ATTACHMENT 6

DOMINION CALCULATION CE-1399, ADDENDUM #00A "EVALUATION OF AGEING EFFECTS OF CONCRETE CASK DROP & TIPOVER EVENTS," REV. 0

Virginia Electric and Power Company (Dominion)
North Anna Power Station
Independent Spent Fuel Storage Installation

Complete Calculation

Calculation # CE-1399 Rev. 0 Add. #00A

Complete the fields with text or an **X** as required.

Calculation Number:	Revision:	Addendum:	Sub type:	Decommissioning Record?
CE-1399	**0**	**#00A**	**STR**	☐ Yes ☒ No

Vendor (If not Dominion):	Calculation Preparation Risk:
N/A	☒ Low ☐ Medium ☐ High

Vendor Proprietary: ☐ Yes ☒ No

Calculation Quality Class: ☒ Safety Related ☐ NSQ ☐ Non-Safety Related

Subject (Calculation Title):

Evaluation of NAPS As-Built ISFSI Concrete Storage Pad

Addendum Title:

Evaluation of Ageing Effects of Concrete on Cask Drop & Tipover Events

Station(s) and Unit(s):

NA ☒ 1 ☒ 2 ☐ 3 ☒ ISFSI KW ☐ ☐ ISFSI

SU ☐ 1 ☐ 2 ☐ ISFSI MP ☐ 1 ☐ 2 ☐ 3 ☐ ISFSI

Affected System(s), Structure(s), or Component(s):

FH

Purpose (Executive Summary):

The purpose of this Calculation Addendum is to evaluate the projected concrete ageing effects over a 60-year service life for NAPS ISFSI Pad #1, with respect to the cask bottom-end drop and tip-over accident events, which were previously evaluated in Calculation No. CE-1399, Rev. 0. This evaluation is in response to US NRC Request for Additional Information, RAI 3-8.

Originator (Qual. Required): Printed Name (1) (3)		Signature: (1) (3)	Date: (1) (3)
Charles A. Zalesiak		Charles A. Zalesiak	01/09/2017
Reviewer (Qual. Required): Printed Name (1)	Type of Review: (2)	Signature:	Date:
Joshua M. Koelzer	**Independent**	Joshua Koelzer	01/11/2017
Approver: Printed Name		Signature:	Date:
James M. Kasper		James M. Kasper	1-11-17

Note: Physical or electronic signatures are acceptable.

Note: (1) Add lines for additional originators or reviewers as necessary. (2) Note if reviews are "Independent," "Peer", "Subject Matter Expert", "Supervisor", or "Owner's". (3) Enter N/A for Owner's Review of Vendor Calculation.

Calculation # CE-1399 Rev. 0 Add. #00A

Instructions: To update the Table of Contents page numbers, click within the Table of Contents to select the table, then select "**Print Preview,**" (Click the **Office Button** at the upper left of the computer screen; then select "**Print,**" and then "**Print Preview**") close "**Print Preview.**" The page numbers should update.

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1. Record of Revisions and Addenda

1.1 Original Dominion Calculation No. CE-1399, Rev. 0, approved 04/08/1998

1.2 Calculation No. CE-1399, Rev. 0, Addendum #00A, approved 01/10/2017

2. Cumulative Effects Review (required for Revisions and Addenda)

There are no cumulative effects as a result of this Calculation Addendum. This Calculation Addendum focuses on the age-related effects of increasing concrete compressive strength on target hardness of the NAPS ISFSI Pad #1 over a service life of 60 years. The original issue of this Dominion Calculation provided an accurate evaluation of Pad #1 target hardness after 28 days.

3. References

3.1. TN-32 Dry Storage Cask Topical Safety Analysis Report, "Safety Evaluation for the Transnuclear Inc., Dry Storage Cask (TN-32), Docket 72-1021 (M-56)", November 1996

3.2. EPRI TR-108760, "Validation of EPRI Methodology of Analysis of Spent-Fuel Cask Drop and Tipover Events", August 1997

3.3. EPRI NP-4830, "The Effect of Target Hardness on the Structural Design of Concrete Storage Pads for Spent-Fuel Casks", October 1986

3.4. EPRI NP-7551, "Structural Design of Concrete Storage Pads for Spent-Fuel Casks, April 1993

3.5. Lawrence Livermore National Laboratory, UCRL-ID-126295, "Evaluation of Low-Velocity Impact Tests of Solid Steel Billet onto Concrete Pads, and Application to Generic ISFSI Storage Cask for Tip-over and Side Drop", March 1997

3.6. US NRC Safety Evaluation Report, "TN-32 Dry Storage Cask Topical Safety Analysis Report", Revision 9, November 1996

3.7. Design Change No. DCP #95-005

3.8. US NRC Safety Evaluation Report, "Issuance of Materials License SNM-2507 for the North Anna Independent Spent Fuel Storage Installation (TAC No. L22113)", June 30, 1998

3.9. NAPS Plant Drawing Nos. 11715-FC-49A-0 and FC-49B-0

3.10. American Concrete Institute, ACI 349/349R-01, "Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary"

3.11. US NRC NUREG/CR-6424, "Report on Aging of Nuclear Power Plant Reinforced Concrete Structures", March 1996

3.12. Army Technical Manual TM 5-1300/NAVAC P-397/AFR 88-22, "Structures to Resist the Effects of Accidental Explosions", November 1990

4. Computer Codes Used

None

5. Identification of Computer Inputs and Outputs

Microsoft Office, Excel 2007 was used to develop a spreadsheet to assist in performing repetitive calculations that could be performed by hand. Formulas used in the spreadsheet are discussed in Section "***11. Calculations***". The results of this spreadsheet calculation were independently reviewed.

6. Purpose (continued from cover sheet if necessary) (optional)

See Cover Page.

7. Background (optional)

As part of the original TN-32 cask licensing basis evaluations (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996), Transnuclear, Inc., applied separate 1-g input deceleration to the bottom and to the side of their TN-32 cask. Resulting forces were calculated at critical locations in the cask body and basket for the 1-g bottom and side cask input deceleration analyses. Based on EPRI methodology contained in (EPRI NP-4830, 1986), Transnuclear, Inc., scaled these 1-g forces by a factor of 50 to obtain equivalent 50-g input deceleration forces. From these linearly calculated 50-g deceleration forces, resulting deceleration stresses were calculated at critical cask body and basket locations. These equivalent 50-g deceleration stresses were compared to the corresponding allowable material stresses to ensure the integrity of the TN-32 cask body and basket. By dividing the resulting 50-g deceleration forces by the TN-32 cask weight, limiting deceleration values were established at these critical cask locations for the Cask Tip-over (a.k.a. Cask Side-Drop) and Cask Bottom-end Drop Accident Conditions. In addition, the US NRC requested that Transnuclear, Inc., apply a 1.6 scale factor to the limiting deceleration values for certain cask body and basket locations to account for dynamic load effects associated with the Cask Tip-over Accident Condition.

Based on a separate study (Lawrence Livermore National Laboratory, 1997), the US NRC issued a Safety Evaluation Report (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996), which confirmed the equivalent 50-g input deceleration analyses for the Cask Tip-over and Bottom-end Drop Accident Conditions. In this Safety Evaluation Report, the US NRC states that cask confinement and fuel retrievability will be assured, if the ISFSI pad is constructed with the following parameters: 1.) Pad thickness, $h \leq 3$ feet, 2.) 28-day concrete compressive strength, $f'_c \leq 4{,}000$ psi and 3.) subgrade soil modulus of elasticity, $E_s \leq 40$ ksi. If any ISFSI pad is constructed with stiffer as-built parameters than those, as listed above, then further analysis and staff review would be required.

NAPS ISFSI Pad #1 was constructed in 1998 (Design Change No. DCP #95-005, 1995), which documented the average, as-built, 28-day, concrete compressive strength, $f'_{c\ 28\text{-}Day} = 5{,}060$ psi, pad thickness, h = 2 ft and the subgrade soil modulus of elasticity, $E_s = 30$ ksi. Since the average, as-built, 28-day concrete compressive strength, $f'_{c\ 28\text{-}Day} = 5{,}060$ psi > 4,000 psi, Dominion performed an evaluation to determine the as-built slab target hardness values, $S_{End\ Drop}$ and $S_{Edge\ Drop}$, from which corresponding as-built deceleration values could be calculated for the critical TN-32 cask body and basket locations and compared to the previously established limiting deceleration values (CE-1399, Rev. 0, 1998). To account for the increased reinforced concrete slab shear resistance, due to the higher rate of loading from a postulated cask drop, a

dynamic increase factor of 1.1 was applied to the average, as-built, 28-day concrete compressive strength, $f'_{c\ 28\text{-}Day}$ = 5,060 psi x 1.1 = 5,566 psi. See Table 4-1 of (TM 5-1300/NAVAC P-397/AFR 88-22, 1990) for this dynamic increase factor reference. Based on the results of this evaluation, all as-built deceleration values were less than their corresponding limiting deceleration value for these critical TN-32 cask body and basket locations, as identified in Reference (US NRC SER TN-32 TSAR Rev. 9, 1996). The US NRC acknowledged this Dominion evaluation for the as-built, average 28-Day concrete strength and other as-built parameters of the NAPS ISFSI Pad #1 in (US NRC Safety Evaluation Report, 1998).

As concrete ages, the hydration process continues within the cement paste, increasing the compressive strength of the concrete, until the hydration process ceases. As of this writing, the concrete in the NAPS ISFSI Pad #1 is approaching the end of its initial 20 year operating license, which expires on June 30, 2018. In anticipation of this date, Dominion has requested that this license be renewed for an additional 40 years to 2058 (see Appendix 17.2, NAPS License Renewal Application); hence, will need to perform another evaluation to determine the effects of continued concrete ageing. Per Appendix 17.1, RAI 3-8, the US NRC has requested that Dominion perform another analysis to evaluate the ageing effects of increased concrete compressive strength for the requested period of extended operation.

Appendix 17.1, RAI 3-8, cites the information contained in (US NRC NUREG/CR-6424, 1996), which supports the claim that "after a 20-year placement, the average concrete compressive strength can increase 67% with respect to the nominal 28-day design basis strength." Since the as-built concrete compressive strength at 28 days is typically higher than the nominal design basis strength, the US NRC also requests that Dominion consider the higher, as-built, 28-day concrete compressive strength of NAPS ISFSI Pad #1 in this analysis.

8. Design Inputs

See Appendix 17.3 for the specific instances of Design Inputs taken from References 3.1 though 3.11.

9. Assumptions

Assumptions are consistently stated within (CE-1399, Rev. 0, 1998).

10. Methodology

For specific details of the methodology used to evaluate the effects of the as-built, average 28-day concrete strength for the NAPS ISFSI Pad #1, see Section 2.2, "Methodology", of Calculation No. CE-1399, Rev. 0. This methodology was adopted from the EPRI study, as reported in (EPRI NP-4830, 1986). This methodology was used to calculate the ISFSI pad target hardness values, S, and corresponding cask input deceleration values, G, for the postulated Cask Tip-over (a.k.a. Cask Side-Drop) and Cask Bottom-end Drop Accident Conditions.

As-built parameters for the TN-32 cask and all other reported, as-built ISFSI pad parameters, corresponding to the average 28-day concrete strength for the NAPS ISFSI Pad #1, as reported in (CE-1399, Rev. 0, 1998) and (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996), were used to calculate target hardness values, S, and corresponding deceleration values, G, at critical cask locations in the TN-32 cask body and basket. These calculated deceleration values are identified under the **110% NAPS 28-Day As-Built** column of the spreadsheet in Appendix 17.3 of this Calculation Addendum. Input parameters used in the

corresponding spreadsheet column **NAPS** in Attachment A of (CE-1399, Rev. 0, 1998) were taken from (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996).

