September 9, 2015

MEMORANDUM TO: Robert J. Pascarelli, Chief
Plant Licensing Branch II-1
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

FROM: Tim Lupold, Chief ***/RA/***
Mechanical and Civil Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

SUBJECT: NORTH ANNA POWER STATION, UNITS 1 AND 2: REVIEW OF COMMITMENT ACTIONS IN CONFIRMATORY ACTION LETTER REGARDING EARTHQUAKE IN 2011 (TAC NOS. MF1807 AND MF1808)

By letter dated May 13, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13135A637), Virginia Electric and Power Company (Dominion, the licensee) submitted a response to address actions in the Confirmatory Action Letter (CAL) No. NRR-2011-002 (ADAMS Accession No. ML11311A201) that the U.S. Nuclear Regulatory Commission (NRC) issued on November 11, 2011, for North Anna Power Station, Units 1 and 2 (North Anna). The NRC issued the CAL to address plant safety issues related to the August 23, 2011, earthquake, which resulted in ground motion exceeding the Operating Basis Earthquake and Safe Shutdown/Design Basis Earthquake at North Anna.

The Mechanical and Civil Engineering Branch (EMCB), Division of Engineering, reviewed the licensee's response to Commitments 1, 2, 4, 5, 6, 9, and 10 in the CAL. The EMCB staff finds that the licensee's response to these Commitments is acceptable and concludes that the licensee has satisfactorily completed the action associated with Commitment 1, 2, 4, 5, 6, 9, and 10.

Docket Nos.: 50-338 and 50-339

Enclosure:
Review of Response to CAL

CONTACT: Yong Li , NRR/DE/EMCB
Chakrapani Basavaraju, NRR/DE/EMCB
Kamal Manoly, NRR/DE

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DATE	08/17/2015	08/17/2015	09/09/2015	08/17/2015

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REVIEW OF COMMITMENT ACTION COMPLETION
CONFIRMATORY ACTION LETTER
REGARDING EARTHQUAKE IN 2011
VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION, UNITS 1 AND 2
DOCKET NUMBERS: 50-338 AND 50-339

1.0 INTRODUCTION

By letter dated May 13, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13135A637), Virginia Electric and Power Company (Dominion, the licensee) submitted a response to address actions in the Confirmatory Action Letter (CAL) No. NRR-2011-002 (ADAMS Accession No. ML11311A201) that the U.S. Nuclear Regulatory Commission (NRC) issued on November 11, 2011 for North Anna Power Station, Units 1 and 2 (North Anna). The NRC issued the CAL to address plant safety issues related to the August 23, 2011, earthquake, which resulted in ground motion exceeding the Operating Basis Earthquake and Safe Shutdown/Design Basis Earthquake at North Anna.

The Mechanical and Civil Engineering Branch (EMCB), Division of Engineering, reviewed the licensee's response to Commitments 1, 2, 4, 5, 6, 9, and 10 in the CAL as follows:

2.0 TECHNICAL EVALUATION

Commitment 1:

The licensee will perform long-term evaluations of plant structures, systems and components [SSCs] in accordance with RG [Regulatory Guide] 1.167/EPRI [Electric Power Research Institute] NP-6695, Section 6.3. Any anomalies identified during the evaluations will be entered into the corrective action system and evaluated for extent of condition.

By letter dated May 13, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13135A637), the licensee submitted a compilation of completed long-term actions. A summary of the results of the evaluation for SSC is given below:

The long-term evaluations, performed in accordance with RG 1.167/EPRI NP-6695, consisted of the following steps:

- Calculation of seismic loads, i.e., structural loads and In-Structure Response Spectra (ISRS) derived from the recorded time-histories of the August 23, 2011, M5.8 earthquake

- Comparison of seismic loads of the August 23, 2011, event with design basis seismic loads

- Seismic re-evaluation of representative structures, ASME Class 1 piping systems and equipment where the calculated loads may have exceeded the design basis loads

The anomalies identified during the evaluations were entered into the corrective action system and components were inspected and evaluated for extent of condition. No issues were found in these inspections and it was concluded that the August 23, 2011, earthquake did not cause any damage to plant SSCs or their anchorages.

