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June 15, 2009
L-09-162

10 CFR 50.90

ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Beaver Valley Power Station, Unit No. 2
Docket No. 50-412, License No. NPF-73
Additional Technical Information Pertaining to License Amendment Request No. 08-027 (TAC No. ME1079)

FirstEnergy Nuclear Operating Company (FENOC) letter to the U.S. Nuclear Regulatory Commission (NRC) dated April 9, 2009 (Reference 1), submitted a license amendment request for Beaver Valley Power Station (BVPS) Unit No. 2. The proposed amendment would revise the Technical Specifications to support the installation of high density fuel storage racks in the BVPS Unit No. 2 spent fuel pool.

Nuclear Regulatory Commission (NRC) letter dated June 1, 2009 (Reference 2) provided the results of the staff's acceptance review of the amendment request. The NRC letter requested additional technical information be provided in sufficient detail to enable the staff's independent assessment regarding the acceptability of the proposed amendment in terms of regulatory requirements and the protection of public health and safety.

The attachment provides the additional technical information requested by Reference 2. Since some of the information contained in this submittal is proprietary to Holtec, this letter has three enclosures. Enclosure A contains the proprietary technical information provided by Holtec. In addition to the proprietary enclosure, Appendix A of the attachment contains proprietary information. Enclosures B and C contain the affidavits required by 10 CFR 2.390. Holtec requests that the proprietary technical information provided in Enclosure A and Appendix A of the attachment, be withheld from public viewing.

The information provided by this submittal does not invalidate the no significant hazard evaluation submitted by Reference 1.

A001
NRR

As stated in Reference 1, FENOC requests approval of the proposed amendment by April 15, 2010, to support the installation phase of the reracking project that is scheduled to begin in May 2010. The reracking will support the Unit No. 2 refueling outage (2R15) scheduled for the spring of 2011. Once approved, the amendment shall be implemented within 30 days.

There are no regulatory commitments contained in this letter. If there are any questions or if additional information is required, please contact Mr. Thomas A. Lentz, Manager – Fleet Licensing, at 330-761-6071.

I declare under penalty of perjury that the foregoing is true and correct. Executed on June 15, 2009.

Sincerely,

Peter P. Sena III

References:
1. FENOC Letter L-09-086, "License Amendment Request No. 08-027, Unit 2 Spent Fuel Pool Rerack," dated April 9, 2009 (ADAMS Accession No. ML091210251)
2. NRC Letter dated June 1, 2009, "BEAVER VALLEY POWER STATION, UNIT NO.2 - SUPPLEMENTAL INFORMATION NEEDED FOR ACCEPTANCE OF REQUESTED LICENSING ACTION RE: SPENT FUEL POOL RERACK (TAC NO. ME1079)," (ADAMS Accession No. ML091520107)

Attachment:
Requested Additional Technical Information

Enclosures:
A. Holtec Report HI-2094370, "CASMO-4 Benchmark for Spent Fuel Pool Criticality Analyses," (Proprietary)
B. Holtec Affidavit 1702-AFFI-2 (Holtec Report HI-2094370) Pursuant to 10 CFR 2.390
C. Holtec Affidavit 1702-AFFI-3 (Holtec Report HI-2084010, Appendix B) Pursuant to 10 CFR 2.390

cc: NRC Region I Administrator
NRC Senior Resident Inspector
NRR Project Manager
Director BRP/DEP
Site Representative (BRP/DEP)

Requested Additional Technical Information

To complete its acceptance review, the Nuclear Regulatory Commission (NRC) staff has requested additional technical information regarding FirstEnergy Nuclear Operating Company (FENOC) license amendment request (LAR) No. 08-027. The staff's request is provided below in bold type followed by the FENOC response for Beaver Valley Power Station (BVPS) Unit No. 2. It is noted that all references to Enclosure A in the staff's request are references to Enclosure B of Reference 1.

1. **CASMO-4 is used in this application to determine reactivity differences for temperature variation, manufacturing tolerances, depletion uncertainty and to calculate the isotopic inventory of the spent fuel for use in MCNP4a. However, there is no code validation for CASMO-4 as required by staff guidance in the NRC Memorandum from L. Kopp to T. Collins, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light-Water Reactor Power Plants," August 19, 1998. Provide a code validation of CASMO-4 consistent with the staff guidance (Kopp letter).**

   The CASMO-4 code benchmark document (Proprietary) is provided in Enclosure A.

   When the 95/95 bias uncertainty of 0.0025 for CASMO-4 is factored into the existing criticality calculations provided in Reference 1, the maximum increase observed in any value of k-effective in Reference 1 is 0.0004 delta k. This increase is negligible relative to the 0.005 delta k of retained margin that was included in all of the Reference 1 calculations. Therefore, the results of the calculations of Reference 1 remain valid.

2. **Section 4.7.5 of HI-2084175 states that the depletion uncertainty is intended to encompass the following calculational uncertainties: lack of critical experiment data of spent fuel storage rack geometries containing both actinides and fission products, uncertainty in actual versus calculated isotopics, and changes in fuel geometry (clad creep, pellet densification, etc.) during irradiation. However, this appears inconsistent with the magnitude of the isotopic uncertainty in Appendix 6E of Holtec Report HI-951251. Provide clarification on the magnitude of these effects, such that the Nuclear Regulatory Commission (NRC) staff may evaluate whether or not 5% of the reactivity decrement associated with the burnup of interest is sufficient to encompass these effects.**

   Holtec report HI-951251 is a proprietary Holtec report that is not available to FENOC. Per a FENOC/NRC telecon conducted on June 11, 2009, it was concluded that FENOC does not need to address the specific details of the subject Holtec report if FENOC demonstrates that the magnitude of the calculational uncertainties referenced in Holtec report HI-2084175 are encompassed within the 5% decrement established in the Kopp memorandum.

It is possible to show that for BVPS Unit No. 2, that the aggregate effect of these calculational uncertainties is less than 5% of the reactivity decrement using BVPS Unit Nos. 1 and 2 specific critical power reactor data comparisons based on CASMO-4 calculations. This approach is similar to that discussed at the May 1, 2009, meeting on spent fuel pool criticality analyses that included the Nuclear Regulatory Commission, Nuclear Energy Institute, and various industry experts.