As a basis of comparison, similar deceleration values were calculated, using this same EPRI methodology, for the cask and ISFSI pad, as reported in the studies conducted under (US NRC SER TN-32 TSAR Rev. 9, 1996), US NRC (US NRC Safety Evaluation Report, 1998), (EPRI NP-4830, 1986), (EPRI NP-7551, 1993), (EPRI TR-108760, 1997). These calculated deceleration values are identified under the **US NRC Reference** column of the spreadsheet in Appendix 17.3 of this Calculation Addendum.

The following input parameters, used in the calculation of ISFSI pad target hardness values, S, and corresponding cask input deceleration values, G, for the **US NRC Reference** ISFSI pad, were taken from (US NRC SER TN-32 TSAR Rev. 9, 1996) and are listed below:

1.) Pad Thickness, $h \leq 3$ feet

2.) 28-Day Concrete Compressive Strength, $f'_c \leq 4{,}000$ psi and

3.) Subgrade Soil Modulus of Elasticity, $E_s \leq 40$ ksi.

In Attachment A of (CE-1399, Rev. 0, 1998) other **US NRC** cask and ISFSI pad parameters were chosen to best represent the cask and ISFSI pad conditions that were analyzed in the above referenced EPRI studies. The intent of the **US NRC** calculation was to see how closely the calculated $\mathbf{G_{US\ NRC}}$ values would compare with the equivalent 50-g cask input deceleration values, upon which Transnuclear, Inc., based their original analyses for the Cask Tip-over (a.k.a. Side-Drop) and Cask Bottom-end Drop Accident Conditions. The following cask drop deceleration limits were ultimately approved by the US NRC for these critical locations, within the TN-32 cask body and basket, in order to ensure that stresses from postulated TN-32 cask drops did not exceed their corresponding code allowable material stresses {Reference (US NRC SER TN-32 TSAR Rev. 9, 1996)}. Note that the following **"Acceptance Limits"** for the **"NAPS"** and **"US NRC"** columns in the spreadsheet of Attachment A of (CE-1399, Rev. 0, 1998) correspond to **"110% NAPS 28-Day As-Built"** and **"US NRC Reference"** columns in the spreadsheet of Appendix 17.3 of this Calculation Addendum. As will be discussed later in **Section 11, *Calculations***, a third column, **"1.67 x 110% NAPS 28-Day Projected"** will be added to the spreadsheet of Appendix 17.3 of this Calculation Addendum to evaluate the effects of concrete ageing up to 60 years.

Bottom-End-Drop Case Acceptance Limits:	**NAPS**	**US NRC**
50-g (Basket)	Reported in CE-1399, Rev. 0	Ref. 3.6, Section 3.3.3
Side-Drop Case Acceptance Limits:		
63-g (Cask Body)	Reported in CE-1399, Rev. 0	Ref. 3.6, Section 3.3.3
88-g (Top of Basket)	Reported in CE-1399, Rev. 0	Ref. 3.6, Section 3.3.3
52-g (90^0 Basket Cross-Section)	Reported in CE-1399, Rev. 0	Ref. 3.6, Section 3.3.3

Using the methodology of (EPRI NP-4830, 1986), cask input deceleration G values were calculated for the Cask Bottom-end-Drop and Cask Tip-over cases for both the **NAPS** and the **US NRC** cask and ISFSI pad conditions (CE-1399, Rev. 0, 1998). Based on a review of the spreadsheet calculations in Attachment A of (CE-1399, Rev. 0, 1998), the calculated cask input deceleration values were reasonably close to the equivalent 50-g cask input deceleration values that were established for the Cask Bottom-end-Drop & Cask Tip-over cases, ~51.58-g > 50-g & ~47.62-g < 50-g, respectively. Calculated cask input deceleration values

for the **NAPS** conditions were normalized to calculated cask input deceleration values for the **US NRC** conditions in order to obtain scale factors, **SF** = ($G_{28\ Days}$ / $G_{US\ NRC}$) for both the Cask Bottom-end-Drop and Cask Tip-over cases. In retrospect, it would have been equally appropriate to normalize both scale factors to the targeted equivalent value of 50-g versus the individually calculated $G_{US\ NRC}$ reference values, given that these calculated cask input deceleration values for the **US NRC** conditions were so close to the targeted equivalent 50-g cask input deceleration values. However, for consistency in methodology, all scale factors in this Calculation Addendum will continue to be normalized by the calculated $G_{US\ NRC}$ reference values. The normalized scale factors were then multiplied by the corresponding cask deceleration limits, as listed above, to provide a conservative estimate of the new decelerations that could occur at corresponding critical locations in the TN-32 cask body and basket. In all cases, the calculated deceleration values were less than their corresponding US NRC limiting deceleration values; hence, the analysis in the original licensing basis (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996) was bounding for the **NAPS** conditions.

Calculated deceleration values at these critical locations of the TN-32 cask body and basket are dependent upon the ISFSI pad target hardness value, S, which is also a function of the concrete compressive strength, f'_c. Since concrete compressive strength, f'_c, increases, with age, calculated pad target hardness, S, and cask input deceleration values, G, will also increase with age. Based on the as-built, average 28-day concrete compressive strength results, conservative estimates of f'_c can be made for a given ISFSI pad over its desired service life. Using these estimated values of f'_c, corresponding new estimates of pad target hardness and cask input deceleration values can be made for a given ISFSI pad, via the methodology established in (EPRI NP-4830, 1986) and (EPRI NP-7551, 1993). Based on a review of the original TN-32 cask licensing basis evaluation (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996), cask body and basket deceleration limits were evaluated, using the NAPS ISFSI Pad #1 as-built, average, 28-day concrete compressive strength (i.e. $f'_{c\ 28\text{-}Day}$ = 5,060 psi) was increased by a dynamic increase factor of 1.1 to account for the higher rate of strain from postulated cask drop loading (CE-1399, Rev. 0, 1998). As in this original analysis, if the newly calculated deceleration values for the aged concrete ISFSI pad are less than the corresponding US NRC approved limiting deceleration values, then the analysis in the original licensing basis (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996) is bounding for the aged concrete ISFSI pad.

By recalculating the ISFSI pad target hardness value, S, for as-built, concrete compressive strengths at 28 days and 60 years of service life, corresponding cask input deceleration values, G, can be determined from equations, as listed in (EPRI NP-4830, 1986) and (EPRI NP-7551, 1993). Calculated cask input G values for the pad at 28 days and 60 years of service life were divided by the calculated US NRC Reference input G values to produce scale factors for a given concrete pad at these service life ages. Multiplying the normalized service life scale factor, SF, times the corresponding US NRC limiting deceleration value, as listed in the (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996) and (US NRC Safety Evaluation Report, 1998), produces an estimate of the corresponding maximum deceleration value that could be obtained at that cask location during postulated impacts upon a concrete pad at 28 days or 60 years of service life. Similarly, if calculated deceleration values are less than their corresponding US NRC limiting deceleration values, then the analysis in the original licensing basis (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996) is bounding.

11. Calculations

In order to recalculate the ISFSI pad target hardness value, S, for as-built, concrete compressive strengths at 60 years of service life, an estimate of the maximum concrete compressive strength will need to be made. Table 2.13, Reference (US NRC NUREG/CR-6424, 1996), as shown below, lists the average concrete compressive strengths for three (3) Material Codes (i.e. test concrete mixtures) at 28-days, 20-years and 30-years of service life. Between 28-day and 20-years, the average percentage compressive strength increase was 67% (i.e. 36.2 MPa / 21.7 MPa = 1.67). However, over the next 10 years, the average compressive strength only increased by an additional 3% (i.e. 37.1 MPa / 36.2 MPa = 1.03).

Table 2.13. Time-dependent compressive strength values for portland cement concretes obtained from SMIC.

Material Code	Compressive Strength, MPa		
	28-day	20-year	30-year
01CB002	19.2	35.9	37.8
01CB003	12.3	25.5	26.1
01CB007	33.6	47.3	47.4
Average =	21.7	36.2	37.1

A review of the above test data shows that Material Code 01CB007, with the highest 28-day average concrete compressive strength of 33.6 MPa (4,873 psi), is closest to the as-built, 28-day average concrete compressive strength of 5,060 psi for NAPS ISFSI Pad #1. Between 28-days and 20-years, the average percentage increase in concrete compressive strength for Material Code 01CB007 was only 41%, which is less than the average for all three (3) Material Codes (i.e. 47.3 MPa / 33.6 MPa = 1.41 < 1.67). Over the next 10 years, the compressive strength increase for Material Code 01CB007 was essentially unchanged, at less than a 0.2% increase (i.e. 47.4 MPa / 47.3 MPa = 1.002). The following trends are consistent in the above test data for each concrete Material Code:

1.) The higher the 28-day, concrete compressive strength, the lower is the percentage increase in concrete compressive strength, going forward in time.

2.) The percentage increase in concrete compressive strength, between 20 and 30 years, is negligible when compared to the reported 28-day, concrete compressive strength.

Based on these observed trends, it will be conservative to use a 1.67 increase factor on the average, as-built, 28-day concrete compressive strength for NAPS ISFSI Pad #1 to account for the age-related strength increase of concrete over the requested 60 year service life for NAPS ISFSI Pad #1.

Using the methodology discussed in (CE-1399, Rev. 0, 1998), a new Excel spreadsheet has been developed to estimate the deceleration values for the NAPS ISFSI Pad #1. These deceleration values will be compared to the 50-g dynamic deceleration input force criteria used in the original licensing basis for the TN-32 cask drop analyses. The ratio of these deceleration values, **($G_{28\text{-Days}}$ / $G_{US\ NRC}$)** or **($G_{60\ Years}$ / $G_{US\ NRC}$)** will determine normalized scale factors, SF, consistent with those of (CE-1399, Rev. 0, 1998) to be used for estimating peak accelerations at the critical locations in the TN-32 cask body and basket. The evaluation in this Calculation Addendum conservatively applies a 1.67 factor to the as-built, 110% average 28-day concrete compressive strength (i.e. 1.67 x 110% $f'_{c\ 28\text{-Days}}$ = 9,295 psi) to evaluate the ageing effects of concrete in the NAPS ISFSI Pad #1 for the requested 60 years of service life. See Appendix 17.3 of this Calculation Addendum for details of this evaluation in the new Excel spreadsheet. See References (EPRI NP-4830, 1986) and (EPRI NP-7551, 1993) for a complete discussion of all as-built ISFSI pad variables used in the calculation of TN-32 cask deceleration values for the Bottom-End and Side-Drop evaluations.

The following sketch of NAPS ISFSI Pad #1 was copied from Plant Drawing No. 11715-FC-49A, Rev. 0:

Security-Related Information
Figure Withheld Under 10 CFR 2.390.

The following cross-sections of NAPS ISFSI Pad #1 were copied from Plant Dwg. No. 11715-FC-49A, Rev. 0:

Security-Related Information
Figure Withheld Under 10 CFR 2.390.

