Response to Region III Technical Assistance Request [TAR]
For LaSalle Station
Independent Spent Fuel Storage Installation (ISFSI) Pad
DSFST Ticket Number: 201000003
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SCOPE:

NRC Region III requested assistance from the Division of Spent Fuel Storage and Transportation, (NMSS/SFST); by memorandum dated October 16, 2009, to perform a technical review of the LaSalle Station (LS) Independent Spent Fuel Storage Installation (ISFSI) Pad to determine whether the licensee's seismic analysis and design of the pad meet the regulatory requirem ents of 10 CFR 72. This technical review is limited to the licensee's documentation, and the relevant calculations prepared by LS and/or their contractors and furnished together with the Technical Assistance Request (TAR) to NMSS/SFST. The results of this technical review will be forwarded to the United States Nuclear Regulatory Commission (NRC) Region III office to assist in assessing the issues identified in the inspection report(s) related to the adequacy of the seismic design of the ISFSI pad at LaSalle Station.

The licensee used results from NUREG/CR-6865, "Parametric Evaluation of Seismic Behavior of Freestanding Spent Fuel Dry Cask Storage Systems," (Ref. 1) in lieu of performing a dynamic analysis of the ISFSI pad. A review of the NUREG/CR-6865 publication suggests that it may have been intended only for NRC use in review of the licensee applications and not for general use by the licensees. The TAR requests guidance regarding the use of NUREG/CR-6865 by the licensee and a review to determine if the licensee has correctly applied the methodology described in the publication and appropriately calculated loads for the design of the pad.

BACKGROUND:

The licensee is required by 10 CFR 72.212(b)(2)(i)(B) to perform written evaluations to establish that the cask storage pads have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion. At the LaSalle Station, the licensee's vendor, HOLTEC International, performed calculations L-003346 (Ref. 2) and L-003347(Ref. 3) to demonstrate compliance with the above regulatory requirement. Calculation L-003347 was performed to analyze the pad, taking into consideration the soil structure interaction and the soil liquefaction potential, in order to determine the loads on the pad under a design basis seismic event. These loads were used as input for the structural evaluation/design of the pad in calculation L-003346. During review of calculation L-003347, the inspectors observed the following:

1. In order to account for the soil structure interaction, the licensee used the nomograms presented in the NUREG/CR-6865 to determine the maximum cask rotation and displacement for 84% confidence level. In response to questions from the inspectors, the licensee added Appendix E to the calculation L-003347 to justify their use of the NUREG/CR report by demonstrating that the LaSalle soil profile falls within the range considered in the report.

2. Licensee initially did not address soil liquefaction in the above analysis or in the geotechnical report. Upon questioning by the inspectors, the licensee prepared a white paper addressing liquefaction and effects on the pad in Appendix F of the calculation L-003347.

3. The license used the Safe shutdown Earthquake (SSE) spectra from the LaSalle UFSAR (Ref. 4) with 0.2 g input. On review of the UFSAR, the inspectors interpreted that the spectra were applied at the foundation level and not at the ground surface level. After questioning by the inspectors, the calculation was revised and the licensee used the ground surface level spectra included in the UFSAR under soil structure analysis for the seismic category I buildings with approximately 0.43 g input. The licensee has not provided justification as to why this is applicable for the pad location.

4. After calculation of the cask rotation, the licensee used the commercial program Visual NASTRAN (VN) (Ref. 5) to calculate the vertical load on the pad due to the cask impacting the pad as it returns to normal position from the rotated position. This calculation used an assumption for a coefficient of restitution of 0.254 based on judgment regarding expected number of bounces. It also assumed the whole pad is loaded for calculating the effective soil stiffness.

5. Statements under the “Foreword” and the “Executive Summary” sections of the NUREG/CR-6865 imply that the results were only intended to aid the NMSS staff in performing the safety review of future licensee Dry Cask Storage System (DCSS) applications and in revising review guidelines.

