

VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

September 17, 2011

10 CFR 100, Appendix A

U.S. Nuclear Regulatory Commission
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SNM-2507

VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNITS 1 AND 2
NORTH ANNA INDEPENDENT SPENT FUEL STORAGE INSTALLATION
SUMMARY REPORT OF AUGUST 23, 2011 EARTHQUAKE RESPONSE AND
RESTART READINESS DETERMINATION PLAN

On August 23, 2011, at 1351 hours, with North Anna Power Station Units 1 and 2 operating at 100% power, a Magnitude 5.8 earthquake occurred approximately 5 miles from Mineral, Virginia. The epicenter was approximately 11 miles WSW of North Anna Power Station. Ground motion was felt and recognized as an earthquake by the Main Control Room operators at the station. The earthquake caused a series of reactor trip signals to both the Unit 1 and Unit 2 reactors, as well as a total loss of offsite power to the station. Per the Event Review Report, the "First Out" reactor trip signals for both units were "High Flux Rate Reactor Trip". Other than the trip signals and subsequent loss of offsite power, which were either directly or indirectly caused by the seismic event, safety systems in the plant responded as expected to the reactor trip and remained functionally undamaged and capable of performing their intended design functions. Separately, the 2H Emergency Diesel Generator developed a coolant leak and was subsequently manually secured. A Root Cause Evaluation of the leak is being performed. Based on evaluation of the US Geological Survey (USGS) data and plant-specific seismic data analysis, Dominion has confirmed that the August 23, 2011 earthquake exceeded the spectral and peak ground accelerations for the Operating Basis and Design Basis Earthquakes ("OBE" and "DBE", respectively) for North Anna Power Station Units 1 and 2.

Demonstration of North Anna Restart Readiness

Paragraph V(a)(2) of Appendix A to 10 CFR 100, states "if vibratory ground motion exceeding that of the Operating Basis Earthquake... Prior to resuming operations, the licensee will be required to demonstrate to the Commission that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public." Consistent with the regulatory requirement, Dominion met with the NRC staff on September 8, 2011 to: 1) provide an overview of

SUNSI Review Complete per Robert Martin

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the station response to the seismic event, 2) summarize the recorded data and analysis to date, and 3) discuss the station restart readiness assessment plan. As a follow-up to that meeting, we are providing detailed information to demonstrate that the post-earthquake analysis, inspection and testing activities that have been or will be completed by Dominion are sufficient to ensure that station structures, systems and components (SSCs) will continue to perform their required design functions such that restart of North Anna Units 1 and 2 may commence without undue risk to the health and safety of the public. Specifically, the enclosures to this letter collectively provide Dominion's North Anna Restart Readiness Assessment Plan as follows:

- Enclosure 1 Characterization of the North Anna Seismic Event of August 23, 2011
- Enclosure 2 Post-Earthquake Inspections of Plant Structures, Systems and Components
- Enclosure 3 Post-Earthquake Evaluation of the Reactor Vessel Internals
- Enclosure 4 Post-Earthquake Assessment of New and Irradiated Fuel
- Enclosure 5 Post-Earthquake Assessment of the Spent Fuel Storage Racks
- Enclosure 6 Post-Earthquake Evaluation of the Independent Spent Fuel Storage Installation (ISFSI)
- Enclosure 7 Post-Earthquake Impact Assessment on Engineering Programs
- Enclosure 8 Near-Term Actions to be Completed Prior to Unit Startup
- Enclosure 9 Long-Term Actions to be Completed After Unit Startup

Based on exceeding the station OBE and DBE seismic criteria, the North Anna Restart Readiness Assessment Plan was based on the guidance contained in the following documents:

1. RG 1.166, *Pre-Earthquake Planning and Immediate Nuclear Power Plant Operator Post-Earthquake Actions*, dated March 1997,
2. RG 1.167, *Restart of a Nuclear Power Plant Shut Down by a Seismic Event*, dated March 1997, and
3. EPRI NP-6695, *Guidelines for Nuclear Plant Response to an Earthquake*, dated December 1989.

EPRI NP-6695, which is endorsed by RG 1.167, bases post-event actions on the EPRI Damage Intensity Scale, which is dependent upon the level of damage observed, and the long-term actions on whether the equipment and structures were subjected to loads greater than the Safe Shutdown Earthquake (SSE) (i.e., DBE). If the level of damage to nuclear power plant equipment and structures observed during the post-shutdown inspections is found to be significant (i.e., corresponds to a Damage Intensity 3, which is based on the EPRI damage scale for nuclear plant facilities given in EPRI NP-6695 Tables 2-1 and 2-2), then the EPRI guidance would direct that long-term evaluations be performed and completed prior to restart. Completed plant inspections of North Anna's

SSCs performed in accordance with EPRI NP-6695 indicate an EPRI Damage Intensity of 0.

EPRI TR-100082, *Standardization of the Cumulative Absolute Velocity*, which is referenced in RG 1.166, provides criteria for calculating a cumulative absolute velocity (CAV) value which is an indicator of expected damage level from a particular earthquake spectrum. The threshold value for the onset of damage, provided in EPRI TR-100082 and mirrored in RG 1.166, is 0.16g-sec. Per EPRI TR-100082, "the adjusted CAV threshold is about a factor of five lower than the lowest CAV value associated with documented damage to an industrial/power facility. It is also about a factor of three lower than the lowest CAV value associated with documented damage to buildings of good design and construction."

In accordance with EPRI NP-6695, Appendix A, the criterion for determining if the OBE has been exceeded is independent of the plant's design OBE and SSE ground response spectra. For plants with a low SSE ground response spectrum (i.e., less than 0.2g,) it is possible to exceed the OBE and even the SSE ground response spectrum and not exceed the OBE CAV criterion if the damage parameters are less than the limit values (i.e., peak 5 percent damped ground motion spectral acceleration less than 0.2g or CAV less than 0.3 g-sec). The 0.3g-sec was later changed to 0.16 g-sec per EPRI TR-100082 using a different calculation methodology.

The CAV values calculated for the North Anna seismic event were below the very conservative threshold of 0.16g-sec defined in NRC RG 1.166 for OBE exceedance in the E-W and vertical directions, and the calculated CAV value exceeded the threshold by about 10% in the N-S direction. Because the plant-specific CAV values only slightly exceeded the specified OBE CAV limit in one of the three directions, no significant physical or functional damage would be expected to either safety related or non-safety related SSCs. This expectation is consistent with the findings of the comprehensive inspections performed on plant SSCs following the earthquake.

Specifically, completed post-shutdown plant walkdowns and inspections have not identified any significant physical or functional damage to safety-related plant SSCs and only limited damage to non-safety related, non-seismically designed SSCs (e.g., Generator Step-Up Transformer bushings). The lack of any significant physical or functional damage to safety-related SSCs and the limited damage to non-safety related systems are consistent with an EPRI Damage Intensity of 0, the indicator of least damage. Despite the lack of evidence of any physical or functional damage to safety-related plant SSCs, a conservative decision was made to perform comprehensive and methodical visual inspections of plant SSCs and to perform expanded inspections and tests in accordance with an EPRI Damage Intensity 1 versus the observed 0. Detailed discussion of the plant walkdowns and inspections is provided in the enclosures.

In addition to the post-earthquake plant walkdowns and inspections noted above, the following reviews and evaluations were also performed: Review of Recorded Vibratory

Data from Seismic Monitoring Instruments, Service Water Reservoir & Main Dam Review, ISFSI Pad and Cask Review, New Fuel and Spent Fuel Pool Inspection Review, Reactor Vessel Internals Evaluation, Design and Licensing Basis Review, Engineering Programs Review, Periodic Tests Review and Underground Piping Review.

Plant Seismic Design Considerations

As noted above, the response spectra developed from the time-histories of the recordings at the Reactor Containment basemat indicate that the Mineral, Virginia earthquake of August 23, 2011 exceeded the North Anna OBE and DBE ground response spectra that are currently specified as the licensing and design bases for North Anna Power Station Units 1 and 2. However, the CAV values and the effective strong motion durations were small.

From our overall assessment, the earthquake exceeded, on average, the North Anna DBE spectral accelerations in the more damaging 2 to 10 HZ frequency range by about 12% in one horizontal orientation, 21% in the vertical orientation, and not at all in the other horizontal direction. The North Anna DBE ground spectra for rock and soil founded structures are anchored to 0.12g and 0.18g peak ground accelerations (PGA) respectively in the horizontal direction. While the above exceedances are at the basemat of the containment, a comparison of the response spectra from the recorded time-histories of this earthquake to the calculated DBE in-structure response spectra (ISRS) at the operating deck of the containment structure (elevation 291') shows that the exceedances are smaller and only at certain narrow frequency bands in the 2 to 10 HZ range. This implies that our calculations of ISRS are conservative. This is significant because other than a few tanks and yard equipment, safety-related systems and components are located at various elevations within structures and are designed and qualified to the calculated DBE and OBE ISRS.

The above assessment is based on the spectral peaks calculated from the recorded time-history data. The use of recorded data is conservative as determined in the NRC sponsored research documented in NUREG/CR-0098, prepared by N.M. Newmark and W.J. Hall. Section 3.1 of NUREG/CR-0098 states that, "Although peak values of ground motion may be assigned to the various magnitudes of earthquake, especially in the vicinity of the surface expression of a fault or at the epicenter, these motions are in general considerably greater than smaller motions which occur many more times in an earthquake. Design earthquake response spectra are based on "effective" values of the acceleration, velocity and displacement, which occur several times during the earthquake, rather than isolated peak values of instrumental reading. The effective earthquake hazards selected for determining design spectra may be as little as one-half the expected isolated peak instrument readings for near earthquakes, ranging up to the latter values for distant earthquakes."

When considering seismic capability of SSCs, equipment within containment, including the reactor core, internals, reactor coolant system piping, steam generators, and

appurtenances, are designed to withstand the loads resulting from a combined design basis seismic and loss of coolant accident (LOCA) event. Because the LOCA, which was not experienced at North Anna, governs calculated loads for a combined seismic and LOCA event, there is additional assurance of the adequacy of design margins for the seismic-only loads experienced on August 23, 2011.

During the implementation of the Generic Letter (GL) 88-20, Supplement 4, *Individual Plant Examination of External Events* (IPEEE) and GL 87-02, *Verification of Seismic Adequacy of Mechanical and Electrical Equipment In Operating Reactors* (USI A-46), programs, several modifications and improvements were made to enhance the plant's seismic safety. In the IPEEE effort, the plant was evaluated to a median-centered ground response spectrum shape anchored to 0.3g PGA. Calculations were performed to determine the high-confidence-of-low-probability-of-failure (HCLPF) capacities of equipment and structures, and only a small number of structures and components were found to have HCLPF capacities below 0.3g. The calculations for those components with HCLPF capacity below 0.3g are being reviewed for potential improvements to increase their seismic capacities; however, detailed inspections of these components by trained and experienced seismic review teams have shown no evidence of damage from the seismic event. Also, comprehensive inspections of plant SSCs were performed, and they likewise showed no significant physical or functional damage to safety-related plant SSCs and only limited damage to non-safety related, non-seismically designed SSCs. In addition, an inspection of plant areas and SSCs where earthquake induced damage would likely be most evident, including non-safety related structures and components such as large, unanchored water storage tanks, was performed by a seismic review team. The team, consisting of several Dominion engineers and industry experts, reached the same conclusion.

It should be noted that if the CAV value in one direction had been about 10% lower, it would be below the very conservative threshold of 0.16g-sec (the other two were already lower), the plant would not have had to shut-down because of this earthquake, provided Dominion had incorporated the RG 1.166 criteria for OBE exceedance into its licensing basis and seismic instrumentation design. Based on the non-damaging parameters (relatively small CAV and the limited effective strong motion duration) of the recent earthquake, detailed inspection results, surveillance and functional tests, improvements made during USI A-46 and IPEEE efforts, and inherent margins shown in the IPEEE program, it is concluded that North Anna's seismic design has adequate margins and the plant can continue to operate safely.

Regulatory Approach

Subject to the completion of the identified near-term actions, the regulatory evaluation and response demonstrates that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public, and provides the basis for restart of North Anna Units 1 and 2. Dominion's response framework was developed on the basis of the following guidance and related

considerations: 10 CFR 100 Appendix A establishes a regulatory requirement following an event that exceeds the OBE earthquake. RG 1.167 provides NRC-endorsed guidance for licensee response to seismic events, and references the guidance of EPRI NP-6695 for required evaluations and inspections based on observed consequences of the seismic event. Inspections and surveillance and functional testing to confirm the functionality of plant SSCs are identified herein, and will be completed prior to restart. Dominion proposes the completion of these inspections and surveillance and functional tests as the necessary pre-conditions for North Anna restart, and requests NRC concurrence with this framework and proposed actions.

The August 23, 2011 event at North Anna is appropriately classified under the guidance provided in IAEA Safety Report Series No. 66, "Earthquake Preparedness and Response for Nuclear Power Plants," as Action Level 5, which requires initial focused inspections and testing prior to restart, and re-evaluation of the seismic hazard after restart, if deemed necessary. Guidance on earthquake response for this event classification requires no revision of the plant's seismic design prior to restart. Seismic design will continue to be evaluated in the context of response to NRC Generic Issue (GI) 199, *Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern US (CEUS) for Existing Plants*, and implementation of the NRC Near-term Task Force Recommendations identified in SECY-11-0124 dated September 9, 2011.

Summary

Dominion has concluded that the North Anna OBE and DBE spectral and peak ground accelerations were exceeded. However, previous evaluations for IPEEE and USI A-46 resolution, as well as the event specific, calculated values for CAV and effective strong motion duration, indicate that no significant damage should be found. The comprehensive walkdowns, inspections, evaluations and surveillances that have been completed confirm the expected lack of significant physical or functional damage to safety-related SSCs. In addition, the surveillance and functional tests and other identified items that will be completed prior to startup will confirm the ability of safety-related and plant support SSCs to perform their design basis functions. Finally, long-term actions have been identified to better inform and strengthen the capability of plant staff to promptly identify future earthquake intensity and to establish plans and methods for seismic evaluation of SSCs going forward pursuant to the resolution of NRC GI-199.

Therefore, it is Dominion's conclusion that, upon completion of the near-term activities discussed within this document, we will have demonstrated that no functional damage has occurred to those features necessary for continued operation without undue risk to the health and safety of the public. NRC concurrence is hereby requested to restart North Anna Units 1 and 2 upon completion of the remaining near-term action items identified in Enclosure 8.

We also acknowledge receipt of the NRC request for additional information (RAI) dated September 14, 2011. Although much of the requested information is provided in this letter, we will provide a docketed response to the RAI in a timely manner.

If you have any questions or require additional information, please contact Mr. Gary D. Miller at (804) 273-2771.

Sincerely,



E. S. Grecheck
Vice President – Nuclear Development

Enclosures

Commitments made in this correspondence:

The commitments included in this correspondence are provided in Enclosures 8 and 9.

COMMONWEALTH OF VIRGINIA)

COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by E. S. Grecheck who is Vice President – Nuclear Development, of Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 17th day of September, 2011.

My Commission Expires: 4/30/2015.

Ginger Lynn Rutherford
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My Commission Expires 4/30/2015



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Enclosure 1

Characterization of the North Anna Seismic Event of August 23, 2011

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

Characterization of the North Anna Seismic Event of August 23, 2011

The vibratory motions from the Magnitude 5.8 Mineral, Virginia earthquake of August 23, 2011 with its epicenter about 11 miles from the North Anna Power Station were recorded in three orientations (North-South [N-S], East-West [E-W], Vertical [V]) at several locations in the plant using two types of instruments: the Engdahl scratch plates that recorded 12 discrete spectral accelerations between 2 and 25.4 Hz, and the Kinometrics analog recorders that recorded time-histories of the accelerations. The North Anna Updated Final Safety Analysis Report (UFSAR), Section 3.7.4.5, states, "Regulatory Guide 1.12 provides a general basis for selection of earthquake instrumentation for Seismic Class I structures and components where instruments are installed. The Guide specifies that the containment be instrumented with two triaxial acceleration sensors. Since the structure is founded on fresh rock, a separate "free field" triaxial acceleration sensor is not required." Consequently, since North Anna did not have free-field instruments, the most appropriate location to determine whether the plant Operating Basis Earthquake (OBE) and Design Basis Earthquake (DBE) were exceeded is at the top of the basemat of the containment structure. The containment was analyzed as a rock founded structure and the calculated spectra at the top of the basemat are close (but slightly conservative) to the free-field rock OBE and DBE spectra that are defined in the North Anna UFSAR. Therefore, this location was best suited for comparing the recorded motions to the North Anna design OBE and DBE spectra and to calculate the Cumulative Absolute Velocity (CAV) values, a damage parameter, from the recorded time-histories.

A comparison of the recordings from the Engdahl scratch plates at the containment basemat to OBE and DBE criteria (see Figures 2.1 and 2.2 in Attachment 2 to this Enclosure) showed that the plant OBE was exceeded. DBE criteria were slightly exceeded, but an analysis of data captured by the Kinometrics recording was needed to make a final determination on whether DBE criteria had been exceeded. Dominion, together with several industry experts, considers the Kinometrics analog recorder data to be more reliable. The Kinometrics data shows that the OBE and DBE were exceeded in all three directions (see Figures 3.1 and 3.2 in Attachment 3); however, in the frequency range most damaging to equipment, 2 to 10 Hz, the DBE was not exceeded in the E-W direction, and the earthquake exceeded the DBE, on average, by about 12% in the N-S direction with the sharpest peak exceeding the corresponding DBE spectral ordinate by a factor of about 1.3, and about 21% in the vertical direction with the sharpest peak exceeding the DBE by a factor of about 1.6.

The CAV values, which are indicators of the earthquake's damage potential, were calculated from the recorded time-histories at the containment basemat. These values were below the very conservative threshold of 0.16g-sec defined in NRC Regulatory Guide (RG) 1.166 for OBE exceedance in the E-W and vertical directions, and the CAV limit was exceeded by about 10% in the N-S direction. Cumulative energy (Husid plots) calculations showed that the effective strong motion duration in the N-S direction was 1 second, in the vertical direction it was 1.5 seconds, and in the E-W direction it was 3.1 seconds. The CAV and the cumulative energy data are consistent with the findings from extensive plant inspections, including a specific plant inspection performed by a

seismic review team consisting of Dominion engineers and several experts from the industry, which showed no significant physical or functional seismically induced damage to safety-related SSCs and only limited damage to non-safety related, non-seismically designed SSCs.

Based on the above, it is concluded that the August 23, 2011 Mineral, Virginia earthquake exceeded the spectral and peak ground accelerations for the OBE and DBE of the North Anna plant; however, CAV, which is an indicator of the earthquake damage potential, was marginally exceeded in only one direction and the effective strong motion duration of the earthquake was small.

North Anna Units 1 and 2 were reviewed in the 1990s under the Unresolved Safety Issue (USI) A-46 for design basis earthquake and under Generic Letter (GL) 88-20, Supplement 4, *Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities*. Numerous plant and procedural improvements and modifications were made during these efforts to improve the seismic safety of the plant. For the IPEEE, a seismic margin assessment was used with a review level earthquake of 0.3g peak ground acceleration (PGA) and a spectral shape given in NUREG/CR-0098. Only a small number of components (~50) were found to have a high-confidence-of-low-probability-of-failure (HCLPF) capacity less than 0.3g. These capacities are being reviewed for potential improvement. A thorough inspection of the small number of components with less than 0.3g HCLPF capacity (with the exception of one group where the relay functionality controlled the HCLPF capacity) is being performed by qualified and trained seismic review teams with no significant physical or functional damage detected to date. It is noted that the IPEEE spectra, based on NUREG/CR-0098 median-centered shape and anchored to 0.3g PGA, envelopes the spectra at the containment basemat from the Kinometrics recorders in all three directions.

With the exception of the IPEEE components with less than 0.3g HCLPF capacity that are currently being inspected, a detailed inspection of structures, systems and components (SSCs) was completed at North Anna and no significant physical or functional damage to safety-related plant SSCs has been identified and only limited damage to non-safety related, non-seismically designed SSCs has been found (See Enclosure 2). In accordance with the flow diagram in EPRI NP-6695 for EPRI Damage Intensity 1, post-shutdown inspections have been performed and surveillance and functional tests are being performed. Based on the inspection assessments, the EPRI plant damage intensity scale was characterized as "0" per EPRI NP-6695.

Several long term (post-startup) seismic evaluations and analyses will be performed for North Anna per EPRI NP-6695 and to address NRC Generic Issue (GI)-199, "Implications of Updated Probabilistic Seismic Hazard Estimates in Central and Eastern US (CEUS) for Existing Plants."

Earthquake Event Description

The US Geological Survey (USGS) reports that a Magnitude 5.8 earthquake occurred August 23, 2011 at 1351 hrs. The epicenter of this seismic event was reported to be at 37.936°N latitude, 77.933°W longitude, which places the event approximately 5 miles from Mineral, VA and 7 miles from Louisa, VA. Per reports, the epicenter was approximately 11 miles from the North Anna Power Station. The depth of the earthquake is reported to be 3.7 miles.

North Anna Power Station Response to the Earthquake

Both units at North Anna automatically tripped. The earthquake caused a series of reactor trip signals to both Unit 1 and Unit 2 reactors, as well as a total loss of offsite power to the station. Per the Event Review Report, the "First Out" reactor trip signals for both units were "High Flux Rate Reactor Trip". Other than the trip signals and subsequent loss of offsite power, which were either directly or indirectly caused by the seismic event, the plant responded as expected to the reactor trip. Separately, the 2H Emergency Diesel Generator developed a coolant leak and was subsequently manually secured.