FENOC reviewed its core follow calculations for BVPS Unit Nos. 1 and 2 that were performed using CASMO-4 cross section data. A total of five cycles of data (99 total data points) were available that contained accurate measurements of critical reactor parameters (including soluble boron-10 depletion effects), and for which critical eigenvalues had already been calculated as part of the core follow calculations (additional analyses were not required). For each of these fuel cycles, two methods were used to determine a reactivity difference that could be associated with depletion uncertainty. The first method was to use the reactivity difference between the highest and lowest calculated eigenvalues over the entire cycle, regardless of when these values were observed during the fuel cycle. The second method used a linear least squares fit trend of eigenvalue versus burnup, which was then evaluated at the lowest and highest cycle burnups for which data were available. For each fuel cycle, the reactivity difference that was largest (most conservative) from these two methods was used to represent the total potential uncertainty due to depletion. This is conservative, as it assumes that all possible sources of eigenvalue variation (core data measurement uncertainty, other modeling uncertainties, etc.) are being attributed to depletion uncertainty. In addition, since all data points are fully encompassed within the reactivity differences, it is reasonable to conclude that these differences represent an uncertainty at a level more stringent than the 95/95 confidence level.

The total reactivity decrement due to fuel depletion for each of these cycles was calculated from single assembly CASMO-4 calculations used to generate cross section data for the fuel cycles in question. The reactivity decrement due to fuel depletion for a given cycle was calculated from the single assembly calculations using the lowest and highest core burnups for that cycle for which critical eigenvalue data existed. A range of initial fuel assembly enrichments was examined, and it was demonstrated that the minimum (bounding) reactivity decrement associated with a given amount of burnup change always occurred in the highest fuel enrichments. Therefore, the highest enrichment used to date in any of these cores was used to bound the total reactivity decrement that occurred in any of these cores. This is conservative, as these cores contain a mixture of enrichments (including axial blankets) that are generally lower than this maximum enrichment.

By comparing the most conservative reactivity difference for a cycle against the total reactivity decrement due to fuel depletion for that same cycle, the uncertainty due to fuel depletion can be calculated in a very conservative fashion. The following table summarizes these results:

Unit & Cycle	No. of Data Points	Most Conservative Reactivity Difference Observed During Fuel Cycle (pcm)	Total Reactivity Decrement Due to Fuel Depletion (pcm)	Conservative Depletion Uncertainty (%)
BVPS Unit No. 1 Cycle 17	19	253	10179	2.49
BVPS Unit No. 1 Cycle 18	19	210	10543	1.99
BVPS Unit No. 1 Cycle 19	21	324	12633	2.56
BVPS Unit No. 2 Cycle 12	21	387	11292	3.43
BVPS Unit No. 2 Cycle 13	19	360	11262	3.20

All of the calculated values for depletion uncertainty for the five BVPS cycles evaluated are less than 5%.

These comparisons between measured power reactor critical data and CASMO-4 based models implicitly include the calculational uncertainties described in the BVPS Unit No. 2 Reference 1 (critical configurations containing actinides and fission products, uncertainty in actual versus calculated isotopics, and changes in fuel geometry due to irradiation) as being addressed using the 5% reactivity decrement method. While these critical configurations are not in a spent fuel storage rack geometry, the ability to calculate reactivity in a spent fuel rack geometry has already been demonstrated with MCNP4a, and the ability to actually predict the effects of fuel depletion, which is reflected in the isotopic data provided from CASMO-4 to MCNP4a for the criticality calculations, has now also been established. Therefore, while the magnitude of the individual effects that are considered to be included under the 5% reactivity decrement have not been quantified, these effects are addressed in an aggregate fashion.

Therefore, reasonable assurance exists that use of the 5% reactivity decrement methodology in this application to address depletion uncertainty, as endorsed in the Kopp memorandum, bounds the actual uncertainties associated with the use of CASMO-4 to predict the reactivity effects of fuel depletion.

3. **Please provide the following information for Section 5.0 of Enclosure A of the application:**

   i. **Specific and detailed information, beyond a superficial description, regarding the theory and methodology underlying the program DYNARACK.**

The following provides an explanation of the theory and methodology underlying the program DYNARACK. This explanation is from both a technical and historical perspective.

DYNARACK, developed in the late 1970s and continuously updated since that time to incorporate technology advances such as multi-body fluid coupling, is a code based on the Component Element Method (CEM) in Reference 3. The chief merit of the CEM is its ability to simulate friction, impact, and other nonlinear dynamic events with accuracy. The high-density racks designed by Holtec International are ideally tailored for the CEM-based code because of their honeycomb construction (HCC). Through the interconnection of the storage racks, the HCC rack essentially simulates a multi-flange beam. The beam characteristics of the rack (including shear, flexure, and torsion effects) are appropriately modeled in DYNARACK using the classical CEM beam spring modeling technique. Each rack is modeled as a prismatic three dimensional (3-D) structure with support pedestal locations and the fuel assembly aggregate locations set to coincide with their respective center of gravity axes. The rattling between the fuel and storage cells is simulated in exactly the same manner as it would be experienced in nature: namely, impact at any of the four facing walls followed by rebound and impact at the opposite wall. Similarly, the rack pedestals can lift off or slide as the instantaneous dynamic equilibrium would dictate throughout the seismic event. The rack structure can undergo overturning, bending, twisting, and other dynamic motion modes as determined by the interaction between the seismic (inertia) impact, friction, and fluid coupling forces. Hydrodynamic loads, which can be quite significant, are included in a comprehensive manner.

In modeling the fuel rack as a multi-degree of freedom structure, the following key considerations are significant:

a) Over 70% of the mass of the loaded rack consists of fuel assemblies, which are unattached to the rack, and resemble a loose bundle of slender thin-walled tubes (high mass, low frequency).

b) In HCC racks, as shown in Reference 4, the rack behaves like a stiff elongated box beam (End Connected Construction racks, built 20 years ago and now obsolete, behave as a beam and bar assemblage).