   After consulting with the NMSS staff, the inspectors shared the concern with the licensee. The licensee in response submitted a letter from HOLTEC International (to R Byers, Exelon, September 18, 2009) (Ref. 6) stating their rationale for use of the NUREG/CR. Based on the above observations, the Region III inspectors expressed concerns that the licensee had not demonstrated that the LaSalle ISFSI pad design meets the requirements of 10 CFR 72.212(b)(2)(i)(B), and that the licensee’s use of the NUREG/CR-6865 may not be consistent with its intent. In addition, since the methodology used by the licensee for determining the loads on the pad is different than what most other licensees use and involves a number of assumptions, the inspectors need assistance in determining adequacy of the licensee evaluations. It was also noted that licensees at

Exelon's Byron and Braidwood sites are using the same methodology as described above for their pad analysis.

Action Requested by NRC Region III to DSFST NRC/HQ: For assistance in resolution of the concerns identified above, Region III is requesting a review of licensee calculation L-003347 by the DSFST staff. The specific questions and/or concerns are as follows:

1. Is the use of NUREG/CR-6865 by a licensee appropriate to satisfy 10 CFR 72.212(b)(2)(i)(B) requirements for consideration of potential amplification of earthquakes through soil-structure interaction in the pad design? HOLTEC's view is that the report is for general use and may be considered a technical reference.

2. Is the licensee justification provided in the calculation and the HOLTEC letter (Ref. 6) for using the NUREG/CR methodology adequate? The justification is based on HOLTEC's view that the report was developed for the HI-STORM 100 cask by a third party and has NRC's and HOLTEC's endorsements. Note that the nomograms developed in the NUREG/CR and used by the licensee are based on statistical approach corresponding to results for 86% confidence level. Also, the pad dimensions used in the NUREG/CR report and the LaSalle site are quite different. The NUREG/CR report is based on analysis for a single cask placed on a pad large enough to accommodate four casks while the LaSalle pad is 246' long x 90' wide and is designed for storage of up to 90 casks, with the minimum clear space between any two casks being approximately 28 inches.

3. Are the methodology and assumptions used to determine the seismic response and for determining the loads on the pad adequate? These include the use of correct seismic spectra (foundation level Vs ground surface level); calculation of soil stiffness; use of Visual NASTRAN (VN) computer program (Ref. 5); assumptions regarding coefficient of friction and coefficient of restitution with the corresponding equivalent damping for use in VN; and the justification for liquefaction potential not affecting the analysis results.

Note: A detailed review of the calculation per item 3 will not be required if, in response to items 1 and 2 above, it is determined that the licensee must perform a dynamic analysis to address the impact of soil structure interaction. *However, the staff's opinion and guidance is requested on the adequacy of assumptions regarding the coefficient of friction and the coefficient of restitution values used by the licensee in calculation L-003347 because these assumptions are likely to be used by the licensee in subsequent analyses.*

ISFSI RELATED REGULATIONS:

Regulatory Requirements: ISFSIs are licensed under 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level

Radioactive Waste, and Reactor-Related Greater Than Class C Waste." 10 CFR 72.210 grants a general license for the storage of spent fuel in an ISFSI to all holders of a Part 50 reactor operating license. The conditions of this general license are given in §72.212. Section 72.212(b)(2)(i) require the general licensee to perform written evaluations, prior to use, that establish that:

(A) Conditions set forth in the Certificate of Compliance have been met;

(B) Cask storage pads and areas have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion; and

(C) The requirements of § 72.104 have been met.

Additionally, 10 CFR 72.212(b)(3) requires that a licensee "review the Safety Analysis Report (SAR) referenced in the Certificate of Compliance and the related NRC Safety Evaluation Report (SER), prior to use of the general license, to determine whether or not the reactor site parameters, including analyses of earthquake intensity and tornado missiles, are enveloped by the cask design bases considered in these reports."

US NRC published NUREG/CR-6865 in 2005:

This study was primarily intended to provide insight into the effect of various parameters on cask behavior. In this study two casks were considered (vertical cylindrical, and horizontal rectangular) with a series of seismic inputs fitting three different spectral shapes. The casks were supported on a flexible concrete pad founded on three substrates ranging from soft soil to rock. This study culminated in the development of nomographs to predict cask response.

