NEXTera ENERGY
DUANE ARNOLD

February 4, 2015

NG-15-0021

Ms. Cynthia Pederson
NRC Region III Administrator
U.S. NRC Region III
2443 Warrenville Road
Suite 210
Lisle, Illinois 60532-4352

Duane Arnold Energy Center
Docket: 50-331
Renewed Op. License No: DPR-49

Subject: NRC Special Inspection of the Duane Arnold Energy Center Torus Coating Delamination

Purpose and Introduction

The purpose of this letter is to provide a summary of NextEra Energy Duane Arnold, LLC's (NextEra) basis for the conclusion of past operability with torus coating delamination at the Duane Arnold Energy Center (DAEC). Further, NextEra is seeking the Nuclear Regulatory Commission's (NRC) specific points of disagreement and references regarding the Past Operability Review (POR). We appreciate the dialogue with NRC staff and seek to fully understand the staff's position on NextEra's operability review. As always, NextEra is interested in providing the NRC staff with all the information needed to complete the inspection.

On October 9, 2014 during the DAEC refueling outage, the coating applied to interior surfaces of the torus during the previous refueling outage in 2012 was observed to have delaminated in some areas.

On October 21, 2014, an NRC Special Inspection Team (SIT) initiated reviews of the condition to assess, among other things, the past operability impact of the coating delamination.

On December 9, 2014, NextEra personnel provided Region III inspection staff a copy of the completed POR of the Emergency Core Cooling Systems (ECCS) with the presence of degraded coatings in the torus during Cycle 24 operation. The site analysis concluded that there is sufficient margin inherent in the design of those safety systems to provide reasonable assurance that the ECCS and its subcomponents would have performed the specified safety functions. That evaluation followed NRC guidance in Inspection Manual Chapter (IMC) 0326, "Operability Determinations and Functionality Assessments for Conditions Adverse to Quality or Safety," and utilized methodologies that have been approved for DAEC as well as other publicly available industry guidance.

Over the ensuing weeks, Region III inspection staff and technical staff from the NRC Office of Nuclear Reactor Regulation (NRR) conducted a very thorough review of the POR including detailed technical questions and discussions. In support of the NRC staff activities, NextEra has provided detailed responses and copies of supporting analyses.

On January 23, 2015, NextEra engineering and licensing staff conducted a teleconference with Region III inspection staff and NRR technical staff, during which NextEra presented its overall evaluation results. In addition, NextEra summarized the basis for its conclusion of past operability, including the basis for the considerable conservative assumptions in the supporting analyses.

The purpose of this letter is to provide clarity with respect to NextEra's conclusion that the ECCS systems would have performed their specified safety functions throughout the full range of anticipated operating conditions consistent with the POR and supporting analyses.

Following is a summary of the condition and the points presented during the teleconference that provide reasonable assurance of past operability.

Event Background and Actions

On October 9, 2014, during the DAEC refuel outage, an initial walkdown on the catwalk in the torus interior above the suppression pool was performed. During this walkdown, an area of coating delamination was identified at the suppression pool water line in bays 1, 12 and 15. Condition Report (CR) 01997546 was issued.

On October 16, 2014, further areas of coating delamination were discovered, affecting bays 2, 3, 5, 6, 7, 9, and 10 as documented in CR 01999648.

As a result of these findings, extensive efforts were implemented to remove loose coating and understand the cause:

- Areas of unqualified coating were removed by manually scraping the torus interior.
- A causal analysis determined that the coating that had come off was the second layer, which had been applied to areas determined not to have met the target dry film thickness during the original coating application.
- Subsequent to initial scraping and industry-standard adhesion testing, high pressure power washing (5000 psi direct water spray) of the torus interior was conducted in two passes to remove all second layer coating that could be removed, including significant areas of coating that had passed adhesion testing prior to the pressure washing.

On November 4, 2014, NextEra completed its Prompt Operability Determination (POD) 01997546-01, which concluded that the affected ECCS systems and Reactor Core Isolation Cooling (RCIC) were operable based on the torus shell delaminated coating debris removal and inspections completed under Work Order (WO) 40278293.

On December 8, 2014, NextEra completed its review of the impact of the delaminated coatings on past operability of the ECCS, as documented in the POR. The conclusion is that the ECCS subsystems would have performed their specified safety functions in accordance with the Technical Specifications (TS). It is recognized that there was some potential for degradation below the full design capabilities; however considerable conservative assumptions were used in the supporting analyses.