Since the BVPS Unit No. 2 racks under inertial loading have overall structural characteristics of a multi-flange beam, it is computationally inefficient to model such a structure as a plate assemblage. The DYNARACK dynamic model preserves the numerical stability of the physical problem by representing the rack structure by an equivalent flexural and shear resisting component element (in the terminology of the Component Element Method in Reference 3).

The inclusion of fluid coupling is also a key element of the program DYNARACK as discussed below.

The phenomenon of fluid coupling between rectangular planform structures was sparsely investigated until the 1980s. Fritz's classical paper (Reference 13) was used in the earliest version of DYNARACK to model rack-to-surrounding fluid effects in the single rack 3-D simulation. Fermi Unit 2 (circa 1980) and Quad Cities Units 1 and 2 (circa 1982) were licensed using this early version. The current version of the code continues to use the same Fritz fluid coupling terms. The Fermi 2 and Quad Cities 1 and 2 submittals were the first rerack applications wherein a rack module was analyzed using the 3-D time-history technique. The adoption of a nonlinear time-history approach helped quantify the motion of a rack under a 3-D earthquake event and as a byproduct, also served to demonstrate that solutions using the Response Spectrum Method (which assumes a linear structure) can be very non-conservative. Practically all rerack licensing submittals after 1980 utilized the 3-D time-history method. While the nonlinear 3-D time-history method was a significant improvement over the Response Spectrum Method (linear) approach, it was limited because only one rack could be modeled in any simulation. The analyst had to assume the behavior of the adjacent racks. Models, which postulated a priori the behavior of the contiguous racks in the vicinity of the rack being analyzed were developed and deployed in safety analyses. The two most commonly used models were the opposed phase model and the in-phase model, the former used almost exclusively to predict inter-rack impacts until 1985. The Holtec International Proprietary Position Paper WS-115 (Reference 5), provides a summary description of these early single rack 3-D models.

The inadequacy of the single rack models (albeit nonlinear) to predict the response of a grouping of submerged racks arrayed in close proximity became an object of prolonged intervenor contention in the reracking of the Pacific Gas and Electric (PG&E) Diablo Canyon units in 1986-87. Holtec International, with active NRC oversight, developed a two dimensional (2-D) multi-rack model for the Diablo Canyon racks; this model helped answer intervention issues, permitting PG&E to rerack. NRC experts testified in support of the veracity of the 2-D multi-rack dynamic models at the Diablo Canyon Atomic Safety and Licensing Board (ASLB) hearings in Pismo Beach, California in June 1987.

The Diablo Canyon intervention spurred Holtec International to develop what later came to be known as the Whole Pool Multi-Rack (WPMR) analysis. A key ingredient in the WPMR analysis is quantification of the hydrodynamic coupling effect that couples the motion of every rack with every other rack in the pool. In 1987, Dr. Burton Paul (Professor Emeritus, University of Pennsylvania) developed a fluid mechanics formulation using Kelvin's recirculation theorem, which provided the fluid coupling matrix (2N x 2N for a pool containing N racks).

For example, with respect to Reference 6, where an array of N (N =16) two-dimensional bodies (each with two degrees of freedom) is illustrated, the dynamic equilibrium of the i-th mass in the x-direction can be written as

$$[m_i + M_{ii}]\ddot{x}_i + \sum_{j=1}^{N}[M_{ij}\ddot{x}_j + N_{ij}\ddot{y}] = Q_{x_i}(t)$$

In the above equation, m_i is the mass of body i (i =1,2... N), and $\ddot{x}_i$ is the x-direction acceleration vector of body i. In the equation M_{ij} and N_{ij} denote the virtual mass effects of body j on body i in the two directions of motion. The second derivative of y with respect to time represents the acceleration in the y-direction.

The terms M_{ij} are functions of the shape and size of the bodies (and the container boundary) and, most important, the size of the inter-body gaps. M_{ij} are analytically derived coefficients. The term Q_{x_i} represents the generalized force that may be an amalgam of all externally applied loads on the mass i in the x-direction. The above equation for mass i in x-direction translational motions can be written for all degrees of freedom and for all masses. The resulting second order matrix differential equation contains a fully populated mass matrix (in contrast, dynamic equations without multi-body fluid coupling will have only diagonal non-zero terms).

The above exposition explains the inclusion of fluid coupling in a multi-body fluid coupled problem using a simplified planar motion case. This explanation provides the building blocks to explain the more complicated formulation needed to simulate freestanding racks. Dr. Paul's formulation is documented in a series of four reports written for PG&E in 1987 (References 7, 8, 9 and 10). The Paul multi-body fluid coupling theory conservatively assumes the flow of water to be irrotational (inviscid) and assumes that no energy losses (due to form drag, turbulence, etc.) occur. NRC personnel reviewed this formulation in the course of their audit of the Diablo Canyon rerack (circa 1987) and subsequently testified in the ASLB hearings on this matter, as stated previously.

While the ASLB, NRC, and NRC consultants (Brookhaven National Laboratory and Franklin Research Center) all endorsed the Paul multi-body coupling model as an appropriate and conservative representation, the multi-body coupling model was still just a theory. Recognizing this perceptual weakness, Holtec International and Northeast Utilities undertook an experimental program in 1988 to benchmark the theory. The experiment consisted of subjecting a scale model of racks (from one to four at one time in the tank) to a two-dimensional excitation on a shake table at a quality assurance (QA) qualified laboratory in Waltham, Massachusetts.

The Paul multi-body coupling formulation, coded in QA validated preprocessors to DYNARACK, was compared against the test data (over 100 separate tests were run). The results are documented in Problem 10 of Reference 14, which was previously provided in the Waterford 3 October 23, 1997 and January 29, 1998 submittals (Docket No. 50-582). The experimental benchmark work validated Paul's fluid mechanics model and showed that the theoretical model (which neglects viscosity effects) is consistently bounded by the test data. This experimentally verified multi-body fluid coupling is the central underpinning of the DYNARACK WPMR solution that has been employed in every fuel rack license application since 1989. The DYNARACK 3-D WPMR solution has been found to predict much greater rack displacements and rotations than the previously used 3-D single rack results (Reference 11).