The study revealed that the displacement and rotation response of the cask was not sensitive to the subgrade parameters of a site-specific soil type as long as the soil type at a given site can be categorized in the range of soil types used in the study. The nomograph parameters were affected by the cask/pad coefficient of friction, but were independent of substrate stiffness. That is, it was concluded in this study that substrate stiffness has little or no influence on the maximum displacement and rotation.

The cask response was sensitive to the coefficient of friction between cask base and ISFSI pad surface. NUREG-1864 (Ref. 7) also used a maximum coefficient of friction of 0.53 to analyze the performance of the HI-STORM 100 cask.

LS ISFSI Analyses and Design:

The ISFSI at LS includes a main reinforced concrete pad 2' thick by 90' wide by 246' long as an onsite storage pad for accommodating the HI-STORM 100 Cask System.

The concrete pad is a stand-alone structure. The ISFSI installation at LS due to the radioactivity of the fuel stored within it is licensed by the NRC under the regulatory requirements of 10 CFR 72.

The geological investigations at the site was conducted by PSI and reported in a report (Ref. 9) and the conditions at the site are as described in that report. The groundwater levels are expected to fluctuate due to seasonal variations in precipitation and due to river level fluctuations.

For the analyses of the ISFSI, LS used the Safe Shutdown Earthquake (SSE) horizontal and vertical response spectra specified in the LS Updated Safety Analysis Report (SAR) (Ref. 4), as a design basis. The recommended Safe Shutdown Earthquake (SSE) was established conservatively as corresponding to a Modified Mercalli Intensity MMI = VII and a peak ground acceleration, PGA = 0.2g. These values were derived based on information from the 1909 South Beloit earthquake. The free field spectrum is the "Surface Spectrum" curve and it is a 5% damped N-S spectrum for Design Basis Earthquake (or SSE). It was determined per Reference 4, that the free field spectrum for LaSalle site, when normalized to 1g has a ZPA (or PGA) of 0.43 g for the SSE event (per Ref. 4).

Per the LS updated SAR, the seismic design criterion for the HI-STORM 100 is based on the seismic design criteria of the storage module. The design basis response spectra used to design the HI-STORM 100 and DSC are based on the response spectrum defined in (Ref. 4) anchored at a peak ground acceleration (PGA) of 0.43g in the horizontal direction and 0.29g in the vertical direction.

For design of the ISFSI pad at the LaSalle Station, the values for the coefficients used were reproduced from (Ref. 4) for the HI-STORM 100 spent fuel storage cask, and were utilized to predict seismic response in lieu of complete dynamic simulations. A friction value of 0.53 was used to determine the maximum impact force used as input for pad structural analysis. The applicant presented in Appendix C of (Ref. 3) how the peak vertical loading from seismic action was estimated using the peak rotation predicted from the nomograph presented in Ref. 1.

NRC/HQ - DSFST Staff's Evaluation:

Background: The ISFSI at the LS is an on-site facility that houses spent nuclear fuel in a dry cask storage system. The main structural components of the ISFSI consist of a reinforced concrete basemat, which supports the spent fuel storage system, and two reinforced concrete approach aprons located on either side of the basemat, which accommodate equipment for the transportation and loading of spent nuclear fuel into the facility. The dry spent fuel storage system selected for use at the LS ISFSI is the HI-STORM 100 Cask System (the cask) that consists of the following components: (1) interchangeable multi-purpose canisters (MPCs), which contain the fuel; (2) a storage overpack (HI-STORM), which contains the MPC during storage; and (3) a transfer cask

(HI-TRAC), which contains the MPC during loading, unloading and transfer operations. The cask is designed to store up to 32 pressurized water reactor (PWR) fuel assemblies or 68 boiling water reactor (BWR) fuel assemblies.

The ISFSI is licensed under the provisions for a general license specified in Part 72, which is granted to holders of a Part 50 operating license. HOLTEC has been issued a Certificate of Compliance (CoC No. 1014 Amendment # 3) for the HI-STORM 100 Cask System by the NRC. As a condition of utilizing their general license to operate an ISFSI, 10 CFR 72.212 requires LS to perform written evaluations that establish that, for their site-specific conditions, the conditions set forth in the Certificate of Compliance have been met and that cask storage pads and areas have been designed to adequately support the static and dynamic loads of the stored casks, considering potential amplification of earthquakes through soil-structure interaction, and soil liquefaction potential or other soil instability due to vibratory ground motion.