North Anna Operating Basis and Design Basis Earthquake

North Anna UFSAR Section 3.7 provides the OBE and DBE ground response spectra and peak ground acceleration values. The DBE horizontal PGA for rock-founded structures is 0.12g and for soil founded structures it is 0.18g. Vertical direction PGAs are two-thirds of the horizontal accelerations and the OBE is half of DBE in the entire frequency range. The horizontal OBE and DBE curves for rock at 5% spectral damping are shown in Figure 1 and the horizontal OBE and DBE curves for soil at 5% spectral damping are shown in Figure 2.

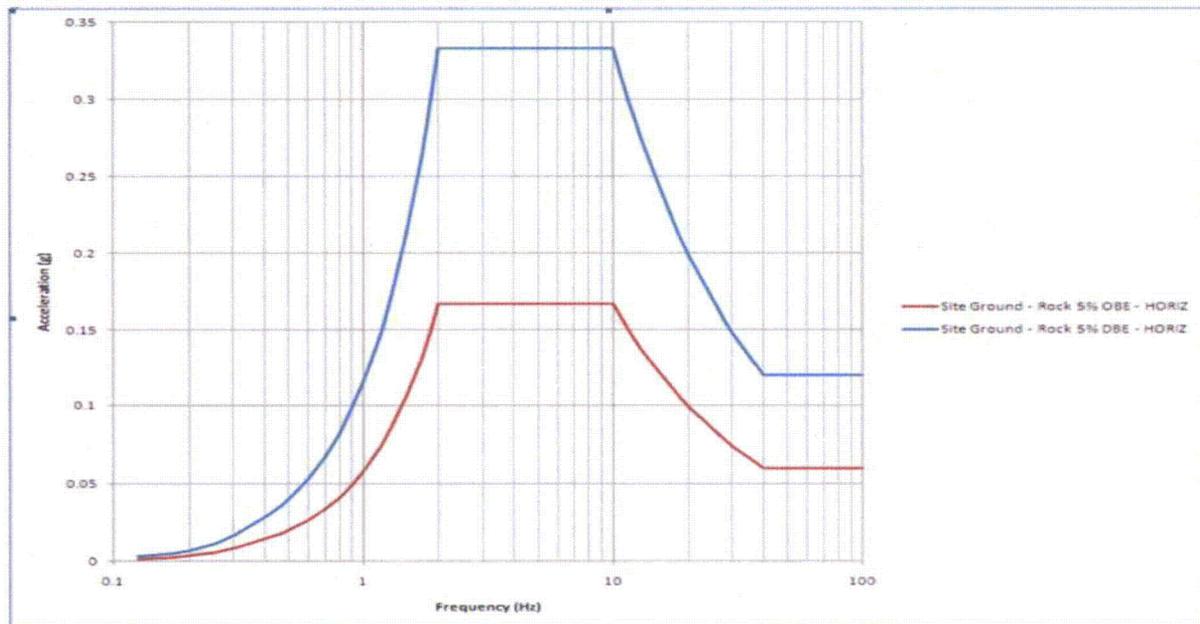


Figure 1 – Horizontal OBE and DBE Response Spectrum Curves for Rock at 5% Damping

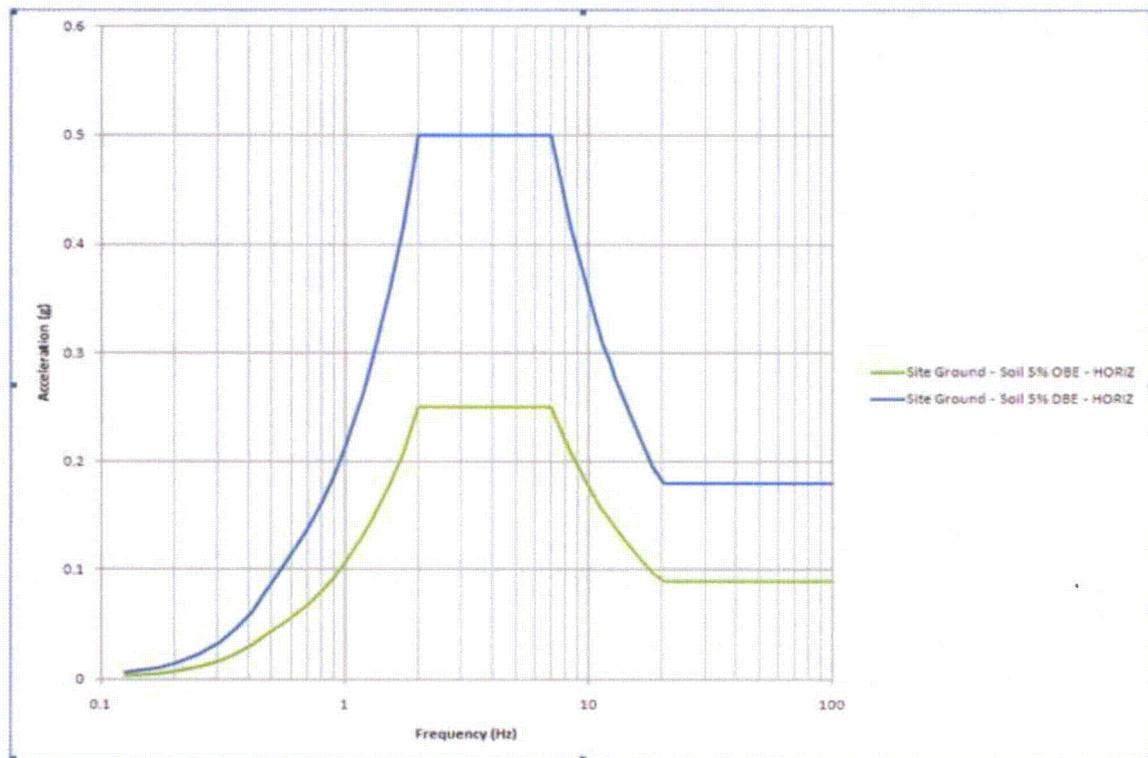


Figure 2 - Horizontal OBE and DBE Response Spectrum Curves for Soil at 5% Damping

NRC USI A-46 and IPEEE Programs and Plant Improvements

North Anna Units 1 and 2 were reviewed in the 1990s under USI A-46 for design basis earthquake and under the IPEEE program required by Generic Letter (GL) 88-20 Supplement 4 to determine vulnerabilities for a beyond design basis event. The USI A-46 program evaluated components in a safe shutdown equipment list (SSEL) that included 20 classes of equipment, tanks and heat exchangers, cable trays and conduits and relays. The IPEEE, which used a seismic margin assessment, consisted of an enhanced SSEL with two success paths to achieve safe shutdown. Several plant and procedural improvements and modifications were made during these efforts to improve the seismic safety of the plant. Some of the significant modifications included tying safety-related electrical cabinets together to prevent banging or relay chatter in the side to side direction for many rows of cabinets, modification of the anchorages of three tanks, improving anchorage of electrical cabinets and other components, improving the control room ceiling, improving seismic housekeeping and implementing a housekeeping procedure, reorienting valves to prevent higher stress along weak axis, and cable tray and conduit support improvements. For the IPEEE, a review level earthquake of 0.3g peak ground acceleration (PGA) was used. It is noted that in the IPEEE evaluations, only a small number of components were found to have a high-confidence-of-low-probability-of-failure (HCLPF) capacity less than 0.3g. These components are listed in Table 1 below. Further, a few masonry block walls were also reported during IPEEE with a capacity less than 0.3g. These block walls are listed in Table 2. A thorough inspection of these components is being performed by qualified

and trained seismic review teams and no significant physical or functional damage has been reported to date. The capacities of these components will be reviewed for potential improvements.

Based on the improvements made to the plant during the USI A-46 and the IPEEE programs, the plant has substantial seismic margin over its initial design. In addition, after USI A-46 was completed, North Anna's procedure for seismic qualification of equipment was updated to use the later versions of IEEE standard 344 (1975 or 1987 version) for seismic qualification of equipment, which also provides improved safety margins.

The rock and soil free-field median-centered response spectra, based on NUREG/CR-0098 and anchored to a 0.3g PGA, were used as the Review Level Earthquake for IPEEE. These spectra are shown in Figure 3.

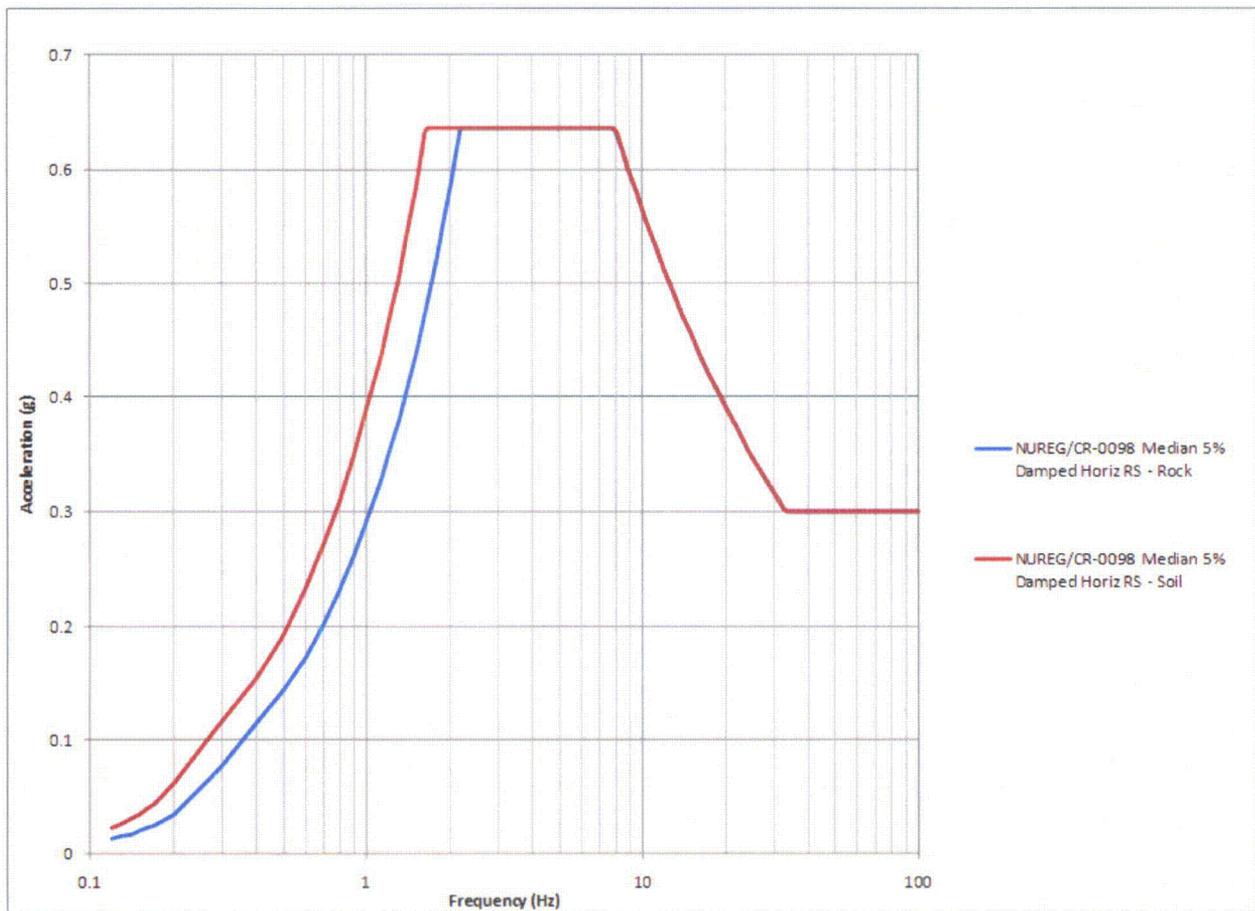


Figure 3 - Review Level Earthquake used in IPEEE – Rock & Soil Founded Structures – Horizontal Direction, 5% Spectral Damping

Table 1 - Summary of HCLPF Capacities Less than 0.3g (IPEEE)

Equipment Mark Number	Equipment Description	HCLPF Capacity	Mode of Failure
1(2)-CN-TK-1	Emergency Condensate Storage Tanks	0.16 g	Overturning moment capacity – see note below
1(2)-QS-TK-1	Refueling Water Storage Tanks	0.18 g	Overturning moment capacity
1-EP-CB-04A, B, C, D 2-EP-CB-04A, B, C, D	120 V Vital AC Bus	0.19 g	Anchorage
1-QS-TK-2	Refueling Water Chemical Addition Tank – Unit 1	0.19 g	Foundation Overturning
1-CH-TK-1A, B, C	Boric Acid Tanks	0.21 g	Anchorage
1-HV-AC-1, 2 2-HV-AC-8, 9	Control Room Air Conditioners	0.21 g	Anchorage
1(2)-EI-CB-21	Sequence of Events Recorders	0.22 g	Anchorage
1-EE-SW-1H, 1J 2-EE-SW-2H, 2J	4160 V Emergency Bus	0.23 g	Relay Capacity
2-QS-TK-2	Refueling Water Chemical Addition Tank – Unit 2	0.24 g	Foundation Overturning
2-EE-BKR-RTA, RTB, BYA, BYB (Cabinets 2-EI-CB-46A, B)	Reactor Trip Breakers –(Unit 2 only)	0.24 g	Anchorage
1(2)-HV-E-4A, B, C	Heating and Ventilation Chiller Units	0.27 g	Anchorage
1-BD-TV-100A, 100C, 100E 2-BD-TV-100A, 100C, 100F	SG Blowdown Containment Isolation Valves	0.28 g	Cast Iron Yokes
1(2)-CC-P-1A, 1B	Component Cooling Water Pumps	0.29 g	Anchorage

Note: The tank is unanchored; however, the tank is enclosed in a concrete missile shield which is approximately 2" away from the tank. This 2" space is filled with Rotofoam. The Rotofoam and the concrete missile shield were not considered when calculating the HCLPF.

Table 2 - Block Walls with HCLPF Capacity Less than 0.3g (IPEEE)

Group	Walls	Construction	Class	Bounding Wall	SMA HCLPF (g)
5	SB-271-17 SB-271-85 SB-294-3 Turbine Building Walls	8" and 12" Thickness	III	SB-271-17	0.21

North Anna Seismic Instrumentation

Refer to Attachment 1.

Engdahl Scratch Plate Recorder Data and Comparisons to Design Basis

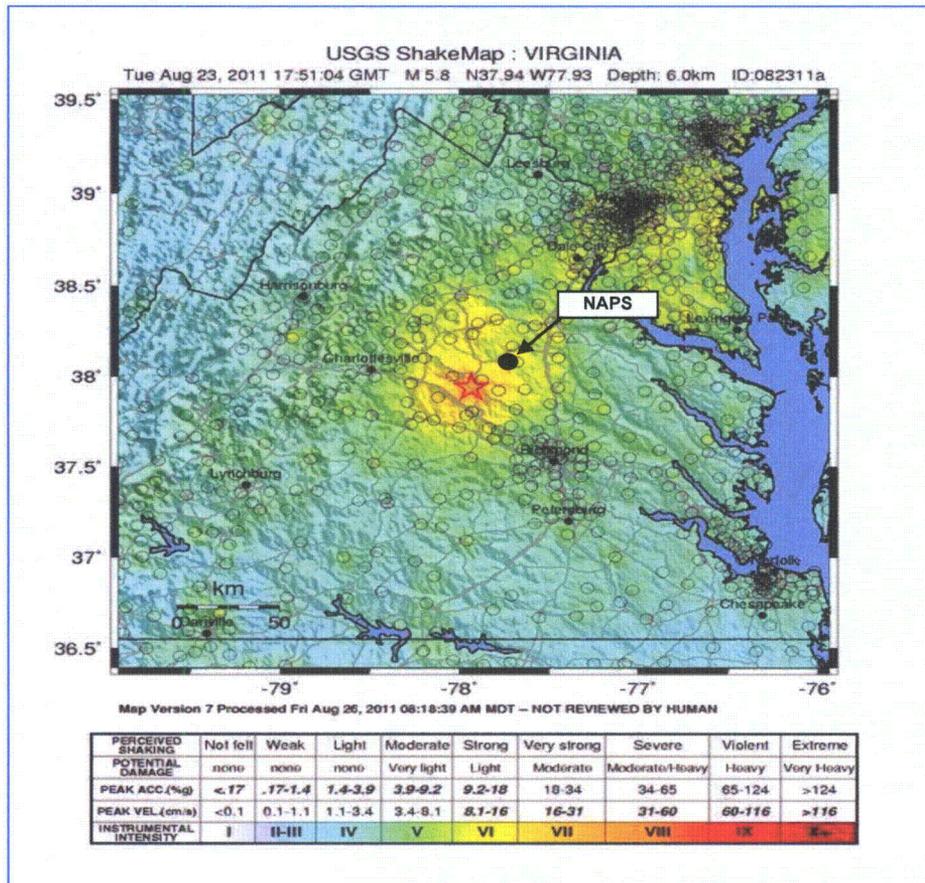
Refer to Attachment 2.

Kinematics Triaxial Recorder Data and Comparisons to Design Basis and IPEEE

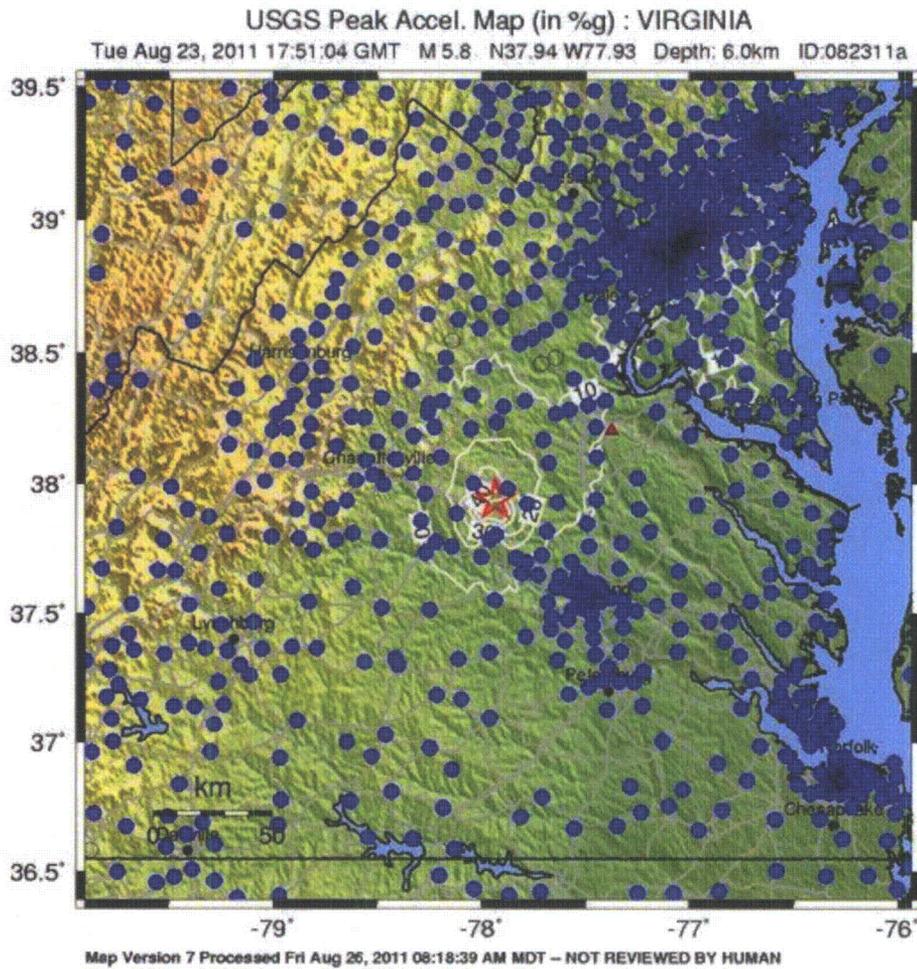
Refer to Attachment 3.

Earthquake Characterization Based on Data from External Sources

The following data about the August 23, 2011 Mineral, Virginia earthquake was obtained from publicly available information from the website of the United States Geological Survey (USGS). North Anna Power Station is approximately 11 miles to the northeast of the epicenter (shown approximately on the map below).



Source: <http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/082311a/>



Source: <http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/082311a/download/pga.jpg>

Based on the above PGA shake map, the location of the plant is just outside of the 0.3g contour plotted above. This appears to be consistent with the peak ground acceleration measured by the Kinematics recorder at the Containment basemat (see Attachment 3).

Interpretations of the Recorded Data Compared to North Anna Plant Design Basis

An assessment of the Engdahl scratch plate recorded data is shown in Attachment 2, and similarly, the assessment of the Kinematics data is shown in Attachment 3. These attachments include the comparison plots at various locations between the recorded data and the North Anna OBE and DBE spectra calculated from time-history dynamic analyses of the two structures in which these recorders are located. The most relevant recorded data is from the Kinematics recorders at the basemat of the containment structure. Based on our discussions with Engdahl and with several industry experts, we believe that the Kinematics data is more reliable than the Engdahl data at the same location. As discussed in Attachment 3, the Kinematics recorders show that the North Anna OBE and DBE spectral and peak ground accelerations were exceeded.

Figure 3.1 in Attachment 3 also compares the response spectra created from the Kinometrics data in the horizontal directions to the Containment basemat spectra used for IPEEE, which is considered close to the free-field rock. The IPEEE curves envelop the spectra from the recorded data for the Containment basemat elevation. Similarly, Figure 3.2 in Attachment 3 shows that for the vertical direction the IPEEE also envelops the recorded data.

