors reviewed the original SB design calculations, the associated industry codes and standards identified in the SB design and licensing bases, and industry guidance for evaluating existing concrete structures. 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 address 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 industry codes or standards that addressed concrete reinforcement effectiveness in proximity to laminar cracking. Therefore, the inspectors, after consultation with the NRC technical review team, questioned if laminar cracking in proximity to the outer face reinforcement was a condition not in conformance with the current design and licensing basis.

As documented in NRC Inspection Report 05000346/2012009 (Reference 9), the licensee subsequently concluded in its Shield Building Root Cause Report dated February 27, 2012, (Reference 2), that the SB, with the laminar cracking in its walls, was operable but non-conforming to the current design and licensing bases with regard to the design stress analysis methodology, and the tornado allowable stress values. Specifically:

- 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 Boiler and Pressure Vessel Code (ASME 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 Updated Safety Analysis Report (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.

As documented in NRC Inspection Report 05000346/2013009 (Reference 8) and to address this concern, the licensee used a combination of testing and calculations to re-establish the design and licensing basis of the SB with laminar cracking. 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 (Reference 3). Using these data as input, the licensee performed an evaluation, calculation C-CSS-099.20 063, Revision 0, "Shield Building Design Calculation," (Reference 4) 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, ACI 318-63, and standard ACI 307-69, referenced in the USAR. Calculation C-CSS-099.20-063 utilized computer software ANSYS to model the shield building and calculate concrete and rebar stress for design basis loading conditions.

The licensee's 10 CFR 50.59 Evaluation 13-00918 concluded that the licensee's use of the ANSYS computer program does not involve a departure from the method of evaluation described in the USAR, because the planned 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 further concluded that a license amendment was not required prior to implementation of the change.

In 10 CFR 50.59, the licensee is allowed to make changes in the facility as described in its USAR without obtaining a license amendment pursuant to 10 CFR 50.90 only if: (1) a change to the technical specification incorporated in the license is not required, and (2) the change does not meet 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." Nuclear Energy Institute (NEI) 96-07, "Guidelines for 10 CFR 50.59 Implementation," Revision 1, is endorsed by the NRC and provides detailed guidance on evaluating changes against that specific criterion. Section 4.3.8 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."

Licensee's Position:

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.

For the rebar splice test results, the inspectors questioned (SBLB-0005) if ACI approval was needed for Davis-Besse to state "the test is consistent with those described in the references and comply with ACI 318." The licensee response, in-part included:

- ACI approval is not required.

    (a). The process of ACI 318 code development and approval (intended for commercial building structures) is different from that of ACI 349 or ASME, as ACI is not specifically intended to cover nuclear quality protocol…ACI 318

Committee does not get involved in any formal approval process for such unique situations.

(b). Section 104 of ACI 318-63 alludes to the fact that analysis or testing may be carried out to cover special systems/situations by competent engineers, and when accepted by the Building Official (in this case Authority Having Jurisdiction) the analysis or testing should be deemed as equivalent to the provisions of the Code (ACI 318-63). As indicated in Item C, a detailed analysis and test program was carried out with the help of lead industry experts in the same manner which forms the basis of the Code provisions.

(c). The discussion provided in the first two paragraphs on Page 2 of 10 CFR 50.59 Screen provides the reasoning behind the acceptability and compliance of the test programs. The first paragraph states "In order to understand and evaluate the bond transfer capacity of reinforcement with a crack in the plane of the rebar, a detailed test plan was developed to determine the bond transfer mechanism and capacity of reinforcement with a simulated crack in the plane of the reinforcement. The confirmatory tests were carried out using the same procedure, means, and methods as are typically used for testing of reinforcement and bond transfer capacity that forms the basis of the ACI Code provisions. The tests were performed at well renowned laboratory facilities under the guidance of well-known subject matter experts." Additionally, the second paragraph states "The commentary to ACI 318-63 (Reference 9) includes References 6-8 as supporting documentation for the description of the basis for the ACI 318-63 Code provisions related to bond and tension splices. References 6-8 describe the test methods and procedures used to establish the bond transfer capacity of reinforcement. Based on a thorough review of References 6-8, it is concluded that the methods and procedures used to perform the confirmatory tests are consistent with those described in the references and comply with the ACI 318-63 Code provisions." These excerpts clarify that the tests were performed under the guidance of industry-renowned subject matter experts in the area of rebar bond and development, experts who have been involved in the ACI code development process in these areas for many years. Additionally, the setup and procedures described in supporting references for the rebar bond and development requirements of ACI 318-63 are consistent with the test procedures and methods used for the Purdue University and University of Kansas test programs.