A report by Exelon, "Dynamic Analysis of HI-STORM 100 Cask on LaSalle ISFSI Pads" Revision 3 " Calc. L-003347 (Ref. 3) was prepared to fulfill the requirements of 10 CFR 72.212. This report determined the maximum displacement at the top of a HI-STORM Cask, the maximum angle of rotation from the vertical, and the peak vertical load applied to the ISFSI pad when subject to a seismic response spectra set that bounds or is equal to the applicable set for the ISFSI Pad at the LaSalle site.

In the Ref. 3 report, instead of using Spectra input from the Regulatory Guide (RG) 1.60 spectra (Ref. 12) that was used in the previous design, the spectra in Figure 3.7- 43 of LaSalle UFSAR, Rev. 17 (Ref. 4) were used. The approach to calculate the spring constant used in the Visual NASTRAN simulation to determine the cask to pad impact load in an SSE event was also changed. The previous calculation was based on a "per cask" approach which significantly overestimated the spring constant due to the overlapping caused by the proximity of casks and the existence of load spreading angle. The new calculation in Appendix C of (Ref. 3) is based on the "whole pad" approach.

ISFSI Pad Assessment: LS, as a general licensee, is required to perform analyses to verify that the site chosen for the proposed ISFSI will meet the design criteria contained in the cask SAR, SER, and CoC No. 1014 for the HI-STORM 100 storage system.

Various NRC guidelines, such as Regulatory Guides, Standard Review Plans, NUREGs, NUREG/CRs, etc. are available to assist in accomplishing this. Note that the specifications for the ISFSI foundation are not identified in the CoC. Also, Part 72 does not specifically require a 3-dimensional SSI analysis. Regulatory documents produced by the NRC (e.g. RG, NUREG, SRP, etc.) that are applicable to the licensing of an ISFSI, provide review guidance and criteria, but do not stipulate requirements for licensing approval of an ISFSI.

As the casks at LS are not physically connected to the ISFSI base mat, they cannot transmit tension to the underlying base mat. The results of the analyses presented by the licensee need to show that the ISFSI pad footing will remain in compression under all three loading cases shown below:

- The empty pad represents the lowest gravity load applied to the structure,
- The first campaign represents the highest mass eccentricity in the structure, and
- The final campaign represents the highest gravity load on the structure.

The ISFSI foundation analysis must include an SSI and must address liquefaction potential (10 CFR 72.212(b) (2)). The dynamic analysis presented did not capture 3-D effects (such as torsion). An asymmetrically loaded pad will have a torsional dynamic response, and it is anticipated that acceleration in short direction will be lower for a fully loaded symmetric structure than for the partially loaded non-symmetric structure. Staff noted that in the EXEON calculations (Ref. 2), a finite element model of the ISFSI pad together with underlying mudmat, engineered fill, and native substrate was modeled and bounding loads were used to establish the stress distribution in the ISFSI pad. Both the full loading and partial loading were evaluated. The stresses were converted to section bending moments and section forces, and compared with allowable value per the ACI Code (Ref. 13). However, the first campaign load and the final campaign load should be compared.

A comprehensive geotechnical investigation performed by Professional Service Industries (Ref. 9) indicated that the proposed site for the ISFSI when prepared as recommended in that report, with the adequate structural fill under the reinforced concrete pad would not have any potential settlement and liquefaction concerns.

A soil-structure interaction analysis is necessary to determine the true dynamic response of the system. LS and its consultants investigated several foundation configurations in the analysis for the ISFSI pad. The out-of-plane flexibility of the concrete ISFSI pad, when evaluating the seismic response of the storage cask should be accounted for. For the proposed ISFSI at LS, the basemat is semi-rigid in the in-plane direction yet, there is no evidence that the out-of-plane flexibility of the basemat is considered in the dynamic analysis performed by EXELON. [See Reference 10 for more on this subject].