In general, the advance from linearized analysis (response spectrum) in the late 1970s to the single rack 3-D analysis in the mid-1980s and, finally, to the 3-D WPMR analyses in the past ten years has, at each technology evolution stage, led to an increase in the computed rack response. The stresses and displacements computed by the DYNARACK 3-D WPMR analysis for the BVPS Unit No. 2 racks, are greater (and more conservative) than the docketed work on similar instances from 20 years ago. The conservatism built into the WPMR solution arises from several simplifying assumptions explicitly intended to establish an upper bound on the results, namely:

a) In contrast to the single rack 3-D models, the fluid forces on every rack in the pool consist of the aggregate of fluid coupling effects from all other racks located in the pool. No assumptions on the motion of racks need be made a priori; the motion of each rack in the pool is a result of the analysis.

b) The fluid coupling terms are premised on classical fluid mechanics; they are not derived from empirical reasoning. Further, the fluid drag and viscosity effects, collectively referred to as fluid damping, are neglected. In short, while the transfer of fluid kinetic energy to the racks helps accentuate their motion, there is no subtraction of energy through damping or other means.

c) The rack-to-rack and rack-to-wall gaps are taken as the initial nominal values. During the earthquake, these gaps will change through the time-history duration. The fluid coupling matrix should be recomputed at each time-step with the associated gap distribution. The inversion of the mass matrix at each time-step (there are over four million time-steps in a typical WPMR run) would, even today, mandate use of a supercomputer. Fortunately, neglect of this so-called nonlinear fluid coupling effect is a conservative assumption. This fact is rigorously proven in a paper by Drs. Soler and Singh entitled "Dynamic Coupling in a Closely Spaced Two-Body System Vibrating in a Liquid Medium: The Case of Fuel Racks," published in 1982. The only docket where recourse to the nonlinear fluid coupling was deemed essential was Vogtle Unit 2 (in 1988) where the margin inherent in the nonlinear fluid effect, published in the above mentioned paper, was reaffirmed. Nonlinear fluid coupling is not employed in this present application which imputes over 15% margin in the computed rack response.

In summary, the program DYNARACK utilizes a fluid coupling formulation that is theoretically derived (without empiricism) and experimentally validated. The assumptions built into the DYNARACK formulation are aimed to demonstrably exaggerate the response of all racks in the pool simulated in one comprehensive model.

ii. Verification of this program by benchmarking with known analytical or experimental results.

The DYNARACK computer software validation manual (Reference 14) provides a detailed description of the experimental testing performed in 1987 by Dr. Burton Paul. The DYNARACK software validation manual was provided in response to NRC requests for additional information (RAI) to support the 1997 reracking license amendment submittal for Waterford Unit 3 (Docket No. 50-582). Detailed discussions about the experimental data that supports the DYNARACK fluid coupling solution method are provided above in the response to Item 3.i.

The Waterford Unit 3 RAIs also requested comparison with experimental work performed by Scavuzzo, et al. Holtec determined that the solver used by Scavuzzo was substantively the same algorithm as that used in DYNARACK, and comparisons performed with DYNARACK found good correlation. These comparisons were documented in the DYNARACK computer software validation manual and were submitted to the NRC under the Waterford Unit 3 reracking license amendment (Reference 15).

The current version of the Holtec International, Inc. (Holtec) proprietary software code, DYNARACK, uses the same algorithm solvers and fluid coupling formulations as the version used to support the Waterford Unit 3 reracking project. There has been no recent key engineering analysis methodology improvements required or performed for the DYNARACK solver.

iii. Sufficient numerical detail regarding the evaluation of the rack geometrical properties, such as the calculation of the various mass and spring properties.

As discussed above, the BVPS Unit No. 2 racks are honeycomb construction (HCC) racks. The numerical formulas used to calculate the spring properties for this type of rack are provided in the published paper by Soler and Singh, "Seismic Response of a Freestanding Fuel Rack Construction to 3-D Floor Motion" (Reference 4).

The mass of each rack (excluding fuel) is divided equally between two mass nodes (nodes 1 and 2 in Figure 5.1 in Section 5.0 of Enclosure B of Reference 1). The total mass of the stored fuel assemblies is divided among five mass nodes (nodes 1* through 5* in Figure 5.1 in Section 5.0 of Enclosure B of

Reference 1). The top and bottom nodes (1* and 2*) are each assigned a mass equal to 12.5% of the total stored fuel mass. The intermediate nodes (3*, 4* and 5*) are each assigned a mass equal to 25% of the total stored fuel mass. Each fuel mass is connected to the rack structure by four compression-only gap elements (see Figure 5.2 in Section 5.0 of Enclosure B of Reference 1). The spring rate for these gap elements is calculated according to the formula given in Section 5.2 of Reference 4.

The fluid mass contributions are calculated using the methodology described above in the response to Item 3.i.

iv. Numerical results for the whole rack analysis.

The numerical results from DYNARACK are archived at appropriate time intervals for permanent record and for subsequent post-processing for structural integrity evaluations as follows:

a) All generalized nodal displacement coordinate values in order to later determine the motion of the rack

b) All load values for linear springs representing beam elasticity

c) All load values for compression-only gap springs representing pedestals, rack-to-fuel impact, rack-to-rack and rack-to-wall impacts.

d) All load values for friction springs at the pedestal/platform interface

The archived data is post-processed using the QA validated program DYNAPOST (Reference 24) in order to obtain the overall maximum results for all racks included in the model and all time instants. The limiting results for each of the whole pool multi-rack runs are summarized in the following table.

