UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

November 12, 2015

The Honorable Stephen G. Burns
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: REPORT ON THE SAFETY ASPECTS OF THE LICENSE RENEWAL APPLICATION FOR DAVIS-BESSE NUCLEAR POWER STATION

Dear Chairman Burns:

During the 629th meeting of the Advisory Committee on Reactor Safeguards (ACRS), November 4 -7, 2015, we completed our review of the license renewal application (LRA) for Davis-Besse Nuclear Power Station. Our review included the NRC staff final safety evaluation report (SER) issued in September 2013 and SER Supplement 1 issued in August 2015. Our Subcommittee on Plant License Renewal reviewed this matter during meetings on September 19, 2012 and September 23, 2015. During these reviews, we had the benefit of discussions with representatives of the NRC staff and First Energy Nuclear Operating Company (FENOC, or the applicant). We also had the benefit of the documents referenced. This report fulfills the requirement of 10 CFR 54.25 that the ACRS review and report on all license renewal applications.

CONCLUSION AND RECOMMENDATIONS

1. The established programs and commitments by FENOC to manage age-related degradation, including LRA Amendment 60 submitted in October 2015, provide reasonable assurance that the Davis-Besse Nuclear Power Station can be operated in accordance with the current licensing bases for the period of extended operation without undue risk to the health and safety of the public.

2. An amendment to the current license to include the methodologies used to analyze the effects of concrete cracking in the shield building should be completed prior to commencement of the period of extended operation.

3. FENOC's application for renewal of the operating license for the Davis-Besse Nuclear Power Station should be approved.

BACKGROUND

Davis-Besse is located approximately 20 miles east of Toledo, Ohio. The NRC issued the construction permit on March 24, 1971 and the operating license on April 22, 1977. The unit is a pressurized water reactor design with a dry ambient containment which consists of a free-standing steel pressure vessel surrounded by a reinforced concrete shield building, with a 4.5-foot annulus between the pressure vessel and shield building. Babcock and Wilcox Corporation supplied the nuclear steam supply system, and Bechtel Corporation designed and constructed the balance of plant. The licensed power output of the unit is 2,817 megawatts thermal, with a gross electrical output of approximately 908 megawatts electric.

By letter dated August 27, 2010, FENOC submitted its LRA to the NRC for renewal of the Davis-Besse operating license for an additional 20 years, commencing with expiration of its current license on April 22, 2017.

In 2011, during construction of an access opening to replace the reactor pressure vessel head, FENOC identified laminar subsurface cracking of concrete along the outer mat of reinforcing steel in particular regions of the shield building parallel to the cylindrical wall. The extent of the cracking was carefully mapped, and characteristics such as crack width and crack depth from the outer wall surface were determined. In 2013 and 2015, follow-up inspections determined that limited growth of cracks mapped in 2011 had occurred in some areas. FENOC conducted analyses and testing to demonstrate that the shield building continues to perform its design function in accordance with the current licensing basis, with ample margin. The design function is to provide biological shielding, environmental protection for the steel containment pressure vessel, and for a controlled release of the annulus atmosphere under accident conditions.

In 2014, the Davis-Besse original steam generators were replaced, and they are currently in their first cycle of operation with no identified tube degradation mechanisms.

DISCUSSION

NRC Staff Review of LRA

In the final SER dated September 2013, and the Supplemental SER dated August 2015, the staff documented its review of the LRA and other information submitted by the applicant and obtained through staff audits and inspections at the plant site. The staff reviewed the completeness of the identification of structures, systems, and components (SSCs) that are within the scope of license renewal, the integrated plant assessment process, the identification of plausible aging mechanisms associated with passive, long-lived components, the adequacy of the Aging Management Programs (AMPs), and the identification and assessment of Time-Limited Aging Analyses (TLAAs) requiring review.

FENOC's license renewal application demonstrates consistency with the Generic Aging Lessons Learned (GALL) Report (NUREG-1801, Revision 1) and documents and justifies deviations from the specified approaches in that report. FENOC will implement 44 AMPs for license renewal at Davis-Besse. The AMPs consist of 31 existing programs and 13 new programs.

For the 13 new AMPs, five of the programs are consistent with the GALL Report, two are consistent with enhancements, and six are plant-specific.