(d). Dr. Darwin from University of Kansas and Dr. Sozen from Purdue University both have independently confirmed the acceptability and conservatism of the new design basis calculation using the test results. They have also confirmed that, based on the test results, the Shield Building is in compliance with ACI 318-63 Code. As noted earlier, they are industry-renowned subject matter experts in the areas of rebar bond and development and have been involved in the ACI code development activities for many years.

In summary, the licensee has concluded that the shield building with identified laminar cracks conforms to the design and licensing basis requirements.

Rebar allowable strength for lap splices within laminar cracks was determined by testing consistent with testing methods referenced in the design code, ACI 318-63.

(a). These tests were performed under the guidance of industry renowned subject matter experts in the area of rebar bond and development, experts who have been involved in the ACI code development process in these areas for many years.

(b). The setup and test procedures described in the supporting references are consistent with the test procedures and methods used for the Purdue University and University of Kansas test programs.

- New calculation C-CSS-099.20-063 is consistent and covered by ACI 318-63. The calculation with laminar cracking was developed using the design methodology stipulated in ACI 318-63 and no special systems of design were used. There are no modifications to the shield building structure proposed as a result of the new analysis.

Following issue of NRC Inspection Report 05000346/2013009, the licensee initiated CR-2014-09425, "NRC URI: Methodology and Acceptance Criteria Utilized for Design and Licensing Basis of Shield Building Laminar Cracking," dated May 23, 2014, as a result of the inspection report unresolved item.

3.0 EVALUATION

As documented in NUREG-0136, "Safety Evaluation Report 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. Excerpts from NUREG-0136 related to ACI 318-63 include:

- The major code used in the design of concrete seismic Category I structures is ACI 318-63.

- The design and analysis procedures that were used for these seismic Category I structures are the same as those approved on previously licensed applications and are in accordance with procedures delineated in ACI 318-63…and are acceptable.

- The various seismic Category I structures are designed and proportioned to remain within the limits established by the staff for the various load combinations. These limits are acceptable based on the ACI 318-63, "Building Code Requirements for Reinforced Concrete" modified as appropriate for load combinations that are considered extreme.

- The criteria used in the analysis, design, and construction of all seismic Category I structures to account for anticipated loadings and postulated conditions that may be imposed upon each structure during its service lifetime are in conformance with established criteria, codes, standards, and specifications acceptable to the regulatory staff.

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 believed the standard was no longer applicable/valid for the current condition.

In reviewing Evaluation 13-00918, NRC inspectors compared the previously approved U.S. EPR Design Certification Application referenced by the licensee against the licensee's analysis for the shield building laminar cracking. The inspectors agreed that the ANSYS software was capable of accurately modeling the laminar cracking as opposed to the original licensing basis methodology. However, given that the licensee's referenced NRC-approved application did not involve modeling of laminar cracking in the structure, the inspectors believed that the licensee's entire 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 evaluation the basis for determining it is approved for use in the intended application. In particular, the inspectors believed that the application to the shield building 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 with respect to the following:

- The licensee used an inappropriate 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 SER was issued pursuant to an interim phase of the U.S. EPR design certification review process, and hence was not considered a final SER. Therefore, the referenced SER cannot be construed as evidence that the method was approved by the NRC.

- The use of Impulse Response testing and confirmatory core borings to validate the design condition (extent of laminar cracking) that was modeled in the Davis-Besse analysis was not part of the referenced NRC-approved application. The ability of this testing to accurately and conservatively determine the design condition has not been previously evaluated by the NRC with respect to permanent design/licensing. In addition, the licensee Evaluation 13-00918 did not consider use of Impulse Response testing and confirmatory core borings to validate the design condition. Hence, the licensee's methodology does not satisfy the terms and conditions for use of the referenced NRC-approved application.