The following NOTES of NAPS ISFSI Pad #1 were copied from Plant Dwg. No. 11715-FC-48A, Rev. 0:

NOTES:
1. ALL CONCRETE WORK SHALL BE DONE IN ACCORDANCE WITH SPECIFICATIONS NAI-0021, NAI-0022, AND NAP-0086. CONCRETE SHALL HAVE A MINIMUM COMPRESSIVE STRENGTH (f'_c) OF 3000 P.S.I. AT 28 DAYS.
2. CONCRETE REINFORCING STEEL SHALL BE ASTM A615, GR 60 (f_y=60 K.S.I.)
3. ALL STEEL PLATES AND ANGLES SHALL CONFORM TO ASTM A36.
4. ANCHOR BOLTS SHALL CONFORM TO ASTM A307 OR A36, U.N.O.
5. EMBEDDED STEEL (OTHER THAN ANCHOR BOLTS) SHALL BE GALVANIZED IN ACCORDANCE WITH ASTM A123.
6. ALL WELDING SHALL BE DONE IN ACCORDANCE WITH THE CORPORATE WELDING MANUAL USING E70XX ELECTRODES. VISUALLY INSPECT ALL WELDS.
7. JOINT SEALANT SHALL BE SIKA FLEX 1A OR APPROVED EQUAL.
8. SURVEY MARKERS FOR THE CAST ALIGNMENT SHALL BE LIETZ COMPANY TYPE 8134-06 OR APPROVED EQUAL. VERTICAL AND HORIZONTAL TOLERANCES FOR PLACEMENT SHALL BE + OR -½"
9. SEE DRAWING 11715-FY-9A FOR CASK STORAGE PAD LOCATION.

The following sketch of a TN-32 cask was copied from FIGURE 3A.1-1 (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996):

Security-Related Information
Figure Withheld Under 10 CFR 2.390.

FIGURE 3A.1-1
CASK BODY KEY DIMENSIONS

The following sketch of a TN-32 cask was copied from FIGURE 3A.3-4 (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996):

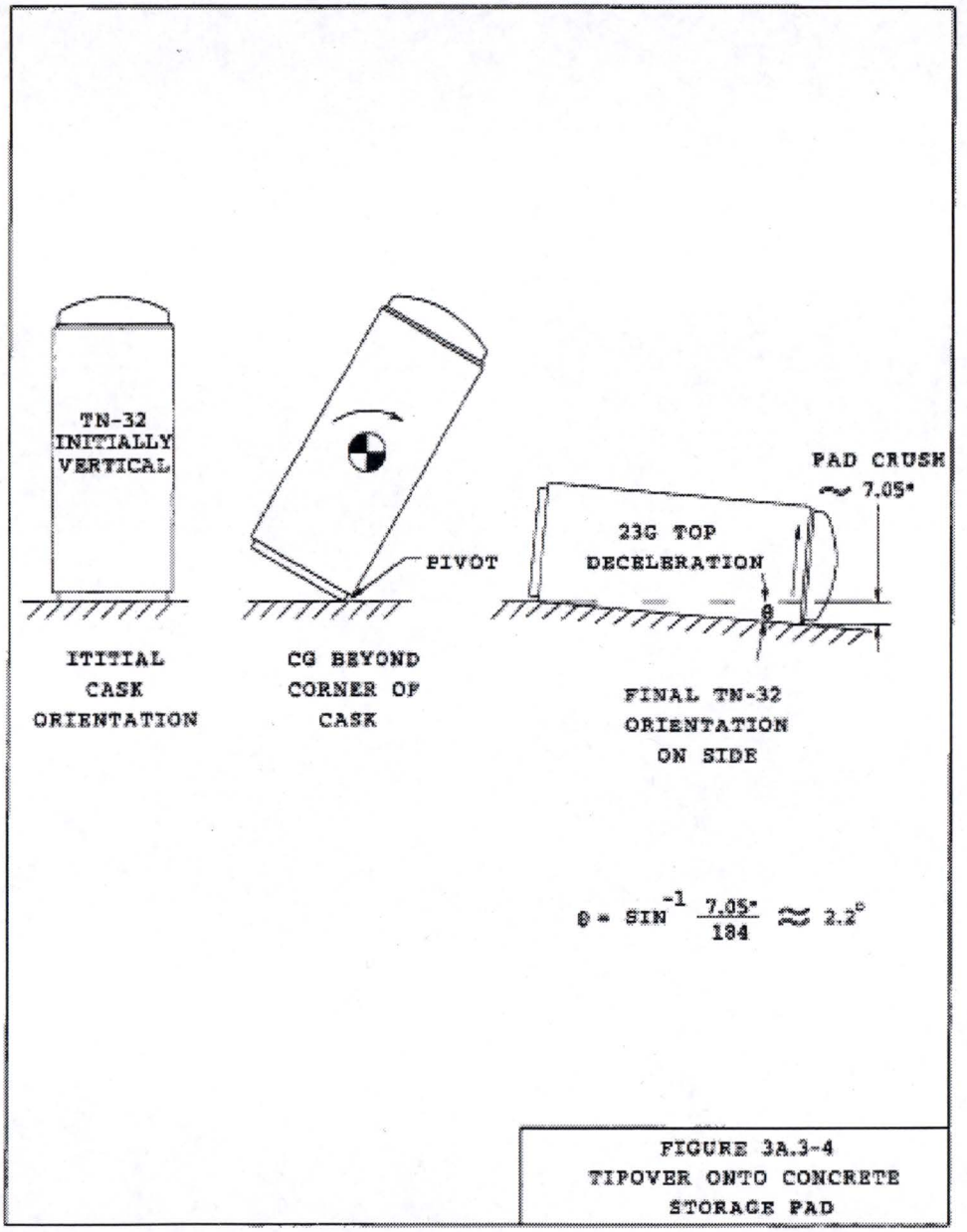

FIGURE 3A.3-4
TIPOVER ONTO CONCRETE
STORAGE PAD

REV. 9A 12/96

Prior to referring to the new Excel spreadsheet in Appendix 17.3, the following discussion explains the use of a few of the Design Inputs used in the original spreadsheet that was developed for (CE-1399, Rev. 0, 1998):

1.) The Length of Cask, L = 183.75", used in both the **"110% NAPS 28-DAY" As-Built"** and **"1.67 x 110% NAPS 28-DAY Projected"** spreadsheet evaluations in Appendix 17.3, matches the L = 183.75" that was assumed in the original licensing evaluation in Appendix 3A of (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996). However, this dimension differs slightly from L = 184.00", which is listed on Figure 3.4-2 of Chapter 3 (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996). Such minor dimensional differences have no numerical significance and can be ignored. The new Excel spreadsheet attached to this Calculation Addendum in Appendix 17.3 was calculated with L = 183.75" for both the "110% NAPS 28-DAY" and "167% NAPS 28-DAY" evaluations to be consistent the original analysis.

2.) The Length of Cask, L = 183.75", used in the **"US NRC"** spreadsheet evaluations in (CE-1399, Rev. 0, 1998), matches the L = 183.75", used in both the **"110% NAPS 28-DAY As-Built"** and **"1.67 x 110% NAPS 28-DAY Projected"** spreadsheet evaluations in Appendix 17.3 of this Calculation Addendum. However, this dimension does not match the L = 200", which was used in the EPRI target hardness studies (EPRI NP-4830, 1986) and (EPRI NP-7551, 1993) and formed the basis of this **"US NRC"** reference case calculation. Such minor dimensional differences have no numerical significance and can be ignored. The new Excel spreadsheet attached to this Calculation Addendum in Appendix 17.3 was calculated with L = 183.75" to be consistent the original analysis.

3.) The value for Soil Modulus of Elasticity, E_s = 30,000 psi, used in both the **"110% NAPS 28-DAY As-Built"** and **"1.67 x 110% NAPS 28-DAY Projected"** spreadsheet evaluations in Appendix 17.3 of this Calculation Addendum was based on reported information in (CE-1399, Rev. 0, 1998). This reported soil modulus value differs slightly from the E_s = 32,600 psi value that was assumed in (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996). Such minor dimensional differences have no numerical significance and can be ignored. A Soil Modulus of Elasticity value of E_s = 30,000 psi was listed in (US NRC Safety Evaluation Report, 1998), pages 11-5 & 11-6 for NAPS ISFSI Pad #1. The new Excel spreadsheet attached to this Calculation Addendum in Appendix 17.3 was completed with E_s = 30,000 psi to be consistent with the Soil Modulus of Elasticity value used and cited in the original licensing basis document.

4.) Similar to (CE-1399, Rev. 0, 1998), all scale factors, SF, were normalized to the calculated cask input deceleration value for the **"US NRC Reference"**, $G_{US\ NRC}$ conditions (eg. **SF** = $G_{28\ Days}$ / $G_{US\ NRC}$) for both the Cask Bottom-end-Drop and Cask Tip-over cases.

5.) Similar to (CE-1399, Rev. 0, 1998), all calculated deceleration, G values, were rounded up to the next whole number for additional conservatism.

12. Acceptance Criteria (optional)

Based on US NRC Reference (US NRC Safety Evaluation Report, 1998) and Transnuclear, Inc. Reference (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996), the following TN-32 cask body and basket deceleration limits must not be exceeded for postulated Bottom-End-Drop and Side-Drop Cases:

Bottom-End-Drop Case Acceptance Limits:	**US NRC Reference** $G_{US\ NRC}$
50-g (Basket)	Ref. 3.6, Section 3.3.3
Side-Drop Case Acceptance Limits:	
63-g (Cask Body)	Ref. 3.6, Section 3.3.3
88-g (Top of Basket)	Ref. 3.6, Section 3.3.3
52-g (90^0 Basket Cross-Section)	Ref. 3.6, Section 3.3.3

13. Results and/or Conclusions

From the new Excel spreadsheet (Appendix 17.3), the following TN-32 cask deceleration values, **G**, are summarized for the **"110% NAPS 28-Day As-Built"**, **"US NRC Reference"** and **"1.67 x 110% NAPS 28-Day Projected"** concrete compressive strengths:

Bottom-End-Drop Case Acceptance Limits:	**110% NAPS 28-Day As-Built** $G_{28\ Days}$	**US NRC Reference** $G_{US\ NRC}$	**1.67 x 110% NAPS 28-Day Projected** $G_{60\ Years}$
50-g (Basket)	> 35-g	< 50-g	> 41-g
Side-Drop Case Acceptance Limits:			
63-g (Cask Body)	> 41-g	< 63-g	> 48-g
88-g (Top of Basket)	> 58-g	< 88-g	> 67-g
52-g (90^0 Basket Cross-Section)	> 34-g	< 52-g	> 40-g

All of the above calculated TN-32 cask deceleration values, $G_{60\ Years}$, for NAPS ISFSI Pad #1 concrete compressive strength at **1.67 x 110% NAPS 28-Day Projected** conditions were less than their corresponding **US NRC Reference** condition acceptance limits deceleration, $G_{US\ NRC}$, values for all Bottom-End-Drop and Side-Drop cases. Previously calculated deceleration values, $G_{28\ Days}$, for the **110% NAPS 28-Day As-Built** conditions have been listed here for comparison purposes only. In summary, the original licensing basis analysis (TN-32 Dry Storage Cask Topical Safety Analysis Report, 1996) is bounding for the predicted concrete target hardness of the NAPS ISFSI Pad #1 at 60 years of service life.

14. Precautions and Limitations

None

15. Recommendations (optional)

None

16. Calculation Review Checklist (may be included as an Attachment)

See Page 16 of 16.