Criteria from EPRI NP-6695 and RG 1.166, and North Anna Data from the August 23, 2011 Event

EPRI NP-6695 provides basically two criteria to determine OBE exceedance, either one of which could be used. One of these two criteria is that the Cumulative Absolute Velocity (CAV) should be less than 0.3g-sec. Subsequent to the initial issue of NP-6695, the methods and the criterion to calculate the CAV were updated (EPRI Report TR-100082) to remove the effects on the CAV of very small cycles of motion. The updated limit was conservatively set at 0.16g-sec. RG 1.166 uses this new CAV criterion of 0.16 g-sec. The CAV values from the time-histories of the August 23, 2011 event at the containment basemat were calculated by three independent consultants in each of the three directions. All three consultants calculated approximately the same values, as shown in Table 3 below. It is noted that per EPRI NP-6695 and RG 1.166, although CAV values should be calculated from the free-field recorded data, it was judged that the top of the containment mat would give a reasonable approximation of the free-field, because the containment is rock-founded and the calculated spectra at the top of the containment mat is fairly close to the corresponding OBE or DBE free-field spectra. The analysis of the recorded data shows that the CAV values were below the very conservative threshold of 0.16g-sec defined in NRC RG 1.166 for OBE exceedance in the E-W and vertical directions, and the CAV exceeded the limit by about 10% in the N-S direction. The cumulative energy (Husid) plots were developed by Simpson, Gumpertz & Heger (SGH) from the containment mat recorded time-histories. These plots show that the effective strong motion duration in the N-S direction was 1.0 second, in the vertical direction it was 1.5 seconds, and in the E-W direction it was 3.1 seconds. The CAV and cumulative energy data are consistent with the inspections, including a specific plant inspection performed by a seismic review team consisting of Dominion engineers and several experts from the industry, which showed no significant physical or functional seismically induced damage to non-safety or safety-related structures and components.

Table 3 - Cumulative Absolute Velocity Results

	East-West (g-sec)	North-South (g-sec)	Vertical (g-sec)
Kinometrics	0.137	0.175	0.118
SGH	0.118	0.169	0.105
Bechtel (preliminary)	0.134	0.181	0.113
Average	0.130	0.175	0.112

Conclusions on Characterization of the North Anna Earthquake Based on the Review of Data

Based on the recorded plant Kinematics data, as documented in Attachment 3, it is concluded that the August 23, 2011 earthquake exceeded the spectral and peak ground accelerations for the OBE and DBE of North Anna plant; however, CAV, which is an indicator of the earthquake damage potential was only marginally exceeded in only one direction and the strong motion duration of the earthquake was small based on the recorded and calculated parameters.

Conclusions Based on Comprehensive Plant Inspections

Comprehensive inspections of non-safety and safety related SSCs were performed. These inspections are discussed in Enclosure 2. Extensive testing of safety related systems and components is ongoing and will be completed prior to each respective unit's startup. The inspections did not reveal any significant physical or functional damage or deformation of safety related SSCs. Reported damage and observations from the earthquake include spurious actuation of the sudden pressure relays on the Reserve Station Service Transformers, limited cracking of ceramic/porcelain components on switchyard equipment and limited cracking of non-safety walls, and movement of the Independent Spent Fuel Storage Installation (ISFSI) casks. The most significant visual damage of a non-safety related SSC was spalled concrete on a condensate polishing tank support pedestal that did not affect function. The most significant damage that required repair on non-safety related equipment was the Generator Step Up (GSU) transformer bushing leakage. This is a heavy bushing which projects out from the transformer and is primarily supported on one end; thus, this damage is not surprising. Other than the above, no significant physical or functional seismically induced damage to non-safety related structures or components has been identified.

Attachment 4 and Enclosure 2 discuss the in-process detailed inspections of the low capacity components identified in IPEEE by trained and experienced seismic review teams that, to date, have not identified any significant physical or functional earthquake based damage or anomaly for these components. Based on the results of the inspections conducted, the earthquake damage to North Anna Power Station is characterized as EPRI Damage Scale Intensity "0" per NP-6695. Based on these observations and the fact that the earthquake maximum CAV value is 0.175 (based on an average of the three values provided in Table 3), no significant physical or functional damage of safety related components would be expected.

Separately, a limited scope plant inspection was conducted by a Seismic Review Team that included Dominion and industry seismic experts. No significant physical or functional earthquake-induced damage was observed for the areas and SSCs inspected. The results of this plant inspection are summarized in Attachment 4 to this Enclosure.

Subsequent to the August 23, 2011 earthquake, USGS has recorded twenty-four aftershocks from August 23 to September 1, 2011 ranging from Magnitude 1.8 to 4.5.

Conclusions

Based on the recorded plant data, it is concluded that the Mineral, Virginia earthquake of August 23, 2011 exceeded the spectral and peak ground accelerations for the OBE and DBE of the North Anna plant; however, CAV, which is an indicator of the earthquake damage potential marginally exceeded the criterion in RG 1.166 in one direction only and the strong motion portion of the earthquake was of relatively small duration based on the recorded and calculated parameters.

Further, comprehensive plant inspections have concluded that the damage to the plant was minimal. Based on the site inspections, documented in Enclosure 2 that were conducted in accordance with EPRI NP-6695, the seismic damage is classified as Damage Intensity 0.

It is concluded that while the recorded data indicating exceedance of the OBE and DBE acceleration spectra, analysis of the time history of the spectra indicates that this earthquake should not have caused significant physical or functional damage to North Anna. The findings of no significant physical or functional damage to safety related SSCs and only limited damage to non-safety related SSCs are supported by the physical inspections and data reflecting the very low damage potential of the earthquake at the site (CAV and Husid plots).

North Anna Seismic Instrumentation

Overview of North Anna Seismic Instrumentation

A brief overview of the North Anna Power Station seismic event recording instrumentation is provided. The power station has two separate recording systems, one provided by Kinometrics Inc. and the other provided by Engdahl. Both systems provide input to the Main Control Room via a common instrumentation panel located on the Backboards of the Unit 2 side. The panel mark number is 1-EI-CB-151. The Kinometrics system will be discussed first followed by Engdahl.

[1] Kinometrics

The sensors for this system are located inside Unit 1 Containment (CTMT). The sensor locations and types are as follows:

Sensor Mark #	Sensor Type	Location/Elevation	Equipment Mounting
1-ER-YE-01	Triaxial Time History Accelerograph, FBA-3	Unit 1 Containment 216'	U1 CTMT Mat
1-ER-VBS-101	Triaxial Seismic Trigger, TS-3	Unit 1 Containment 216'	U1 CTMT Mat
1-ER-VBS-102	Triaxial Seismic Switch, SP-1/TS-3	Unit 1 Containment 216'	U1 CTMT Mat
1-ER-YE-02	Triaxial Time History Accelerograph, FBA-3	Unit 1 Containment 291'	U1 CTMT Operating Deck

Seismic Trigger (TS-3), 1-ER-VB-101, activates at a sensed acceleration of 0.01g in any direction. The trigger starts the tape recorders for the CTMT Mat and Operating deck to record a time history of the event. It also initiates the event indicator (turns from black to white), local event alarm (yellow light) on SMA-3 control panel, and Earthquake Trouble Annunciator, window 1A-B6, on the Main Control Board. The trigger does not lock in and will reset on its own once the seismic event ends. A time delay ensures that the tape recorders continue recording for 10 seconds after the trigger has returned to normal. Once the trigger resets, the Main Control Board annunciator and local event alarm will clear. The event indicator requires a manual reset.

Seismic Switch (SP-1/TS-3), 1-ER-VBS-102, activates at a sensed acceleration of 0.04g vertical and 0.06g horizontal. Switch activation initiates the Earthquake Trouble annunciator, 1A-B6, and a yellow event alarm on the seismic switch power supply drawer. Both auto reset after the switch resets.

Kinometrics Specifications:

Tape recorders (SMA-3 and FBA-3)	Scaled for $\pm 1g$	Response 0 to 50Hz
Trigger (TS-3)	Adjustable from 0.005 to 0.05g	Flat response 1 to 10Hz
Switch (SP-1/TS-3)	Adjustable from 0.025 to 0.25g	Flat response 0.5 to 15Hz

North Anna Seismic Instrumentation

Kinematics is an active system and requires power. The Main Control Room panel receives 120VAC power from Semi-Vital Bus "1A." This panel loses power during a loss of offsite power (LOOP) until the 1H Emergency Diesel Generator (EDG) picks up the load on the bus. This panel will receive power as soon as the EDG output breaker closes as this load rides the bus. Kinematics instrumentation is provided with a battery back-up in control room panel 1-EI-CB-151 that is sized to provide one hour of back-up power. This ensures that the local alarms activate and that the tape recorders record the seismic event even with a LOOP. The input relays to the Main Control Board Earthquake Trouble Annunciator are Westinghouse ARD control relays that do not have battery back-up. With a LOOP, the Earthquake Trouble Annunciator will not function.

[2] Engdahl

Sensors for this system are located in the Unit 1 Containment and in the Auxiliary Building. The sensor locations and types are as follows:

Sensor Mark #	Sensor Type	Location/Elevation	Equipment Mounting
1-ER-RCDR-216A/B/C	Triaxial Response Spectrum Recorder PSR-1200	Unit 1 Containment 216'	Unit 1 CTMT Mat
1-ER-RCDR-231A/B/C	Triaxial Response Spectrum Recorder PSR-1200	Unit 1 Containment 231'	Unit 1 Residual Heat Removal (RHR) pump and heat exchanger area
1-ER-RCDR-244A/B/C	Triaxial Response Spectrum Recorder PSR-1200	Aux Building 244'	In between Unit 1 and 2 Component Cooling (CC) pumps
1-ER-RCDR-274A/B/C	Triaxial Response Spectrum Recorder PSR-1200	Aux Building 274'	Near Unit 1 "A" CC heat exchanger, 1-CC-E-1A
1-ER-RCDR-03	Triaxial Peak Accelerograph PAR-400	Unit 1 CTMT 218'	On pipe 12"-SI-125-1502, Unit 1 "C" Safety Injection Accumulator discharge piping
1-ER-RCDR-02	Triaxial Peak Accelerograph PAR-400	Unit 1 CTMT 241'	On Unit 1 "B" RHR heat exchanger, 1-RH-E-1B
1-ER-RCDR-04	Triaxial Peak Accelerograph PAR-400	Aux Building 279'	On Unit 1 "A" CC heat exchanger, 1-CC-E-1A

These devices are passive and have no immediate earthquake output except for 1-ER-RCDR-216A/B/C, which provides input to the Main Control Room Peak Shock Annunciator panel located in 1-EI-CB-151.

North Anna Seismic Instrumentation

Engdahl Specifications:

PAR-400 scribe plates	0 to 5g	0 to 51Hz, tri-axis, one plate in each axis
PSR-1200	0 to 2g	2 to 25.4Hz in 1/3 octave increments, tri-axis, 12 plates in each axis

Engdahl is a passive system and requires no power except for the Peak Shock Annunciator (PSA) in the Main Control Room. The PSA panel is located in 1-EI-CB-151 and is powered from Semi-Vital bus same as Kinometrics. The PSA panel; however, does not have back-up power. During a LOOP, this panel does not function. If a seismic alarm came in during the period of time between the loss of power and cleared before restoration of power; the alarm circuits will not indicate this alarm on restoration of power.

Kinometrics Measuring Equipment Discrepancies

It was identified that the Kinometrics Seismic Instrumentation, FBA-3 Time History Recorders, were incorrectly installed. Specifically, devices 1-ER-YE-01 and 1-ER-YE-02 were 90 degrees off. The CTMT operating level (291') accelerometers cable was pointing called West and the CTMT basement was pointing called East. Per the vendor and the vendor tech manual, the cable coming out should be pointing towards called North. Therefore, the results obtained for the Transverse direction, which are supposed to correlate to East-West, apply to the North-South direction and the results obtained for the longitudinal direction, which are supposed to correlate to North-South, apply to the East-West direction.

Transverse = North-South
Longitudinal = East-West

This error in installation was relayed to Kinometrics via Dominion prior to processing of the data; therefore, the Kinometrics results properly account for the discrepancy.

Note that a subsequent concern was raised regarding the possibility that the East-West and Vertical Direction were errantly switched as well, based on the comparisons of the recorded spectra at the basemat and elevation 291' of the containment. An investigation was undertaken to determine whether there were any additional wiring/configuration errors. No additional anomalies were identified.

Engdahl Scratch Plate Data

Review and Comparison of the Data

The scratch plates retrieved from the Engdahl PSR-1200 scratch recorder units were sent to the vendor for reading. The Engdahl data consists of measurements at 2% damping for 12 discrete frequencies ranging from approximately 2 to 25 Hz.

Results are plotted below for the 4 locations where these recorders are installed:

1. RC Containment base mat elevation – Figures 2.1 and 2.2 in this Attachment
2. RC Containment RHR Flats elevation (231') – Figures 2.3 and 2.4 in this Attachment
3. Auxiliary Building base mat elevation (244') – Figures 2.5, 2.6, and 2.7 in this Attachment
4. Auxiliary Building elevation 273' near the CCHXs – Figures 2.8, 2.9, and 2.10 in this Attachment

The above plots of the Engdahl recorded accelerations include a comparison of the data to design OBE and DBE spectra for the corresponding Auxiliary and Containment elevations at 2% spectral damping.

As previously documented in this enclosure, it is the consensus of Dominion engineering and Dominion's consultants that the recorded data from the Kinometrics instruments (refer to Attachment 3), located on the basemat of the Unit 1 Containment Building at North Anna plant reflects the best source of earthquake time-histories and response spectra to determine whether the OBE and DBE at North Anna plant were exceeded. The Engdahl data, by comparison, is considered to be less reliable and concerns were raised over the adequacy of the recorded data based on differences between Engdahl and Kinometrics results and also the existence of several "zero" readings obtained at certain frequencies.

Containment Basemat Elevation

As demonstrated in Figure 2.1 for horizontal directions and Figure 2.2 for vertical directions, the Engdahl data for the Containment basemat elevation shows that OBE levels were exceeded. For DBE, however, there are only slight exceedances at a few frequencies.

Engdahl Scratch Plate Data

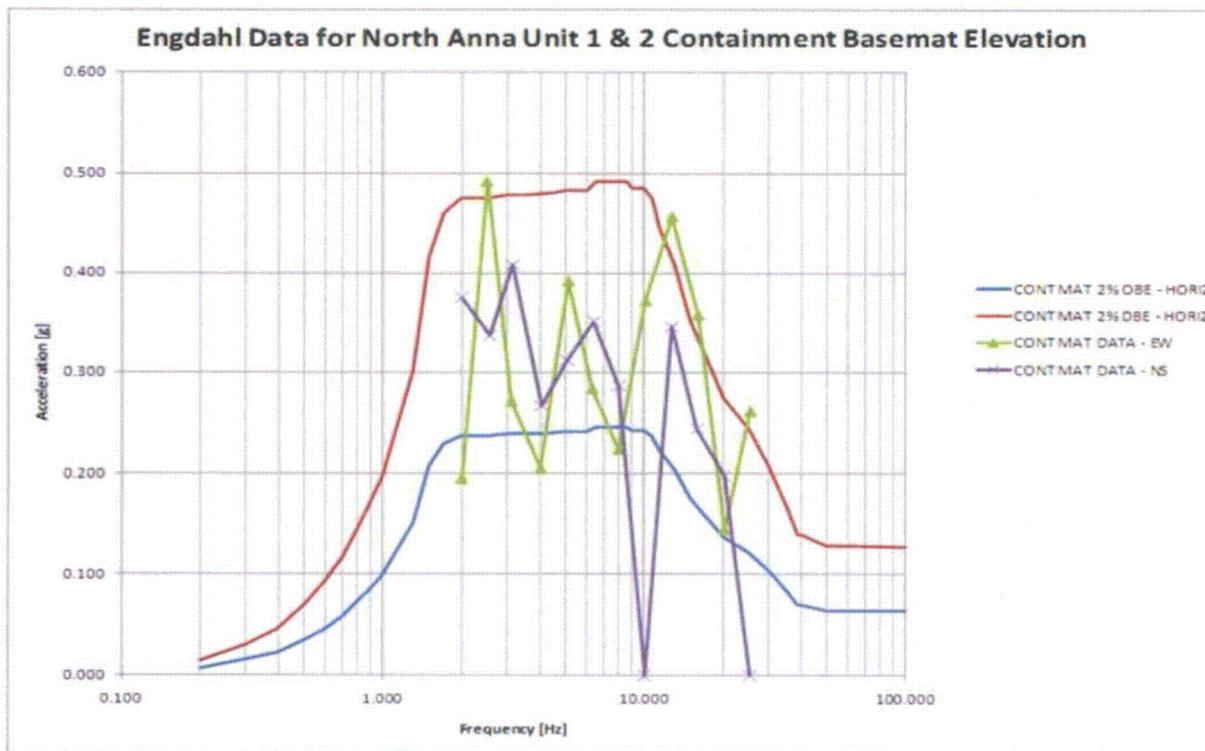


Figure 2.1 – Engdahl Data from Containment Basemat Recorder – Horizontal Directions

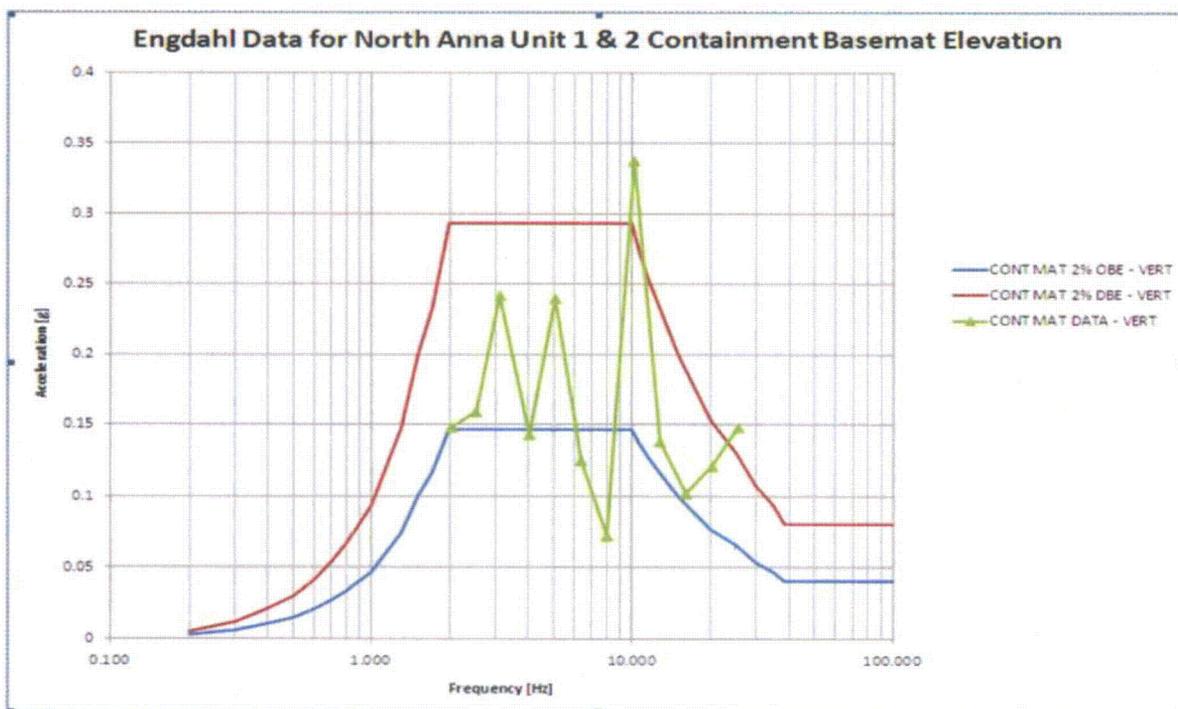


Figure 2.2 – Engdahl Data from Containment Basemat Recorder – Vertical Direction

Engdahl Scratch Plate Data

Containment RHR Flat Elevation (231')

As demonstrated in Figure 2.3, Engdahl recorded data in East-West and North-South directions at the RHR Flat elevation of Containment are less than OBE and DBE for frequency ranges up to approximately 16 Hz. Exceedances over DBE in the East-West direction occur around 25 Hz, in the high frequency range.

As demonstrated in Figure 2.4, Engdahl recorded data in vertical direction at the RHR Flat elevation of Containment exceeds OBE in several frequencies, but remains less than DBE.