Run No. (note 1)	Max. Stress Factor (note 2)	Max. Vertical Load on Single Pedestal (pound (force))	Max. Shear Load on Single Pedestal (pound (force)) (X or Y)	Max Fuel to Cell Wall Impact (pound (force))
1	0.307	231,000	39,400	582.4
2	0.367	326,000	113,000	610.2
3	0.315	247,000	122,000	586.7
4	0.507	170,000	33,800	590.8
5	0.542	230,000	74,700	556.4
6	0.563	245,000	115,000	558.5

Notes:

1. Run numbers are as defined in Section 5.5.4 of Enclosure B of Reference 1.
2. Allowable limit is 1.0.

v. **In Table 5.4.1, DYNARACK is listed as having been used in ANO 2 spent fuel pool rerack. The final safety evaluation dated September 28, 2007 (ADAMS Accession No. ML072620412) has no reference to this computer program. Provide justification.**

Table 5.4.1 of Enclosure B of Reference 1 is a partial listing of plants that have used DYNARACK in the rack structural analysis. Enclosure A of Reference 1 lists nine plants as precedent for LAR No. 08-027. These plants were chosen because they all used high density Metamic racks designed and analyzed by Holtec. Section 4.3 of Enclosure A of Reference 1 states that all of the referenced submittals except Arkansas Unit 1, St. Lucie and Shearon Harris used DYNARACK in the rack structural analysis. Although DYNARACK may not have been specifically referenced in the cited ANO 2 rerack amendment safety evaluation, Holtec stated that the program was provided to the licensee for the project. However, an alternative method may have been submitted by the licensee. A further review of the plants cited as precedent has revealed that, although the St. Lucie amendment safety evaluation does not reference DYNARACK, the license amendment request states that DYNARACK was used. This further review also revealed that the amendment safety evaluations for Crystal River and Monticello do not reference DYNARACK. Since these two submittals did not use DYNARACK, it is consistent that they do not appear in Table 5.4.1. However the statement in Section 4.3 of Enclosure A of Reference 1 should state that all of the referenced submittals except Arkansas Units 1 and 2, Crystal River, Monticello and Shearon Harris used DYNARACK in the rack structural analysis. The inaccurate identification of what plants used DYNARACK does not imply that DYNARACK is not an acceptable code to be used in the rack structural analysis.

4. **Please provide the following information for Section 5.5.2 of Enclosure A of the application:**

   i. **Information regarding the Holtec program GENEQ and reference and reference whether or not this program was reviewed and accepted by the NRC staff.**

The program GENEQ is a QA validated synthetic time-history generator, and it has been used by Holtec International to generate statistically independent artificial acceleration time histories in over 40 reracking projects. GENEQ accepts an initial digitized response spectrum as input and generates an acceleration time history along with a new response spectra corresponding to the artificial time history. GENEQ also outputs power spectral density (PSD) curves corresponding to both the input response spectrum and the generated response spectrum.

The program GENEQ is adapted from the public domain program SIMQKE, originally developed by the Department of Civil Engineering at Massachusetts Institute of Technology. A brief description of the motion generation procedure is provided in Reference 12.

The QA validation of the program GENEQ is documented in Reference 16. In 2007, this report was audited and accepted by NRC consultants (Brookhaven National Laboratory) as part of the review process for the Westinghouse AP1000 spent fuel rack design.

   ii. **The time histories that form the basis for the development of the artificial time histories.**

Artificial time histories were developed from the amplified response spectra provided to Holtec by FENOC. Holtec developed the artificial time histories (Reference 17) using the GENEQ computer program. The amplified response spectra that were provided to Holtec to develop the artificial time histories are located in Appendix B of Reference 17.

iii. The basis for specifying 5% damping for the spectra.

The basis for 5% damping for the spectra is NUREG-0800, Standard Review Plan 3.7.1, Seismic Design Parameters, Rev. 3, May 2007. This is consistent with the BVPS Unit No. 2 existing design basis.

iv. A comparison of the artificial response spectra and the target response spectra.

Typical comparison plots of the artificial response spectra versus the target response spectra are provided in Figures 1 through 6. One set of response spectrum is provided for Operating Basis Earthquake and one set is provided for Safe Shutdown Earthquake. The attached plots are extracted from Reference 17.