These long-term evaluations corroborate the results of extensive plant inspections and functional tests that were performed in support of the plant restart effort where no physical or functional damage was observed in safety-related SSCs. The NRC staff reviewed summary of results submitted by the licensee in its letter dated May 13, 2013 (ADAMS Accession No. ML13135A637) that was also documented in the UFSAR. On the basis of the review, the staff concluded that the licensee provided sufficient information to determine that the exceptions identified during the evaluations were entered into the corrective action system, and this meets the NRC requirements. Therefore, the NRC concludes that Dominion has satisfactorily completed this commitment.

Commitment 2:

The licensee will develop a plan to characterize the seismic source and any special ground motion effects due to the relative locations of the fault and the site and will update the NRC accordingly.

The licensee developed a plan to characterize the seismic source and any special ground motion effects due to the relative locations of the fault and site. The earthquake catalog contained within the Central and Eastern US Seismic Source Characterization (CEUS-SSC) model and the database was updated to include the last three years of seismicity data (through mid-December 2011). This update includes the magnitude 5. 8 earthquake in Louisa County, Virginia, and was issued on March 8, 2012.

The licensee obtained data from the United Stated Geological Survey (USGS) and the Virginia Seismologic Observatory at Virginia Tech on the main shock and aftershocks resulting from the earthquake. The aftershocks define a planar feature in the subsurface that appears to be a previously unknown fault.

The licensee states that, although readily observable geological deformation evidence was not found during the field reconnaissance, seismic geophysical data obtained from the numerous aftershocks revealed that the August 23, 2011, event likely originated along a previously unmapped fault estimated to be approximately 6.2 miles in length with a N 280 to 300 E strike and 45 to 51 SE dip angle.

By letter dated March 12, 2012 (ADAMS Accession No. ML12053A340), the NRC issued a request for information pursuant to Title 10 of the *Code of Federal Regulations* Part 50, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The licensee's commitment has been addressed by its response to 50.54(f) letter request in reevaluating seismic hazard for operating nuclear power plants. This seismic reevaluation process includes seismic source characterization and special ground effects, as mentioned in the commitment because the reevaluation is based on current NRC's standards and criteria. The licensee submitted the reevaluation report on September 12, 2013 (ADAMS Accession No. ML13256A070). After a thorough review, assisted by confirmative analyses, the NRC staff did not identify any issues

with the licensee's final ground motion response spectrum or GMRS. Therefore, based on the above, the NRC staff concludes that Dominion has satisfactorily completed this commitment.

Commitment 4:

The licensee will implement a design change to replace the existing seismic equipment and Main Control Room indication with upgraded and enhanced seismic monitoring instrumentation equipment, which includes installation of a permanent, free field seismic monitor. Permanent, seismically qualified backup power to a new Seismic Monitoring Panel will also be installed including a backup battery power supply. The seismic instrumentation will be installed and maintained in accordance with RG 1.12, Rev 2, *Nuclear Power Plant Instrumentation for Earthquakes*. The project will also install seismic recording instrumentation at the station Independent Spent Fuel Storage Installation (ISFSI) pad.

New seismic instruments and associated controls/indication were installed in the Unit 1 containment and main control room during the spring 2012 refueling outage. The remainder of the instruments (auxiliary building, ISFSI and free field) were installed in November 2012. The licensee installed the free field seismic monitor and connected the seismic monitoring panel at MCR with seismic qualified battery backups. The licensee also installed seismic instrumentation for the ISFSI pad. Accordingly, its seismic instrumentation for the operating reactors following RG 1.12, Revision 2 has been documented in UFSAR 3.7.4.

On December 31, 2012, the NRC completed an inspection at North Anna Power Station Units 1 and 2. (ADAMS Accession No. ML13135A637 dated January 31, 2013). The inspectors reviewed the completed permanent plant modification design change and conducted walkdowns of the installations, discussed the desired improvements with system engineers, and reviewed the 10 CFR 50.59 Safety Review/Regulatory Screening, technical drawings, test plans and the modification package to assess the TS implication of each design change. No findings were identified during this inspection. Therefore, the NRC concludes that Dominion has satisfactorily completed this commitment.

Commitment 5:

The licensee will perform a re-evaluation of the plant equipment identified in the IPEEE [Individual Plant Examination of External Events] review with HCLPF [high confidence of low probability of failure] capacity <0.3g, which will include an assessment of potential improvements.