17. Appendices and/or Attachments (may be included in the Table of Contents pages if applicable) (optional)

17.1. US NRC Draft Letter, "Request for Additional Information for Review of the Application for Renewal of the North Anna Power Station Independent Spent Fuel Storage Installation License No. SNM-2507 (CAC No. L25121)", May 16, 2016 (Pages 1-18 of 18)

17.2. NAPS ISFSI License Renewal Application, Serial No. 16-031, Docket No. 72-16, License No. SNM-2507, May 25, 2016 (Pages 1-2 of 2)

17.3. New Excel Spreadsheet for Calculation of NAPS ISFSI Pad #1, Target Pad Hardness and Deceleration Values for the Bottom-End-Drop and Side-Drop Cases, (Pages 1-2 of 2)

Complete Calculation

Calculation # CE-1399 Rev. 0 Add. #00A

NOTE: If "Yes" is not answered, an explanation may be provided below. Reference may be made to explanations contained in the calculation or addendum.

Questions:	Yes	N/A
1. Have the sources of design inputs been correctly selected and referenced in the calculation?	[X]	[ ]
2. Are the sources of design inputs up-to-date and retrievable/attached to the calculation?	[X]	[ ]
3. Where appropriate, have the other disciplines reviewed or provided the design inputs for which they are responsible?	[ ]	[X]
4. Have design inputs been confirmed by analysis, test, measurement, field walkdown, or other pertinent means as appropriate for the configuration analyzed?	[X]	[ ]
5. Have the bases for assumptions been adequately and clearly presented and are they bounded by the Station Design Basis?	[X]	[ ]
6. Were appropriate calculation/analytic methods used and are outputs reasonable when compared to inputs?	[X]	[ ]
7. Are computations technically accurate?	[X]	[ ]
8. Has the calculation made appropriate allowances for instrument errors and calibration equipment errors?	[ ]	[X]
9. Have those computer codes used in the analysis been referenced in the calculation?	[ ]	[X]
10. Have all exceptions to station design basis criteria and regulatory requirements been identified and justified in accordance with NQA-1-1994?	[ ]	[X]
11. Has the design authority/original preparer for this calculation been informed of its revision or addendum, if required?	[X]	[ ]
12. Was the pre-job brief completed without any identified HU error precursors/compensating actions? (If HU error precursors/compensating actions were identified, then mark N/A and provide explanation/summary below or attach pre-job brief form to calculation.)	[X]	[ ]

Comments: (Attach additional pages if needed)

3. **No other disciplines were required to review or provide design inputs for this Calculation Addendum.**
8. **No instrument errors or calibration equipment errors were introduced into this Calculation Addendum.**
9. **No computer codes were used in the analysis.**
10. **No exceptions to station design basis criteria or regulatory requirements were taken for this Calculation Addendum.**

Signature: Charles A. Zalesiak (Preparer) Date: 01/09/2017

Signature: [signature] (Reviewer) Date: 01/11/2017

Signature: N/A (Owner's Review, if applicable) Date: N/A

Note: Physical or electronic signatures are acceptable.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

November 23, 2016

Mr. Daniel G. Stoddard
Senior Vice President and Chief Nuclear Officer
Innsbrook Technical Center
5000 Dominion Boulevard
Glen Allen, VA 23060-6711

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR REVIEW OF THE APPLICATION FOR RENEWAL OF THE NORTH ANNA POWER STATION INDEPENDENT SPENT FUEL STORAGE INSTALLATION LICENSE NO. SNM-2507 (CAC NO. L25121)

Dear Mr. Stoddard:

By letter dated May 25, 2016, Virginia Electric and Power Company (Dominion) submitted an application for renewal of License No. SNM-2507 for the North Anna Power Station Independent Spent Fuel Storage Installation (ISFSI) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16153A140). In my letter dated, July 21, 2016, I acknowledged acceptance of your application for a detailed technical review and provided a proposed schedule for U.S. Nuclear Regulatory Commission (NRC) review (ADAMS Accession No. ML16207A104).

In connection with the NRC staff's review, we need the information identified in the enclosed request for additional information (RAI). We request that you provide this information by January 19, 2017. Inform us at your earliest convenience, but no later than January 5, 2017, if you are not able to provide the information by that date. To assist us in re-scheduling your review, you should include a new proposed submittal date and the reasons for the delay. Discussion of the RAIs and RAI response date occurred on November 16, 2016.

The NRC staff is also reviewing a license amendment request from Dominion for authorization to store high-burnup fuel (HBF) in a modified TN-32B cask under License No. SNM-2507, and the staff expects to complete its review in the first quarter of 2017. If the NRC approves the HBF amendment request, the HBF cask would then be a part of the licensing bases for the ISFSI and would need to be addressed in the license renewal application. In the case that NRC approves the HBF amendment request, we request that you address the HBF cask in a supplement to the license renewal application within 30 days following the amendment issuance. This was the subject of a July 14, 2016, meeting (ADAMS Accession No. ML16207A310) and was discussed in the November 16, 2016, teleconference.

Please reference Docket No. 72-16 and CAC No. L25121 in future correspondence related to this request. The staff is available to clarify these questions, and if necessary, to meet and discuss your proposed responses.

If you have any questions regarding this matter, please contact me at (301) 415-7116 or Kristina.Banovac@nrc.gov.

Sincerely,

/RA/

Kristina L. Banovac, Project Manager
Renewals and Materials Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 72-16
License No. SNM-2507

CAC No. L25121

Enclosure: Request for Additional Information

cc: North Anna Service List
North Anna ISFSI Renewal Service List

If you have any questions regarding this matter, please contact me at (301) 415-7116 or Kristina.Banovac@nrc.gov.

Sincerely,

/RA/

Kristina L. Banovac, Project Manager
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Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Docket No. 72-16
License No. SNM-2507

CAC No. L25121

Enclosure: Request for Additional Information

cc: North Anna Service List
North Anna ISFSI Renewal Service List

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ADAMS Accession No.: ML16330A715

OFC	NMSS/DSFM/ RMB	NMSS/DSFM/ RMB	NMSS/DSFM/ RMB	NMSS/DSFM/ CSRAB	NMSS/DSFM/ CSTB
NAME	KBanovac	TAhn	JWise	MCall for ZLi	DTang
DATE	10 / 20 /16	10 / 31 /16	10 / 25 /16	10 / 28 /16	10 / 26 /16
OFC	NMSS/FCSE/ ERB	NMSS/FCSE/ ERB	NMSS/DSFM/ SFLB	NMSS/DSFM/ CSRAB	NMSS/DSFM/ CSTB
NAME	JTrefethen	DDiaz-Toro	WWheatley	TTate	JPiotter
DATE	10/ 28 /16	10 / 28 /16	11 / 3 /16	11 / 14 /16	11 / 8 /16
OFC	NMSS/DSFM/ SFLB	NMSS/FCSE/ ERB	NMSS/DSFM/ RMB		
NAME	JMcKirgan	JCaverly	MRahimi		
DATE	11 / 15 /16	11 / 3 /16	11 / 23 /16		

OFFICIAL RECORD COPY

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Request for Additional Information
Virginia Electric and Power Company (Dominion)
Docket No. 72-16
License No. SNM-2507
License Renewal

By letter dated May 25, 2016, Virginia Electric and Power Company (Dominion) submitted an application for renewal of License No. SNM-2507 for the North Anna Power Station (NAPS) Independent Spent Fuel Storage Installation (ISFSI). This request for additional information (RAI) identifies information needed by the U.S. Nuclear Regulatory Commission (NRC) staff in connection with its review of the renewal application. The requested information is listed by chapter number and title in the application. NUREG-1927, Revision 1, "Standard Review Plan for Renewal of Specific Licenses and Certificates of Compliance for Dry Storage of Spent Nuclear Fuel" and NUREG-1748, "Environmental Review Guidance for Licensing Actions Associated with NMSS Programs" were used by the staff in its review of the application.

Each individual RAI describes information needed by the staff for it to complete its review of the application and to determine whether the applicant has demonstrated compliance with the regulatory requirements.

Chapter 1 – General Information

RAI 1-1

Provide the following additional information with respect to cumulative impacts for all resource areas. If no impact is expected please make a statement to that effect.

1. Clarify the amount of spent fuel expected to be generated by NAPS Unit 1 and Unit 2 throughout their license life and the amount of ISFSI storage capacity necessary to accommodate the generated spent fuel.

2. Dominion anticipates expanding the general-licensed ISFSI to store additional spent fuel from Units 1 and 2. Provide a description of the plans to expand the general-licensed ISFSI, including construction of additional pads and their locations. Discuss the potential cumulative impacts of this potential expansion for all resource areas. Provide a description of and quantify, where possible, the factors considered in evaluating the potential cumulative impacts. Provide mitigation measures that have been or would be taken to reduce or avoid potential cumulative impacts.

3. The specific-licensed ISFSI is authorized to store 84 TN-32 sealed surface storage casks on three pads. The general-licensed ISFSI Pad 2 occupies the location identified for a second pad under the specific-licensed ISFSI. Explain the process followed to locate the general-licensed ISFSI Pad 2 here and clarify whether this process would be used to locate any future pads under the general-licensed ISFSI.

4. Discuss the potential cumulative impacts of construction and operation of the proposed third nuclear power unit, designated as Unit 3.

Dominion's Environmental Report (ER) Supplement, submitted as part of the license renewal application, includes a description of the following activities associated with the NAPS, but that are not part of the license renewal request:

- Continued operation of the NAPS Units 1 and 2. These units operate under separate NRC licenses (NPF–4 and NPF–7, respectively) that will expire in 2038 and 2040, respectively. In the ER Supplement, Dominion states it considered the potential cumulative impacts of the ISFSI continued operations with the NAPS Units 1 and 2 operations.

- North Anna Unit 3 Combined License Application (COLA) is currently under review by the NRC. Dominion is proposing to construct and operate a third nuclear power unit, designated as Unit 3. In the ER Supplement, Dominion states it considered the potential cumulative impacts of the ISFSI continued operations with the reasonably foreseeable future action of construction and operation of the proposed Unit 3.

- General-licensed ISFSI Pad 2, which is located adjacent to the specific-licensed ISFSI Pad 1. In the ER Supplement, Dominion explains that it has no plans to expand the pad capacity under the specific-licensed ISFSI beyond Pad 1, but it retains the authority to do so. Dominion further clarifies that the potential environmental impacts of such expansion are considered and discussed in the ER Supplement (see page E-2). Dominion also explains that future dry cask storage of spent fuel at NAPS, including construction of any additional pads, would be anticipated to occur under the general license (see page E-3).

Although the proposed license renewal only applies to the NAPS specific-licensed ISFSI Pad 1, these actions are considered past, present, or reasonably foreseeable future actions that could affect the same resources impacted by the proposed action. The NRC will consider these actions in its cumulative impact analysis of the environmental review.

This information is necessary for the NRC staff to assess the environmental impacts of the proposed action, as required by 10 CFR 51.30.

RAI 1-2

Provide a description of all maintenance or aging management activities that Dominion anticipates carrying out over the proposed 40-year renewal period and discuss the environmental impacts from such activities.

In the ER Supplement, Dominion states that no construction or refurbishment beyond normal maintenance and aging management is currently planned for TN-32 dry cask storage. Dominion further explains that maintenance activities, such as re-coating the casks, are the only activities expected over the proposed 40-year period of extended operation, and that there would be no environmental impacts from refurbishment or construction beyond those analyzed in the original environmental assessment (see page E-28).

This information is necessary for the NRC staff to assess the environmental impacts of the proposed action, as required by 10 CFR 51.30.