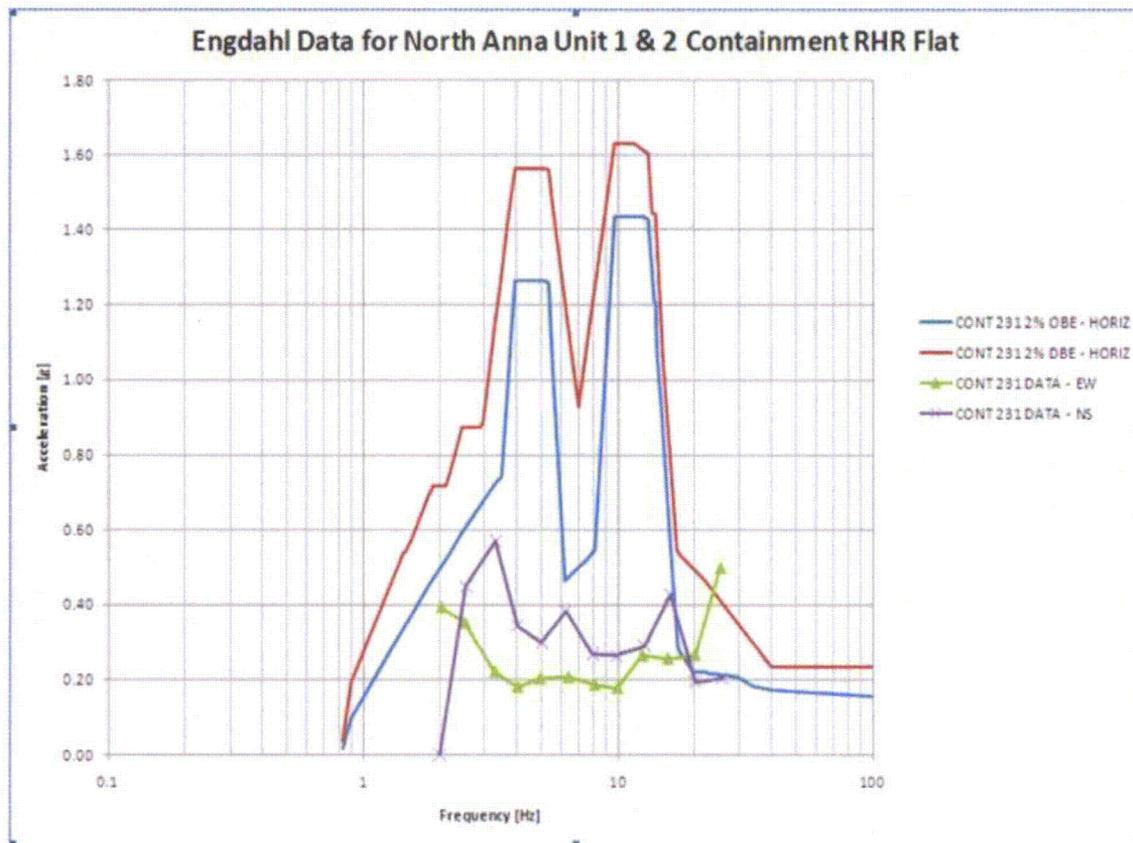


Figure 2.3 – Data from Containment RHR Flat Recorder – Horizontal Directions

Engdahl Scratch Plate Data

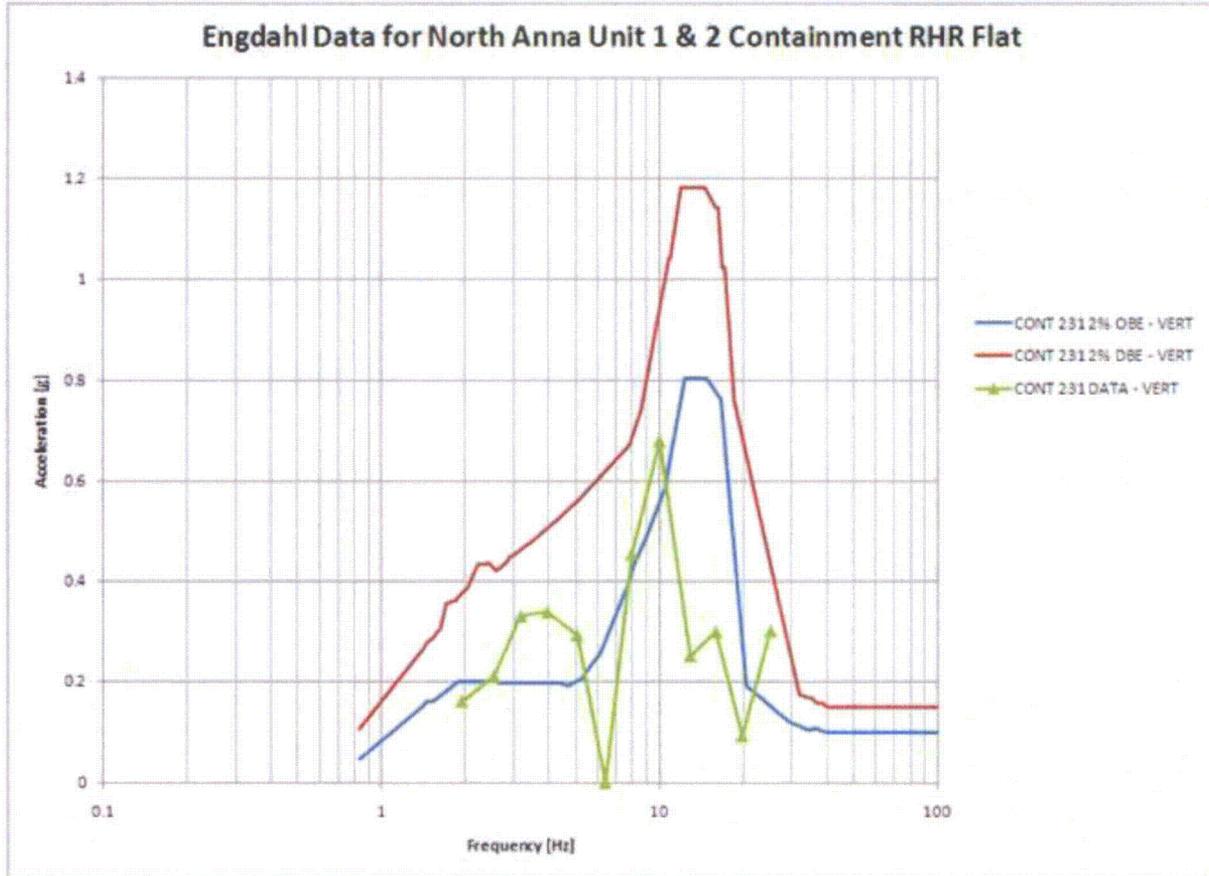


Figure 2.4 – Engdahl Data from Containment RHR Flat Recorder – Vertical Direction

