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Dominion®

July 9, 2012

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Serial No. NA3-12-009R
Docket No. 52-017
COL/BCB

DOMINION VIRGINIA POWER
NORTH ANNA UNIT 3 COMBINED LICENSE APPLICATION
SRP 19: RESPONSE TO RAI LETTER 97

On March 15, 2012, the NRC requested additional information to support the review of certain portions of the North Anna Unit 3 Combined License Application (COLA), which consisted of one question. The response to the following Request for Additional Information (RAI) Question is provided in Enclosure 1:

- RAI 6312, Question 19-6 — Extreme High Winds Contribution to CDF

This information will be incorporated into a future submission of the North Anna Unit 3 COLA, as described in the enclosure.

Please contact Regina Borsh at (804) 273-2247 (regina.borsh@dom.com) if you have questions.

Very truly yours,

Eugene S. Grecheck

D089
NRO

Enclosure:

1. Response to NRC RAI Letter No. 97, RAI 6312, Question 19-6.

Commitments made by this letter:

1. This information will be incorporated into a future submission of the North Anna Unit 3 COLA, as described in the enclosure.

COMMONWEALTH OF VIRGINIA

COUNTY OF HENRICO

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

Acknowledged before me this 9th day of July, 2012
My registration number is 7173057 and my
Commission expires: August 31, 2012

Wanda K Marshall
Notary Public

WANDA K. MARSHALL
Notary Public
Commonwealth of Virginia
7173057
My Commission Expires Aug 31, 2012

cc: U. S. Nuclear Regulatory Commission, Region II
C. P. Patel, NRC
T. S. Dozier, NRC
G. J. Kolcum, NRC

ENCLOSURE 1

Response to NRC RAI Letter No. 97

RAI No. 6312, Question 19-6

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

North Anna Unit 3

Dominion

Docket No. 52-017

RAI NO.: 6312 (RAI LETTER NO. 97)

SRP SECTION: 19 – PROBABILISTIC RISK ASSESSMENT AND SEVERE ACCIDENT EVALUATION

QUESTIONS for PRA and Severe Accidents Branch (SPRA)

DATE OF RAI ISSUE: 03/15/2012

QUESTION NO.: 19-6

The staff reviewed the applicant's response to RAI question 19-3 regarding the high winds shutdown assessment. In the applicant's response, only tornado strike frequencies were considered. For example, tornado wind speeds of 86-110 mph were reported to have a strike frequency of 8E-5 per year (Table 19-201, Page 19-92). However, Chapter 2 of the COLA (Table 2.0-201, Page 2-10) references a site specific extreme wind speed (other than tornado) of 96 mph in 1/100 years. Using the site specific extreme wind speed and exceedance frequency referenced in Chapter 2 of the COLA:

(1) Please confirm that extreme winds as discussed in Chapter 2 of the DCD do not contribute more than 10 percent of the shutdown core damage frequency compared to the US-APWR DC PRA. In this assessment, please consider that the containment equipment hatch could be opened which requires AC power to close. Please also consider that the switchyard could be damaged resulting in a LOOP event that cannot be recovered within 24 hours. Please consider the site impacts of the site specific extreme wind speed on non-safety related SSCs.

(2) Please confirm that extreme winds as discussed in Chapter 2 of the DCD do not contribute more than 10 percent of the full power core damage frequency compared to the US-APWR DC PRA. Please also consider that the switchyard could be damaged resulting in a LOOP event that cannot be recovered within 24 hours. Please consider the site impacts of the site specific extreme wind speed on non-safety related SSCs.

Dominion Response

The site specific extreme wind speed exceedance frequency referenced in FSAR Chapter 2 is 1E-2/yr for 96 mph. This value is not the frequency of a loss of offsite power (LOOP) or core damage initiating event because an extreme wind event does not necessarily disable offsite power supplies or impact SSCs in a manner that will result in core damage.

NUREG/CR-6890 (Vol. 1, "Analysis of Loss of Offsite Power Events: 1986-2004") analyzed LOOP events and core damage risk at U.S. commercial nuclear power plants and calculated the frequency of such events due to various causes, including weather. For the purpose of estimating core damage frequency (CDF) for North Anna Unit 3 as a result of extreme wind events, a study was performed that conservatively assumed that the frequency of all weather related events leading to a LOOP, as identified in NUREG/CR-6890, were attributed to extreme winds. This frequency was applied to the PRA model while maintaining the existing PRA assumptions of (1) no recovery of the LOOP and, (2) no credit for systems that are not protected from tornadoes. This second assumption is conservative because the potential for damage from extreme winds is less than that for tornado winds (site characteristic values of 96 mph and 200 mph, respectively). The resulting site-specific CDF values for low-power and shutdown (LPSD) and full power conditions were compared to the corresponding DCD CDF values. The methodology, assumptions and results of the study are summarized below.