By letter dated May 13, 2013, the licensee submitted the details of re-evaluation performance of the plant equipment review with the HCLPF calculations for each of the components with a HCLPF < 0.3g. There was significant conservatism in the previous calculations; therefore, more realistic analyses were performed. Four groups of SSCs, representing 14 items of equipment (including the Emergency Condensate Storage Tanks, the 4160V Emergency Busses, the Reactor Trip Breaker cabinets, and the Component Cooling Pumps) are now shown to have a HCLPF capacity greater than 0.3g for the Review Level Earthquake (RLE). For other components, where immediate improvements to the HCLPF analyses could not be made, potential conservatisms in those analyses were noted, as well as any potential physical modifications that might improve seismic capacity. In addition, the licensee plans to review the

need for potential improvements to these components in the near future as part of a seismic probabilistic risk assessment (PRA) using site-specific seismic hazard curves to address the NRC Fukushima Near-Term Task Force Recommendation 2.1.

By letter dated December 17, 2014 (ADAMS Accession No. ML14357A059), the licensee provided its Expedited Seismic Evaluation Process (ESEP) report in a response 50.54(f) letter, for the North Anna Power Station, Units 1 and 2. The NRC staff assessed the licensee's implementation of the ESEP guidance through the completion of a reviewer checklist. Based on the NRC staff review of the ESEP report, the NRC staff concluded that the licensee's implementation of the interim evaluation meets the intent of the guidance. The licensee's ESEP assessment provides additional assurance which supports continued plant safety while the longer-term seismic evaluation is completed to support regulatory decision making. NRC issued staff review of Interim evaluation associated with reevaluated seismic Hazard implementing near-term task force Recommendation 2.1(ADAMS Accession No. ML15182A392) on July 7, 2015. In addition, the NRC staff reviewed summary of reevaluated HCLPF calculations results submitted by the licensee in their letter dated May 13, 2013. Based on these the staff concluded that the licensee provided sufficient information to determine the CAL closure. Therefore, the staff concludes that the licensee has satisfactorily completed this commitment.

Commitment 6:

The licensee will develop a plan with the NSSS [Nuclear Steam Supply System] vendor consisting of additional evaluations or inspections, as warranted, to assure long term reliability of the reactor internals.

The licensee stated that additional inspections and evaluations of the reactor vessel internals (RVI) beyond those already required by existing programs is not warranted for assuring the long-term reliability of the reactor internals. This determination was based on licensee's evaluations and inspections of the RVI that were performed following the August 23, 2011, earthquake. RVI inspections performed during the spring 2012 Unit 1 refueling outage did not identify any seismically induced issues and determined that the RVI remains capable of reliably performing their safety functions.

The licensee completed inspections of SSCs in accordance with EPRI NP-6695 indicate an EPRI Damage Intensity of 0. Despite the lack of evidence of any physical or functional damage to safety-related plant SSCs, performed comprehensive and methodical visual inspections of plant SSCs and expanded inspections and tests in accordance with an EPRI Damage Intensity 1 versus the observed Intensity 0. For RVI, EPRI NP-6695 recommends no specific inspections unless the Damage Intensity is 3 or above. The North Anna RVI were evaluated for loads generated during a seismic event (either OBE or DBE), using results of existing design analyses. The results were evaluated for several key RVI interface load points in the vessel. The calculated seismic-only loads were compared with allowable load limits which correspond to allowed stress limits for Upset conditions (Normal + OBE Loads) for which no deformation is allowed. This provides a more stringent criterion than is typically applied to the DBE loads when assessed in normal design calculations (UFSAR 3.9.3.1.1). With the exception of the lower radial keys, by inspection all calculated RVI interface seismic loads had considerable margin to the load limits associated with the Upset condition, which would accommodate significant increases in seismic-only loading and still be within the limit for Upset conditions. The lower

radial keys had limited margin, and were reanalyzed using calculated loads from a reactor vessel seismic analysis of the August 23, 2011 event. Results of this supplemental analysis demonstrated that the lower radial keys had margin to the Upset, allowable (no yield) stress limit.

Application of this conservative, no yield, stress criterion provides additional assurance that RVI dimensions and geometry are maintained. These evaluations support the conclusion that the earthquake resulted in no significant physical or functional damage to the RVI, and that the RVI remain capable of performing their design bases functions. Therefore, additional inspections and evaluations of the RVI beyond those already required by existing programs is not warranted for assuring the long-term reliability of the reactor internals. The NRC staff concludes that the Dominion has satisfactorily completed this commitment.