Engdahl Scratch Plate Data

Auxiliary Building 244' and 273' Elevations

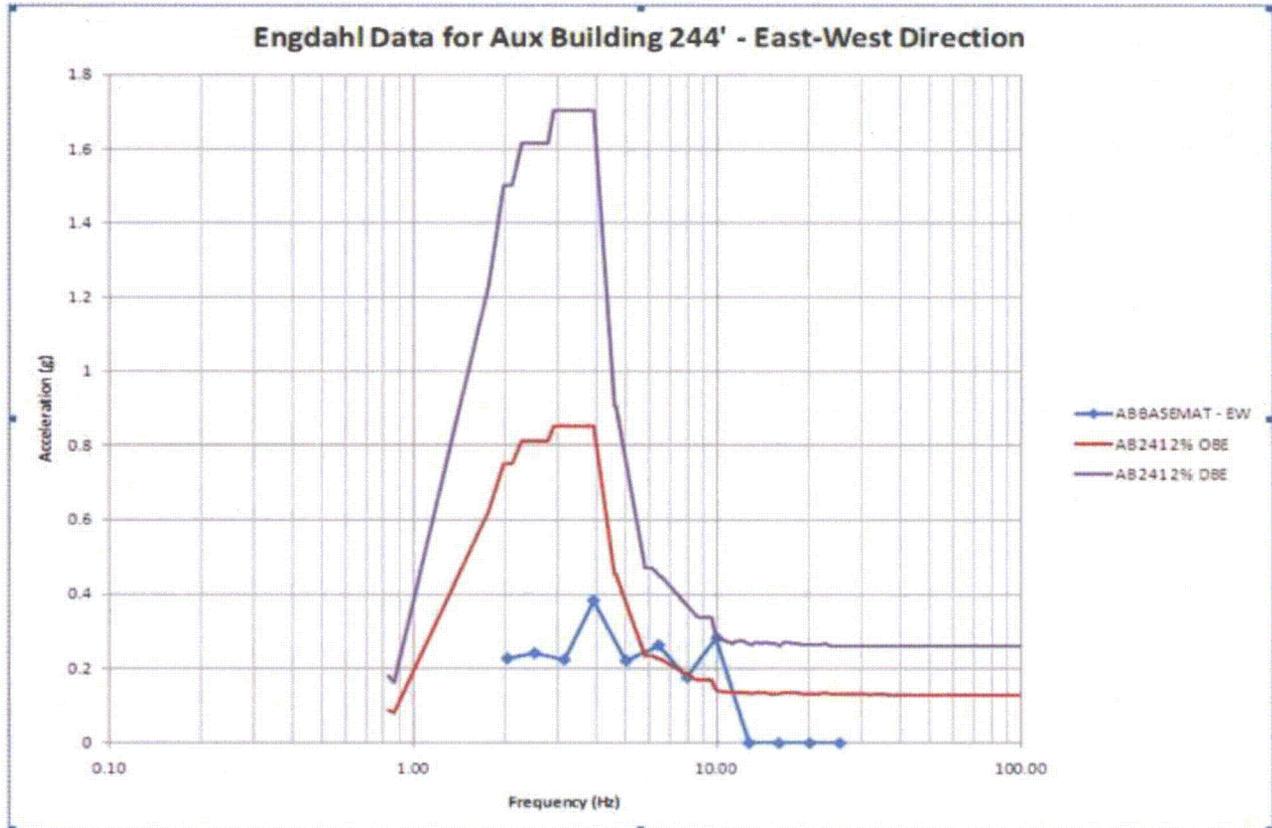


Figure 2.5 – Engdahl Data from Aux Building 244' Recorder – E-W Direction

Engdahl Scratch Plate Data

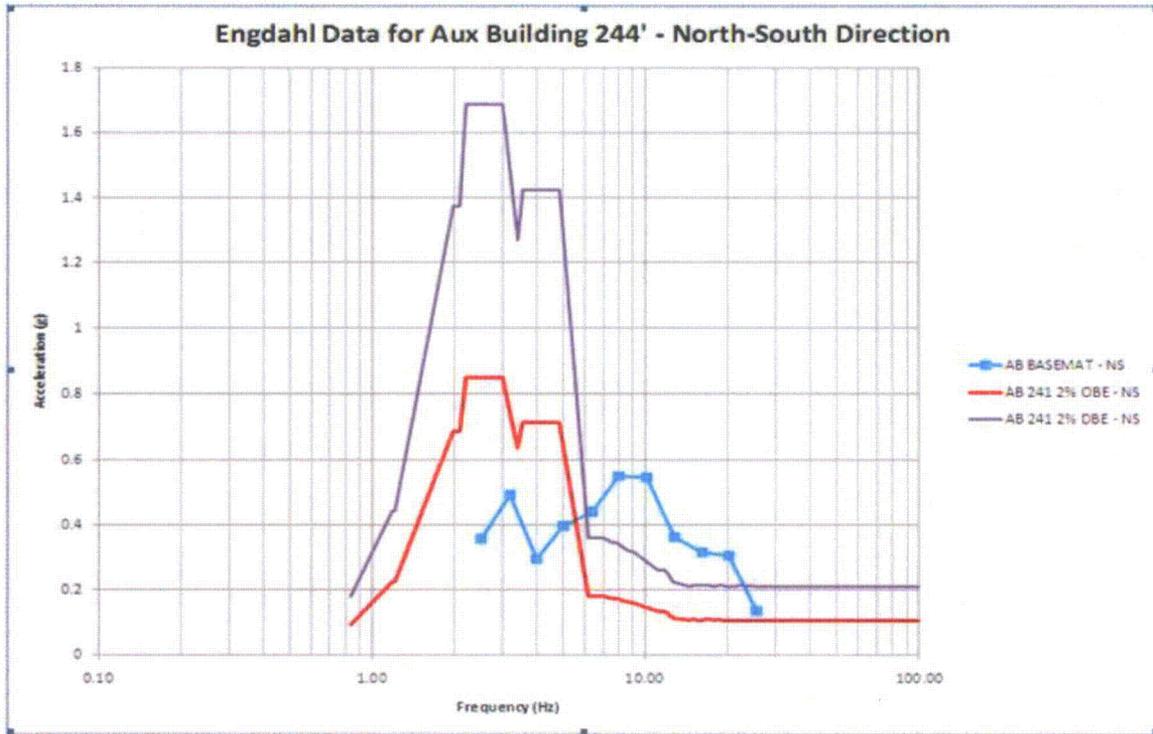


Figure 2.6 – Engdahl Data from Aux Building 244' Recorder – N-S Direction

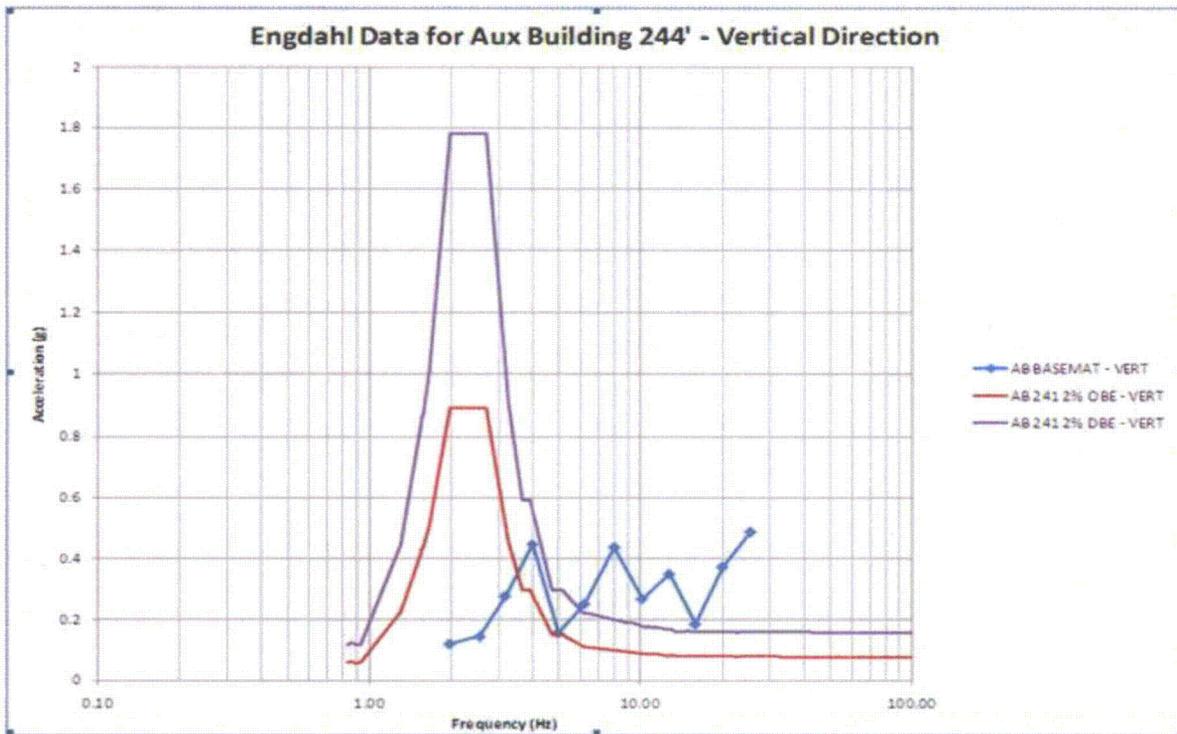


Figure 2.7 – Engdahl Data from Aux Building 244' Recorder – Vertical Direction

Engdahl Scratch Plate Data

Auxiliary Building 273' Elevation

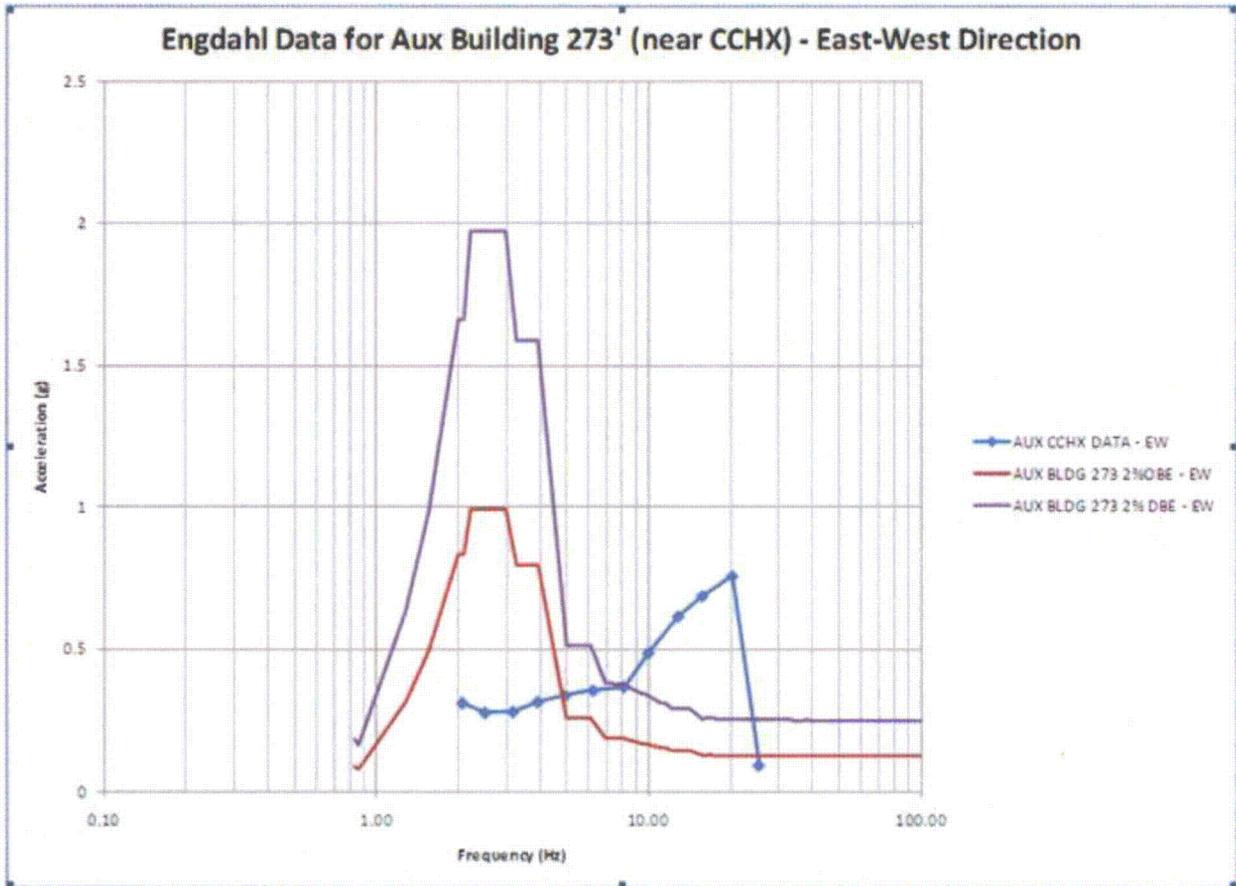


Figure 2.8 – Engdahl Data from Aux Building 273' Recorder – E-W Direction

Engdahl Scratch Plate Data

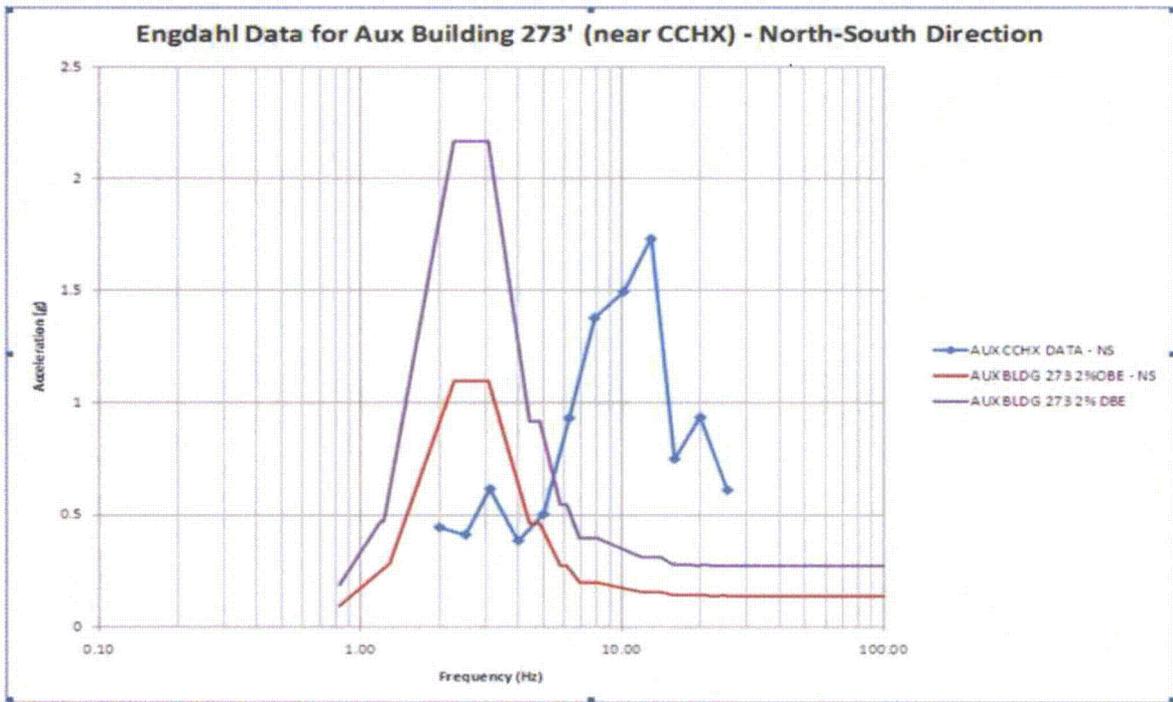


Figure 2.9 – Engdahl Data from Aux Building 273' Recorder – N-S Direction

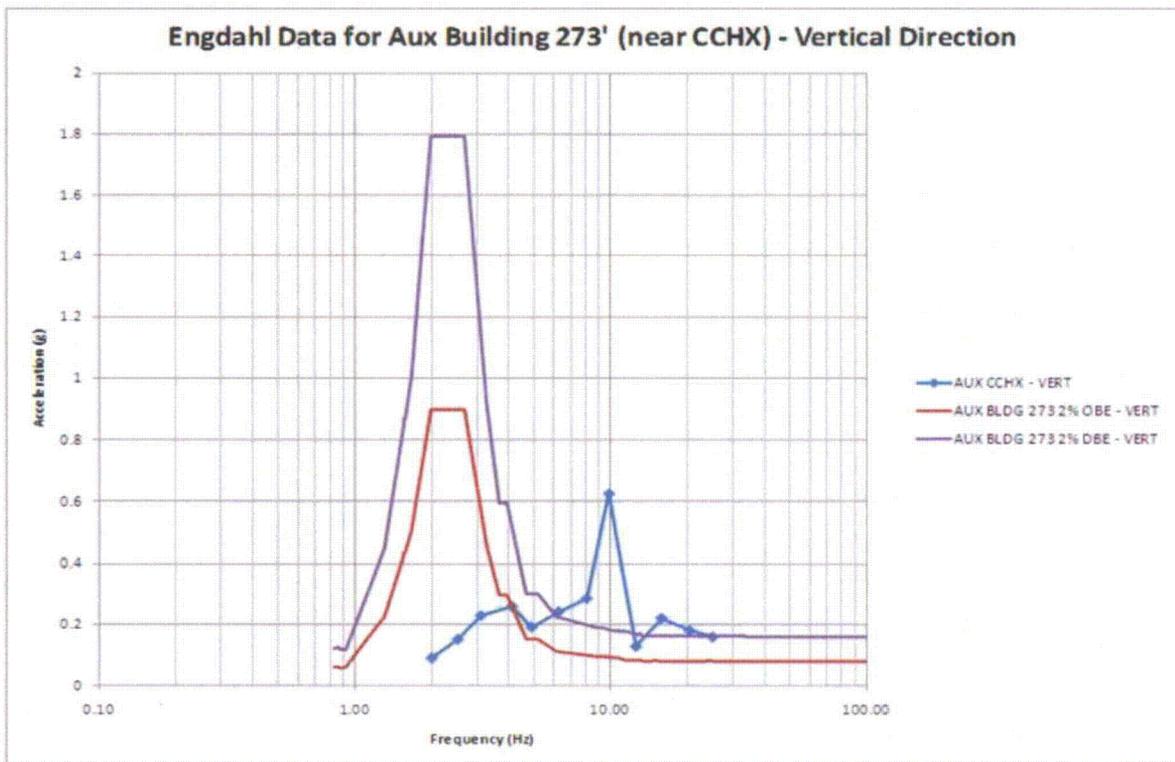


Figure 2.10 – Engdahl Data from Aux Building 273' Recorder – Vertical Direction

Kinematics Triaxial Recorder Data

Review and Comparison of the Data

The recorded data from the Kinematics Model FBA-3 Triaxial Time History Accelerograph Recorders were sent to the vendor for reading, calibration, and baseline correction. The results from the vendor are baseline-corrected time histories for the two elevations in Containment where these instruments are installed. The baseline correction appears to be reasonable based on a review of the velocity and displacement plots. The two elevations are the top of base mat elevation (216') and the 291' elevation. The time histories, which are digitized with 5 milliseconds intervals, are converted into response spectra up to 50 Hz. It is noted that the time interval of 0.005 second would give reasonably accurate spectral values up to about $(1/0.005)/10$ or 20 HZ, and some approximations may be introduced up to about 50 HZ. However, this is judged to be reasonable. The response spectra created from the Kinematics data in the following pages was developed by Kinematics, and by Dominion engineering using finite element analysis software from the recorded, baseline corrected time histories provided from Kinematics. Both Bechtel and SGH also independently calculated response spectra using the same time histories. As expected, the spectra are the same from these sources. The data have been confirmed to be consistent.

Containment Basemat, Elevation 216'

For the Containment basemat elevation, the results are plotted at 5% damping against the design OBE and DBE response spectra corresponding to the top of the basemat. Further, a comparison is made to the IPEEE response spectrum created using the NUREG/CR-0098 median-centered site ground motion for rock as input. As noted previously, the design basis OBE and DBE spectra are exceeded by the recorded data in several frequencies; however, the recorded data is enveloped by the IPEEE response spectra curve.

See Figures 3.1 and 3.2 for horizontal and vertical comparison, respectively.

Average Exceedance

As shown in Figures 3.1 and 3.2, the data shows that the OBE and DBE were exceeded in all three directions; however, for purposes of quantifying how much the recorded response spectra exceeds the design basis earthquake spectra, the average exceedance is calculated in the frequency range from 2 to 10 Hz. This calculation is made for the north-south and vertical directions only since the recorded spectrum in the east-west direction is completely enveloped in that range by the DBE spectrum. The range of 2 to 10 Hz is chosen since this is the range of frequencies associated with damage to engineered structures and much of the plant equipment as defined in EPRI report NP-5930 and Reg. Guide 1.166.

Kinematics Triaxial Recorder Data

Table 3.1 – Average Exceedance from 2 to 10 Hz

VERTICAL DIRECTION					NORTH-SOUTH DIRECTION				
Frequency [Hz]	DBE [g]	Recorded * [g]	Exceedance [g]	%Exceed	Frequency [Hz]	DBE [g]	Recorded * [g]	Exceedance [g]	%Exceed
2	0.219	0.1318	No Exceed	-39.81%	2	0.352	0.33836	No Exceed	-3.88%
2.25	0.219	0.1411	No Exceed	-35.59%	2.25	0.359	0.35321	No Exceed	-1.61%
2.5	0.221	0.1686	No Exceed	-23.70%	2.5	0.359	0.37645	0.0175	4.86%
2.75	0.222	0.2091	No Exceed	-5.79%	2.75	0.361	0.40261	0.0416	11.53%
3	0.222	0.2386	0.0166	7.46%	3	0.362	0.41980	0.0578	15.97%
3.25	0.222	0.2582	0.0362	16.30%	3.25	0.362	0.43222	0.0702	19.40%
3.5	0.221	0.2630	0.0420	19.02%	3.5	0.362	0.46852	0.1065	29.42%
3.75	0.22	0.2968	0.0768	34.92%	3.75	0.361	0.45424	0.0932	25.83%
4	0.221	0.3097	0.0887	40.12%	4	0.363	0.40768	0.0447	12.31%
4.25	0.221	0.2799	0.0589	26.63%	4.25	0.363	0.41682	0.0538	14.83%
4.5	0.221	0.2756	0.0546	24.71%	4.5	0.364	0.41936	0.0554	15.21%
4.75	0.224	0.2847	0.0607	27.12%	4.75	0.366	0.41089	0.0449	12.27%
5	0.224	0.2823	0.0583	26.02%	5	0.366	0.40077	0.0348	9.50%
5.25	0.227	0.2947	0.0677	29.81%	5.25	0.366	0.42666	0.0607	16.57%
5.5	0.227	0.2861	0.0591	26.04%	5.5	0.366	0.46472	0.0987	26.97%
5.75	0.227	0.2641	0.0371	16.33%	5.75	0.366	0.46155	0.0955	26.11%
6	0.227	0.2573	0.0303	13.33%	6	0.366	0.42878	0.0628	17.15%
6.25	0.227	0.2379	0.0109	4.82%	6.25	0.366	0.40593	0.0399	10.91%
6.5	0.227	0.2535	0.0265	11.66%	6.5	0.372	0.41769	0.0457	12.28%
6.75	0.227	0.2877	0.0607	26.75%	6.75	0.372	0.41214	0.0401	10.79%
7	0.226	0.3191	0.0931	41.21%	7	0.372	0.39544	0.0234	6.30%
7.25	0.224	0.3450	0.1210	54.03%	7.25	0.372	0.38257	0.0106	2.84%
7.5	0.224	0.3649	0.1409	62.90%	7.5	0.372	0.36939	No Exceed	-0.70%
7.75	0.224	0.3534	0.1294	57.77%	7.75	0.372	0.36049	No Exceed	-3.09%
8	0.224	0.3379	0.1139	50.84%	8	0.372	0.35955	No Exceed	-3.35%
8.25	0.226	0.3148	0.0888	39.28%	8.25	0.372	0.36656	No Exceed	-1.46%
8.5	0.226	0.2993	0.0733	32.44%	8.5	0.367	0.38500	0.0180	4.90%
8.75	0.226	0.2827	0.0567	25.10%	8.75	0.367	0.40535	0.0383	10.45%
9	0.226	0.2621	0.0361	15.99%	9	0.367	0.42293	0.0559	15.24%
9.25	0.226	0.2438	0.0178	7.89%	9.25	0.367	0.43923	0.0722	19.68%
9.5	0.226	0.2551	0.0291	12.88%	9.5	0.367	0.44551	0.0785	21.39%
9.75	0.226	0.2749	0.0489	21.65%	9.75	0.367	0.44426	0.0773	21.05%
10	0.226	0.2911	0.0651	28.80%	10	0.367	0.44791	0.0809	22.05%
AVERAGE EXCEEDANCE FROM 2 - 10 Hz				21.12%	AVERAGE EXCEEDANCE FROM 2 - 10 Hz				12.17%

* Read directly from Kinematics Data Report ("NAPS Containment Mat 5% OBE SSE (DBE).PDF")

As shown above, the earthquake exceeded the DBE, on average, by about 12% in the N-S direction with the sharpest peak exceeding the corresponding DBE spectral ordinate by a factor of about 1.3, and about 21% in the vertical direction with the sharpest peak exceeding the DBE by a factor of about 1.6.

Kinematics Triaxial Recorder Data

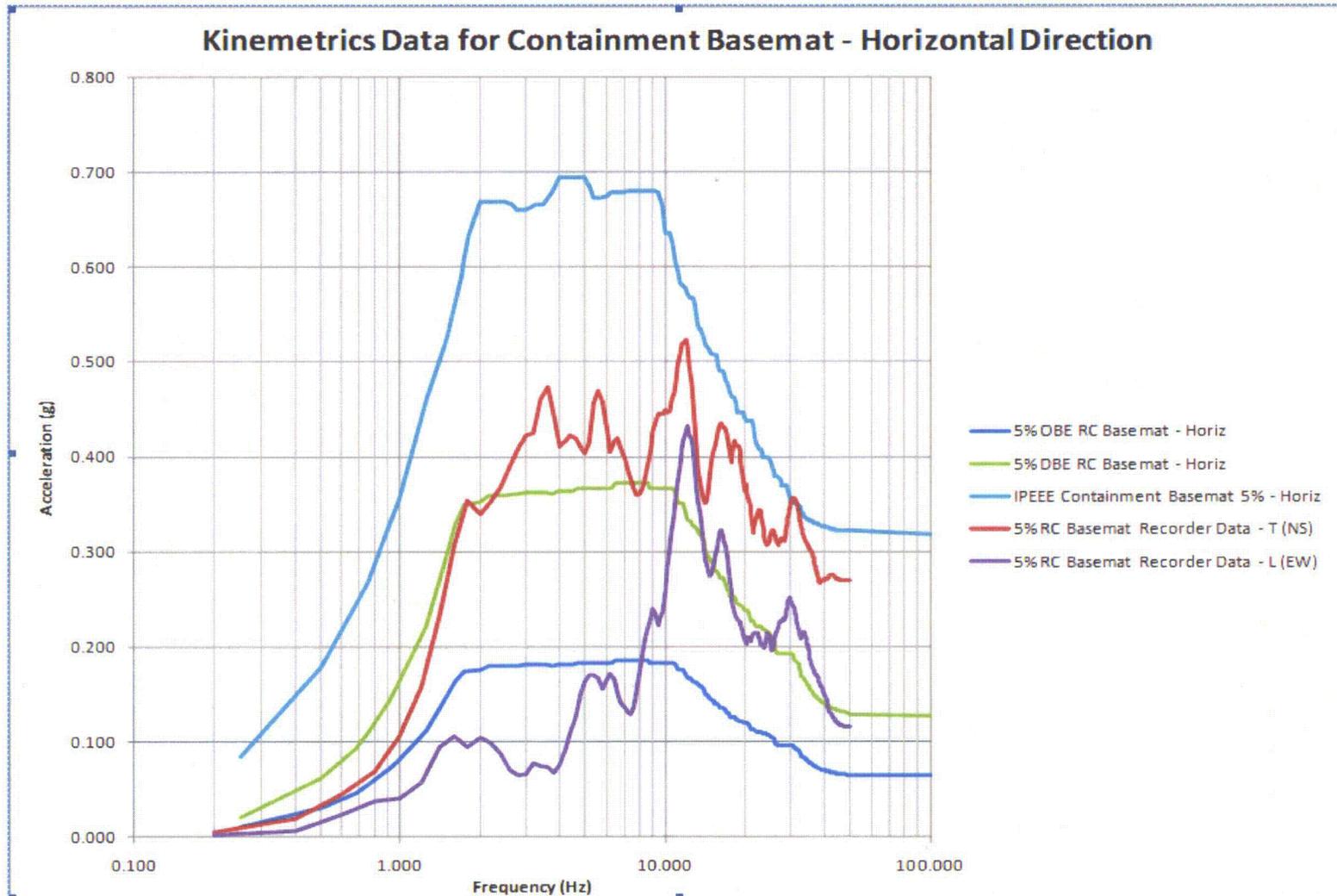


Figure 3.1 – Containment Basemat - Horizontal

Kinematics Triaxial Recorder Data

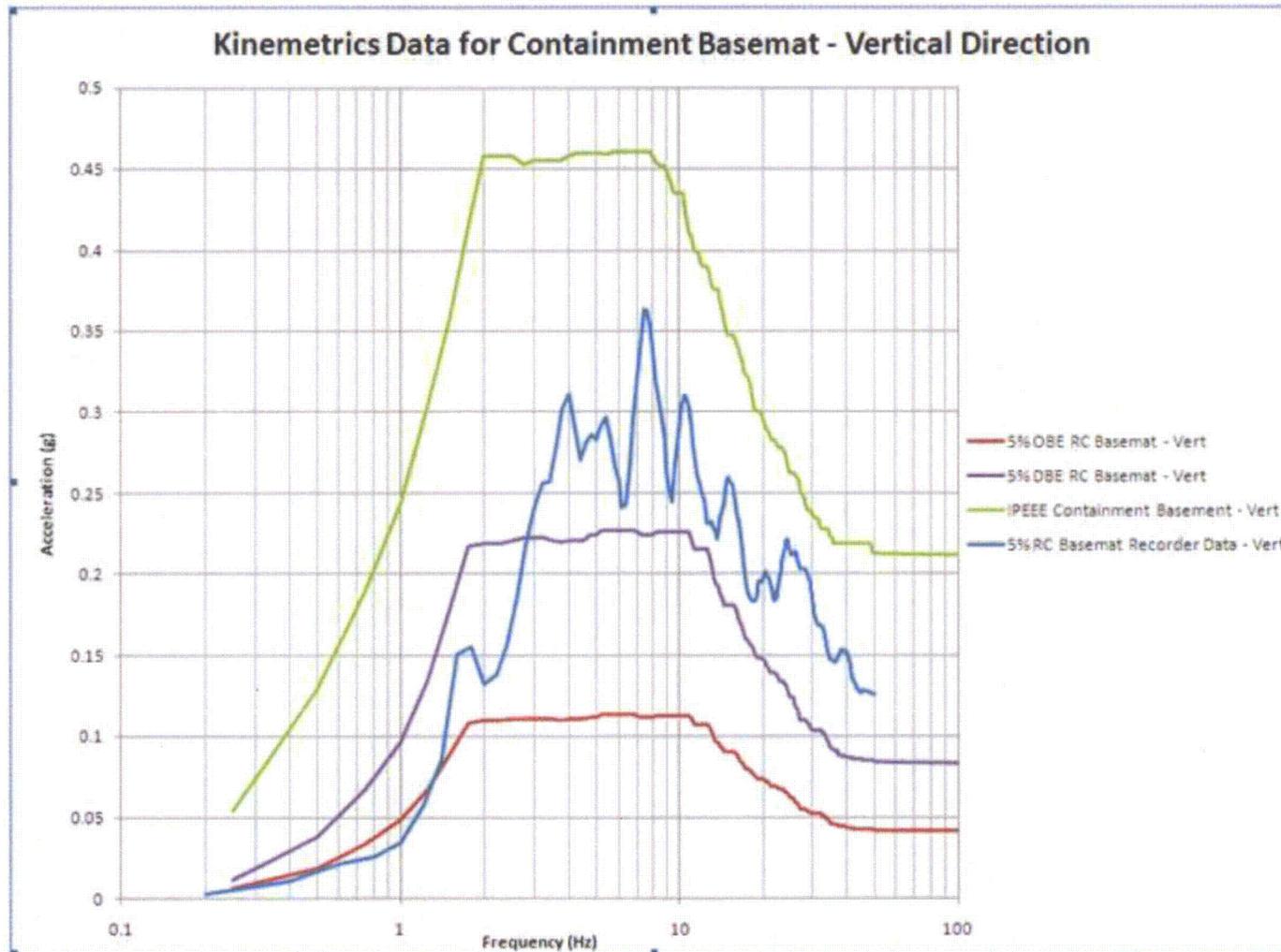


Figure 3.2 – Containment Basemat - Vertical

Kinematics Triaxial Recorder Data

Containment Operating Deck, Elevation 291'

For the 291' elevation of Containment, the Kinematics results are plotted at 5% damping against the design DBE response spectrum at the same elevation.

See Figures 3.3 and 3.4 for horizontal and vertical comparison, respectively.