RAI 1-3

Describe the NAPS' radiological protection programs that the specific-licensed ISFSI relies on for safe operation. Also, discuss how Dominion plans to maintain those NAPS' radiological protection programs that the specific-licensed ISFSI relies on after the expiration of the license for, or shutdown of, Units 1 and 2 (whichever comes first).

In the ER Supplement, Dominion states that the design and operational features of the TN-32 dry storage casks, along with the NAPS' radiological protection program, mitigate radiological impacts (see page E-28). If the specific-licensed ISFSI license renewal request is approved, the license would expire in 2058. The NAPS Units 1 and 2 licenses, however, expire in 2038 and 2040, respectively.

This information is necessary for the NRC staff to assess the environmental impacts of the proposed action, as required by 10 CFR 51.30.

Finally, the information the NRC uses to conduct and inform its National Environmental Policy Act environmental reviews, including the information in the ER Supplement, must be publicly available, as appropriate. Therefore, please ensure that the information included in response to RAIs 1-1 to 1-3 can be made publicly available.

Chapter 2 – Scoping Evaluation

RAI 2-1

Provide justification for excluding the lift beam and cask lid handling tools from the scope of renewal. Alternatively, include these components in the renewal scope, provide an aging management review, and describe the aging management activities used to manage the identified aging effects.

Table 2.3-2 of the renewal application states that the lift beam and lid handling tools are important to safety; however, these components were excluded from the scope of renewal based on the existence of inspection activities already performed to meet the requirements of the reactor operating license. However, NUREG-1927, Revision 1, states that all important-to-safety structures, systems, and components (SSCs) should be within the scope of renewal and should be addressed with an aging management review. Also, 10 CFR 72.42(a) states that renewal applications should include descriptions of aging management programs (AMPs) for the management of aging issues for SSCs important to safety.

The staff notes that the existence of current site monitoring and inspection procedures is not recognized in the NRC regulations and guidance as a basis for excluding SSCs from the scope of renewal. It is the staff's expectation that an aging management review be performed on all important-to-safety SCCs and, if appropriate, any existing activities that address aging management be incorporated by reference into the ISFSI renewal documentation.

This information is required to determine compliance with 10 CFR 72.42(a).

RAI 2-2

Provide information to show that the earth berm is not credited in the calculations of dose at the controlled area boundary and justify that the berm should not be included in the renewal scope. Alternatively, include the berm in the scope of renewal and provide an aging management review and adequate aging management program for managing the aging effects of the berm.

In Table 2.3-2, Scoping Results, of the license renewal application for the NAPS specific-licensed ISFSI, the licensee states, "The ISFSI SAR Section 7.3.2 states: 'An earth berm was constructed inside the north and east perimeter fences of the ISFSI to reduce direct radiation.' The berm is not addressed in Technical Specifications or the Safety Evaluation Report. Additionally, the 10 CFR Parts 20, 72.104 and 72.106 dose analyses do not credit the berm as providing shielding."

Appendix A.1 of the "North Anna Power Station Units 1 & 2, Independent Spent Fuel Storage Installation (ISFSI), Safety Analysis Report" (ISFSI SAR) states, "The North Anna ISFSI Technical Specifications, and the TSAR, Revision 9A, however will govern the use of TN-32, Revision 0, casks at the North Anna ISFSI, except to the extent that specific analyses (e.g., criticality or thermal performance) from the FSAR, Revision 0, have been added to the ISFSI SAR."

Section 7.3.2.1 of the ISFSI SAR states that the shielding analyses performed for the TN-32 cask is described in "TN-32 Dry Storage Cask Final Safety Analysis Report, Revision 0, January 2000," (FSAR, Revision 0), listed as reference 1 in Section 7.3.4 of the ISFSI SAR. The staff did not find any other referenced analysis or discussion on the modeling of the earth berm within the shielding analysis and therefore assumes that the analysis used for shielding is that of FSAR, Revision 0.

However the modeling assumptions within FSAR, Revision 0 with respect to the earth berm are not consistent with the statement that the berm is not credited in the 10 CFR Parts 20, 72.104 and 72.106 dose analyses. For example, page 10.2-2 of the FSAR, Revision 0, states, "For the skyshine analyses, an earthen berm was added to the basic long distance models. The berm was modeled as 4.2 meters high and was located 20 meters from the cask centerline." In addition, on page 10.2-2 of the same document, it states, "The dose rates from a typical ISFSI are evaluated based on the sky shine results from a single cask (without inserts) and assuming the presence of a berm." Also, from the MCNP input file on pages 5.5-26 to 5.5-29, it appears that the earth berm is included in the MCNP model (particularly cells 740, 780, 800, etc.), though the note on the input file states that there is no berm. Page 10.2-2 of the FSAR, Revision 0, also states that dose rates at the site boundary will depend on specific parameters, such as the presence of the berm; however, the staff did not find detailed information on how this is done at NAPS.

The applicant should clarify the licensing basis for the shielding and radiation protection evaluation for the NAPS specific-licensed ISFSI. If it is FSAR, Revision 0, the applicant should provide details on how the berm is excluded from the model. If the berm is credited in the shielding model, the applicant needs to justify why the earth berm is scoped out of the renewal. Otherwise, the berm should be scoped into the renewal and an aging management review conducted and adequate aging management program provided for the berm.

The NRC staff needs this information to determine compliance with 10 CFR 72.42(a), 10 CFR 72.104, 10 CFR 72.106, and 10 CFR 20.1301(a) and (b).

RAI 2-3

If the NRC issues the license amendment for authorization to store high-burnup fuel (HBF) in a modified TN-32B cask under License No. SNM-2507, the staff requests Dominion, within 30 days following the amendment issuance, provide information on the HBF cask and whether the HBF itself, or any new SSCs that make up the cask modifications, are within the scope of license renewal and subject to an aging management review. The staff also requests updated application documents, as appropriate, to address the HBF cask.

Dominion has submitted a license amendment request for authorization to store HBF in a modified TN-32B cask under License No. SNM-2507, which is still under review by the staff in a separate licensing action. If the NRC approves the HBF amendment request, the HBF cask would then be a part of the licensing bases for the NAPS ISFSI and would need to be addressed in the license renewal application. Due to the concurrent timing of two review activities (i.e. the license amendment request to store HBF and the license renewal) and in order to ensure proper consideration of the two reviews, the NRC requests clarification on how Dominion will address the HBF cask in the renewal application.

This information is needed to determine compliance with 10 CFR 72.42(a).

RAI 2-4

Clarify how the licensing basis for the shielding and radiation protection evaluation for the NAPS specific-licensed ISFSI is maintained during the requested period of extended operation, considering storage of additional radioactive materials at the NAPS under different licenses (e.g., general-licensed ISFSI).

The NAPS ISFSI SAR includes dose analyses to demonstrate that the specific-licensed ISFSI meets the regulatory requirements of 10 CFR 72.104(a), which requires inclusion of dose contributions from other facilities (including new ISFSIs under different licenses) near the specific-licensed ISFSI. The NAPS ISFSI SAR discusses the assumptions used in the dose analyses, such as three storage pads filled with 84 TN-32 sealed surface storage casks (SSSCs), each pad having 28 SSSCs. However, in addition to the site's reactors, the specific-licensed ISFSI is co-located with an ISFSI under a different license (i.e., a general license) that uses a different storage system design and may continue to increase in storage capacity over the period of extended operation of the specific-licensed ISFSI. Therefore, it is not clear that the SAR dose analyses will remain valid for the duration of the requested period of extended operation of the specific-licensed ISFSI, considering storage of additional radioactive materials at the NAPS in different storage systems and higher number of storage systems per pad under different licenses.

This information is required to determine compliance with 10 CFR 72.42(a) and 10 CFR 72.104(a).

Chapter 3 – Aging Management Reviews

RAI 3-1

Clarify the material designation for the vent and drain port cover bolts in the TN-32 cask.

Table 1.2-2 of the TN-32 Topical Safety Analysis Report, Revision 9A, states that the vent and drain port cover bolts are constructed of stainless steel. In the renewal application, the aging management review (AMR) results table and the TN-32 Dry Storage Cask aging management program (page A-6) defines the subject bolts as being constructed of low-alloy steel.

If the material designation as a low-alloy steel is correct, provide a reference to the applicable design basis information. If the material designation is not correct, provide the AMR for the corrected material and revise the material designation in other areas of the application, as appropriate.

This information is required to determine compliance with 10 CFR 72.24(c) and 10 CFR 72.42(a).

RAI 3-2

Justify why microbial degradation, salt scaling, and corrosion of reinforcing steel are not included as aging mechanisms for concrete. Alternatively, include these aging mechanisms in the aging management review and revise the Table of Aging Effects in the ISFSI SAR supplement.

The application excludes three aging mechanisms in the Monitoring of Structures Aging Management Program, Aging Management Review Results (Table AMR Results-3) and the Table of Aging Effects (Table C2.1-1; New ISFSI SAR Table 9.7-1):

(i) Microbial Degradation
(ii) Salt Scaling
(iii) Corrosion of Reinforcing Steel

Chloride attack of the reinforcing steels within concrete structures is a well-known phenomenon. The alkaline environment of the concrete typically results in a metal-adherent oxide film on the reinforcing steel bar surface, which passivates the steel. However, chloride ions can break down the passive layer, triggering corrosion that leads to cracking and spalling of the concrete. The applicant provided the limit of less than 500 ppm of chloride concentration and pH greater than 5.5 in groundwater to prevent the corrosion. However, some data suggests the limit of 300 ppm (ASME, 1995). Chlorides may already exist at low levels within the base mix constitutes, and chlorides can be concentrated in damp or dry environments.

Biodeterioration (Microbial Degradation) is caused by colonization of microbes and microorganisms that grow on concrete surfaces that offer favorable environmental conditions (e.g., available moisture, near neutral pH, presence of nutrients). Conducive environments may have elevated relative humidity (i.e., greater than about 60 percent), long cycles of humidification and drying, freezing and thawing, high carbon dioxide concentrations, high concentrations of chloride ions or other salts, or high concentrations of sulfates and small amounts of acids (Wei et al., 2013). Biodeterioration may lead to reduction of the protective cover depth, and increase both concrete porosity and the transport of aggressive chemicals (Sanchez-Silva and Rosowsky, 2008), and this degradation mode can promote a reduction in concrete pH, loss of concrete strength, and spalling/scaling.

Salt scaling is defined as superficial damage caused by freezing a saline solution on the surface of a concrete body. The damage is progressive and consists of the removal of small chips or

flakes of material. Similar to freeze and thaw damage, salt scaling takes place when concrete is exposed to freezing temperatures, moisture, and dissolved salts.

The staff requests the bases for this exclusion. If the applicant determines that these aging mechanisms are credible, the aging mechanisms should be included in the aging management review and in the Table of Aging Effects (Table C2.1-1; New ISFSI SAR Table 9.7-1). This information is needed to determine if the aging management review is comprehensive in identifying all pertinent aging mechanisms and effects applicable to the SSCs within the scope of renewal and that a summary of the information is included in the renewal application and FSAR supplement.

This information is needed to determine compliance with the requirements of 10 CFR 72.42(a).

References:

ASME. "ASME Boiler and Pressure Vessel Code, Section XI, Subsection IWL." New York, New York: American Society of Mechanical Engineers. 1995.

Sanchez-Silva, M. and D. Rosowsky. "Biodeterioration of Construction Materials: State of the Art and Future Challenges." Journal of Materials in Civil Engineering. Vol. 20. pp. 352-365. 2008.