NRC Reviews

On October 21, 2014, the NRC SIT entrance meeting was held with station management. Over the next two and a half months, NextEra staff worked to provide the NRC SIT with all requested information, discussions and walkdowns. The NRC SIT was able to review the causal analysis, observe torus clean-up efforts and review operability evaluations. During the inspection period, the NRC SIT reached the conclusion that the root cause determination was correct and that the PODs allowing plant mode changes (including start-up) were correct. The NRC SIT also reviewed the site's POR.

On January 8, 2015, NRC conducted an exit brief for the SIT, during which a performance deficiency was identified for the failure to have adequate controls in place for installing the torus interior coating during the 2012 refueling outage. That deficiency is consistent with NextEra's root cause evaluation. At the exit brief, the significance was yet to be determined, pending completion of NRC review of the site's POR.

NextEra personnel have provided the staff with technical information in the form of detailed analyses, engineering evaluations, source documents and original licensee design basis information which support the conclusions drawn in the POR. Additionally, NextEra engaged industry experts to conduct an independent review of the analyses that support the conclusions of the POR. These independent experts have been involved with the NRC and industry through the Boiling Water Reactor Owners' Group (BWROG) ECCS Suction Strainers working group for many years.

On January 23, 2015, NextEra and its expert consultants participated in a teleconference with Region III and NRR personnel to provide further clarity on the nature of the loose coating, the licensee evaluation of past operability of the ECCS and the significant conservative assumptions in the supporting analyses.

Past Operability Review

The POR was completed in accordance with NextEra's procedure for Operability and Functionality, which is based on the guidance in NRC IMC 0326. The ECCS operability was reviewed against the Technical Specification specified safety function criteria. Further, the systems were evaluated against the functionality descriptions contained in the DAEC Updated Final Safety Analysis Report (UFSAR).

The design basis for the suction strainers was established in 1996, with resolution of NRC Bulletin 96-03, "Potential Plugging of Emergency Core Cooling Suction Strainers by Debris in Boiling-Water Reactors," and that same analysis technique was employed by GE-Hitachi to assess the potential impact of the loose coatings during design basis Loss of Coolant Accidents (LOCA). When the original analysis technique did not provide sufficient insights to assess functionality, more recent publicly available literature was used to support the engineering evaluations. Subsequent computational fluid dynamics (CFD) analysis of the flow of suppression pool water in the torus, performed by Structural Integrity Associates, has confirmed the initial engineering evaluations.

Many conservative assumptions were incorporated into the POR to assure the result of the evaluations and analyses would bound any scenario. A summary of those assumptions follows:

- The design basis scenario assumes the debris from the drywell is transported to the torus immediately and 100% of the unqualified coating is immediately transported to the suppression pool;
- All unqualified coating is assumed to be removed instantaneously at the start of a Design Basis Accident (DBA)(i.e., t = 0), which is conservative because coatings not directly in the zone of influence would be less likely to be removed until later in the event resulting in less impact on run out

conditions and the probability that some of the coating would not transport to the strainers;

- The bounding analysis included qualified coating that was also removed by high pressure power washing (5000 psi direct spray), which is conservative because it roughly tripled the amount of coating evaluated;
- Additional particulate (sludge and zinc) was included in the bounding analysis, which is conservative because it was roughly three times the actual amount found in the torus;
- The worst case functionality event assumed continuous flow of steam from the Safety/Relief Valves (SRV). This was conservative because the six SRVs would not exhaust continuously. In reality, only the two Low-Low-Set SRVs would be intermittently exhausting. Any coating chips churned up into suspension would begin to settle back to the floor of the torus where water flow was shown to be much lower;
- ECCS margins have been established without taking credit for established procedural controls which direct operators to manage flow rates if runout conditions challenge pump net positive suction head (NPSH). Control room alarms are present to provide indication;
- Containment design pressure calculations reserve an additional 2.7 psia available that is not required to demonstrate operability, further supporting the conclusion of ECCS reliability to perform its safety function.