Investigating the influence of three parameters, pad flexibility, soil properties, and cask arrangement, on the seismic response of the cask are among some of the most critical steps of any analyses to demonstrate the adequacy of ISFSI foundation to comply with 10 CFR Part 72.212. [See Reference 11 for more on this subject]. If the fundamental frequency of the cask in the lateral direction lies within the resonant band of the response spectrum, higher amplification could occur at the CG of the cask. The seismic stability of the storage cask is based on the seismic acceleration at the CG of the cask, and is not based on the PGA at the top of the pad. The analyses of the proposed ISFSI at LS need to consider the seismic response at the CG of the cask as a basis for acceptance. The LS analysis as-of-date indicates that these and other issues are not adequately addressed.

The NUREG/CR-6865 provides a statistical approach based on a parametric analysis to characterize the sliding and rocking response of casks on an ISFSI pad subject to ground motion input. As clearly stated in the abstract, executive summary and body of the NUREG, "The results of these parametric analyses have been compiled in nomographs to facilitate the safety review of licensing applications by the staff….." The document was never intended to be used for the original design of an ISFSI pad.

Nonetheless, the staff does find NUREG/CR-6865 acceptable as a design tool to predict the maximum sliding and rocking response of a cask on an ISFSI pad at a specific site provided the following conditions are met:

1. It can be shown that the site soil profile is bounded by the soil profiles used in the NUREG.

2. The site-specific ground spectra are bounded by the spectra used in the NUREG, particularly at the lower frequencies. Should the site-specific spectral shape deviate significantly from those used in the NUREG study, the degree of confidence required for a specific application should be increased accordingly.

3. If there is high confidence that the actual site response will not exceed the response results in the NUREG. This can be accomplished by using a degree of confidence in the response results equal to the 95% non-exceedence probability (NEP). [Note: Since the NUREG is intended as an NRC evaluation tool, rather than a design tool, the NUREG provides response results at the 84% NEP level. To calculate responses for other confidence levels, the NUREG also provides the equations and constants from which responses for any NEP can be calculated].

Additional Discussions regarding:

(A) HOLTEC Calculation HI-2094398 (Rev. 1) [Included as Appendix A to the EXELON Calculation L-003347 Rev. 3] (Ref. 3)
(B) EXELON Calculation L-003346 Rev. 1, (Ref. 2)

(1) The HOLTEC calculation notes that the LaSalle site-specific spectrum is not a good match with any of the spectra used in the NUREG/CR, and, as recommended in the NUREG/CR, HOLTEC uses the response results developed for all spectra with site specific input at 1 Hz and 5% damping as well as the results for RG.1.60 to predict cask displacement and rotation. However, HOLTEC failed to heed the other recommendation in the NUREG/CR, found on page 82:

"Judgment is certainly required in applying these results to site-specific spectra that have different shapes than those used in this study. The degree of confidence required for a specific application should be increased as a function of the amount of deviation of the shape of the response spectrum from the shape of those used in this study."

(2) The HOLTEC calculation uses the 84% NEP response results from the NUREG/CR. Comparing the RG 1.60 (Ref. 12) spectrum used in the NUREG/CR to the LaSalle site-specific spectrum, it is clear that the deviation between the two shapes is significant. On the basis of this alone, HOLTEC should have increased the degree of confidence in the response results to at least the 95% NEP.

(3) Appendix D of the HOLTEC calculation, "Justification for Impact Damping Value", determines the Coefficient of Restitution and Percent-Critical Damping for the cask to pad impact. The calculation assumes that after 2 rebounds of the cask impacting the pad, the ratio of the rebound height to the original "drop" height is 0.01. With no physical or analytical basis for this assumption, the calculation proceeds to determine a Coefficient of Restitution of 0.254 and a critical damping of 40% and then states that *"the use of 40% critical damping produces a result that matches physical expectations."* This is a circular argument, since it is based on the assumed physical expectation that after 2 rebounds the ratio of the rebound height to the original "drop" height is 0.01. Staff has no knowledge of where the value 0.01 for this ratio comes from? The calculation provides no basis for it. Moreover, to arrive at the 40% critical damping result, the HOLTEC calculation does not even use 2 rebounds. The calculation uses 1.68 rebounds. Staff question how a non-integer number of rebounds can occur?