Kinematics Triaxial Recorder Data

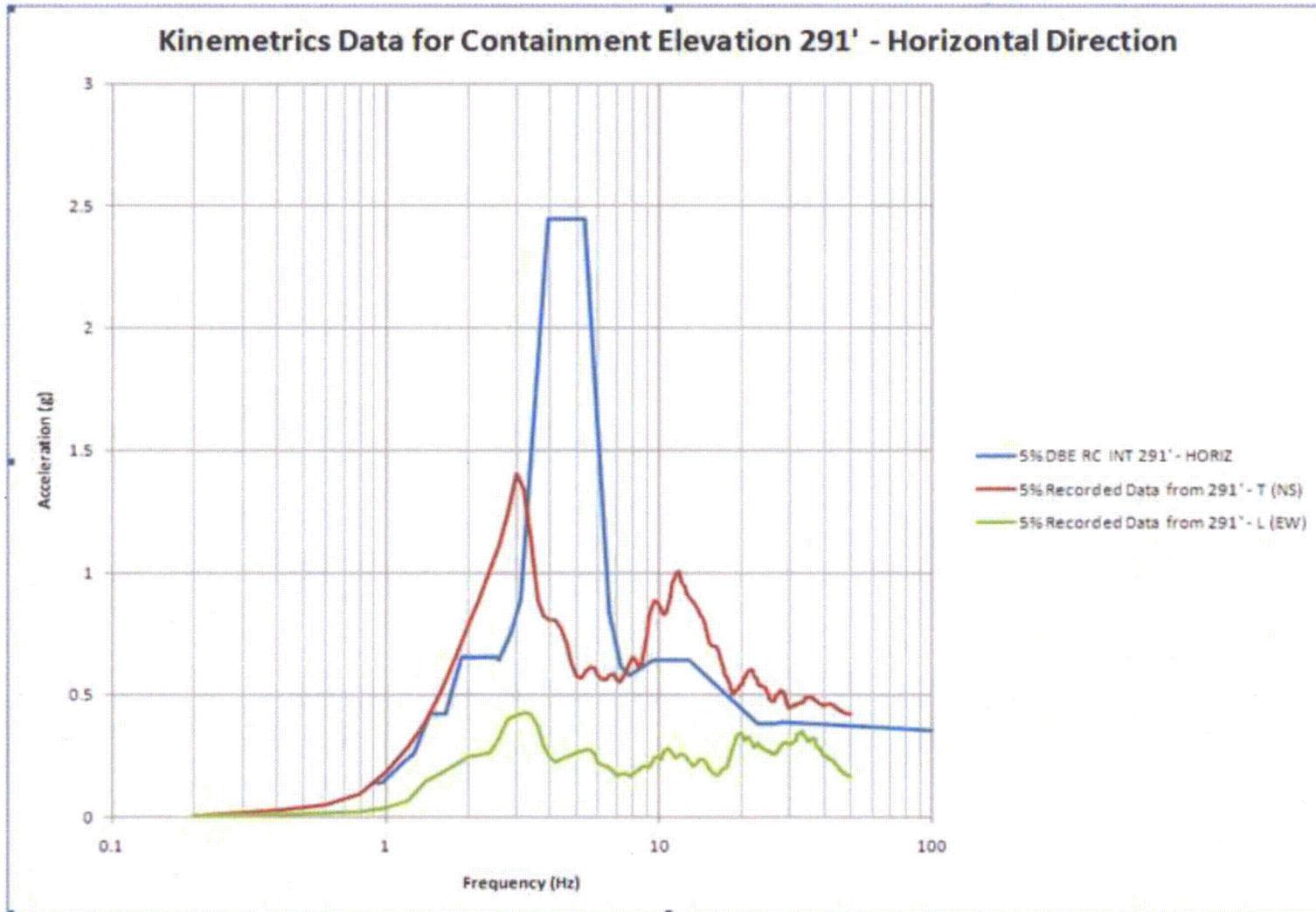


Figure 3.3 – Containment 291' Elevation - Horizontal

Kinematics Triaxial Recorder Data

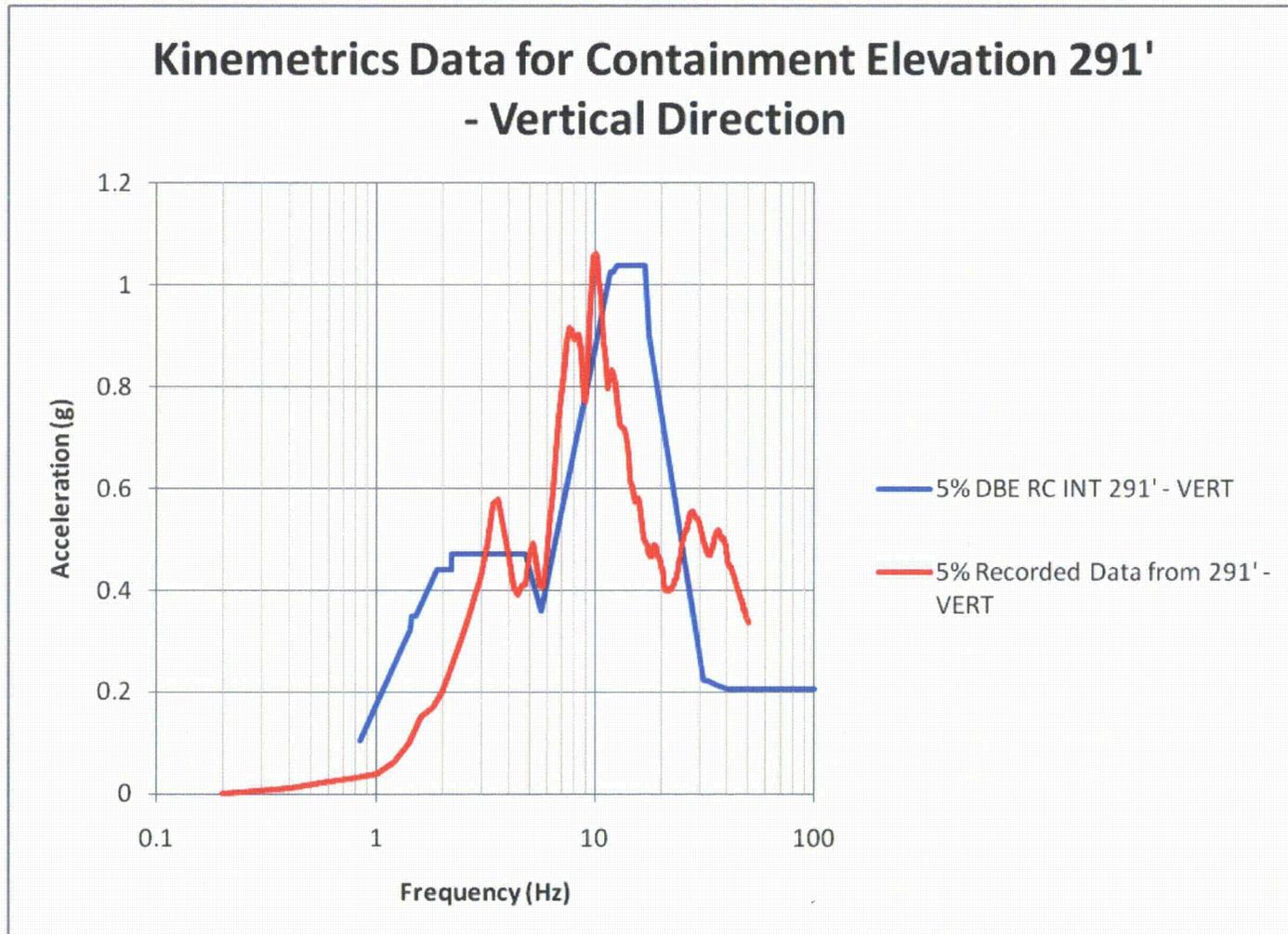


Figure 3.4 – Containment 291' Elevation - Vertical

Report of Inspections by a Seismic Review Team Including Industry Experts

Inspection Report Summary

On Friday, September 2, 2011, Dominion engineers were accompanied by several nuclear industry seismic experts for an inspection of North Anna Power Station looking for significant physical or functional earthquake-induced damage. The experts included the following individuals:

1. Robert P. Kennedy, Ph.D., RPK Structural Mechanics Consulting
2. Gregory S. Hardy, Senior Principal, Simpson, Gumpertz, & Heger (SGH)
3. Sanj Malushte, Ph.D., Bechtel Power Corporation
4. James R Martin Ph.D., Department of Civil Engineering and Environmental Engineering, Virginia Polytechnic Institute.
5. Russell A Green Ph.D., Department of Civil Engineering and Environmental Engineering, Virginia Polytechnic Institute.
6. Matthew R Eatherton Ph.D., Department of Civil Engineering and Environmental Engineering, Virginia Polytechnic Institute.
7. Martin C Chapman Ph.D., Department of Geosciences, Virginia Polytechnic Institute

The inspections were conducted in several plant locations and included a variety of plant equipment with an emphasis on areas/equipment where significant physical or functional earthquake induced damage would have been likely. Also, the inspection included non-safety related equipment and several of the low capacity items (i.e., HCLPF below 0.3g) identified during the IPEEE review. Areas and equipment inspected included the following:

- Emergency Condensate Storage Tanks (1-CN-TK-1) (On Grade - Yard)
- Refueling Water Chemical Addition Tank (1-QS-TK-2) (On Grade - Yard)
- Refueling Water Storage Tank (1-QS-TK-1) (On Grade - Yard)
- Primary Grade Storage Tanks (1-PG-TK-1A/B) (On Grade - Yard)
- Auxiliary Boiler Building (On Grade - Yard)
- Unit 2 Mechanical Equipment Room (291' elevation)
- Unit 2 Emergency Switchgear Room (254' elevation)
- Unit 2 Chiller Room (254' elevation)

Report of Inspections by a Seismic Review Team Including Industry Experts

- Unit 2 Main Control Room Area (273' elevation)
- Turbine Building (Multiple elevations), and
- Normal Condensate Storage Tanks (On Grade – Yard)

Inspection Results Summary

No significant physical or functional earthquake-induced damage was identified during the inspections conducted by the seismic expert review team. Some observations that could be speculated to be earthquake-induced damage were dispositioned as previously existing or not significant. A few minor non-earthquake related deficiencies were identified and are being tracked for disposition.

Enclosure 2

Post-Earthquake Inspections of Plant Structures, Systems and Components

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

Post-Earthquake Inspections of Plant Structures, Systems and Components

EPRI-NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," was used to develop the North Anna methodology for performing inspections to assess significant physical or functional earthquake-related damage to structures, systems, and components (SSCs). EPRI-NP-6695 provides guidelines for responding to an earthquake that include immediate, post-shutdown, and long-term actions, and based on the findings during each stage, the level of additional effort required to ensure the plant is ready for operation. The following excerpt was taken from EPRI-NP-6695, Section 3.2, and details the recommended post-shutdown actions:

1. **Focused Inspections.** These are detailed, visual inspections of a pre-selected sample of representative structures and equipment. The equipment and structures included in the focused inspections should be selected to sample all types of safety-related equipment and structures found in the nuclear power plant, and should include equipment and types of structures which are considered most likely to be damaged from an earthquake. The focused inspections should also include non-safety-related, non-seismic equipment and structures which experience has shown to be of low seismic capacity to serve as earthquake damage indicators. These inspections should be performed by engineers experienced in the observation and evaluation of earthquake related damage to industrial and power facilities. The purpose of these inspections is to determine the need for expanded inspections and tests and to provide data to establish the EPRI Damage Intensity.
2. **Determination of EPRI Damage Intensity.** Using the information collected during the focused inspections and other observations, a group of experienced engineers should establish the EPRI Damage Intensity for the event using the guidelines presented in Section 2 of this report. Using the results of these inspections and the assessment of the EPRI Damage Intensity, the future course of actions needed to restart the plant are identified in the Figure 3-2.
3. **Expanded Inspections.** In the event that damage to the pre-selected sample of equipment or structures is found, or the EPRI Damage Intensity is determined to be 1 or greater, expanded inspections by qualified engineers should be undertaken to further define and evaluate potential damage to all components, systems and structures required for operation. This information can then be used to: (1) establish corrective actions and repairs that may be required to return the plant to a state of operational readiness, and (2) identify the need and timing for additional analytical and other engineering evaluations which may be prudent to assure the long-term integrity and reliability of the plant.
4. **Surveillance Tests.** Surveillance tests required by Technical Specifications should be performed to verify the operability of equipment needed for plant operation.

Initial visual inspections were performed by engineering personnel immediately following the August 23, 2011 earthquake, and the subsequent aftershocks up to

August 26, 2011. The damage discovered during these inspections did not identify any significant physical or functional damage to safety-related SSCs and only limited damage to non-safety related, non-seismically designed SSCs. Condition Reports (CRs) were submitted for the identified discrepancies. The results of these and additional focused inspections supported an EPRI Damage Intensity of 0, which is defined in Table 2-1 in EPRI NP-6695. To confirm the EPRI Damage Intensity, conservative measures were taken to perform comprehensive and methodical expanded inspections of the plant to further assess the impact of the earthquake on plant SSCs. The expanded inspections performed as part of the post-shutdown actions defined in EPRI NP-6695 are discussed below. Surveillance tests will also be completed prior to Unit 1 and 2 startups, respectively, to further demonstrate that SSCs can perform their design functions. The testing effort is also discussed in greater detail below.

System Inspections

The comprehensive system inspections included over eighty-systems for Unit 1 (which includes common systems) and over fifty-systems for Unit 2. These inspections were performed in accordance with station procedure 0-GEP-30, "Post Seismic Event System Engineering Walkdown," which was developed using the guidance provided in EPRI NP-6695. Inspection results were documented in procedure inspection logs, and discrepancies were entered into the Corrective Action System. The inspections were performed by qualified engineering personnel who had been trained on identifying seismic related damage.

Structural Component Inspections

The structural component inspections consisted of safety related and non-safety related structural components that meet regulatory requirements for Maintenance Rule and contribute to the operation of the station. These components are identified in procedure ER-NA-INS-104, "Monitoring of Structures North Anna Power Station," and the inspections were performed in accordance with this procedure. Attachment 8 of ER-NA-INS-104, "Seismic Event Inspection," was created based on the EPRI-NP-6695 guidelines and details the inspections to be performed on concrete structures, steel structures, and low pressure tanks. The inspection team looked for significant physical or functional damage caused by the earthquake that exceeded the acceptance criteria. The acceptance criteria are defined in procedure ER-NA-INS-104 and meet the guidelines established in EPRI NP-6695. The inspection results were documented in accordance with procedural requirements. The inspections were performed by qualified engineering personnel as defined in ER-NA-INS-104.

Detailed Inspections

In accordance with methods developed for the IPEEE, the plant was evaluated to a median-centered ground response spectrum shape anchored to 0.3g peak ground accelerations. Calculations were performed to determine the high-confidence-of-low-

probability-of-failure (HCLPF) capacities of equipment and structures, and only a limited number of structures and components were determined to have HCLPF capacities below 0.3g. Thorough inspections of these components (with the exception of one group where relay chatter controlled the HCLPF capacity) are being performed by engineering personnel trained under the EPRI Seismic Qualification Utility Group (SQUG) course. The inspections are in progress and have not identified any evidence of significant physical or functional seismically related damage to date.

Electrical Inspections

For the 4160VAC, 480VAC, Vital/Semi-Vital 120VAC, and 125VDC equipment, the areas of focus consisted of four systems: Emergency Electrical (EE), Vital Bus (VB), Battery (BY), and Electric Power (EP). Comprehensive external inspections were performed in accordance with station procedure 0-GEP-30, "Post Seismic Event System Engineering Walkdown." Attachment 1, "Post Seismic Event Walkdown Checklist," of 0-GEP-30 contains the focus areas of these inspections for each type of equipment. In addition to the external inspections, an internal inspection was performed on the above mentioned equipment. This inspection was divided into categories of safety related systems and non-safety related systems. Safety related systems received nearly 100% internal inspections. For the non-safety related systems (EP), a sample of 10-15% of electrical cubicles, which contained various types of breakers and are located in several different plant locations and elevations, were internally inspected. Focus areas of the internal inspections were as follows: 1) Wiring pull-out from terminal blocks, 2) Damaged insulators (porcelain, ceramic, or plastic), 3) Wiring pull-out from lugs, 4) Wiring harness spacing issues, 5) Backed out or missing hardware from electrical bus work, 6) Foreign material, 7) Components that have become loose from electrical sockets, 8) Insulator damage to conductors, 9) Signs of electrical flashover, 10) Odd smells or sounds of resonance, and 11) Mechanical and Electrical misalignment. The inspection results were documented in the applicable inspection logs included in the procedure, and identified discrepancies were entered into the Corrective Action System.

A best effort visual inspection of the switchyard was initially conducted following the event. Additional inspections of the North Anna switchyard are currently being planned.

Potential for Hidden Damage

Although visual inspections have been performed, the possibility of "hidden damage", i.e., damage to SSCs that cannot be identified visually, was also considered. Based on the lack of significant physical or functional damage to safety-related plant SSCs, and only limited damage to non-safety related, non-seismically designed SSCs, identified in the System and Structural Component inspections, no hidden damage is expected. This is also based on review of industry insights from EPRI research related to the effect of the Niigata Chuetsu-Oki (NCO) earthquake of 2007 on the Kashiwazaki-Kariwa Nuclear Power Station (K-K) in Japan. Specifically, the NCO earthquake of 2007 was a Magnitude 6.6 earthquake that occurred on July 16, 2007 in the northwest Niigata region of Japan. The K-K plant is located approximately 15 miles from the epicenter of

the earthquake. While the NCO earthquake exceeded the seismic design basis of the plant, it consisted of less than ten cycles of significant motion at frequencies generally less than 4Hz. EPRI's post-NCO earthquake peer review and plant walkdown inspection observed no significant damage to safety related SSCs but did observe consequential damage to non-safety related facilities, such as that resulting from soil collapse. As a result of the earthquake and the consequent damage to non-safety related SSCs, an extensive review of the SSCs in the K-K plant was completed.

EPRI established an expert panel to address the potential for hidden damage in SSCs that were subjected to the July 16, 2007 NCO earthquake near the K-K plant. The panel adopted a multi-element working approach addressing both experimental and analytical elements. The experimental elements included both seismic testing and earthquake field observations. The analytical elements included both structural analysis and physics of failure modes. Using the multi-element approach, the panel determined six specific equipment items and four general issues that had a potential for hidden damage. The plant owner, Tokyo Electric Power Company (TEPCO), investigated the ten items identified as significant by the EPRI panel, and in addition, investigated another fifteen areas which the EPRI panel had identified as less significant items. In total there were twenty-five potential non-visible damage items investigated in more detail by TEPCO. TEPCO reported to EPRI that they did not have any abnormal findings for the ten items identified as significant by the panel. A second panel also reviewed the potential for hidden damage in concrete structures. This panel concluded that if no surface cracks were visible, then there would be no hidden damage since non-surface opening (interior cracks) will not occur, and, even if small interior cracks did exist, the concrete was designed to accommodate the cracks.

Also, the two earthquakes, NCO and Mineral, Virginia, have several differences. Most notably is the fact that the K-K plant had significant damage to non-safety related SSCs, while North Anna had only limited damage to non-safety related SSCs. This is expected, as indicated by the CAV calculated from the ground motion recordings of the two earthquakes. The CAV values for the NCO earthquake are, on average, about six times higher than the CAV values for the Mineral, Virginia earthquake. Based on the review of the hidden damage evaluation process at the K-K plant and the lack of any abnormal findings, we believe that North Anna's comprehensive walkdown and inspection effort, together with functional tests of systems and components that are being completed after the August 23, 2011 seismic event, are adequate to conclude that North Anna SSCs do not have any further potential for hidden damage and that hidden damage in concrete structures is highly unlikely.

Nevertheless, additional activities are being pursued to further validate the expectation of no hidden damage. Vibration monitoring, pump/motor oil analysis, and thermography are being used during performance testing where applicable. Increased station awareness of operations, maintenance, and engineering personnel has resulted in identification of potential seismically induced concerns, although to date none of these concerns for SSCs has identified any significant physical or functional damage as a result of the earthquake. Extent of condition reviews as part of the normal corrective

action process will also address any self-revealing "hidden damage". Also, in addition to the normal in-service inspection nondestructive examination activities planned for the ongoing Unit 2 refueling outage, additional Unit 1 and 2 sample weld inspections are planned for piping and pipe supports judged to be susceptible to a seismic event.

Although no hidden damage is expected based on the minimal damage observed visually, the activities discussed above are deemed adequate to identify any hidden damage from the seismic event, should it exist. In addition, the following specific actions have been/are being taken: 1) buried piping system pressure tests are being performed on the buried portions of Quench Spray, Recirculation Spray, and Service Water System piping, 2) dry transformers were inspected as part of the electrical system inspections, 3) station batteries were inspected with thermography, as well as individual cells checked using the associated periodic test, 4) float switches and induction relays are being tested as part of the scheduled functional tests, 5) long vertical pumps (e.g. Low Head Safety Injection and Outside Recirculation Spray Pumps) were tested, and vibration and tribological results were acceptable, 6) expansion anchor bolts were inspected, and some tightness checks were performed, and 7) a sampling of electrical connections were tested for tightness, and found to be acceptable.

Inspections of the North Anna Service Water Reservoir and the Main Dam

The North Anna Power Station Service Water Reservoir and Main Dam structures were inspected and evaluated following the August 23, 2011 seismic event. The Service Water Reservoir structure is classified as safety-related since it provides cooling for the Recirculation Spray Heat Exchangers when they are called upon to provide containment heat removal during a loss of coolant accident. The Main Dam is categorized as non-safety related with regulatory significance (NSQ) as it impounds Lake Anna and provides circulation water to the plant.

Available piezometric and settlement data at the Service Water Reservoir, and piezometric and drainage weir data at the Main Dam have been examined in response to the seismic event. This information, together with visual inspection observations, has been analyzed to determine if these structures and their appurtenances remain stable and capable of performing their design functions. The instrument data indicates that the pore water pressures and deformations are generally within the expected fluctuations, or are at levels that are insignificant and within typical structural tolerances for the facilities being considered. Inspections of these structures corroborated well with the instrument data and did not indicate any issues that would compromise their design functions. Based upon the available instrument data and the inspection observations, the Service Water Reservoir and the Main Dam sustained no significant physical or functional damage and remain capable of performing their intended design functions.

Inspection Results Summary

Comprehensive and methodical inspections of North Anna Units 1 and 2 SSCs were completed in accordance with station procedures. These procedures were created

/revised to incorporate EPRI NP-6695 guidance regarding post-shutdown inspections following a seismic event. The expanded inspections did not identify any significant physical or functional damage to safety related SSCs that would render them incapable of performing their design functions. Reported damage and observations from the earthquake include spurious actuation of the sudden pressure relays on the Reserve Station Service Transformers, limited cracking of ceramic / porcelain components on switchyard equipment, limited cracking of non-safety related walls, and movement of the Independent Spent Fuel Storage Installation casks. The most significant visual damage of a non-safety related SSC was spalled concrete on a condensate polishing tank support pedestal that did not affect function. The most significant damage that required repair of non-safety related equipment was Generator Step Up (GSU) transformer bushing leakage. This is a heavy bushing that projects out from the transformer and is primarily supported on one end; thus, this damage is not surprising. Other than the above items, no significant physical or functional seismically induced damage to non-safety related SSCs has been observed. The inspection results support an EPRI Damage Intensity of 0. Furthermore, based on the inspection results, as well as the EPRI research related to the effect of the 2007 NCO earthquake on the K-K nuclear plant, hidden damage is not expected to have occurred.

Surveillance Tests

Section 5 of EPRI NP-6695 provides guidelines for post-shutdown inspections and tests of nuclear plant equipment and structures required for operation prior to restart of a nuclear plant which has been shut down due to an earthquake which exceeds the OBE. To further evaluate the effect of the earthquake on the functionality of nuclear plant equipment, it recommends that surveillance tests, required to verify that the limiting conditions for operation as defined in the plant Technical Specifications (TS) are met, also be performed.

A Unit 1 and a Unit 2 list of the surveillance tests to be performed have been developed using guidance from EPRI NP-6695, Appendix B, "Typical Surveillance Tests for PWRs." To ensure a comprehensive test program is completed prior to restart, additional testing has also been included. Surveillance tests are being performed to demonstrate the availability and operability of components and systems important to nuclear safety or required to mitigate the consequences of an accident as identified in the TS. This will result in well over 400 surveillance tests being performed for Unit 1 prior to restart. In addition to the tests normally performed during a refueling outage, over 150 additional surveillance tests are being performed for Unit 2 prior to its restart.

Enclosure 3

Post-Earthquake Evaluation of the Reactor Vessel Internals

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

Post-Earthquake Evaluation of the Reactor Vessel Internals

The impact of the August 23, 2011 seismic event in Virginia on the ability of North Anna Units 1 and 2 Nuclear Steam Supply System (NSSS) Reactor Vessel (RV) internals to perform their design bases functions was assessed and is summarized below.