Of the 31 existing programs, nine are consistent with the GALL Report, eleven are consistent with enhancements, two are consistent with exceptions, and five are consistent with both enhancements and exceptions. Four of the existing programs are plant-specific.

The LRA includes seven exceptions to the GALL Report. The exceptions are in the areas of the Bolting Integrity Program, the Closed Cooling Water Chemistry Program, the Fire Protection Program, the Fuel Oil Chemistry Program, the Open-Cycle Cooling Water Program, the Water Control Structures Inspection Program, and the Reactor Head Closure Studs Program. We reviewed all of these exceptions and consider them to be acceptable.

The staff conducted license renewal audits and performed license renewal inspections at Davis-Besse. The audits verified the appropriateness of the scoping and screening methodology for AMPs, the appropriateness of the aging management review, and the acceptability of the TLAAs. The inspections verified that the license renewal requirements will be implemented appropriately. The inspections, and the reports of those inspections, as documented in the SER and SER Supplement 1, were thorough.

Based on the audits, the inspections, and the staff reviews related to this license renewal application, the staff concluded that the proposed activities will manage the effects of aging of the SSCs and that the intended functions of these SSCs will be maintained consistent with the current licensing basis for the period of extended operation as required by 10 CFR 54.21(a)(3). We concur with that conclusion, subject to the addition of the inspection enhancements included in LRA Amendment 60.

Shield Building AMP - Background

Among the AMPs which are specific to Davis-Besse is the Shield Building AMP. It is also unique to Davis-Besse due to the need for the AMP to address previously identified laminar subsurface cracking of the concrete. This cracking was discovered by FENOC in 2011, and a thorough inspection was then conducted of the entire cylindrical structure. A root cause analysis attributed the laminar cracks to the extreme environmental conditions of a blizzard in 1978. The cracks were initiated when moisture within the concrete froze and expanded in regions of high concrete stress. At the time, the building did not have an exterior coating to prevent moisture intrusion. In order to prevent additional moisture intrusion, a coating was subsequently applied to the shield building exterior. Also, FENOC established a shield building crack monitoring program.

In 2013 and 2015, monitoring program inspections determined that limited additional crack growth has occurred in some areas. A root cause analysis attributed this growth to moisture repeatedly freezing and expanding at the tips of the laminar cracks which had been initiated during the 1978 blizzard. This moisture had entered the concrete prior to application of the coating in 2012.

In accordance with American Concrete Institute Report ACI 349.3R, "Evaluation of Existing Nuclear Safety-Related Concrete Structures," the propagation of the laminar cracks is a condition which is not passive and requires ongoing monitoring. The Shield Building AMP includes an extensive monitoring program for this purpose.

Cracking is of concern because the concrete must transfer rebar tension loads across the overlap splices which exist between lengths of horizontal rebar. This transfer occurs through shear loading between the concrete and the rebar at numerous splices throughout the cylindrical structure. In the presence of cracking, the effectiveness of the transfer of shear loads depends on the crack width not exceeding an acceptable size which has been established by testing. The applicant sponsored test programs at Purdue University and the University of Kansas that showed for crack geometries comparable to those in the shield building, the horizontal splices in the cracked regions are able to carry at least 90% of their original design capacity. Thus, measuring the width of the cracks, as well as mapping their extent, is an important element of the Shield Building AMP.

Shield Building AMP – Inspection Program

In LRA Amendment 60, dated October 6, 2015, FENOC provided a description of, and committed to, an updated shield building monitoring program, including enhancements to the primary method of monitoring the areal extent of laminar cracking. This method is a non-destructive technique known as impulse response mapping. It involves monitoring and recording the reflection of a manual impulse to the building exterior wall to determine if a crack exists within the concrete at the location of the impulse.

The monitoring program also includes visual inspections of the cracks themselves using core bores perpendicular to the building exterior wall. The core bores allow both inspection for the presence of cracking at the bore location and measurement of the width of the crack at that location. A narrow crack width is critical to the ability of the concrete to transfer in shear the rebar tension loads at a splice location where cracking exists. The AMP includes a limit on the width so that it does not exceed the size which has been demonstrated by testing to reliably transfer loads across a rebar splice.