Wei, S., Z. Jiang, H. Liu, and M. Sanchez-Silva. "Microbiologically Induced Deterioration of Concrete–A Review." Brazilian Journal of Microscopy. Vol.44. pp. 1,001-1,007. 2013.

RAI 3-3

Clarify the TN-32 cask aging management review results for the silver lid seal, which is stated to be subject to loss of material, but no aging mechanism or aging management program is cited.

Table AMR Results – 1, "Transnuclear TN-32 Dry Storage Cask," of the renewal application includes loss of material as an aging effect for the silver lid seal in the atmosphere/weather environment. However, the table does not include an associated aging mechanism or aging management program. In addition, Table C2.1-1, "Table of Aging Effects (New ISFSI SAR Table 9.7-1)," of the renewal application does not identify any aging effects for silver.

If loss of material is a credible aging mechanism for the silver lid seal, provide an aging management activity that will ensure that the seal's pressure boundary function will be maintained in the period of extended operation.

This information is required to determine compliance with 10 CFR 72.42(a).

RAI 3-4

Justify why effects due to thermal and radiation exposure (e.g., cracking) and loss of shielding due to boron depletion are not included as aging effects/mechanisms for the neutron shields in the TN-32 cask. Alternatively, revise the aging management review tables and address these aging effects with an aging management program or time-limited aging analysis (TLAA).

Heat and radiation can induce changes in polymers that include embrittlement, decomposition, and changes in physical configuration (e.g., loss of hydrogen or water) (EPRI, 2002; McManus

and Chamis, 1996; Cota, 2007; Fu, 1988). Shrinkage and embrittlement can result in (localized) losses of shielding material and lead to cracking. In addition, if the borated radial neutron shield material is exposed to sufficient neutron fluence over time, the consumption of B-10 atoms could impact the material's shielding function.

This information is required to determine compliance with 10 CFR 72.42(a), 10 CFR 72.104, 10 CFR 72.106, and 10 CFR 20.1301(a) and (b).

References:

EPRI. "Technical Bases for Extended Dry Storage of Spent Nuclear Fuel." TR-1003416. Palo Alto, California: Electric Power Research Institute. 2002.

McManus, H.L. and C.C. Chamis. "Stress and Damage in Polymer Matrix Composite Materials Due to Material Degradation at High Temperatures." NASA Technical Memorandum 4682. Cambridge, Massachusetts: Massachusetts Institute of Technology. 1996

Cota, S.S., V. Vasconcelos, M. Senne, Jr., L.OL. Carvalho, D.B. Rezende, and R.F. Cõrrea. "Changes in Mechanical Properties Due to Gamma Irradiation of High-Density Polyethylene." Brazilian Journal of Chemical Engineering. Volume 24, No. 02. pp. 259–265. 2007

Fu, L., R.A. Fouracre, and H.M. Banford. "An Investigation of Radiation Damage in Cured Epoxy Resin System Using Regression Experiment Design, Electrical Insulation and Dielectric Phenomena." 1988 Annual Report, Conference on Electrical Insulation and Dielectric Phenomena. IEEE Dielectrics and Electrical Insulation Society. October 1988

RAI 3-5

Discuss how the buildup of flammable gas generated in the radial neutron shield is managed in the period of extended operation.

TN-32 cask design uses polymer material or borated polymer material as neutron shields. Radiation degradation of polymer materials releases hydrogen or low-molecular weight hydrocarbons, which may reach flammable concentrations over extended periods of time. To alleviate this problem, a hole is made in the top of the lid neutron shield to provide a vent path for the buildup of gases. However, the application does not include discussion of flammable gas buildup in the radial neutron shield in the period of extended operation. The licensee needs to address how the potential flammable gas buildup aging effect in the radial neutron shield will be managed during the period of extended operation, including any means used to alleviate flammable gas buildup.

This information is required to determine compliance with 10 CFR 72.120(d).

RAI 3-6

Provide the technical basis for the proposed change to ISFSI SAR Section A.1.3, "Criticality Evaluation," where the stated time of the neutron poison effectiveness is proposed to be revised to 60 years.

The revisiting of a design-basis analysis to show that it is still valid for the period of extended operation typically would be considered a TLAA. As recommended in NUREG-1927, Revision 1, the renewal application should address a TLAA by either (1) demonstrating that the SSC will continue to perform its intended function or (2) managing the effects of aging through an aging management program.

No basis was provided in the renewal application for extending the time for which the poison material will continue to remain effective.

This information is required to determine compliance with 10 CFR 72.42(a) and 10 CFR 72.124.

RAI 3-7

Clarify the basis for the proposed change to ISFSI SAR Section A.1.4, "Thermal Evaluation," where the stated time of safe storage of the spent fuel, based on the thermal design, is proposed to be revised from 20 to 60 years.

It is not clear whether this SAR statement is a summary statement of the thermal evaluation in general, or if the timeframe in the SAR statement is associated with a specific time-related aspect of the design-basis thermal evaluation. The revisiting of a design-basis analysis to show that it is still valid for the period of extended operation typically would be considered a TLAA. As recommended in NUREG-1927, Revision 1, the renewal applicant should address a TLAA by either (1) demonstrating that the SSC will continue to perform its intended function or (2) managing the effects of aging through an aging management program.

This information is required to determine compliance with 10 CFR 72.42(a) and 10 CFR 72.128(a).

RAI 3-8

Considering the effects of age on concrete strength, perform an analysis of the ISFSI pad to estimate the concrete compressive strength (fc') and modulus of elasticity (E) at the end of the requested period of extended operation. For any increase in the concrete modulus of elasticity, determine the applicable deceleration g-loads and re-evaluate the TN-32 SSSC structural capability to withstand the design basis cask tip-over and bottom-end drop accidents. Also revise, as appropriate, Appendix C, "ISFSI Safety Analysis Report Supplement."

Appendix 3A of TN-32 Dry Storage Cask Topical Safety Analysis Report (TSAR), Revision 9A, considered a concrete compressive strength of 3,000 psi in the target hardness method, per the EPRI Report NP-4830, to determine the maximum cask side impact deceleration. A design basis cask deceleration was then selected for the cask body and basket structural analyses in Appendices 3A and 3B, respectively. However, in Appendix 3C of the TSAR, Revision 9A, a design basis deceleration with a different value was introduced in demonstrating the structural capability of the TN-32 SSSC basket undergoing inelastic response.

Concrete compressive strength is known to increase with age. As noted in NUREG/CR-6424, "Report on Aging of Nuclear Power Plant Reinforced concrete Structures," after a 20-year placement, the average compressive strength can realize an increase of 67% with respect to the nominal, 28-day design basis strength. Also, given that the as-built concrete could have a higher than nominal strength, the applicant should use the as-built concrete for the analysis.

This information is needed to determine compliance with the requirements of 10 CFR 72.42(a).

RAI 3-9

Clarify the extent of coverage for the periodic visual inspections of the TN-32 dry storage cask and the concrete pad. Revise Appendix C of the renewal application to provide these details in the ISFSI SAR supplement.

Neither the TN-32 Dry Storage Cask Aging Management Program nor the Monitoring of Structures Aging Management Program explicitly define the extent of coverage for the periodic visual inspections. For the concrete pad, the staff noted that Section 3.5.1 of American Concrete Institute (ACI) 349.3R-02 states that "[t]he scope of the visual inspection should include all exposed surfaces of the structure...."

If 100 percent of all accessible surfaces of both the casks and pad will not be inspected, provide the justification for the extent and location of the inspected areas.

This information is required to determine compliance with 10 CFR 72.42(a).

RAI 3-10

Clarify and provide the justification for the timing of the initial 20 ± 5-year scheduled inspection of the TN-32 dry storage cask bottom and under the protective cover and the first 5-year periodic visual inspection of the concrete pad. Revise Appendix C of the renewal application, as appropriate.

Neither the TN-32 Dry Storage Cask AMP nor the Monitoring of Structures AMP explicitly defines when the initial inspections of the normally inaccessible cask components and the concrete pad will occur. The inspection timing and its justification should be clear to support the licensee's development of the implementation procedures and NRC oversight of inspection activities.

This information is required to determine compliance with 10 CFR 72.42(a).

RAI 3-11

Provide details on the thermoluminescent dosimeter (TLD) measurements and perimeter fence radiation surveys that support their capability to detect neutron shield degradation, including localized degradation (e.g., shrinkage, cracking) of the individual casks. Specifically,

1. Demonstrate that the combination of TLD monitoring and perimeter radiation surveys will be capable of detecting neutron shield degradation of each individual cask.

2. For the perimeter surveys, provide details on the locations where radiation will be measured and recorded.

3. Provide the acceptance criteria that will be used to determine the upward trend of dose rates that indicates a loss of intended function of the neutron shield, including a description of how the criteria account for decay of the spent fuel source term.

4. Provide details regarding the trending of the TLD dose measurements and perimeter radiation surveys, including the specific method and procedures of the engineering evaluation used for determining trends in the dose rates.

5. Add the details of the perimeter surveys to Appendix C of the renewal application (proposed ISFSI SAR supplement).

The renewal application indicates that TLDs located along the ISFSI perimeter fence will be used to ensure the casks' neutron shielding continues to perform its function during the period of extended operation. Section A.2.1 of the renewal application, "TN-32 Dry Storage Cask Aging Management Program," states that TLD radiation monitoring is supplemented by quarterly gamma and neutron radiation surveys at the ISFSI perimeter fence. The Acceptance Criteria program element states:

> The aging management program [TN-32 Dry Storage Cask Aging Management Program] will be enhanced to include annual trending of TLD neutron and gamma radiation measurements at the ISFSI perimeter fence. The acceptance criterion for radiation monitoring is the absence of an increasing trend (as determined by Engineering evaluation) in neutron and gamma quarterly TLD readings at the ISFSI perimeter fence.

However, it is not clear from the information presented in the application, how the TLD measurements, perimeter radiation surveys, and the trending evaluations will be able to identify degradation of the neutron shields of individual casks.

This information is required to determine compliance with 10 CFR 72.42(a), 10 CFR 72.104(a), 10 CFR 72.106, and 10 CFR 20.1301(a) and (b).

RAI 3-12

For the TN-32 Dry Storage Cask AMP and the Monitoring of Structures AMP, clarify the criteria for when a visual inspection result is entered into the Corrective Action Program.

The renewal application contains some ambiguities regarding the criteria for writing a corrective action report.

In some cases, the application states that a condition report is written when AMP acceptance criteria are not met, including:

- Section A2.1, Element 7, "Corrective Actions"
- Section C2.1.1.1
- Section A2.2, Element 7, "Corrective Actions"
- Section C2.1.1.2

In other cases, the threshold for writing a condition report is stated to be conditions or indications "adverse to quality," including:

- Section A2.1, Element 5, "Monitoring and Trending"
- Section A2.1, Element 6, "Acceptance Criteria"
- Section A2.2, Element 5, "Monitoring and Trending"

Finally, in one case, the threshold for writing a condition report is stated to be "unacceptable results"

- Section A2.2, Element 6, "Acceptance Criteria" (for cracking)

The staff notes that inspection results that do not meet the AMP acceptance criteria may not necessarily be considered conditions adverse to quality. As a result, the language in various parts of the AMPs discussed above could be interpreted differently. NUREG-1927, Revision 1 states that all conditions that do not meet the AMP acceptance criteria should be entered into the Corrective Action Program.

The staff requests clarification in all areas of the renewal application of whether all inspection results that do not meet AMP acceptance criteria will be entered in the Correction Action Program. If not, state the threshold for which an inspection result will be entered into the Corrective Action Program.