Design basis functions of the reactor internals are given in the North Anna Updated Final Safety Analysis Report (UFSAR) Section 4.2.2.

The design functions of the RV internals can be met as long as their structural integrity has been maintained. For this evaluation, the criterion used for structural integrity is that no dimensional changes occur (i.e., there is no yield in internals components). If this criterion is met, dimensions of the RV internals components are maintained. The RV internals will thus continue to perform their design functions. In this evaluation, the structural integrity confirmation is assessed by application of a conservative criterion to calculated load results from either the Operating Basis Earthquake (OBE) or Design Basis Earthquake (DBE), to confirm that margins exist.

Basis for Conclusion of Functionality

As noted in Enclosure 2, evidence of inspections is consistent with Damage Intensity 0 on the EPRI seismic damage scale. EPRI NP-6695 describes how prescribed inspections and tests are keyed to the severity of the earthquake. No specific inspections of reactor internals or associated components are specified in EPRI NP-6695 for Intensity 0 earthquakes. Since the earthquake produced only minimal damage to non-seismically designed equipment, and since there was no significant physical or functional damage to seismically designed systems, structures, and components that were examined following the event, there is a reasonable assurance that there was no significant physical or functional damage to RV internals, and that the RV internals remain functional and capable of performing their design functions. Additional evaluations of RV internals design margins have been performed based on existing design analyses of the structural integrity of the RV internals. These evaluations, in addition to the above-described reasonable assurance of continued functionality, support the conclusion that the earthquake resulted in no significant physical or functional damage to the RV Internals, and that the RV internals remain capable of performing their design bases functions.

Evaluation of RV Internals Loadings

The details of the dynamic analyses, input forcing functions, and response loadings are presented in UFSAR Section 3.9.1.2.3. The RV internals are modeled to determine dynamic loads produced by a reactor coolant loop (RCL) branch line pipe rupture (for both cold-leg and hot-leg breaks), and for the response due to operational-basis and design-basis earthquakes.

The following events are considered in the structural analysis of the RV internals:

1. Loads produced by a RCL branch pipe rupture for both cases (LOCA): cold-leg and hot-leg break.
2. Response due to a DBE.
3. Maximum stresses obtained in each case are added in the most conservative manner.

Only the loads calculated for a seismic event (either the OBE or DBE) are of interest for this evaluation. Calculated results from existing design analyses were evaluated for several key RV internals 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). This conservative criterion provides additional assurance that RV dimensions and geometry are maintained. The interface loads evaluated satisfied this criterion.

This provides a reasonable assurance that even though the seismic event of August 23, 2011 exceeded the OBE and DBE the RV internals will continue to satisfy their design bases functions. This conclusion is based on the system-wide evaluation above, using conservatively calculated design loads. To augment this analytical-based evaluation, one long-term action is identified relating to reactor vessel internals. This action is to develop a plan with the Nuclear Steam Supply System (NSSS) vendor consisting of additional evaluations or inspections, as warranted, to assure long term reliability of the reactor internals for North Anna Unit 1 and 2 (Enclosure 9). In addition, visual examination of the RV internals will be conducted following the Unit 2 fuel offload. Any identified discrepancies would be appropriately dispositioned through the Corrective Action System.

Conclusions

Results of system inspections and walkdowns conducted following the August 23, 2011 seismic event are consistent with Intensity 0 on the EPRI seismic damage scale [EPRI NP-6695 and Enclosure 1]. No significant physical or functional damage to seismically designed components (which includes reactor internals) is expected for an Intensity 0 event. No specific inspections of reactor internals are recommended in EPRI NP-6695 for an Intensity 0 classification. Since the earthquake produced only minimal damage to non-seismically designed equipment, and since there was no significant physical or functional damage to seismically designed systems, structures, and components that were examined following the event, there is a reasonable assurance that there was no significant physical or functional damage to RV internals, and that the RV internals remain functional and capable of performing their design functions. RV internals are designed to withstand combined seismic and LOCA forces; calculated loads on RV internals are dominated by LOCA forces, which did not occur during this event. The North Anna RV internals have been evaluated for loads generated during a

seismic event (either OBE or DBE), using results of existing design analyses. These conservatively calculated loads have margin when compared to a conservative allowable load (applicable to the OBE). These evaluations support the conclusion that the earthquake resulted in no significant physical or functional damage to the RV Internals, and that the RV internals remain capable of performing their design bases functions.

Enclosure 4

Post-Earthquake Assessment of New and Irradiated Fuel

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

Post-Earthquake Assessment of New and Irradiated Fuel

An earthquake occurred in the vicinity of the North Anna Power Station on August 23, 2011. As a result of its potential impact on station equipment, verification of the acceptability of the fuel assemblies and non-fuel core components in the new fuel storage area, the spent fuel pool, and the Unit 1 and Unit 2 cores must be performed. The purpose of this review is to identify the inspections that have been or will be performed to confirm that the recent seismic event at North Anna did not result in significant physical or functional damage to the fuel assemblies and the fuel insert components. These inspections allow for confirmation of the condition of both the new and spent fuel, as well as non-fuel core components such as control rods and burnable poison assemblies.

Discussion

Dominion is working with AREVA, the current fuel supplier for North Anna, to assess the margins in the fuel. For this evaluation, the acceptance criterion is that no plastic deformation is predicted. In addition, Dominion – with AREVA's input - has compiled a list of inspections to be conducted for fuel and fuel inserts in the new fuel storage racks and spent fuel pool, and during offload of the Unit 2 core, to verify the acceptability of the Unit 2 fuel for use or reuse. Unit 2 fuel will be examined prior to the Unit 1 startup. The Unit 2 fuel will be used to assess the condition of the Unit 1 fuel. If the Unit 2 fuel meets all of the inspection criteria described herein, no inspections of Unit 1 fuel are planned.

The EPRI "Guidelines for Nuclear Plant Response to an Earthquake" (Reference 1) only mentions fuel and controls rods briefly. Results of physical inspections indicate the seismic event damage is consistent with Intensity 0 on the EPRI seismic damage scale. Reference 1 describes how prescribed inspections and tests are keyed to the severity of the earthquake. No specific inspections of fuel or associated components are specified in Reference 1 for Intensity 0 earthquakes. Since the earthquake did not produce any significant physical or functional damage to safety-related plant SSCs and only limited damage to non-safety related, non-seismically designed SSCs that were examined following the event, there is reasonable assurance that there was no significant physical or functional damage to the fuel, and that the fuel remains functional and capable of performing its design functions. The inspections described herein provide additional confirmation of the expectation that the earthquake resulted in no significant physical or functional damage to the fuel or fuel inserts, and that they remain fully functional and capable of performing their design basis functions.

Miscellaneous Inspections to Support Fuel Inspections

The following inspections have been performed:

- Prior to any movement of fuel assemblies for inspection, the handling equipment - including handling tools, new fuel elevator and bridge crane - was verified as operational using functional checkouts required in the fuel handling procedures.

- The racks are predicted to move during a DBE (Reference 2). The spent fuel storage rack arrays were inspected to confirm that the racks had not shifted significantly or become distorted during the earthquake. This was accomplished by verifying that the indexing used on bridge crane remains accurate and can still be used to remove or insert fuel assemblies into rack. The indexing coordinates were verified by inserting and removing the dummy fuel assembly in at least one empty spent fuel cell in each rack. Recent videos of the rack cells taken after the earthquake were also compared with previously existing videos of the racks to confirm there was no apparent damage of the supports for the storage racks.
- The dummy fuel assembly was lifted and visually inspected prior to its use for any other system checkouts or verification.

New Fuel Storage

At the time of the earthquake, there were eighteen new fuel assemblies in the new fuel storage area, eleven of which contained burnable poison rod assemblies (BPRAs). In addition, there was one new BPRAs hanging from a support plate in a new fuel storage cell. The 18 fuel assemblies were free standing in their storage cells and thus able to move and contact the cell walls during a seismic event. There is slightly more than ½ inch clearance between the cell and the assembly if it is sitting to one side of the cell. These 18 assemblies were visually inspected for any evidence of impact between the storage cell and the grids or any other parts of the assembly. This inspection was performed when the assemblies were moved to the spent fuel pool and was more involved than the normal new fuel receipt inspections. AREVA provided recommendations on the scope and criteria to be used during these inspections. All 18 assemblies were found to satisfactorily meet the inspection criteria.

Prior to moving any assemblies, an inspection of the underneath portion of the New Fuel Storage area was conducted to ensure there was no significant physical or functional damage or distortion that would lead to interferences between the assemblies and the storage cells when raising the fuel assemblies. There were no issues identified from that inspection that indicated conditions exist that would result in any adverse impact on the fuel.

The eleven BPRAs that were in new fuel assemblies were each lifted a short distance by hand and lowered back into the assembly to ensure that they would self-seat. Additional inspections were performed on these eleven BPRAs in accordance with the AREVA recommendations, including inspections of the nuts and welds connecting the poison rodlets to the BPRAs baseplates and, while the BPRAs were slightly raised, inspecting the BPRAs rodlets for dents or abrasions to the extent possible. The BPRAs that was currently hanging from the support plate was inspected when it was removed from the support plate and placed in a fuel assembly. AREVA provided separate inspection recommendations for this BPRAs. The inspected BPRAs were determined to satisfactorily meet the inspection criteria.

Spent Fuel Pool

The spent fuel pool rack cells are 8.875 inches square on the inside. There is slightly less clearance between the fuel and the cell walls in the spent fuel racks compared to the new fuel storage cells, and the potential for fuel damage in the spent fuel pool is further reduced by hydraulic damping effects. Nevertheless, the following inspections were performed:

- Five new fuel assemblies scheduled for use in Unit 2 Cycle 22 that were placed into the spent fuel pool prior to the earthquake were video inspected for any signs of damage. These assemblies were inspected in accordance with the recommendations provided by AREVA.
- During preparation of the spent fuel pool prior to the Unit 2 offload, a pre-offload fuel shuffle was performed. During this shuffle, a sample consisting of ten of these assemblies was also video inspected for any signs of damage.

When inspecting these irradiated assemblies, recommendations provided by AREVA were used to supplement Dominion's normal criteria for irradiated fuel inspections. The population of new fuel assemblies and pre-offload shuffle assemblies inspected provides a representative sample of the fuel designs and storage locations across the spent fuel pool. The fuel assemblies examined during these inspections satisfactorily met the inspection criteria.

Unit 1 and Unit 2 Cores

There are currently no failures in the Unit 2 core and an estimated two failed rods in the Unit 1 core, which were identified earlier in the operating cycle. The Unit 1 and Unit 2 RCS coolant activity following shutdown was consistent with the known fuel condition at the time of the earthquake, and indicated that no fuel failures occurred in either unit as a result of the earthquake.

The lateral clearances between fuel assemblies and between the fuel assemblies and the core baffle are very small. It is expected that any impact loading between assemblies was small enough that no damage to grids would have occurred. Binocular visual inspections of the Unit 2 assemblies are conducted during offload and during normal detailed visual inspection (using video) of a sample of the assemblies in the core. During these video inspections, additional attention will be given to the grids to look for distortion or any deflection of the inner grid straps and mixing vanes. As necessary, assembly movement will be stopped at grid elevations and camera angles will be varied to allow the best possible visual inspection of the grid structure. If the vertical acceleration was sufficient to lift the core and compress the top nozzle hold down springs, some indications may appear on the springs or on the corner pads if the springs bottomed out. Detailed inspections of the side of the nozzle when the benchmark inspections are being performed should identify any such damage to the nozzles.

Dominion fuel inspection procedures requires inspection of each fuel assembly with binoculars or by camera during the offload, and a detailed video inspection of a sampling of assemblies after the offload. These binocular and video inspections are normal outage scope work. During the Unit 2 fuel offload, the 157 assemblies in the core will be visually inspected using binoculars or a camera for any signs of damage. Prior to the earthquake, thirteen assemblies had been selected for inspection during the North Anna 2 refueling outage, and video inspections will also be performed on additional assemblies recommended by AREVA that resided in core locations that are most susceptible to seismic damage. This level of video inspection is consistent with the approach identified in Reference 3 (only inspecting a sample of the fuel assemblies since no fuel failures were indicated by the Unit 2 radiochemistry data). Additional inspection criteria provided by AREVA will be used during these detailed video inspections.

Based on recent North Anna experience, it is expected that the visual inspections during the Unit 2 core offload will identify excessive fuel rod bow in some of the fuel assemblies. Any of these assemblies that are slated for reuse will also be inspected for any sign of seismic damage during the detailed video inspection campaign, using the AREVA criteria. Fuel assemblies with excessive fuel rod bow that are not planned for reuse will be inspected to normal Dominion criteria.

The operability determinations (ODs) previously prepared for the fuel rod bow concern in AREVA fuel will be formally reviewed, although the recent seismic event is not expected to impact the fuel rod bow ODs. The RCS radiochemistry data indicates there are no fuel rod failures in Unit 2, and shows no indications of new fuel failures in either unit resulting from the earthquake. Additionally, grid deformation that might be seen during a combined seismic and LOCA event would not impact the fuel rod bow phenomenon. The fuel assembly's ability to maintain a coolable geometry is the main concern associated with grid deformation. While the fuel rod bow phenomenon causes the closure of one water channel, it also opens the water channel on the opposite side. Therefore, the assembly's ability to maintain a coolable geometry is not compromised by fuel rod bow, even with possible grid deformation.

Acceptable results of the visual inspections performed during the Unit 2 offload, together with acceptable results of the detailed video inspections of fuel assemblies in the core during the earthquake that are inspected to the additional criteria provided by AREVA, will support the continued use of Unit 1 fuel without inspection.

When the units tripped during the recent seismic event, all control rods fully inserted. However, testing will be performed to confirm that the rod cluster control assemblies (RCCAs) still freely travel within the fuel assembly guide tubes. After the Unit 2 offload, the RCCA drag loads will be measured in the spent fuel pool to assess whether the fuel assembly or the RCCAs have any distortion. Post-latch drag testing and hot rod drops of the RCCAs are already required as part of the normal start-up activities and will insure that the RCCAs and CRDMs are functional. A video inspection of the RCCA central hubs will be performed to provide additional confirmation of RCCA integrity. A satisfactory assessment of the Unit 2 RCCAs (rod drag measurements and spent fuel

pool video inspections) will provide assurance that the Unit 1 RCCAs are in a similar condition. Although normally required only at BOC, hot rod drop testing of the Unit 1 RCCAs in accordance with normal station procedures will be performed prior to the restart of Unit 1 to confirm the continued acceptable condition of the Unit 1 RCCAs.

Conclusions

Table 1 lists the inspections that were mentioned in this Enclosure. Completed tasks are identified.

The inspections listed in this Table will permit assessment of the condition of the fuel assemblies in the new fuel storage area, spent fuel pool, and North Anna Unit 1 and Unit 2 cores at the time of the earthquake. If the inspection results are satisfactory, the fuel assemblies can be considered acceptable for use or reuse. If any significant seismic damage is observed during any fuel inspections, then the scope of the program (defined herein) will be reassessed.

References

1. EPRI Report NP-6695, "Guidelines for Nuclear Plant Response to an Earthquake," December 1989.
2. "A Summary of Information in Support of Increasing the Spent Fuel Storage Capacity at North Anna Power Station Units 1 and 2," Attachment 3 to Letter from R. H. Leasburg to H. R. Denton (U. S. NRC), "Amendment to Operating Licenses NPF-4 and NPF-7, North Anna Power Station Unit Nos. 1 and 2, Proposed Technical Specification Changes," Serial Number 450, August 20, 1982.
3. EPRI Report No. 1016317, "EPRI Independent Peer Review of the TEPCO Seismic Walkdown and Evaluation of the Kashiwazaki-Kariwa Nuclear Power Plants," January 2008.

**Table 1
Fuel and Miscellaneous Inspections**

Area	Task	Status
New Fuel Storage	Inspect BP1729 (hanging from support plate in new fuel storage cell) when transferring to new fuel assembly 13L. Use AREVA Inspection criteria.	Complete
	Inspect 18 New Fuel Assemblies prior to transfer to SFP. Use AREVA inspection criteria.	Complete
	Inspect 11 BPRAs in Fuel Assemblies. Use AREVA inspection criteria.	Complete
	Drag test 7 New Fuel Assemblies.	Complete
Spent Fuel Pool	Inspect a sample (10) of assemblies during the pre-offload shuffle. Video inspect according to the normal benchmark video inspection requirements.	Complete
	Inspect a sample (5) of new fuel assemblies and BPRAs. Use AREVA inspection criteria.	Complete
Unit 1 Core	Hot Rod Drop Tests. Follow standard North Anna procedure used at BOC.	See Enclosure 8
Unit 2 Core	Prior to core offload, inspect top nozzle locking lug position of two assemblies. Ensure positive lock of the quick disconnect mechanisms.	Complete
	Verify RCCAs still freely travel within the fuel assembly guide tubes. Measure RCCA drag loads in the spent fuel pool.	See Enclosure 8
	Perform routine binocular visual inspection during core offload. Any anomalous conditions will be video inspected.	See Enclosure 8
	Perform video inspections on 13 benchmark assemblies and AREVA recommended fuel assemblies. The AREVA recommendations include fuel assemblies from specific core locations susceptible to grid damage during seismic events.	See Enclosure 8
	Perform video inspection of RCCA central hubs.	See Enclosure 8
	Perform video inspections on assemblies with any anomalies observed during binocular inspections. Part of normal outage scope. Normal Dominion irradiated fuel inspection criteria apply. Assemblies planned for reuse will also be inspected to the AREVA criteria.	See Enclosure 8

Area	Task	Status
Unit 2 Core (cont.)	Post-latch drag testing and Hot Rod Drops. Both are part of normal outage scope and will follow standard North Anna procedures.	See Enclosure 8
Miscellaneous Inspections	Prior to picking up any fuel, verify that all handling equipment including handling tools, new fuel elevator, and bridge crane are operational prior to fuel inspections.	Complete
	Visually inspect dummy fuel assembly prior to picking up other fuel in spent fuel pool and prior to moving new fuel to pool.	Complete
	Visually inspect spent fuel storage racks for indications of significant rack movement and distortion prior to fuel movement. Functionally verify no significant change to indexing coordinates by inserting and removing dummy fuel assembly at a minimum of one per rack.	Complete

Enclosure 5

Post-Earthquake Assessment of Spent Fuel Storage Racks

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

Post-Earthquake Assessment of Spent Fuel Storage Racks

The purpose of this assessment is to summarize the results of inspections and testing that were performed to confirm that the spent fuel storage racks are able to perform their intended design function after the seismic event on August 23, 2011. Inspections and functional testing of the spent fuel storage racks were performed to confirm their current structural condition prior to the offload of fuel assemblies from either core.

Spent fuel storage rack descriptions and design function from Reference 1 and consistent with UFSAR Section 9.1.2:

The spent fuel storage racks are classified seismic Category I and are designed to withstand the effects of the DBE and yet remain functional and maintain subcriticality.

The storage cell structure, acting in concert with the rack base and the rack support feet, provides the structural strength and stiffness characteristics required for the rack to accommodate the applicable seismic accelerations presented for NAPS. No wall bracing or attachments are required to support the fuel racks under any design condition. Sufficient space is provided between adjacent spent fuel racks to preclude impact/collision in the event that sliding occurs during a seismic event.

The spent fuel pool criticality analysis of record was submitted to the NRC and subsequently approved in References 3 and 4. This analysis eliminated the spent fuel storage rack Boraflex credit. Therefore, the post-seismic condition of the Boraflex panels is not important to the design function of the spent fuel storage racks.

The following inspection and test have been performed on the spent fuel storage racks post-earthquake:

1. Foreign Object Search and Retrieval (FOSAR) video of the spent fuel storage racks, and
2. Insertion of the dummy fuel assembly into two empty cells in all 16 spent fuel storage racks.

The FOSAR video inspection (performed on September 5, 2011) shows the entire spent fuel storage racks after the earthquake. Review of this video does not show any significant physical or functional damage to the spent fuel storage racks (i.e., the racks as a whole are still fully intact and supporting all the fuel assemblies as intended by the design). The racks have sufficient spacing, and there is no evidence that they came into contact with each other or the walls of the spent fuel pool. In particular, the spacing between rack modules and the gap between the rack modules and the wall appear unchanged from pre-earthquake conditions. Sliding of the racks during an earthquake is consistent with the design and hypothesized seismic behavior, as stated in the design function discussion above. The observation that the post-seismic spent fuel storage rack gaps are not abnormal and no significant physical or functional damage was found supports a conclusion that even if sliding occurred, the spent fuel storage racks are still

properly positioned, and continue to be able to support the movement and storage of fuel assemblies.

To confirm the structural integrity of the spent fuel racks, a sample of images of individual spent fuel storage cells in the September 5, 2011 FOSAR video were viewed in detail, and compared to existing images from pre-earthquake fuel inspections in the spent fuel pool¹ to determine if any change in appearance occurred that could possibly be attributed to the earthquake. Specifically, the connecting bars (called tie-plates) between the individual cells were visually examined. Some of these tie-plates were observed to have a dimensional discrepancy to the design drawing when viewing the September 5, 2011 FOSAR video inspection. However, the comparison results from racks throughout the spent fuel pool show that these tie-plate images are the same in appearance both before and after the earthquake. These results provide high confidence that no significant physical or functional damage or distortion occurred to the spent fuel storage rack cells during the earthquake that would preclude the spent fuel storage racks from performing their intended design function.