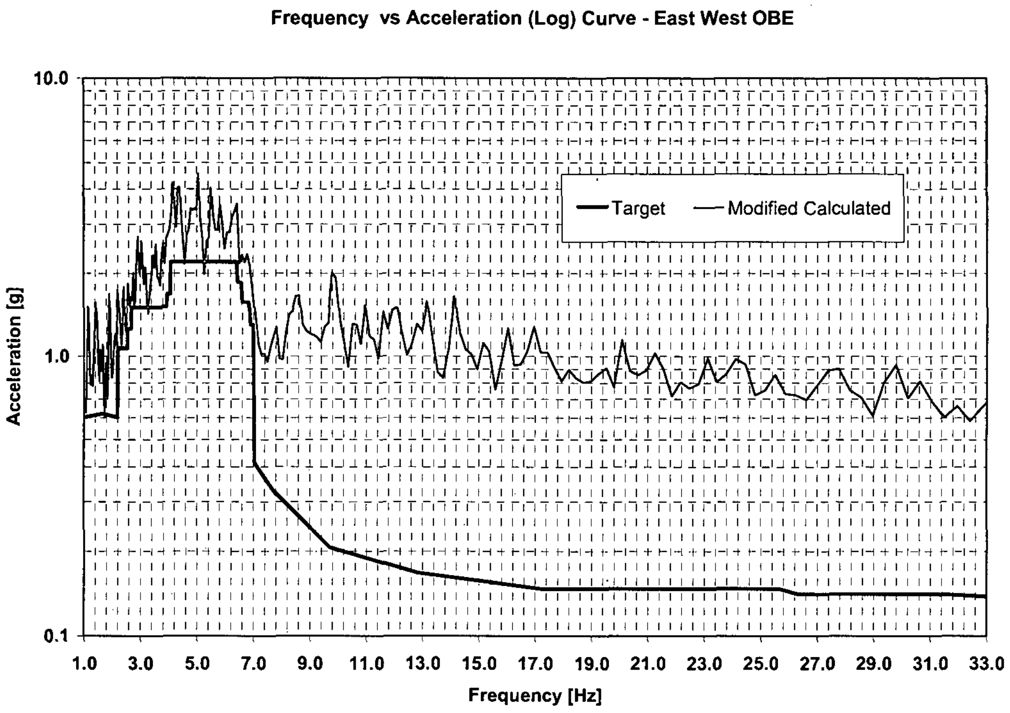


Figure 1: Response Spectrum in East-West Direction – Set I

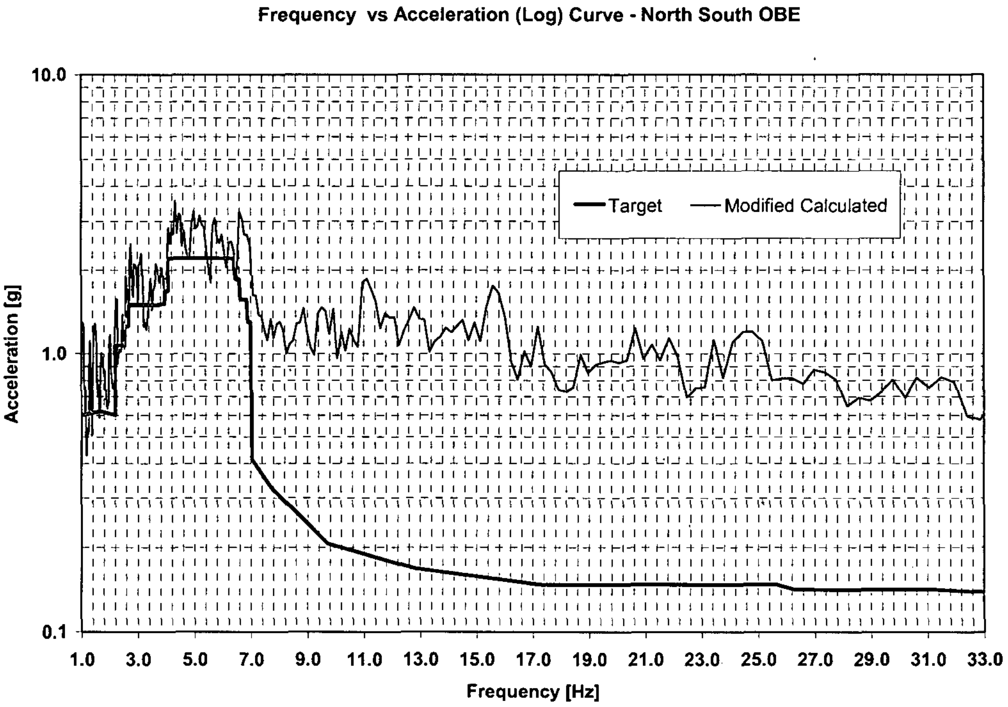


Figure 2: Response Spectrum in North-South Direction – Set I

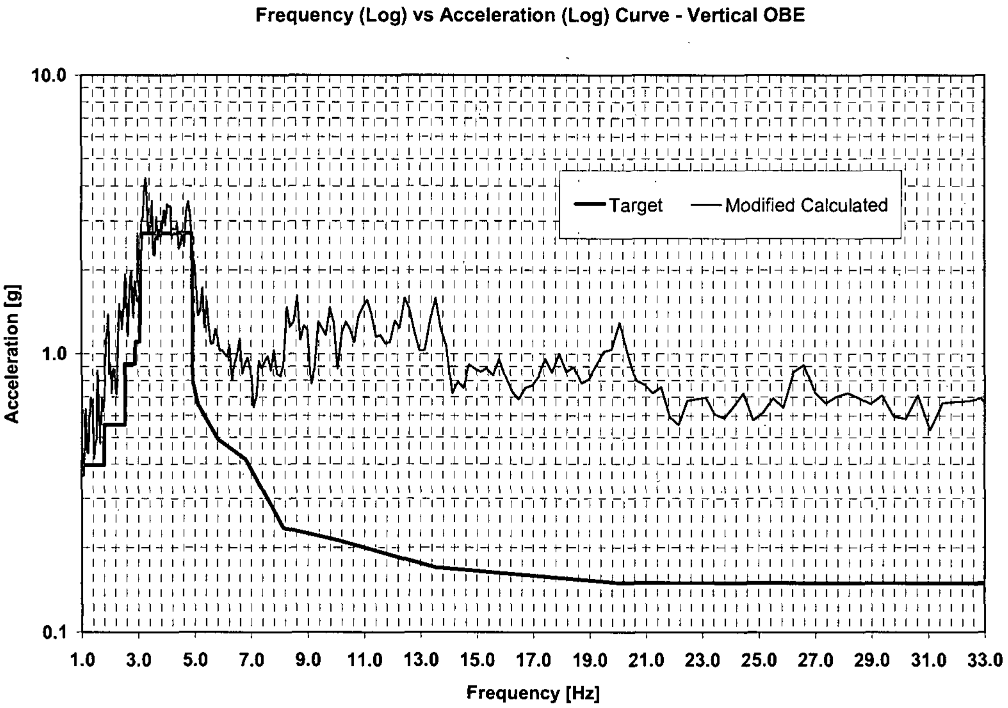


Figure 3: Response Spectrum in Vertical Direction – Set I

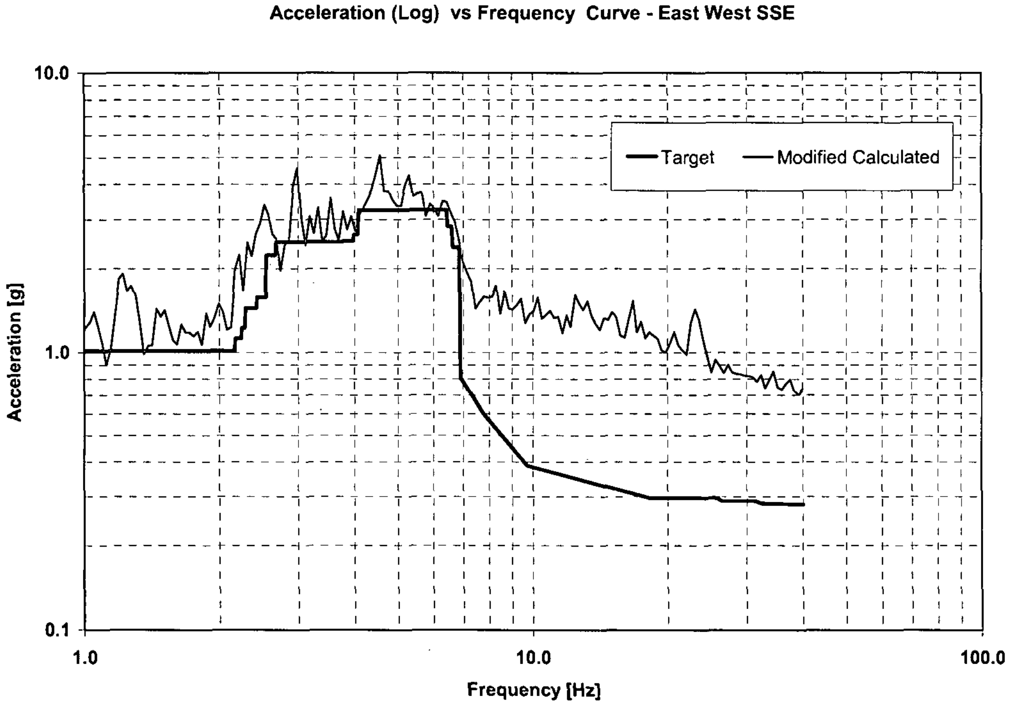


Figure 4: Response Spectrum in East-West Direction – Set I