1. Data describing the frequency of a LOOP event was reviewed to perform a sensitivity study using the constraints and assumptions proposed by the RAI question to evaluate the potential for extreme winds contributing to CDF during LPSD conditions. NUREG/CR-6890 identifies that the average U.S. frequency of a LOOP due to weather-related causes for shutdown operation is 3.5E-2/year. This value applies to weather-related events from all causes and includes events in which power may be recovered in a relatively short time period. If it is assumed that all such weather-related LOOP events are due to extreme winds and the potential for recovery is ignored, a conservative estimate of extreme winds causing a LOOP of duration sufficient to lead to core damage is 3.5E-2/year. The study assumed that this LOOP event is coincident with the loss of the nonsafety-related SSCs that support the alternate component cooling water functions of the Fire Suppression System and Non-Essential Chilled Water System, and makeup function of the Refueling Water Storage Auxiliary Tank. The study also assumed the most limiting LPSD conditions in terms of core inventory, i.e., reduced inventory operation.

   The conditional core damage probability (CCDP), assuming unavailability of nonsafety-related equipment located outside of Seismic Category I or II structures, is dependent on the plant operational state (POS) because the plant configuration is not common to all POSs. The study assumed that the plant uses a two-year fuel cycle with a nominal 25-day outage and that the equipment hatch is open for the duration of the outage. The duration of the reduced inventory condition, based on a review of POSs in the US-APWR PRA, is assumed to be ten days of a 25-day outage.

$$
\begin{aligned}
CDF &= \Sigma CDF_{POS\ i} \\
&= \Sigma\ (IE_{POS\ i} \times CCDP_{POS\ i}) \\
&= \Sigma\ (IE \times t_{LPSD/RedInv,POS\ i} \times CCDP_{POS\ i}) \\
&= IE \times \Sigma\ (t_{LPSD/RedInv,POS\ i} \times CCDP_{POS\ i}) \\
&= 8.5E\text{-}10 \text{ per year}
\end{aligned}
$$

$POS_{(i)}$	$t_{LPSD/RedInv\ POS\ I}$ [hr]	$CCDP_{POS\ i}$
3	24	7.2E-05
4-1	24	7.2E-05
4-2	12	7.0E-05
4-3	36	2.0E-04
8-1	60	4.0E-04
8-2	12	1.5E-04
8-3	24	2.8E-04
9	8	2.8E-04
11	33	2.8E-04

where:

$POS_{(i)}$ = Plant Operational State "i"
IE = Frequency of Initiating Event
$CCDP_{POS\ I}$ = CCDP of $POS_{(i)}$
$t_{LPSD/RedInv\ POS\ I}$ = Fraction of time in reduced inventory of $POS_{(i)}$

In the sensitivity study, the dominant core damage scenario is a LOOP event involving a station blackout with a failure to connect the alternate alternating current gas turbine generators (AAC GTG) to the Class 1E buses, which results in no Reactor Coolant System (RCS) injection or decay heat removal systems. If core cooling and makeup functions are unavailable, RCS inventory would eventually be lost through boil-off. No credit is taken in the sensitivity study for recovery. For configurations other than reduced inventory, the time to boil is longer, which would allow credit to be taken for mitigative actions.

Based on these assumptions, the CDF for this extreme wind event sensitivity study is less than 1% of the LPSD CDF of 1.8E-7 per reactor year, as identified in DCD Revision 3. In the sensitivity study, the Large Release Frequency (LRF) was conservatively assumed to be equal to the CDF because no credit is taken for closure of the containment hatch.

Given the insights from the sensitivity study and conservatisms applied, the CDF and potential LRF contribution due to extreme wind damage during LPSD is not considered significant because the extreme wind CDF and LRF values are less than

10% of the LPSD CDF. (Note that although the calculated extreme wind risk would increase for shorter operating cycles, e.g., 12 months, the conclusion regarding relative risk would remain valid).

2. For full power operations, the CCDP for a LOOP event assuming no recovery and loss of nonsafety-related SSCs is 4.6E-5. The dominant core damage scenario is a LOOP event involving a station blackout with a failure to connect the AAC GTGs to the Class 1E buses, which results in a loss of mitigating systems.