Note: EXELON calculation (Ref. 3) claims that this approach has been used previously by HOLTEC for Columbia Generating Station and at Private Fuel Storage, LLC. HOLTEC should to provide the physical basis and arguments that were provided to the two licensees to justify a non-integer number of rebounds and drop height ratio of 0.01.

Using two (2) rebounds and a ratio of the rebound height to the original "drop" height of 0.02, instead of 0.01, the staff calculated a coefficient of restitution of 0.376 and a critical damping of 28%. This demonstrates how sensitive the results are to the number of rebounds and the ratio of rebound heights assumption.

(4) For design of the ISFSI pad, the HOLTEC Calculation uses the load combination of dead load (D), live load (L) and seismic load (E') and states that since the ISFSI pad is not-important-to-safety "the ISFSI pad design need only follow the guidance of ACI-318…." In Chapter 9 of ACI-318 (Ref. 13) it states:

> "Where structural effect: T of differential settlement, creep, shrinkage…. or temperature change are significant in design, the required strength U shall be at least equal to

U = 0.75(1.4D + 1.4T + 1.7L)
But, required strength U shall not be less than
U = 1.4(D + T)."

ACI-349 (Ref. 14) further explains that where the structural effects of differential settlement may be significant, they shall be included with dead load D in load combinations that include E'. The internal pad moments and forces that are the basis for the design of the pad must not only include D + L + E', but also the structural effects of differential settlement, which HOLTEC has not included in the final load combination for the design of the ISFSI pad.

(5) Long-term settlement is calculated to be approximately 4 inches. HOLTEC should explain what the bending moments were in the pad associated with this amount of settlement? Also, why were these moments not added to the bending moments due to D + E'?

(6) The dead load of a cask is 360,000 lbs. The dead load (D) + seismic vertical load (E') is 1,050,000 lbs per cask. The ratio is 1,050,000/360,000 = 2.92. From Reference 2, Table 8.7 the maximum moment in the pad for a fully loaded pad due to D + E' is 66,918 in-lbs/in, and the maximum moment in the pad for a fully loaded pad due to static loading (dead load, D, only) is 61,797 in-lbs/in. The ratio is 66918/61797 = 1.08. This situation is not possible. Something is either wrong or the calculation is deficient in its explanation as to what was done.

SUMMARY AND CONCLUSIONS:

NRC/HQ -DSFST staff reviewed the dynamic analysis (Ref. 3) and the structural qualification (Ref. 2) and other pertinent documents presented to the NRC/HQ staff, for the LaSalle Station ISFSI pad and storage modules. The purpose of the study by the licensee was to evaluate the seismic response of the ISFSI pad under the SSE for the site, and to qualify structural design of the ISFSI pad. The DSFST staff does not concur with the methodology and approach currently presented for reasons sited herein. The results and conclusions presented by the licensee are therefore not acceptable to the staff.

(1) The use of the NUREG is acceptable for determining the maximum sliding and rocking of the cask provided three conditions are met: a) It can be shown that the site soil profile is bounded by the soil profiles used in the NUREG. b) The site-specific ground spectra are bounded by the spectra used in the NUREG, particularly at the lower frequencies. Should the site-specific spectral shape deviate significantly from those used in the NUREG study, the degree of confidence required for a specific application must be increased accordingly. c) There is high confidence that the actual site response will not exceed the response results in the NUREG. This can be accomplished by using a degree of confidence in the response results equal to the 95% non-exceedence probability (NEP).

(2) Due to a lack of transparency with respect to the use of Visual NASTRAN (VN) to determine the rotational impact force between the cask and the pad, VN must be benchmarked against LS-DYNA to ensure it is being appropriately applied to this problem.

(3) The staff does not agree with the assumptions used to calculate the Coefficient of Restitution and % Critical Damping used in the VN analysis. Due the sensitivity of the results to these assumptions, the assumptions require clear justification.