This information is required to determine compliance with 10 CFR 72.42(a).

RAI 3-13

Clarify the concrete inspection acceptance criteria in Appendices A and C of the renewal application.

The description of the Monitoring of Structures Aging Management Program in Section A2.2 of the renewal application provides a list of acceptance criteria for the concrete pad inspections. However, that list is stated to apply to "...cracking of concrete surfaces..." It is unclear as to whether that list is also meant to apply to the other identified aging effects: loss of material and change in material properties.

Revise the acceptance criteria to clearly address all of the identified aging effects.

This information is required to determine compliance with 10 CFR 72.42(a).

RAI 3-14

Provide justification for the use of the Institute of Nuclear Power Operations (INPO) Consolidated Event System (ICES) for share operating experience to ensure continued AMP effectiveness.

Sections A2.1 and A2.2 of the renewal application, Element 10, "Operating Experience," state that operating experience will be identified and reported via the Institute of Nuclear Power Operations Consolidated Event System.

NUREG-1927, Revision 1 recommends that, to confirm the effectiveness of an AMP or to identify the need to enhance an AMP, renewal applicants should reference the specific system for sharing operating experience. However, it is unclear to the staff whether the ICES is capable of effectively obtaining and sharing dry storage operating experience.

NEI 14-03, Revision 1, "Format, Content and Implementation Guidance for Dry Cask Storage Operations-Based Aging Management," recommends the use of the new Aging Management INPO Database (AMID) system to collect and disseminate dry cask storage aging management information. In addition, NEI 14-03 recommends that licensees document and share their

periodic assessments of AMP effectiveness ("tollgates") through AMID. NUREG-1927 references the AMID system as one means of sharing operating experience within the industry to ensure AMP effectiveness.

The staff notes that a unique feature of the AMID system is the lower threshold for sharing information in comparison to the ICES. For example, NEI 14-03, Section 4.5.2 recommends that aging-related conditions are reported if any of the following are found: new or unexpected aging effects, new or unexpected trends, unexpected inspection results, aging mechanisms found through new or improved tests methods, and when deficiencies are found that indicate an AMP is not effective. These categories of inspection findings would not necessarily be expected to be reported under the ICES (absent a more significant associated deficiency), so it is not clear if the use of this system is appropriate.

This information is required to determine compliance with 10 CFR 72.42(a).

VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

May 25, 2016

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Director, Division of Spent Fuel Management
Office of Nuclear Material Safety and Safeguards
Washington, DC 20555-0001

Serial No. 16-031
NLOS/TJS R0
Docket No. 72-16
License No. SNM-2507

VIRGINIA ELECTRIC AND POWER COMPANY
OLD DOMINION ELECTRIC COOPERATIVE
NORTH ANNA POWER STATION INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)
LICENSE RENEWAL APPLICATION

Pursuant to 10 CFR 72.42, Virginia Electric and Power Company (Dominion Virginia Power or Dominion) on behalf of itself and Old Dominion Electric Cooperative (ODEC) submits the attached application for renewal of the North Anna Power Station site-specific ISFSI license SNM-2507. The current license expires on June 30, 2018. The application requests that this license be renewed for an additional 40 years.

The License Renewal Application (LRA) was prepared in accordance with applicable provisions of 10 CFR 72 as directed by NUREG-1927, "Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance," dated March 2011 (with consideration given to draft Revision 1 dated June 2015).

Approval of this license renewal application is requested by June 30, 2018. Dominion requests a 60-day implementation period after receiving the renewed license so that applicable program and procedure changes can be completed.

1.0 GENERAL INFORMATION

Virginia Electric and Power Company (Dominion Virginia Power or Dominion) and Old Dominion Electric Cooperative (ODEC) are filing this application for renewal of the Independent Spent Fuel Storage Installation (ISFSI) license for North Anna Power Station, License Number SNM-2507. The original 20-year North Anna ISFSI license will expire on June 30, 2018. This application requests renewal of the original site-specific North Anna ISFSI license for a period of 40 years, and includes the applicable general, technical, and environmental supporting information required by 10 CFR 72.42(b). This application addresses the requirements for ISFSI license renewal, which are more limited in scope than those for initial licensing.

The design basis for the ISFSI will be carried forward through the period of extended operation, except as revised by the amendment process of 10 CFR 72.56. Dominion has a pending amendment to SNM-2507 to use a modified TN-32B cask (TN-32B HBU) to store high burnup spent fuel for North Anna Units 1 and 2.

The information contained in this section includes:

1. Information on application format and content (Section 1.1).
2. A general description of the North Anna ISFSI site (Section 1.2).
3. The information required by 10 CFR 72.22 (Section 1.3).
4. Summary of acronyms (Section 1.4).
5. A distribution list for written communications related to the application (Section 1.5).

1.1 Application Format and Content

The application format and content are based on the guidance for renewal of site-specific Part 72 licenses described in the Standard Review Plan for Renewal of Spent Fuel Dry Cask Storage System Licenses and Certificates of Compliance (Reference 4.1) and has taken into consideration its proposed revision. The application includes:

1. General Information - Section 1.0 has been expanded beyond the requirements of 10 CFR 72.22 to provide (1) information on the format and content of the application; (2) a general facility description; (3) a summary of acronyms used in the application; and (4) a distribution list for written communications related to the application.
2. Scoping Evaluation - Section 2.0 provides the scoping evaluation for the North Anna ISFSI components.
3. Aging Management Reviews - Section 3.0 includes the methodology used to perform aging management reviews (AMRs).

ISFSI STORAGE PAD TARGET HARDNESS		110% NAPS 28-DAY As-Built	US NRC Reference	1.67 x 110% NAPS 28-DAY Projected	NAPS Design Basis Reference	US NRC Technical Reference
Cask Parameters:						
$r =$	Cask Bottom Radius, (in)	43.875	44	43.875	TSAR, Appendix 3A, Section 3A.2.3.2.1, Page 3A.2-6	EPRI NP-4830, Page 2-10
$A_{ed} = \pi r^2 =$	Area Bottom of Cask, End Drop, (in^2)	6048	6082	6048	TSAR, Appendix 3A, Section 3A.2.3.2.1, Page 3A.2-6	EPRI NP-4830, Page 2-6
$L =$	Length of Cask, (in)	183.75	183.75	183.75	TSAR, Appendix 3A, Section 3A.2.3.2.1, Page 3A.2-7	EPRI NP-4830, Page 2-10, See Notes 1 & 2 on Page 13 of 16.
$A_{sd} = L \times 10''$	Area Side of Cask, Side Drop, (in^2)	1837.5	1837.5	1837.5	TSAR, Appendix 3A, Section 3A.2.3.2.1, Page 3A.2-7 & EPRI NP-4830, Page 2-5	EPRI NP-4830, Page 2-10
$W =$	Weight of Cask, (lbs)	228000	200000	228000	TSAR, Appendix 3A, Section 3A.2.3.2.1, Pages 3A.2-6 & 7	EPRI NP-4830, Page 2-10
Pad Parameters:						
$h = 24''$ (NAPS) & $36''$ (US NRC) =	Pad Thickness, (in)	24	36	24	Plant Drawing No. 11715-FC-49A, Rev. 0, Section A-A	US NRC Safety Evaluation Report, Section 3.3.3
$f'_c = 5{,}060$	As-Built, 28-Day Concrete Compressive Strength, (psi)	5566	4000	9295	Calculation No. CE-1399, Rev. 0, Attachment B	US NRC Safety Evaluation Report, Section 3.3.3
$f_y = 60{,}000$	Rebar Yield Strength, (psi)	60000	60000	60000	Plant Drawing No. 11715-FC-49A, Rev. 0, Note 2	US NRC Safety Evaluation Report, Section 3.3.3
A_s / ft= #10@12" (NAPS) & #11@12" (US NRC) =	Tension Steel Area / Foot, (in^2)	1.27	1.56	1.27	Plant Drawing No. 11715-FC-49A, Rev. 0, Section A-A	EPRI NP-4830, Page 2-10
$E_c = 57{,}000\,(f'_c)^{1/2} =$	Concrete Modulus of Elasticity, (psi)	4252521	3604997	5495468	ACI 349/349R-01, Section 8.5.1	EPRI NP-4830, Page 2-10
$v_c = 0.17$ (NAPS & US NRC) =	Poisson's Ratio for Concrete	0.17	0.17	0.17	EPRI NP-7551, Page 2-5	EPRI NP-4830, Page 2-10
$c = 3''$ (NAPS) & $2''$ (US NRC) =	Clear Concrete Cover, Bottom, (in)	3	2	3	ACI 349/349R-01, Section 7.7.1	EPRI NP-4830, Page 2-10
d_b = #10 (NAPS) & #11 (US NRC) =	Diameter, Bar, (in)	1.27	1.41	1.27	Plant Drawing No. 11715-FC-49A, Rev. 0, Section A-A	EPRI NP-4830, Page 2-10
$d = h - c - d_b / 2 =$	Depth to Tension Steel, (in)	20.365	33.295	20.365	Plant Drawing No. 11715-FC-49A, Rev. 0, Section A-A	EPRI NP-4830, Page 2-4
$b = 12''$ (NAPS & US NRC) =	Unit Width of Concrete Section, (in)	12	12	12	Plant Drawing No. 11715-FC-49A, Rev. 0, Section A-A	EPRI NP-4830, Page 2-4
$M_u = A_s f_y [d - (A_s f_y) / (2*0.85*f'_c b)] =$	Moment, Ultimate Strength, (lb-in)	1500676	3009047	1521192	ACI 349/349R-01, Section 10.2	EPRI NP-4830, Page 2-4
Soil Parameters:						
v_s = 0.49 or 0.25 (NAPS) & 0.45 (US NRC) =	Poisson's Ratio for Soil	0.49	0.45	0.49	TSAR, Appendix 3A, Section 3A.2.3.2.1, Page 3A.2-6	EPRI NP-7551, Page 2-5
E_s = 30 for ksi (NAPS) & 40 ksi (US NRC) =	Soil Modulus of Elasticity, (psi)	30000	40000	30000	Reported in Calculation No. CE-1399, Rev. 0, (See Note 3 on Page 13 of 16.)	US NRC Safety Evaluation Report, Section 3.3.3
$k = \pi E_s / (1 - v_s^2) =$	Foundation Modulus, End Drop, (psi)	124027	157572	124027	TSAR, Appendix 3A, Section 3A.2.3.2.1, Page 3A.2-6	EPRI NP-4830, Page 2-4
Calculate S & G, (End Drop):						
$D_c = E_c h^3 / [12 (1 - v^2)] =$	Concrete Slab Rigidity / Unit Width, (lb/in^2)	5044695784	1.4E+10	6519183674	EPRI NP-4830, Page 2-4	EPRI NP-4830, Page 2-4
$\beta = [E_s / (4 D_c)]^{1/4} =$	Subgrade Stiffness Factor, (in^{-1})	0.0349	0.0289	0.0328	EPRI NP-4830, Page 2-4	EPRI NP-4830, Page 2-4
$e^{-\beta r} =$	Intemediate Term	0.2161	0.2810	0.2377	EPRI NP-4830, Page 2-4	EPRI NP-4830, Page 2-4
$\cos \beta r =$	Intemediate Term	0.0387	0.2968	0.1335	EPRI NP-4830, Page 2-4	EPRI NP-4830, Page 2-4
$1 - e^{-\beta r} \cos \beta r =$	Intemediate Term	0.9916	0.9166	0.9683	EPRI NP-4830, Page 2-4	EPRI NP-4830, Page 2-4
$S = 2 r A_{ed} k M_u f'_c / [W^3 (1 - e^{-\beta r} \cos \beta r)] =$	Hardness Number	46776	138432	81093	EPRI NP-4830, Page 2-5	EPRI NP-4830, Page 2-5
$G = -345 + 33.5 \ln S =$	Deceleration Value for $1.2E05 \le S \le 1.47E07$		51.58		EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2
$-88 + 11.5 \ln S =$	Deceleration Value for $1.33E04 \le S \le 1.2E05$	35.66		41.99	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2
$-15.35 + 3.85 \ln S =$	Deceleration Value for $S < 1.33E04$				EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2
SF =	$G_{110\%\ NAPS\ 28\text{-}Day} / G_{US\ NRC} =$	0.69			See Note 4 on Page 13 of 16.	
	$G_{US\ NRC} / G_{US\ NRC} =$		1.00		See Note 4 on Page 13 of 16.	
	$G_{1.67 \times 110\%\ NAPS\ 28\text{-}Day} / G_{US\ NRC} =$			0.81	See Note 4 on Page 13 of 16.	