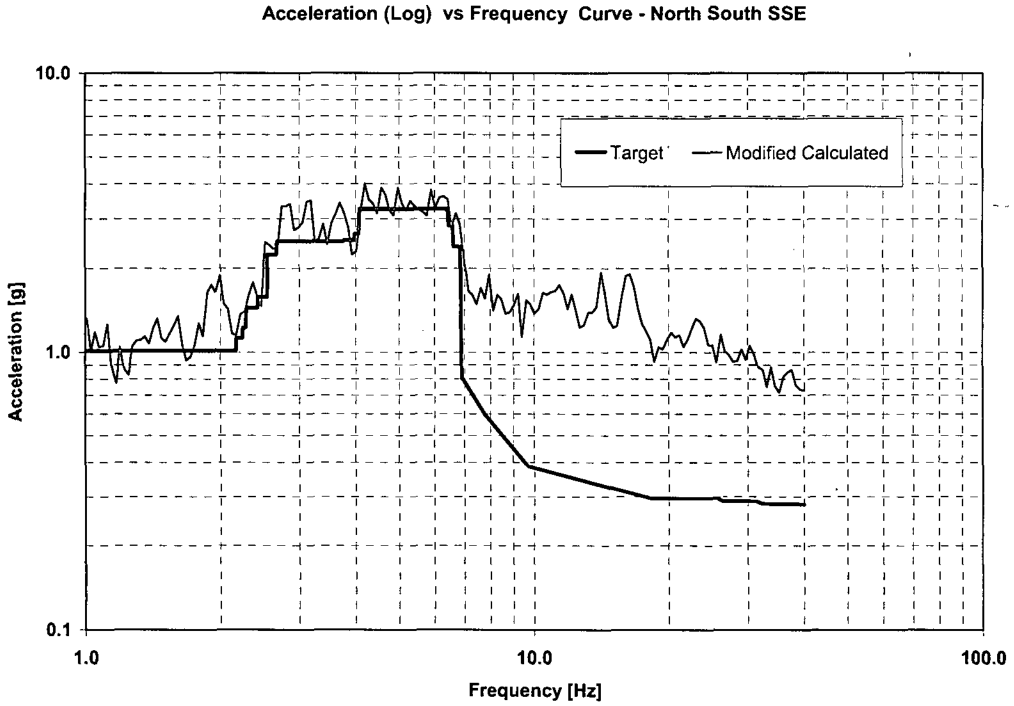


Figure 5: Response Spectrum in North-South Direction – Set I

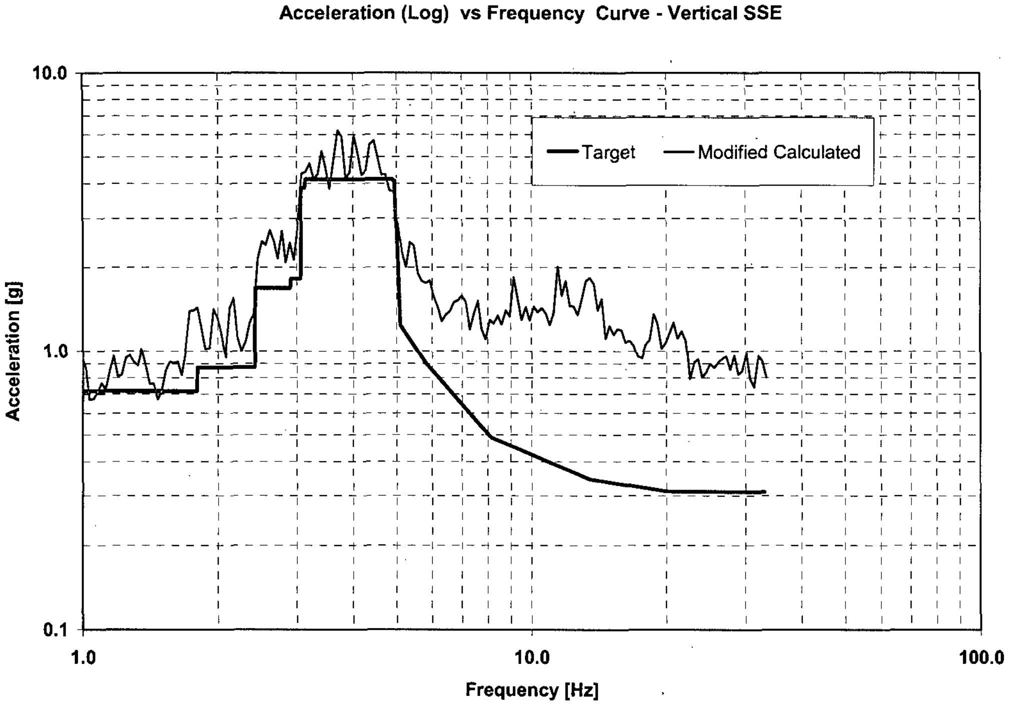


Figure 6: Response Spectrum in Vertical Direction – Set I

5. **For Section 5.5.3 of Enclosure A of the application demonstrate that the rack modules meet the provisions of NF-3322.2(d) for width ratios.**