Shield Building AMP – Margins Evaluation

In order to evaluate the effectiveness of the Shield Building AMP during the period of extended operation, we examined the applicant's calculations which demonstrate that the intended functions will be maintained under design basis loadings. Initially, FENOC performed structural integrity calculations pursuant to 10 CFR 50.59, which were reviewed by the NRC staff as part of the operability assessment of the shield building. It was subsequently determined that the analysis methodologies should also be submitted for approval as an amendment to the current license. In order for us to assess the margins for the purpose of evaluating the Shield Building AMP, the calculations were provided to the NRC docket for review in advance of submittal of the amendment to the current license.

In a letter dated October 6, 2015, FENOC provided additional information which clarified the margins with respect to the cracked area. Results of the calculations indicate that the cracked area can increase by a factor of at least 2.6 and the shield building will continue to perform its intended functions under design basis loads. Based on our review of this additional information, we conclude that adequate margin exists such that the AMP, with the enhanced inspections as provided in LRA Amendment 60, will assure against loss of intended functions due to crack area propagation.

With regard to crack width, the Shield Building AMP requires that any width greater than 0.013 inch would require further evaluation and testing in order to continue to credit load transfer at affected splices. We conclude that adequate margin exists for crack width such that the AMP, with the enhanced inspections as provided in LRA Amendment 60, will assure against loss of intended functions due to increases in crack width.

As noted, our review and the resulting conclusions concerning Shield Building AMP adequacy were based on the results of the analysis methodologies used by FENOC. To support these conclusions, an amendment to the current license to include the methodologies used to analyze the effects of concrete cracking in the shield building should be completed prior to commencement of the period of extended operation.

Our review also included consideration of two other potential cracking effects. The first potential effect we considered was whether existing cracks would propagate sufficiently to challenge the intended building functions during a design-basis seismic event. In those areas where the thickness of concrete between the crack layer and the exterior surface provides sufficient mass to produce large inertial forces under seismic cyclic loading, closely spaced rebar perpendicular to the exterior surface ties the concrete to the inner rebar mat of the building. Accordingly, in these areas, inertial forces due to seismic cyclic loading are transferred into the inner rebar mat, and crack propagation due to cyclic loading will not occur. In other areas, where the layer of concrete outside a laminar crack is thinner, inertial forces under seismic cyclic loading of the much smaller mass are not expected to result in significant crack propagation during the limited duration of the seismic event.

The second potential effect was that the laminar cracks could permit separation of pieces of concrete under design loading conditions. Sufficiently heavy sections of falling concrete could impact and damage adjacent safety-related SSCs. However, as noted above, the thicker concrete areas are tied by rebar to the building interior rebar mat and are not subject to this failure, even if cracked. The thinner concrete areas are not similarly tied to the inner rebar mat, but the mass of potential pieces which might become separated from the building due to cracking during a seismic event is estimated to be well below the SSC design requirements for protection against tornado missiles. Therefore, cracking in the thinner areas does not represent a threat to SSCs.

Containment Vessel

In its foundation area, the steel containment vessel is subject to wetting on its exterior due to the intrusion of groundwater past a protective membrane. It has also been exposed to water accumulation on its interior surface due to leakage from the refueling canal. That source of leakage was subsequently repaired. The applicant has performed inspections to verify that corrosion has not reduced the thickness of the vessel wall to less than the minimum required. These inspections will be repeated during the period of extended operation prior to the end of 2025. Also, there is an ongoing program providing for visual inspections and sampling of any water accumulation in the annular area at the base of the containment vessel. These measures, which are included in License Renewal Commitments 35 and 36, provide adequate assurance that corrosion will not threaten the containment function.

SUMMARY

There are no issues related to the matters described in 10 CFR 54.29(a)(1) and (a)(2) that preclude renewal of the Davis-Besse operating license. The established programs and commitments by FENOC provide reasonable assurance that Davis-Besse can be operated in accordance with its current licensing basis for the period of extended operation without undue risk to the health and safety of the public. The FENOC application for renewal of the operating license for Davis-Besse should be approved.

Sincerely,

/RA/

John W. Stetkar
Chairman

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20. FirstEnergy Nuclear Operating Company, FENOC Report L-15-328, “Davis-Besse, Unit 1 – Additional Information for the Advisory Committee on Reactor Safeguards Review of the License Renewal Application,” October 19, 2015 (ML15299A143).

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