Engineering has reviewed the manufacturer's design documentation for the North Anna Power Station Fuel Storage Racks, as well as pictures and videos which indicate that not all cell tie-plates are at perfect 90 degree angles as shown on the design drawings. Comparison of post and pre-seismic event videos shows these observed discrepancies existed prior to the earthquake. This as-found condition has been evaluated and determined to not compromise the ability of the storage racks to perform their structural design basis function.

The dummy fuel assembly was inspected and found to be in satisfactory condition, with no signs of any seismic damage. The dummy fuel assembly was then placed into 32 different spent fuel storage rack locations, which translates to two empty cells in each of the 16 spent fuel storage racks. The insertion and removal of the dummy assembly into these empty cells demonstrates that the spent fuel storage racks are functional and can support the insertion and removal of fuel assemblies using normal handling techniques.

Detailed video inspections were performed on the fuel during the pre-offload fuel pool shuffle (10 assemblies) and on five new fuel assemblies and Burnable Poison Rod Assemblies (BPRA) that were in the spent fuel storage racks during the earthquake. The irradiated fuel inspections were done using Dominion's normal criteria for fuel inspections, and the new fuel assembly inspections were done in accordance with the recommendations provided by AREVA. The results of these video inspections showed no anomalies or significant physical or functional damage due to the earthquake. These detailed video inspections provide assurance that there is no distortion of the fuel or BPRAs within the spent fuel storage racks. The fuel assembly video inspections also show that there was no evidence of any damage due to interaction between the fuel assembly and the storage cell. The pre-offload fuel pool shuffle consisted of more than

¹ Previous video exams from FOSARs, physical inventories or other pool activities were used to document the condition prior to the earthquake.

70 fuel assembly moves and was completed satisfactorily. Therefore, the detailed video inspections of these 15 fuel assemblies and the movement of other fuel assemblies as part of the pre-offload shuffle supports the conclusion that there is no degradation, rack deformation, or repositioning that could challenge the ability of the spent fuel racks to perform their intended function.

Conclusions

The inspections and testing that have been performed on fuel residing in the spent fuel storage racks, as well as on the racks themselves, show no discernable signs of earthquake-induced degradation or deformation that could challenge the ability of the spent fuel racks to perform their design functions. The current condition of the spent fuel storage racks has been evaluated and the ability of the racks to perform their structural design basis functions has been confirmed. Therefore, the spent fuel storage racks can be used for fuel movements, as allowed by current analyses and procedures. There are no spent fuel storage rack restrictions imposed as a result of this assessment.

References

1. "A Summary of Information in Support of Increasing the Spent Fuel Storage Capacity at North Anna Power Station Units 1 and 2," Attachment 3 to Letter from R. H. Leasburg (VEPCO) to H. R. Denton (USNRC), "Amendment to Operating Licenses NPF-4 and NPF-7, North Anna Power Station Unit Nos. 1 and 2, Proposed Technical Specification Changes," Serial Number 450, August 20, 1982.
2. NAPS UFSAR Section 9.1.2, "Spent-Fuel Storage."
3. Letter to USNRC (Document Control Desk) from VEPCO (L. N. Hartz), "Virginia Electric and Power Company, North Anna Power Station Units 1 and 2, Proposed Technical Specification Changes, Increased Fuel Enrichment and Spent Fuel Pool Soluble Boron and Fuel Burnup Credit," dated September 27, 2000 (ADAMS No. ML003758403).
4. Letter to VEPCO (D. A. Christian) from USNRC (S. Monarque), "North Anna Power Station, Units 1 and 2 – Issuance of Amendments RE: Technical Specifications Changes to Increase Fuel Enrichment and Spent Fuel Pool Soluble Boron and Fuel Burnup Credit (TAC Nos. MB0197 and MB0198)," dated June 15, 2001 (ADAMS No. ML011700557).

Enclosure 6

Post-Earthquake Evaluation of the Independent Spent Fuel Storage Installation

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

Post-Earthquake Evaluation of the Independent Spent Fuel Storage Installation

Following the earthquake on August 23, 2011, the North Anna Independent Spent Fuel Storage Installation (ISFSI) was evaluated to determine if the earthquake had any detrimental effect on the spent fuel dry storage casks or the facility itself. The ISFSI is made up of two cask storage pads. Pad 1 is a long rectangular concrete pad upon which the dry storage casks stand vertically and positioned in pairs. Pad 1 contains Transnuclear TN-32 type storage casks. Pad 2 is a Nuclear Horizontal Modular Storage System (NUHOMS) where dry storage casks are placed horizontally in individual storage bunkers.

Design Criteria

The North Anna ISFSI Safety Analysis Report (SAR) for Pad 1, Section 3.2.3, defines the Design Basis Earthquake (DBE) peak ground acceleration values of 0.18g horizontal and 0.12g vertical for Seismic Class I structures founded on saprolite more than 15 feet thick. Both Pad 1 and Pad 2 are designed to these values. On Pad 1, the Transnuclear TN-32 casks were evaluated using the same design acceleration values as the pads. The TN-32 casks were evaluated for sliding at these values, and it was determined that sliding or tipping of the casks should not occur during a DBE.

On Pad 2, the NUHOMS Final Safety Analysis Report (FSAR), Section 2.2.3 states that the seismic design criteria for the NUHOMS HD System is based on NRC Regulatory Guide 1.60. The response spectra are anchored to a maximum ground acceleration of 0.30g for the horizontal components and 0.20g for the vertical component. The results of the frequency analysis of the Horizontal Storage Module (HSM)-H structure (which includes a simplified model of the dry storage cask) yield a lowest frequency of 23.2 Hz in the transverse direction and 28.4 Hz in the longitudinal direction. The lowest vertical frequency exceeds 33 Hz. Thus, based on the R.G. 1.60 response spectra amplifications, the corresponding seismic accelerations used for the design of the HSM-H are 0.37g and 0.33g in the transverse and longitudinal directions, respectively, and 0.20g in the vertical direction. The corresponding accelerations applicable to the dry storage casks are 0.41g and 0.36g in the transverse and longitudinal directions, respectively, and 0.20g in the vertical direction.

Inspection Observations

Following the August 23, 2011 seismic event, two inspections of the ISFSI were conducted by the North Anna Fuel Handling team, Nuclear Analysis and Fuel, and Transnuclear personnel. The following conditions were observed at the ISFSI:

On Pad 1, an inspection was conducted on August 24, 2011 where it was observed that there were indications that twenty-five (25) of twenty-seven (27) TN-32 casks had moved slightly from their original placement locations. The pad is crowned in the middle with a 0.6 degree downward slope towards the ends; however, cask movement

appeared to be independent of the slope of the pad. Directions of the cask movements are indicated in Table 1.

On a follow up inspection on September 1, 2011, location measurements of specific casks TN-32.42 and TN-32.32 were inconsistent with measurements taken on August 24, 2011. Measurements of TN-32.42 indicated a difference of 1.5 inches in measurement placing the cask 3 inches from its original placement. Measurements of TN-32.32 indicated a difference of 1 inch in measurement placing the cask 2.5 inches from its original placement. Match marks were added to the north and south of each cask and on the cask itself to provide a future reference of the placement locations of the TN-32 casks. Due to the limited data available, it is not possible to conclusively determine the cause of the discrepancy.

Inspections also revealed that the center-to-center spacing between twelve casks was less than the 16 feet nominal value provided in the ISFSI Technical Specifications. The two casks with the least separation are casks TN-32.16 and TN-32.23. The spacing of these casks measured 15 feet 3.5 inches during the inspections. The September 1, 2011 follow-up measurements identified an additional cask to be located less than 16 feet from another. Measurement of the distance between the outside trunnions of TN-32.32 and TN-32.42 was determined to be 15 feet 11.5 inches. The casks with spacing less than 16 feet between them following the seismic event are provided in Table 2.

The required spacing between TN-32 casks is specified in Section 4.2.3 of the North Anna ISFSI Technical Specifications (TS) and is a nominal 16 feet. TN-32 casks with a total decay heat above 27.1 kW require a minimum of 16 feet spacing. Of the thirteen casks that are closer than the 16 feet nominal value, two casks TN-32.38 and TN-32.48 were initially loaded with decay heat values exceeding 27.1 kW. Casks TN-32.38 and TN-32.48 were initially loaded with decay heat values of 28.7kW and 30.1kW, respectively. However, TN-32.38 was determined to have a decay heat of 24.3 kW as of January 1, 2008, and TN-32.48 was determined to have a decay heat of 25.7 kW as of January 1, 2009. Consequently, these two casks are currently below the 27.1 kW TS limit. The other TN-32 casks whose spacing is less than 16 feet were initially loaded with decay heats below 27.1kW.

On August 29, 2011 an inspection was conducted of the ISFSI with Transnuclear personnel present. During the inspection, visual inspection of the scrapes on the pad where the TN-32 casks had moved revealed paint that had come off of the bottom of the casks. The paint on the bottom of the casks is not credited for operability but is used to prevent corrosion of the carbon steel components. This observation was documented in a Condition Report.

Table 1: Pad 1 Cask Movement		
Cask No.	8/24/2011 Measurement	9/1/2011 Measurement
TN-32.49	E 2" and S 2.5"	E 2" and S 2.5"
TN-32.45	E 1.5"	E 1.5"
TN-32.43	E 2.5" and S 2.5"	E 2.5" and S 2.5"
TN-32.38	NW 1"	NW 1"
TN-32.37	SE 3"	SE 3"
TN-32.36	NW 4"	NW 4"
TN-32.29	S 2"	S 2"
TN-32.20	E 1"	E 1"
TN-32.23	SE 3.5"	SE 3.5"
TN-32.14	NW .75"	NW .75"
TN-32.16	NW 3.5"	NW 3.5"
TN-32.13	N 1"	N 1"
TN-32.12	NE .5"	NE .5"
TN-32.06	E 1.5"	E 1.5"
TN-32.10	SE 2.5"	SE 2.5"
TN-32.21	SE 4.5"	SE 4.5"
TN-32.19	E 2.25"	E 2.25"
TN-32.24	E 3"	E 3"
TN-32.26	E 1.25"	E 1.25"
TN-32.32	SE 1.5"	SE 2.5"
TN-32.30	No Movement	No Movement
TN-32.41	No Movement	No Movement
TN-32.42	SE 1.5"	SE 3"
TN-32.47	S 1"	S 1"
TN-32.48	NW 2"	NW 2"
TN-32.52	NW 2"	NW 2"
TN-32.53	SE 2.5"	SE 2.5"

Table 2: Pad 1 Casks Center-to-Center Spacing Measurements (from Outside Trunnions)		
Cask Nos.	8/24/11 Measurement	9/1/11 Measurement
TN-32.13 and TN-32.10	15'-6"	15'-6"
TN-32.16 and TN-32.23	15'-3.5"	15'-3.5"
TN-32.26 and TN-32.30	15'-10"	15'-10"
TN-32.42 and TN-32.48	15'-11"	15'-10.5"
TN-32.06 and TN-32.12	15'-11.5"	15'-11.5"
TN-32.45 and TN-32.38	15'-11"	15'-11"
TN-32.32 and TN-32.42	16'	15'-11.5"

Above ground pressure monitoring systems including the remote monitoring panel were visually inspected and no significant physical or functional damage was found. No pressure monitoring system alarms were received during or subsequent to the event. No loss of electrical power at the ISFSI occurred during the event. Visual inspection of the pad itself did not reveal any cracking or damage from the seismic event. Visual inspections of the TN-32 casks also did not reveal any significant physical or functional damage to the casks. Radiological surveys of the casks on Pad 1 indicated no changes to the cask surface dose. Checks were done on six randomly selected pressure switches on August 30, 2011. It was verified during these inspections that setpoints had not drifted outside of what would normally be expected and helium pressure was found to be consistent with expectations.

An inspection of Pad 2 was conducted on August 24, 2011. Observations are documented below and also include supplemental information obtained during a subsequent inspection performed with Transnuclear personnel on August 29, 2011. From these inspections, it was determined that the only damage observed on the Horizontal Storage Modules (HSMs) would not impact the structural integrity or radiation shielding capability of the HSMs. With the exception of HSM 01 and HSM 03, damage to the HSM array was limited to unloaded HSMs. The spaces between some HSMs indicated that some minor movement had occurred with a maximum gap between HSM 24 and HSM 26 of 1.5 inches at the top. The inspections identified the following items, which were documented in a Condition Report:

Table 3: Pad 2 Observations	
Components	Description
HSM 24-HSM 26	Side by side gap was .75" at the bottom and 1.5" at the top
HSM 24-HSM 26	Inlet bird screen indicated buckling
HSM 24-HSM 26	Outlet vent cover appears to have moved pulling the bird screen away and damaging concrete.
HSM 06-HSM 08	Side by side gap was .75" from bottom to top
HSM 06-HSM 04	Roof gap .5"
HSM 13-HSM 15	Roof gap 1.125"
HSM 15-HSM 17	Roof vent had broken concrete with exposed rebar and bird screen has been pulled away 3/16"
HSM 18-HSM 20	Outlet vent cover cracked
HSM 3	Cracked/chipped concrete at inlet screen that extended behind bird screen
HSM 1	Minor crack on lower front of the base
HSM 25	Concrete loose on left rear top corner
HSM 23- HSM 25	Outlet vent cover is cracked
Handrails	Moved 0.5" N

In addition to the observations in Table 3, on a follow-up inspection the HSM fasteners on one roof vent cover and on the south west end wall were discovered to be loose. A work order was requested to inspect and tighten all fasteners as required. The loaded HSMs have been determined to be capable of performing their intended design functions, and radiological conditions around the HSMs are normal. Damage to the HSMs will need to be repaired prior to loading. Cask movement has been restricted to prevent loading the HSMs prior to repair. Visual inspection of cracks in the pad indicated they were preexisting and unrelated to the seismic event.

Conclusions

Following the seismic event at North Anna, there were indications of cask movement. On Pad 1, there were indications the TN-32 casks had moved and center-to-center spacing between thirteen casks is below the 16 feet nominal value. There were no indications of significant physical or functional damage to the casks. On Pad 2, two loaded HSMs indicated minor cracks on the bases. The majority of the damage was to unloaded HSMs; however, no significant physical or functional damage was identified,

and it will not affect the HSMs ability to perform their intended functions. Radiological conditions remained unchanged for both pads at the ISFSI.

Open issues associated with the ISFSI have no impact on the return to service of Unit 1 or Unit 2 and are being tracked in the Corrective Action System. Finally, Dominion has concluded that the TN-32 casks and the NUHOMS HD systems continue to perform their shielding, criticality, thermal, and confinement design functions.

Enclosure 7

Post-Earthquake Impact Assessment on Engineering Programs

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

Impact Assessment of August 23, 2011 Earthquake on Engineering Programs

The purpose of this assessment is to evaluate the impact of the August 23, 2011 seismic event at North Anna Power Station on Engineering Programs through the review of Dominion procedures, regulatory documents, and industry related source documents for each of the identified functional areas to determine if plant equipment or supporting documentation requires additional analysis or inspection in response to exceeding either the Operating Basis Earthquake (OBE) or the Design Basis Earthquake (DBE).

The Engineering Programs that were reviewed in detail as part of this assessment include the following:

1. Aging management,
2. Air Operated Valves,
3. Generic Safety Issue (GSI)-191, Containment Sump Performance,
4. Environmental Qualification,
5. Fire Protection/Appendix R,
6. Heat Exchangers (Generic Letter 89-13),
7. Inservice Inspection Program,
8. Inservice Inspection Program - Containment,
9. Inservice Inspection Program - Repair and Replacement,
10. Inservice Inspection Program - System Pressure Tests,
11. Motor Operated Valves,
12. Maintenance Rule Program Compliance,
13. Steam Generators,
14. Reactor Vessel and Internals/Reactor Coolant System, and
15. Buried Pipe Monitoring/Ground Water Monitoring Program.

A review of the Dominion, regulatory, and industry documents for each of the identified functional areas has been completed based upon the magnitude of the earthquake exceeding the DBE. As a result of these reviews, it was concluded that additional program actions are necessary for certain Engineering Programs beyond the guidance given in EPRI Technical Report NP-6695. The affected Engineering Programs include the following functional areas:

1. Steam Generators,
2. GSI-191, Containment Sump Performance,

3. Inservice Inspection (ISI),
4. Buried Pipe Monitoring/Ground Water Monitoring Program,
5. Reactor Vessel and Internals/Reactor Coolant System,
6. ISI - Repair & Replacement, and
7. Aging Management.

The following actions were identified and will be completed prior to unit restart based on exceeding the spectral and peak ground accelerations of the DBE.

Steam Generators: EPRI Steam Generator Management Program Pressurized Water Reactor Steam Generator Examination Guidelines, Revision 7, Section 3.10 states that forced outage examinations shall be performed during plant shutdown subsequent to seismic occurrence greater than the OBE.

Perform a 20% sample inspection of Unit 1 "A" and Unit 2 steam generators. The Unit 1 "A" steam generator inspection is in progress, and, to date, no adverse indications have been identified as a result of the seismic event. The Unit 2 "A" and "C" steam generators will be inspected during the current refueling outage as previously planned.

GSI-191, Containment Sump Performance

1. Perform containment inspections to identify and remove debris that may have resulted from the earthquake, as required.
2. Perform a visual examination of the sump strainer gaps in accordance with the applicable periodic test.

Inservice Inspection

Perform sample weld inspections of reactor coolant loop drain lines, service water tie-in vault, and penetration area pipe lines with anchors.

Buried Pipe Monitoring/Ground Water Monitoring Program

Perform buried pipe inspections of:

- the two areas of buried fire protection pipe that are currently excavated,
- the Unit 2 circulating water discharge tunnel and associated liquid waste line, and
- the buried pipe between the Unit 1 auxiliary feedwater tunnel and the Unit 1 Quench Spray Pump House.

Enclosure 8

Near-Term Actions to be Completed Prior to Unit Restart

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

NEAR-TERM ACTIONS TO BE COMPLETED PRIOR TO UNIT RESTART		
Restart Activity		Comments
A. Seismic Monitoring and Design Basis		
1	Provide temporary backup power to the Main Control Room Seismic Monitoring Panel.	Complete
2	Install temporary free field seismic monitoring instrumentation.	Prior to Unit 1/2 Restart
3	Revise Abnormal Procedure 0-AP-36 to improve procedural guidance for determining whether an onsite earthquake exceeds OBE and/or DBE peak acceleration criteria.	Prior to Unit 1/2 Restart
B. Nuclear Fuel		
1. Unit 1 Core		
a	Perform hot rod drop testing.	Prior to Unit 1 entering Mode 2
2. Unit 2 Core		
a	Perform RCCA drag testing.	Prior to Unit 2 onload
b	Perform hot rod drop testing.	Prior to Unit 2 entering Mode 2
c	Perform routine binocular visual inspection during core offload.	Prior to Unit 1 Restart
d	Perform video inspections on 13 benchmark assemblies and additional vendor-recommended assemblies.	Prior to Unit 1 Restart
e	Perform video inspection of RCCA hubs.	Prior to Unit 1 Restart
f	Perform video inspections on assemblies with anomalies observed during binocular inspections.	Prior to Unit 1 Restart
C. Root Cause Evaluations		
1	Reactor Trip	Prior to Unit 1/2Restart

NEAR-TERM ACTIONS TO BE COMPLETED PRIOR TO UNIT RESTART		
Restart Activity		Comments
2	Unit 2H Emergency Diesel Generator Coolant Leak	Prior to Unit 1/2 Restart
<i>D. Inspections</i>		
1	<u>Steam Generators</u> - Perform a 20% sample inspection of Unit 1 and Unit 2 steam generators.	Prior to Unit 1/2 Restart
2	<u>Containment</u> - Perform containment inspections to identify and remove debris that may have resulted from the earthquake, as required.	Prior to Unit 1/2 Restart
3	<u>Containment Sump Strainers</u> Perform a visual examination of the sump strainer gaps in accordance with the applicable periodic test.	Prior to Unit 1/2 Restart
4	<u>Inservice Inspection</u> Perform sample weld inspections.	Prior to Unit 1/2 Restart
5	<u>Buried Pipe Monitoring/Ground Water Monitoring Program</u> Perform buried pipe inspections of: <ul style="list-style-type: none"> • the two areas of buried fire protection pipe that are currently excavated, • the Unit 2 circulating water discharge tunnel and associated liquid waste line, and • the buried pipe between the Unit 1 auxiliary feedwater tunnel and the Unit 1 Quench Spray Pump House. 	Prior to Unit 1/2 Restart
<i>E. Testing</i>		
1	Complete Unit 1/2 Surveillance Periodic Tests as determined by the Seismic Event Response Team.	Prior to and during Unit 1/2 Startup per Technical Specifications (Unit specific tests will be completed prior to and during that Unit's startup)

Enclosure 9

Long-Term Actions to be Completed After Unit Restart

**Virginia Electric and Power Company
(Dominion)
North Anna Power Station**

LONG-TERM ACTIONS TO BE COMPLETED AFTER UNIT RESTART	
Activity	
A. Seismic Monitoring and Evaluations	
1	Provide permanent backup power to the Main Control Room Seismic Monitoring Panel.
2	Install permanent free field seismic monitoring instrumentation.
3	Reevaluate plant equipment identified in the IPEEE review with HCLPF capacity <0.3g.
4	Perform seismic evaluations in the context of EPRI NP-6695, NRC GI-199 and as an outcome of NRC Task Force recommendations identified in SECY-11-0124.
B. Reactor Vessel Internals	
1	Develop a plan with the NSSS vendor consisting of additional evaluations or inspections, as warranted, to assure long term reliability of the reactor internals.