(4) Torsional effects due to the unsymmetrical cask loading must be considered in the SSI analysis.

(5) The effect of out-of-plane flexibility of the pad on cask response must be considered in the SSI analysis.

(6) It must be demonstrated that the smaller pad used in the NUREG bounds the response of a cask on the larger site specific pad.

(7) The effects of long-term settlement and creep must be included in the load combination with seismic and dead load.

The CoC (Ref. 15) clearly states: “If this static equilibrium based inequality cannot be met, a dynamic analysis of the cask/ISFSI pad assemblage with appropriate recognition of soil/structure interaction effects shall be performed to ensure that the casks will not tip over or undergo excessive sliding under the site's Design Basis Earthquake”.
It further states that, “For free-standing casks, the ISFSI pad shall be verified by analysis to limit cask deceleration during design basis drop and non-mechanistic tip-over events to $\leq$ 45 g's at the top of the MPC fuel basket”. Licensee has attempted to perform a nonlinear analysis to justify safe design of the ISFSI pad, but the analyses in its current form is not acceptable due to reasons discussed above.

The final foundation design configuration consists of a basemat supported on an engineered structural fill. The ISFSI pad has to provide an adequate foundation for the cask loading. However, based on the review of methodology, approach, results and conclusions discussed above, the NRC staff believes that adequate analyses and justifications, demonstrating the structural performance of the foundation to meet the acceptance criteria specified in 10 CFR 72.212(b)(2)(i)(B) during a safe-shutdown earthquake has not been shown by the licensee.

Staff finds that although the substrate data for the LaSalle plant may have been enveloped by the substrate range considered in the NUREG, the use of the nomographs is acceptable for determining the maximum sliding and rocking of the cask, <u>provided</u> the licensee incorporates the additional analyses as applicable, to address all the issues discussed above.

In summary, staff's review and conclusions are pertinent only to the LaSalle Station ISFSI pad. The documentation provided to date falls short of demonstrating that the pad meets regulations specified in 10 CFR 72.212(b). In particular, staff has additional questions regarding several modeling assumptions, and anticipates that the licensee's calculations may need to be revised and additional analysis performed..

<u>REFERENCES</u>:

1) NUREG/CR-6865, dated February 2005 “Parametric Evaluation of Seismic Behavior of Freestanding Spent Fuel Dry Cask Storage Systems”, V. Luk, et.al.

2) EXELON Analysis No. L- 003346, “Structural Qualification of the ISFSI Pad at LaSalle under Static and Seismic Loading” Revision 1, dated 08/27/2009..

3) EXELON Analysis No. L - 003347, “Dynamic analysis of HI-Storm 100 Cask on LaSalle ISFSI Pads” Revision 3, dated 08/17/2009.

4) LaSalle County Power Station Updated Final Safety Analysis Report, Rev. 17.

5) Visual NASTRAN (VN) Desktop, 2004.

6) HOLTEC Letter from Robert Byers to Exelon “NUREG/CR-6865 Methodology for BB&L”, dated September 18, 2009

7) NUREG-1864, “A Pilot Probabilistic Risk Assessment of a Dry Cask Storage System at a Nuclear Power Plant”.

8) Not used.

9) Professional Services Industries, Inc. 042-75034 for LaSalle (Aug. 2007).

10) “Influence of ISFSI Design Parameters on the Seismic Response of Dry Storage Casks”, Bjorkman Gordon; et.al., Transactions, SMiRT 16, Washington, DC, August 2001, Paper # 1601.

11) “Examining Opposing Requirements for ISFSI Pads when Evaluating Cask Tip-Over”, Tripathi, Bhasker, Transactions, SMiRT 19, Toronto, Canada, August 2007, Paper # W01/1.

12) Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Regulatory Guide, 1.60, “Design Response Spectra for Seismic Design of Nuclear Power Plants”, Revision 1, December 1973.

13) ACI-318, American Concrete Institute: (ACI-318-89) or later.

14) ACI-349, American Concrete Institute: (ACI- 349-97) or later.

15) Certificate of Compliance (CoC) No. 1014, Appendix B.

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