Results and Bases

The results of the POR evaluations and analyses, including the conservative assumptions summarized above, demonstrated that the ECCS flow rates specified in TS would still be maintained, thereby satisfying the specified safety functions. Further, these systems were also reviewed against the full range of operations described in the UFSAR and the conclusion is that there is adequate margin to the pump NPSH requirements for functionality. The following factors led NextEra to that conclusion:

For the Specified Safety Functions

- NPSH calculations for TS operability conditions at bounding coating debris loads demonstrate margin:
    - TS 3.5.1.4 ECCS Core Spray requires a flow of 2718 gpm per train. The analysis considered the pump drawing suction from its strainer at peak pool temperatures and 3100 gpm, which resulted in 1.96 psia (4.71 feet) of margin. This represents Case B in Table A.

- TS 3.5.1.4 ECCS LPCI mode of RHR requires a total flow of 12,960 gpm or a maximum of 8640 gpm per train. The analysis considered two pumps per train operating through the single RHR strainer at 9600 gpm, which resulted in 2.7 psia (6.38 feet) of margin at 10 minutes into the event. This corresponds to the time assumed in the design basis in which no operator actions are credited. This represents Case C in Table A.

- TS 3.6.2.3 Suppression Pool Cooling mode of RHR requires 4800 gpm per train. The analysis considered one of the two RHR pumps drawing suction from its strainer at peak suppression pool temperatures, which resulted in 4.14 psia (9.96 feet) of margin. This represents Case A in Table A.

- TS 3.6.2.4 Suppression Pool Spray mode of RHR requires the same flow as that required for Suppression Pool Cooling, which resulted 4.14 psia (9.96 feet) of margin.

For Pump Runout Conditions

During the January 23, 2015 teleconference, NextEra summarized the considerable conservative assumptions in the supporting analyses of pump runout. Based on the conversation, NextEra determined the margins in the runout conditions by aligning the containment pressure calculations with specific strainer debris loading calculations. The results are shared below.

NPSH calculations for pump runout conditions described in the strainer design for LOCA conditions were assessed, assuming automatic initiation and no operator action to reduce flow. These cases are very conservative because they assume operators would take no action for the full 10 minutes as the design specifies. These cases also conservatively assume the containment pressure was minimized to establish bounding conditions for the design.

- Containment pressure analysis was performed for NPSH with operation of all six ECCS pumps. In this case, the debris is distributed to all four strainers.

  - Core Spray flow of one pump at 4500 gpm with all four strainers operating results in margin of 1.08 psia (2.55 feet). This represents Case D in Table A.

  - RHR flow of two pumps at 13,000 gpm with all four strainers operating results in margin of 1.23 psia (2.91 feet). This represents Case E in Table A.

- Containment pressure analysis was performed for NPSH with operation of three ECCS pumps. In this case, the debris is distributed to two strainers.

    - Core Spray flow of one pump at 4500 gpm with only two strainers in operation results in margin of 5.17 psia (12.2 feet). This represents Case F in Table A.

    - RHR flow of two pumps at 13,000 gpm with only two strainers in operation results in margin of 3.7 psia (8.75 feet). This represents Case G in Table A.

In addition, Operators would act to throttle flow in accordance with existing Annunciator Response Procedures and training. Recognition of these reduced margins under design conditions resulted in the conclusion that the ECCS pumps were operable but degraded below full design capability. The compensatory measures that already exist in procedures would result in reducing flows to TS values, thereby establishing additional margin to NPSH.

It is important to note that NextEra did not take credit in the POR for the additional 2.7 psi margin for containment overpressure that is approved for the Duane Arnold accident analysis. That additional margin would clearly have further bolstered the determination of Operability and functionality of ECCS.

Table A below summarizes the results from the above evaluated cases and clearly shows the conservative assumptions inherent in the analyses. Each of these cases used the maximum coating loading previously described.

Table A

Case #	System	Flow Rate gpm	Flow Rate required by TS	Pool Temp	Headloss ft	Pressure Required psia	Pressure available psia	NPSH Margin psia (ft)	With additional 2.7 psia License Margin psia (ft)
A	RHR	4800	4800	209.2	4.92	17.86	22	4.14 (9.96)	6.86 (16.48)
B	CS	3100	2718	209.2	4.42	20.04	22	1.96 (4.71)	4.66 (11.2)
C	RHR	9600	8640	164.3	~9.44	13.7	16.4	2.7 (6.38)	5.4 (12.77)
D	CS	4500	2718	164.3	~2.8	15.32	16.4	1.08 (2.55)	3.8 (8.99)
E	RHR	13000	8640	164.3	~12.9	15.17	16.4	1.23 (2.91)	3.93 (9.29)
F	CS	4500	2718	164.3	~3.28	15.53	20.7	5.17 (12.2)	7.87 (18.6)
G	RHR	13000	8640	164.3	~17.3	17.0	20.7	3.7 (8.75)	6.4 (15.1)