   Data describing the frequency of a LOOP event was reviewed to perform a sensitivity study using the constraints and assumptions proposed by this RAI question to evaluate the potential for extreme winds contributing to CDF during power operation. NUREG/CR-6890 identifies the average U.S. frequency of a LOOP due to weather-related causes for critical operation as 4.8E-3/year. This value applies to weather-related events from all causes and includes events in which power may be recovered in a relatively short time period. If it is assumed that all such weather-related LOOP events are due to extreme winds and the potential for recovery is ignored, a conservative estimate of extreme winds causing a LOOP of duration sufficient to lead to core damage is 4.8E-3/year.

   CDF = IE x CCDP
   = (4.8E-3) x (4.6E-5)
   = 2.2E-7 per year

   where:
   IE = Frequency of Initiating Event
   CCDP = Conditional Core Damage Probability

   The CDF for extreme winds during power operation is 2.2E-7 per year, constituting approximately 8% of the CDF of 2.8E-6/reactor year for internal and external (internal flooding and fire) events at power.

   Given the insights from the sensitivity study and conservatisms applied, the CDF due to extreme wind damage during power operation is not considered significant.

Proposed COLA Revision

FSAR Section 19.1.5 and Table 19.1-205 will be revised, as indicated on the attached markup, to reflect the results of the sensitivity study described above.

Markup of North Anna COLA

The attached markup represents Dominion's good faith effort to show how the COLA will be revised in a future COLA submittal in response to the subject RAI. However, the same COLA content may be impacted by revisions to the DCD, responses to other COLA RAIs, other COLA changes, plant design changes, editorial or typographical corrections, etc. As a result, the final COLA content that appears in a future submittal may be somewhat different than as presented herein.

CCW initiating event to the large release frequency (LRF) for operations at power is considered insignificant. It has been therefore determined that consideration of the site-specific UHS would have no discernible effect on the Level 2 PRA results that are based on the standard US-APWR design. Therefore, the results described below are considered sufficient and applicable.

19.1.5 Safety Insights from the External Events PRA for Operations at Power

NAPS COL 19.3(4)

Replace the second and third paragraphs in DCD Subsection 19.1.5 with the following.

The last three events listed above receive detailed evaluation in the following subsections. The first four events are subject to the screening criteria consistent with the guidance of ASME/ANS RA-Sa-2009 (Reference 19.1-50), taking into consideration the features of advanced light water reactors.

The assessment of the other external events is provided below:

The screenings for other external events are performed using the following steps taking into consideration the features of advanced light water reactors. At first, qualitative screenings are performed because they are easy to obtain lower risk from advanced reactors design features or site characteristics. The qualitative screenings are performed using the analysis reported in Chapter 2 in accordance with the guidelines of ASME/ANS RA-Sa-2009. Section 6.2 of the standard defined the initial preliminary screening criteria as supporting technical requirement EXT-B1. The five qualitative screening criteria are:

1. Lower damage potential than a design basis event
2. Lower event frequency of occurrence than another event
3. Cannot occur close enough to the plant to have an affect
4. Included in the definition of another event
5. Sufficient time to eliminate the source of threat or to provide an adequate response

Following the qualitative screenings, quantitative screenings are performed. The supporting technical requirement EXT-B2 of ASME/ANS

RA-Sa-2009 states that the criteria provided in the 1975 Standard Review Plan can be used as an acceptable basis for the screening criteria of external events. The criteria are:

i. the contribution to CDF is less than 10^{-6}/year, or

ii. the design-basis event at annual frequencies of occurrence is between 10^{-7} and 10^{-6}.

For Unit 3, a value of 10^{-7} for the annual frequency of occurrence is used as a more conservative quantitative screening criterion. If an event frequency is greater than 10^{-7}/year, perform bounding analysis or PRA to confirm that the risk is sufficiently low for advanced light water reactors such as less than 1% of total CDF. The remaining external events which do not meet the above screening criteria are assessed using a bounding analysis.

The qualitative and quantitative screenings are performed using the analysis reported in Sections 2.2, 2.3, 2.4, and 3.5. The summary of the screenings are described in Table 19.1-205. Only tornado events are not screened because the annual frequency of expected maximum tornado wind speed on the site is close to 10^{-7}/year.

High Winds and Tornadoes

For high winds and tornadoes, tornadoes are evaluated using level 1 PRA as a bounding analysis from the discussion in Section 2.3.1.3.2.

The following sections show the results of the tornado PRA elements: 1) tornado hazards, 2) plant vulnerabilities, 3) accident scenario, and 4) quantification.

- Tornado hazard

  A tornado wind speed hazard curve for Unit 3 was developed following NUREG/CR-4461 which also forms the basis for NRC RG 1.76. The tornado hazard methodology developed in NUREG/CR-4461 fully meets the requirements of ASME/ANS RA-Sa-2009.

