SEISMIC RESPONSE CHARACTERISTICS OF HI-STAR 100 CASK SYSTEM ON STORAGE PADS

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Spent fuel storage casks installed on reinforced concrete pads must be qualified for kinematic stability and stress compliance under the postulated Design Basis Earthquake for the facility. A dynamic analysis method to predict the response of a loaded cask subjected to 3-D seismic excitation is presented in this paper. The methodology permits parametric evaluation of variables such as cask-to-pad friction coefficient, MPC-to-overpack gap, basket stiffness, and fuel compliance characteristics. A set of acceptance criteria to ensure stability with a large margin of safety are also proposed for possible adoption by the regulatory authorities.

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iv. Restriction on the maximum deflection of the storage cell wall due to rattling at the cell wall/SNF interface.

Proposed limits on the above response variables are given below.

Sliding Limits: As we show using the numerical example of HI-STAR 100, limiting the maximum displacement δ to 25% of the cask contact circle ensures that the DBE will be well within the "stable" zone.

Axial Tilt, ψ: Restricting the maximum axial tilt of the cask to 25% of the incipient tipping angle, as we show using the HI-STAR 100 example, ensures that the DBE event is well within the "stable" zone.

SNF/Fuel Cell Impact Load, F: The impact load between the SNF and the storage cell due to rattling of the fuel during the seismic event should not exceed the maximum value specified by the fuel supplier.

Basket Cell Wall Stress: In order to ensure that the storage cell walls do not sustain deformations leading to violation of the provisions of the applicable section of CFR72, the maximum stress level in the basket cell walls should be limited to Level D limits of the ASME Code for Subsection "NG" components.

9.0 CLOSURE

A method to predict the seismic response of free-standing spent fuel storage casks under a three-dimensional seismic excitation has been presented. A storage cask containing a "free-to-rattle" canister basket and nuclear fuel assemblies is an epitome of a nonlinear structure. Furthermore, the range of variations in variables with potentially significant effect on the cask response can be quite large. For example, the cask-to-ISFSI pad interfacial coefficient of friction can vary within a large range (as low as 0.1 in a wet interface to 0.8 in dry rough conditions). The analysis methodology presented herein enables the analyst to make parametric analyses to establish the most pessimistic (maximum displacement and/or rotation) cask response. Exploratory analyses on a HI-STAR 100 System show that the cask response is a highly nonlinear function of the ZPA of the seismic event. After a certain threshold

value, the response (viz. maximum tilting of the cask axis) increases rapidly with increase in the ZPA level. For this reason, it is recommended that the acceptable response parameters, e.g., maximum rotation of the cask axis, be set at one-fourth of the "ultimate" value (at which the cask will tip over). In addition to kinematic limits, specific requirements on stress limits in critical cask contents are also proposed.

While the methodology is developed for the general case of free-standing casks, special cases, such as the case of anchored casks, can be analyzed using this method without any difficulty.

The standard Regulatory Guide 1.60 spectrum was used for purposes of illustration. Analyses showed that a Reg. Guide 1.60 earthquake pegged at 0.45g ZPA in three orthogonal directions produces acceptable levels of sliding and rotation for HI-STAR 100. Acceptable response spectra for HI-STAR 100, therefore, must be enveloped by the Reg. Guide 1.60 spectrum with 0.45g ZPA.

10.0 REFERENCES

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