- The use of laboratory testing and analyses of the test data to establish/validate rebar splice capacity within laminar crack areas assumed in the Davis-Besse analysis was not part of the referenced NRC-approved application. The validity of this testing methodology and conclusions has not been previously evaluated by the NRC. Hence, the licensee's methodology does not satisfy the terms and conditions for use of the referenced NRC-approved application.

- As noted in NRC Inspection Report 05000346/2013004 (Reference 10), pursuant to testing conducted for the licensee's Shield Building Monitoring Program, the licensee in

August/September 2013 identified new crack indications, some of which was evidence of crack growth. As a result, the licensee performed additional testing and analysis with the resulting licensee evaluation completed in mid-2014. Analysis of a structure with ongoing crack growth was not part of the referenced NRC-approved application. Hence, additional licensing basis questions may need to be pursued that were not considered in the referenced NRC-approved application. For example, it was not clear to the inspectors whether specific monitoring requirements or acceptance criteria with respect to extent of cracking needed to be approved by the NRC for the current operating license.

The licensee's Evaluation 13-00918 pursuant to 10 CFR 50.59 did not specifically address the above concerns despite the guidance in NEI 96-07 that the licensee should document, in the evaluation, the basis for determining its methodology is approved for use for the intended application. Hence, the inspectors concluded that acceptance of the shield building laminar cracking with respect to design and licensing basis results in a departure from a method of evaluation described in the FSAR (as updated) within the context of 10 CFR 50.59(c)(2)(viii), and hence requires prior NRC approval.

4.0 REGULATORY REQUIREMENTS

Criterion 10 CFR 50.59(c)(2)(viii) states that licensees 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 a departure from a method of evaluation described in the FSAR (as updated) used in establishing the design bases or in the safety analyses. Definition in 10 CFR 50.59(a)(2) states *Departure from a method of evaluation described in the FSAR (as updated) used in establishing the design bases or in the safety analyses* means (i) changing any of the elements of the method described in the FSAR (as updated) unless the results of the analysis are conservative or essentially the same; or (ii) changing from a method described in the FSAR to another method unless that method has been approved by NRC for the intended application.

NRC Regulatory Guide 1.187, which endorses NEI 96-07, Revision 1, "Guidelines for 10 CFR 50.59 Implementation," Section 3.10 defines *Methods of Evaluation* as the calculational framework used for evaluating behavior or response of the facility or an SSC. Section 3.10 further states that the methods of evaluation described in the UFSAR subject to criterion 10 CFR 50.59(c)(2)(viii) include methods of evaluation used in supporting UFSAR analyses that demonstrate intended design functions will be accomplished under design basis conditions that the plant is required to withstand, including natural phenomena, environmental conditions, dynamic effects, station blackout and anticipated transient without scram.

NEI 96-07, Rev. 1, Section 4.3.8.2 discusses 10 CFR 50.59(a)(2)(ii) 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."

Further, 10 CFR 50.59(d)(1) states, "The licensee shall maintain records of changes in the facility, of changes in procedures, and of tests and experiments made pursuant to paragraph (c) of this section. These records must include a written evaluation which provides the bases for the determination that the change, test or experiment does not require a license amendment pursuant to paragraph (c)(2) of this section."

Simply put, the above requirements and guidance for 10 CFR 50.59, criterion viii, specify that a license amendment is required prior to implementation **IF All of the Following are TRUE**:

(1) The activity revises or replaces any method of evaluation (defined as calculational framework) that is described in the FSAR that is used to predict plant performance;

a. Staff Assessment is: **TRUE.** Since, at Davis Besse, the design change to accept as-is 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 USAR Section 3.8.2.2, ASME Code, Section III, 1968, Articles 1-2 and 1-3, and USAR 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.

(2) The method of evaluation either is used to demonstrate that plant performance will meet a design basis or is used as part of a safety analysis in the UFSAR;

a. Staff Assessment is: **TRUE**. Since, at Davis Besse, ANSYS was the method of evaluation used to demonstrate the SB with laminar cracking had structural capacity to perform its design functions to protect the containment building from missiles and loadings resulting from external events (e.g., earthquakes, hurricanes, tornados, aircraft hazards, and explosion pressure waves) and to provide an additional preventative barrier to the release of radiation or contamination in the event of accident conditions.