  The Unit 3 is near Lake Anna, Virginia, and is located at 38° 03' latitude and 74° 47' longitude. The tornado hazard curve has been developed based on data reported in NUREG/CR-4461 for the 2° box surrounding the site, which recorded 232 tornado occurrences from 1950 through 2003. The hazard curve produced for the Unit 3 is shown in Figure 19.1-201. Strike and exceedance frequencies for tornadoes categorized in enhanced F-scale intensity are shown in Table 19.1-201.

- Plant vulnerabilities

Components significant to the internal events PRA were reviewed to identify component vulnerability during tornadoes. Component failures that could cause initiating events were also reviewed.

All systems and components essential for safe shutdown and for maintaining the integrity of the reactor coolant pressure boundary are located within seismic category I buildings, which are designed to withstand the loading of a design basis tornado. The design basis tornado is described in Section 3.3 and in Table 19.1-202.

Based on a review of components, the following were identified as potential vulnerabilities during tornadoes with intensities below the design basis tornado.

•• Plant switchyard

•• Piping of the FSS

•• CTW for the non-essential chilled water system and associated pipings

•• Selector circuit and breakers of the alternate ac power supply system

•• Permanent buses of the non-safety power system

•• Main steam supply system downstream of the MSIVs

•• Main feedwater system upstream of the MFIVs

Structure, system, and components (SSCs) will be designed using the site-specific basic wind speed of 96 mph or higher. Within this analysis, plant vulnerabilities located outdoors that are not Seismic Category I or II structures are assumed to be damaged for tornado strikes of intensity enhanced F-scale 1 and greater. In this analysis, the following systems are assumed to be damaged for tornado strikes of intensity enhanced F-scale 1 and greater:

•• Plant switchyard

•• Non-essential chilled water system - Cooling tower only

Alternate CCW function, which utilizes the non-ESW system or the FSS, is conservatively assumed to be unavailable for tornado strikes of intensity enhanced F-scale 1 and greater.

Seismic Category II structures are designed to withstand a basic wind speed of 155 mph. The Seismic Category II structure that contains PRA related equipment is the turbine building (T/B). Tornado induced failure of the T/B is conservatively assumed to have an effect on the operability of alternate ac power system. In this analysis, the following systems are assumed to be damaged by tornado strikes resulting in failure of the T/B:

- Plant switchyard
- FSS
- Non-essential chilled water system
- Non-safety electric power system
- Alternate ac power supply system

NAPS ESP VAR 2.3-1

Site-specific structures and components, e.g., UHS, are damaged by tornadoes exceeding the site-specific tornado maximum wind speed (200 mph). Direct damage to the US-APWR standard design Seismic Category I structures and components within the structure can be caused by tornadoes exceeding the design basis tornado (230 mph). Since safety-related systems are cooled by CCWS, through ESWS sharing with UHS, a tornado strike of greater than 200 mph wind speed can result in functional failures of safety-related systems. In this analysis, safety-related systems are assumed to be damaged for tornado strikes exceeding the site-specific tornado maximum wind speed (wind speed >200 mph).

- Accident scenario

When a tornado strikes the plant, there is a probability that a tornado initiated accident scenario may be induced with some mitigation functions inoperable due to damage from a tornado strike. Based on plant vulnerabilities identified in the previous section, the internal events PRA was reviewed to identify initiating events or degradation of mitigation functions that may be caused by a tornado strike. The following internal events accident initiators may be caused by a below design basis tornado strike:

- LOOP
- Main steam line break downstream of MSIVs
- Loss of feedwater flow
- Feedwater line break upstream of the MFIVs

The following mitigation and support systems may be degraded by tornado-induced failures from a below design basis tornado strike:

- Alternate CCW utilizing the FSS
- Alternate CCW utilizing the non-essential chilled water system
- Non-safety electric power system
- Alternate ac power supply system (this is a mitigation system for LOOP events, which is an initiating event potentially caused by a tornado strike)

Based on the results of the plant vulnerability analysis and the discussion above, tornado induced accident scenarios were categorized into three scenarios as shown in Table 19.1-203. The frequency of each scenario derived from the hazard fragility analysis of the T/B is also shown.