Commitment 9:

The licensee will re-evaluate the Time-Limiting Aging Analyses (TLAAs) that include seismic inputs to either: 1) quantitatively demonstrate that the TLAAs are still bounding, or 2) re-analyze the TLAAs, based on the August 23, 2011 earthquake.

By letter dated May 13, 2013, the licensee quantitatively demonstrated that the TLAAs are still bounding, after the effects of the August 23, 2011, earthquake was considered. The only possible influence of an earthquake on a TLAA can be component fatigue in an extreme situation, where cyclic seismic induced stresses are a significant contributor to the component's usage factor. Therefore, attention was focused on seismic induced component fatigue. The ASME Class 1 components were reviewed by Westinghouse in October 2000 for TLAAs and the review is documented in a License Renewal Technical Report LR-1010/LR-2010. Fatigue-related TLAAs for the components were reviewed to identify significance of the contribution of seismic loading to determine the effects, if any, of the August 23, 2011, earthquake. The results of the review showed that the August 23, 2011, earthquake had insignificant effect on component fatigue.

The NRC staff reviewed summary of results submitted by the licensee in their letter dated May 13, 2013 (ADAMS Accession No. ML13135A637). The NRC staff also reviewed the additional clarifications provided by the licensee (ADAMS Accession No. ML15231A585 dated August 18, 2015) regarding the locations where the ratio of moments between the August 23, 2011 event and the OBE was greater than unity. The licensee performed an in-depth review as summarized below to determine their acceptability.

(a) At some locations such as 6 inch hot leg branch line where the ratio of the resulting moments was 1.22, but the previous Cumulative Usage Factor (CUF) in fatigue calculation was only 0.03. The increase was considered acceptable because of a large margin in CUF to accommodate the small increase in the seismic stress.
(b) At some locations such as the inlet nozzle of reactor coolant pump where the OBE moment used in Westinghouse calculation was 20180 in-kip, compared to 7606 in-kip from the Mineral event of August 23, 2011. Thus, Westinghouse generic OBE loads used in the previous analyses provided a significant margin.
(c) At some locations, the CUF was primarily governed by thermal transients at the gross discontinuity and not by the seismic loading. Therefore, marginal increases in seismic

moment were considered acceptable. An example is the Low Head Safety Injection branch line where the ratio of the moments was 1.23. The CUF was only 0.07, which was primarily due to thermal transients

The NRC has evaluated all the submitted information. The staff confirms that the licensee has demonstrated adequately to address the impact of 2011 Mineral earthquake on fatigue of class 1 components and piping in TLAAs. In majority of the cases, the forces and moments from 2011 earthquake were enveloped by the corresponding values used in the previous seismic case. In a few cases where some increases were noted, the licensee accepted by reviewing the margins or by a re-analysis. Therefore NRC concludes that August 2011 earthquake had insignificant impact on component fatigue, and the conclusions of TLAAs continue to remain valid. The NRC staff accepts the results of the licensee's analysis. The NRC also agrees that the TLAA conclusions remain valid. Therefore, the NRC concludes that Dominion has satisfactorily completed this commitment.

Commitment 10

The licensee will implement a long term Seismic Margin Management Plan to address the impact of the August 23, 2011 earthquake. Specifically, to ensure adequate seismic margins are maintained for plant SSCs, Dominion will revise the design change process for North Anna Power Station to require explicit evaluation of plant modifications for the effects of the August 23, 2011 earthquake using In-Structure Response Spectra (ISRS) for the Containment, Auxiliary Building, and other buildings containing safety related SSCs developed based on actual time-histories recorded during the event. In support of future plant design changes, the evaluation of plant SSCs will require design verification and code compliance with the stresses, loads, accelerations, and displacements generated from the analysis with the design basis ISRS or the analysis with the ISRS for the August 23, 2011 earthquake, whichever are higher.

The licensee has completed this action on December 31, 2011, which entailed a revision to the Nuclear Design Control Program to incorporate controls that will ensure that seismic margin is maintained at North Anna Power Station for plant modifications performed after the August 23, 2011, earthquake. The NRC staff reviewed the letter submitted by the licensee on May 13, 2013 (ADAMS Accession No. ML13135A637). Based on the information submitted, the staff concludes that Dominion has satisfactorily completed this commitment.

3.0 CONCLUSION

Based on the above evaluations, the NRC staff concludes that the licensee has satisfactorily completed the action associated with CAL Commitments 1, 2, 4, 5, 6, 9, and 10.

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