(3) **EITHER**

(i) Implementation of the activity changes any of the elements of the currently specified method of evaluation described in the UFSAR (i.e., revises an existing UFSAR method of evaluation) AND, the results of the revised method are neither conservative nor essentially the same;

a. Not Applicable: ANSYS is a new method and thus is not a change to any elements of the currently specified method of evaluation;

OR

(ii) Implementation of the activity changes a method of evaluation described in the UFSAR to another method (i.e., replaces or adopts a new method of evaluation)

AND, the new method of evaluation had not been previously "approved by the NRC for the intended application;"

a. Staff Assessment is: **TRUE.** Since, at Davis Besse, ANSYS is a change from a method of evaluation described in the UFSAR to another method that the licensee's 10 CFR 50.59 written evaluation did not demonstrate was "approved by the NRC for the intended application." The licensee's 10 CFR 50.59 written evaluation stated that ANSYS had been approved by the NRC in an NRC memorandum to ACRS 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." However, NRC Region III inspectors correctly point out that this memorandum was not issued to a licensee/applicant and was not an NRC approval. Rather, the memorandum was from the NRC staff to ACRS which stated, "The SE with Open Items is being provided to support a meeting of the subcommittee of the ACRS scheduled to be held on January 17 and 18, 2012." Additionally, as pointed out by the inspectors, the use of ANSYS in the referenced US EPR Design Certification application that is currently under NRC review does not involve design analyses of an existing shield building with laminar cracking, which is the intended application in this case.

The NRC staff determined that based on the requirements and guidance for 10 CFR 50.59, criterion viii, all of the above conditions for the Davis Besse SB were **TRUE** for requiring a license amendment prior to implementation.

5.0 CONCLUSION

The NRC finds the licensee's use of the ANSYS computer program to evaluate SB laminar cracking does result in a departure from a method of evaluation which requires prior NRC approval under 10 CFR 50.59(c)(2), criterion viii.

6.0 POTENTIAL OUTCOME PATHS

- Immediate Implications: Upon receiving the conclusions of this TIA, the licensee would be expected to enter the issue into their corrective action program.

- Generic Implications: Resolution of this issue does not warrant the issuance of a generic communication, as the issue is plant-specific.

- Backfit Considerations: Resolution of this issue does not constitute a backfit because it does not involve a new or different position from a previously applicable staff position.

7.0 REFERENCES

1. Davis-Besse Nuclear Power Station Reactor Vessel Head Replacement and Shield Building Cracking Inspection Report 05000346/2012007(DRS); dated May 7, 2012; ADAMS Accession No. ML12128A443.

2. Davis-Besse Nuclear Power Station, Root Cause Analysis Report: Concrete Crack within Shield Building Temporary Access Opening; dated February 27, 2012; ADAMS Accession No. ML120600056.
3. Bechtel Power Corporation 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; dated July 30, 2012.
4. FirstEnergy Calculation C-CSS-099.20-063; Shield Building Design Calculation; Revision 0.
5. Memo Re: Position Paper – Assessment of ACI 318-71 As Design basis for Category I Concrete Structures Affected by Alkali-Silica Reaction at Seabrook Station; dated June 10, 2013; ADAMS Accession No. ML13128A521.
6. ACI 318-63; Building Code Requirements for Reinforced Concrete.
7. ACI 349-06; Code Requirements for Nuclear Safety-Related Concrete Structures and Comments.
8. Davis-Besse Nuclear Power Station – Design and Licensing Basis of the Shield Building with Laminar Cracking Inspection Report 05000346/2013009; dated May 12, 2014; ADAMS Accession No. ML14132A259.
9. Davis-Besse Nuclear Power Station – Inspection to Evaluate the Root Cause Evaluation and Corrective Actions for Cracking in the Reinforced Concrete Shield Building of the Containment System Inspection Report 05000346/2012009(DRS); dated June 21, 2012; ADAMS Accession No. ML12173A023.
10. Davis-Besse Nuclear Power Station – NRC Integrated Inspection Report 05000346/2013004; dated November 1, 2013; ADAMS Accession No. ML13308A283

Principal Contributor: Brian K. Harris

Date: April 1, 2015