- Quantification

For the tornado induced accident scenarios, the CDF was calculated based on the internal event PRA results. The dominant core damage scenarios were the following:

- Failure of all safety systems by a beyond design basis tornado. This event leads directly to core damage. This CDF for this scenario is 1.2E-07/RY.
- Tornado strike induced LOOP caused by EF-scale 1 or EF-scale 2 tornado

  Plant switchyard is damaged by an EF-scale 1 or EF-scale 2 tornado strike and LOOP that cannot be recovered within 24 hours. The FSS and the non-essential chilled water system are also damaged by the tornado strike, resulting in unavailability of the alternate component cooling function. If the gas turbine power generators fail and SBO occurs, RCP seal LOCA will occur and eventually the core is damaged. If the CCW pumps or the ESW pumps fail to restart, RCP seal LOCA will occur and eventually the core is damaged. The CDF for this scenario is 1.6E-08/RY.

The total CDF caused by a tornado strike during at-power operation is on the order of magnitude of 1E-07/RY. Tornado induced CDF is one order of magnitude lower than the total CDF for internal events and internal flood and internal fire events. A bounding assessment for extreme winds has been performed. The results show that the extreme wind CDF is less than 10 percent of the internal events CDF at power operation.

The CDF from tornadoes during LPSD does not contribute more than ten percent of the total shutdown CDF and total shutdown LRF compared to the design certification PRA. Tornado events during LPSD do not have a significant contribution to risk. A bounding assessment for extreme winds has been performed. The results show that the extreme wind CDF and LRF values are less than 10 percent of the LPSD CDF.

External Flooding

Section 2.4.2 systematically considers the various factors that can contribute to the incident of external flooding. Based on the discussions in this section, the contribution of such events to the total CDF is considered insignificant. These events meet the preliminary screening criteria of ASME/ANS RA-Sa-2009.

Transportation and Nearby Facility Accidents

These events consist of the following:

- Hazards associated with nearby industrial activities, such as manufacturing, processing, or storage facilities
- Hazards associated with nearby military activities, such as military bases, training areas, or aircraft flights
- Hazards associated with nearby transportation routes (aircraft routes, highways, railways, navigable waters, and pipelines)

In Section 2.2.3, design basis events internal and external to the nuclear power plant are defined as those events that have a probability of occurrence on the order of about 10^{-7}/RY or greater and potential consequences serious enough to affect the safety of the plant to the extent that the guidelines in 10 CFR 100 could be exceeded. The following categories are considered for the determination of design basis events: explosions, flammable vapor clouds with a delayed ignition, toxic chemicals, fires, collisions with the intake structure, and liquid spills.

The effects of these events on the safety-related components of the plant are insignificant as discussed in Section 2.2.3. These events meet the preliminary screening criteria of ASME/ANS RA-Sa-2009.

NAPS COL 19.3(4) **Table 19.1-205 External Events Screening and Site Applicability**

Category	Event	SSAR/ FSAR Section Disposition	Description	Screening and Applicability Criteria	Freq. (/yr)	Site Appl.
Nearby Industrial, Transportation and Military facilities *(continued)*	Site Proximity Missiles	FSAR 3.5.1.5	No potential site-proximity missile hazards are identified except aircraft, which are evaluated in Section 3.5.1.6.	3	None	No
	Turbine Missile	FSAR 3.5.1.3.2	Technical Reports MUAP-10005-NP, "Probability of Missile Generation From Low Pressure Turbines for Model L54" (Reference 3.5-17R), and MUAP-07029-NP, "Probabilistic Evaluation of Turbine Valve Test Frequency," (Reference 3.5-18R) are used to establish the procedures and criteria for PSI, ISI intervals, and turbine valve test frequencies. Additionally, procedures implement the applicable operating criteria specified in SRP 3.5.1.3. These actions maintain the probability of turbine failure resulting in the ejection of turbine rotor (or internal structure) fragments through the turbine casing such that the acceptable risk rate is maintained at less than 10^{-7} per year.	2,3	$<10^{-7}$	No
Meteorology	Extreme Winds	SSAR 2.3.1.3.1	According to American National Standard, ANSI 58.1-1982, the operating basis wind velocity at 33 feet (10 meters) above ground level in the Unit 3 site area associated with a 100-year return period is 64 miles per hour (mph). The fastest-mile-wind speed is defined as the passage of one mile of wind with the highest speed for the day. The actual observed fastest-mile-wind speed at Richmond (68 mph) was recorded at that station in October 1954. The 3-second gust wind speed that represents a 100-year return period is 96 mph at 10 meters above ground. This wind speed was determined in accordance with the guidance in SEI/ASCE 7-02, Revision of ASCE 7-98, and is selected as a conservative basic wind speed site characteristic. A bounding assessment determined that the risk from extreme winds is not significant.	~~1,4~~ Not screened (bounding analysis conducted)	None	No