ISFSI STORAGE PAD TARGET HARDNESS		110% NAPS 28-DAY As-Built		US NRC Reference		1.67 x 110% NAPS 28-DAY Projected	NAPS Design Basis Reference	US NRC Technical Reference
$G_{US\ NRC\ End\ Drop}$ =	50g = 51.58 g			50			US NRC Safety Evaluation Report, Section 3.3.3	US NRC Safety Evaluation Report, Section 3.3.3
$G_{End\ Drop}$ =	$SF_{110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ End\ Drop}$ =	34.57	<	50			See Note 5 on Page 13 of 16, $G_{End\ Drop}$ = 35-g.	
	$SF_{US\ NRC}$ x $G_{US\ NRC\ End\ Drop}$ =			50				
	$SF_{1.67\ x\ 110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ End\ Drop}$ =			50	>	40.70	See Note 5 on Page 13 of 16, $G_{End\ Drop}$ = 41-g.	
Calculate S, G & G_{Peak} (Side Drop):								
I_c =	$L h^3 / 12$ =	211680		714420		211680	EPRI NP-4830, Page 2-5	EPRI NP-4830, Page 2-5
β =	$[E_s / (4 E_c I_c)]^{1/4}$ =	0.009553967		0.00789		0.008960746	EPRI NP-4830, Page 2-5	EPRI NP-4830, Page 2-5
DAF =	Dynamic Amplification Factor =	1.6		1.6		1.6	TSAR, Appendix 3C, Section 3C.1, Page 3C.1-1	TSAR, Appendix 3C, Section 3C.1, Page 3C.1-1
S =	$2 A_{sd} E_s M_u f'_c / [W^3 β)]$ =	8132		28018		14678	EPRI NP-4830, Page 2-6	EPRI NP-4830, Page 2-6
G = -345 + 33.5 ln S =	Deceleration Value for 1.2E05 ≤ S ≤ 1.47E07						EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2
-88 + 11.5 ln S =	Deceleration Value for 1.33E04 ≤ S ≤ 1.2E05			29.77		22.33	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2
-15.35 + 3.85 ln S =	Deceleration Value for S < 1.33E04	19.31					EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2	EPRI NP-7551, Pg. 2-46 & EPRI Report No. TR-108760, Pg. 2-2
G_{Peak} =	G x $DAF_{1.6}$	30.90		47.63		35.73	TSAR, Appendix 3C, Section 3C.1, Page 3C.1-1	TSAR, Appendix 3C, Section 3C.1, Page 3C.1-1
SF =	$G_{110\%\ NAPS\ 28\text{-}Day}$ / $G_{US\ NRC}$ =	0.65					See Note 4 on Page 13 of 16.	
	$G_{US\ NRC}$ / $G_{US\ NRC}$ =			1.00			See Note 4 on Page 13 of 16.	
	$G_{1.67\ x\ 110\%\ NAPS\ 28\text{-}Day}$ / $G_{US\ NRC}$ =					0.75	See Note 4 on Page 13 of 16.	
$G_{US\ NRC\ Side\ Drop\ -\ Cask\ Body}$ =	63g			63			US NRC Safety Evaluation Report, Section 3.3.3	US NRC Safety Evaluation Report, Section 3.3.3
$G_{US\ NRC\ Side\ Drop\ -\ T/Basket}$ =	55g x $DAF_{1.6}$ = 88g			88			US NRC Safety Evaluation Report, Section 3.3.3	US NRC Safety Evaluation Report, Section 3.3.3
$G_{US\ NRC\ Side\ Drop\ -\ 90^0\ Basket\ X\text{-}Section}$ =	52g			52			US NRC Safety Evaluation Report, Section 3.3.3	US NRC Safety Evaluation Report, Section 3.3.3
$G_{Side\ Drop\ -\ Cask\ Body}$ =	$SF_{110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ Side\ Drop\ -\ Cask\ Body}$ =	40.88	<	63			See Note 5 on Page 13 of 16, $G_{Side\ Drop\ -\ Cask\ Body}$ = 41-g.	
$G_{Side\ Drop\ -\ T/Basket}$ =	$SF_{110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ Side\ Drop\ -\ T/Basket}$ =	57.10	<	88			See Note 5 on Page 13 of 16, $G_{Side\ Drop\ -\ T/Basket}$ = 58-g.	
$G_{Side\ Drop\ -\ 90^0\ Basket\ X\text{-}Section}$ =	$SF_{110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ Side\ Drop\ -\ 90^0\ Basket\ X\text{-}Section}$ =	33.74	<	52			See Note 5 on Page 13 of 16, $G_{Side\ Drop\ -\ 90^0}$ = 34-g.	
$G_{Side\ Drop\ -\ Cask\ Body}$ =	$SF_{1.67\ x\ 110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ Side\ Drop\ -\ Cask\ Body}$ =			63	>	47.27	See Note 5 on Page 13 of 16, $G_{Side\ Drop\ -\ Cask\ Body}$ = 48-g.	
$G_{Side\ Drop\ -\ T/Basket}$ =	$SF_{1.67\ x\ 110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ Side\ Drop\ -\ T/Basket}$ =			88	>	66.02	See Note 5 on Page 13 of 16, $G_{Side\ Drop\ -\ T/Basket}$ = 67-g.	
$G_{Side\ Drop\ -\ 90^0\ Basket\ X\text{-}Section}$ =	$SF_{1.67\ x\ 110\%\ NAPS\ 28\text{-}Day}$ x $G_{US\ NRC\ Side\ Drop\ -\ 90^0\ Basket\ X\text{-}Section}$ =			52	>	39.01	See Note 5 on Page 13 of 16, $G_{Side\ Drop\ -\ 90^0}$ = 40-g.	

INDEX DOCUMENT INFORMATION FORM

"Evaluation of NAPS As-Built ISFSI Concrete Storage Pad," CALC-CE-MISC-CE-1399, Rev. 0, Add. 00A, by Charles A. Zalesiak, dated JAN 11 2017.

INDEX DOCUMENT INFORMATION
Index Document ID: CE-1399-0-00A
Index Entry Preparer(s): Chuck Zalesiak
Index Entry Reviewers: None

Document Title: Evaluation of NAPS As-Built ISFSI Concrete Storage Pad
Document Author: Charles A. Zalesiak
Document Date: 01/11/2017
Responsible Department: NE
Responsible Group: NE-CCE - Corporate Civil Engineering
Applicable Sites: North Anna Unit 1,North Anna Unit 2
Vendor Deliverable?: No
Owner Review Performed?: No
Owner Review Comments:

DOCUMENT HANDLING

Secure/Confidential Document?: No
Governing Department For Confidential Document: NE
Vendor Proprietary Information?: No
Proprietary Information Owner:
Confidential or Proprietary Document Handling Information:

Records Management Information

Quality Record?: Yes
Plant Decommissioning Record: No
ISFSI Decommissioning Record: No
ISFSI Record: Yes
Records Management Document Type: CALC
Records Management Document SubType: str
Applicable Sites: North Anna Unit 1,North Anna Unit 2
User Specified Instructions:
Additional Records Management Information: NOTE TO DOCUMENT PREPARER CONCERNING CALC STATUS CHANGE FORMS: A Calculation Status Change Form should be submitted (via INDEX) to, and processed by, Nuclear Document Management as a Supporting Document with Supporting DocType=RCN. The Document Number on the Calculation Status Change Form (and in INDEX) should be set to be equal to the Document Type (CALC), Document Number/ID (e.g., ME-1234), and Revision Number of the Calculation for which the Status is being changed. The basis for the Calculation Status Change must be documented on the Calculation Status Change Form, and the Preparer and Approver (Supervisor) must sign (or electronically authenticate) the form.
Site Specific Records Management Instructions: NOTE TO DOCUMENT PREPARER: Processing of Calculations is governed by both Procedure RM-AA-101 and site-specific requirements described in GARD CM-AA-CLC-301-1001, Attachment 4, Section 5.0. Per GARD CM-AA-CLC-301-1001, Calculations are subjected to engineering review by the KPS DBD Process Owner prior to processing of the document by Kewaunee Nuclear Document Management. Calculation preparers must include a completed DBD Load Form GNP-05.27.07-1 per Procedure GNP-05.27.07 as part of the Calculation. When the INDEX entry is Sent to Recipients, the Calculation and its data are automatically submitted to the KPS DocEm location, which is monitored by the KPS DBD Process Owner. The DBD Process Owner will incorporate the data in the DBD Load Form (GNP-05.27.07-1) per Procedure GNP-05.27.07 into the Design Basis Database.NOTE TO DOCUMENT PREPARER: Processing of Calculations is governed by both Procedure RM-AA-101 and site-specific requirements described in GARD CM-AA-CLC-301-1001, Attachment 5, Section 6.0. Per GARD CM-AA-CLC-301-1001, Calculations are subjected to engineering review by the MPS Passport Process Owner prior to processing of the document by Millstone Nuclear Document Management. Calculation preparers must include a completed Passport Database Input Form as part of the Calculation. When the INDEX entry is Sent to Recipients, the Calculation and its data are automatically submitted to the MPS DocEm location, which is monitored by the MPS Passport Process Owner. The Passport Process Owner will incorporate the data into the controlled Documents module of Passport prior to processing the Calculation into Documentum.

RELATED REFERENCES

INDEX DOCUMENT INFORMATION FORM - Files

FILES USED TO CREATE FINAL DOCUMENT PACKAGE

1. CE-1399 R0 ADD #00A.docx (1/11/2017 3:33:10 PM)

COMPUTER I/O FILES

1. Target Hardness Spreadsheet App 17-3.xlsx (1/11/2017 11:26:41 AM)

INDEX DOCUMENT INFORMATION FORM - Correspondence

ASSOCIATED CORRESPONDENCE

SENT DATE:

Recipients: Joshua M Koelzer,James M Kasper,Tony Banks,Paul Aitken,Ellery J Baker

CC Recipients:

LETTER TEXT

INDEX DOCUMENT INFORMATION FORM - Approvals

"Evaluation of NAPS As-Built ISFSI Concrete Storage Pad," CALC-CE-MISC-CE-1399, Rev. 0, Add. 00A, by Charles A. Zalesiak, dated JAN 11 2017.

APPROVER	PURPOSE OF ELECTRONIC AUTHENTICATION	DATE APPROVED