Coating Failure – Chips vs. Particulate

The NRC has expressed concern that the failure mode of the delaminated epoxy coating could result in complete disintegration and significant particulate matter. The NextEra evaluation is based on the DAEC design basis, which contains documentation previously reviewed by the NRC stating that epoxy coatings, in general, will fail as chips and not particles. While there is considerable ongoing discussion of the entire debris generation and transport models used by the BWR industry to address the concerns stated in NRC Bulletin 96-03, to date there has not been any definitive research that refutes that methodology. Since this question is the subject of ongoing unresolved industry-wide debate, the current design basis debris generation assumptions should be used as the best available input to the evaluation of the torus coating delamination.

The "NRC Staff Review Guidance Regarding Generic Letter 2004-02 Closure in the Area of Coatings Evaluation" was issued in March 2008 (ML080230462). Note that GL 2004-02 was not addressed to DAEC and post-dates the plant's license basis for ECCS Suction Strainers, however, the NRC review guidance is instructive for the purpose of understanding the NRC position on debris characteristics. This guidance was developed for the NRR staff reviews of responses from PWR licensees to assess information submitted in a supplemental response to GL 2004-02. That document also describes acceptable technical assumptions based on research conducted by the NRC and the industry to address technical uncertainties in areas such as coating debris characteristics, unqualified coating performance, and assessment of qualified coatings. Section 4 of that document describes what debris characteristics were assumed, i.e., chips, particulate, size distribution, and provides the bases for the assumptions.

That guidance document also describes industry testing conducted to determine actual debris characteristics for coatings subjected to DBA conditions. Testing was conducted for Comanche Peak by Keeler & Long (Keeler & Long Report No. 06-0413) which subjected failed phenoline 305 chips, with a CZ-11 inorganic zinc primer attached to the backside, to a simulated DBA test in accordance with ASTM 3911. The result of this testing was that all of the epoxy failed as chips and the inorganic zinc failed in particulate form, which is consistent with the NextEra experience and assumptions.

The manufacturer of the epoxy coating used at DAEC, Carboline Company, compared the material characteristics of the phenoline 305 tested at Comanche Peak by Keeler & Long and the DAEC Carboguard 6250N epoxy torus coating material. The conclusion from the vendor was that Carboguard 6250N is a novolac epoxy that is 100% solids and applied in a thicker film than lower solid epoxy coatings like Carboguard 890N or Phenoline 305. The 6250N is also glass flake reinforced, which adds to the structural strength of the coating, The thicker film, with glass flake reinforcement, makes it very difficult for the coating to break into small paint chips and virtually impossible to generate particulates. If the Carboguard 6250N would blister or lose adhesion, the resultant debris would

be paint chips and not particulate matter. Based on the referenced NRC guidance, previously approved industry testing, and material similarities between tested material and the Carboguard 6250N, NextEra concluded that the DAEC torus coating epoxy would fail as chips and not as particles.

Conclusion

The conclusion of the NextEra Past Operability Review is that the ECCS pumps that rely on water from the torus would satisfy their specified safety functions and that all functional criteria are met. The analysis, as summarized herein, conforms to the current license basis and was supplemented with current state of the industry knowledge for debris generation and transport. As described, significant conservative assumptions were included in the calculations to account for any uncertainties. In point of fact, the ample margin clearly demonstrates that there is negligible probability that the delaminated coatings would have contributed to any failures of ECCS.

NextEra believes that the inspection staff has been provided with the necessary technical information for a regulatory judgment on the past operability review. If there are specific points of disagreement that remain unaddressed, NextEra is committed to providing that information for the inspection staff.

Accordingly, NextEra requests that the staff provide a response detailing any questions, concerns and technical references for any remaining NRC staff points of disagreement.

I appreciate your prompt attention to this important matter.

If you have any questions regarding this matter, please contact me at (319) 851-7568.

T. A. Vehec
Vice President, Duane Arnold Energy Center
NextEra Energy Duane Arnold, LLC

cc: Project Manager, DAEC, USNRC
Senior Resident Inspector, DAEC, USNRC