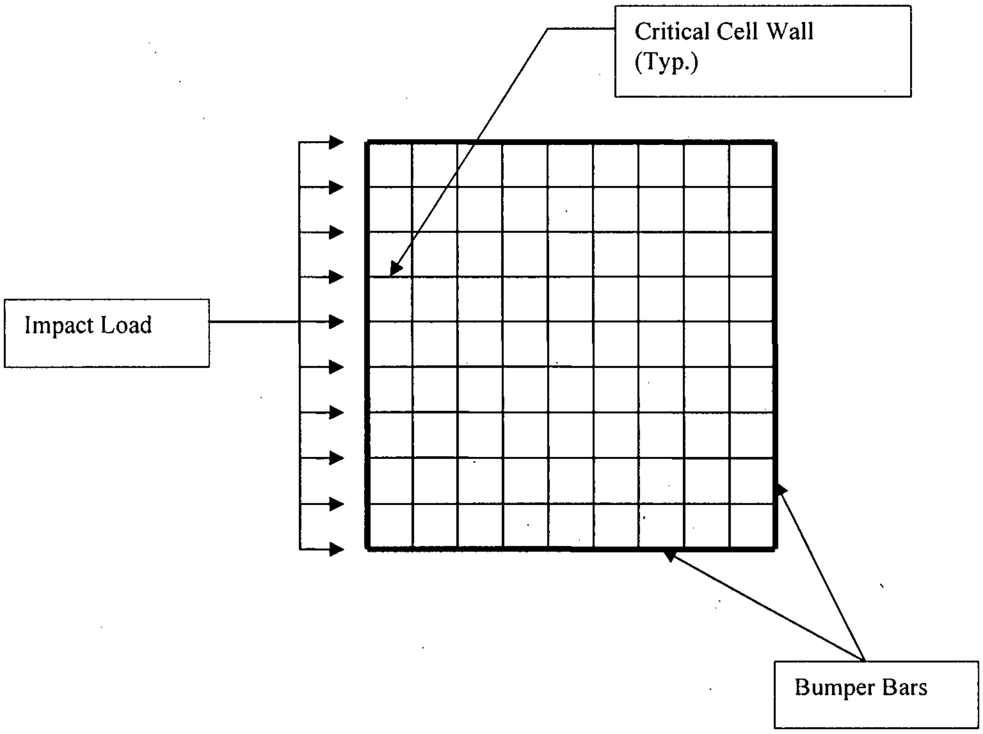
NF-3322.2 of the ASME Code considers the effect of slenderness ratio for single boxes, and it is not clear whether this section of the Code applies to the honeycombed structure design of the fuel storage racks. Nevertheless, the provisions of NF-3322.2 for width ratios have been included in the structural evaluation of the BVPS Unit No. 2 spent fuel racks.

Since the slenderness ratio of a single fuel storage cell within the honeycomb array exceeds the limit imposed by NF-3322.2, the stress results from DYNARACK have been manually adjusted to incorporate the slenderness ratio effects. This is accomplished by calculating the effective section properties (area and moment of inertia) of the rack cellular structure using the methodology in NF-3322.2 for a single rectangular beam. Next, the stress adjustment factors are calculated as the ratio of the effective section properties to the gross section properties. Finally, the maximum stress factors from DYNARACK are divided by the limiting adjustment factor to account for the slenderness ratio effect. The details of the calculation are documented in Reference 18.

6. **Please provide the following information for Section 5.6 of Enclosure A of the application:**

    i. **The licensee stated that rack-to rack impact occurs at several locations in the spent fuel pool and that the safety factor against buckling collapse of the storage cells has been determined to be greater than 1.5. Provide calculations to support this assertion and details regarding the buckling criterion.**

Rack-to-rack impact loads are evaluated to ensure that they do not cause permanent damage to the storage cells that would prevent the fuel from being unloaded using normal handling equipment. To that end, calculations have been performed to demonstrate that the maximum impact load between two adjacent racks (at the top of rack elevation) does not cause the cell walls that are perpendicular to the exterior face of the rack to buckle. The sketch below shows the impact load on the rack and the cell walls that resist the impact load for a typical rack. The impact load is distributed across the full width of the rack.



To strengthen the racks against impact loads, the BVPS Unit No. 2 racks are equipped with 1/4 inch thick steel bumper bars, which are welded on all four sides of the rack around its entire perimeter. Thus, the total impact load is resisted by the combination of the perpendicular cell walls plus two exterior bumper bars. In the calculation, the portion of the total impact load that is resisted by the cell walls is determined according to the area ratio of the cell walls versus the bumper bars.

The local buckling capacity of the cell wall is calculated according to Case 1b of Table 35 from Roark's Formulas for Stress & Strain (6th Edition), where the values of a, b and t are equal to the following:

a = 8 inches

b = vertical height of tie bars where cells are joined = 8 inches

t = cell wall thickness = 0.075 inch

The safety factor is calculated as the ratio of the critical compressive stress to the actual compressive stress. The minimum required safety factor of 1.5 comes from Appendix F of the ASME Code, Section III, which requires that the maximum load on an axially loaded compression member (under Level D conditions) must be less than 2/3 of the critical buckling load. The details of the calculation are documented in Reference 18.

ii. Detailed information regarding the methodology for supporting the assertion that the cumulative usage factor is 0.615.

ASME Code Section III, Subsection NB-3222.4 for Class I components is the reference code section that outlines the procedure for fatigue analysis. The section is written for Class I components, but it is applied to the extent practicable for the Class 3 fuel racks. The procedure outlined makes use of fatigue data in Appendix I of the ASME Section III Code and also refers to sections NB-3222.2, NB-3228.5, NB-3215, and NB-3216. The analysis method outlined in the above sections of the code is briefly summarized below, as it is applied to spent fuel storage racks. Strict compliance with ASME Section III, Subsection NB is neither required nor implied.

a) Develop a model of the area that is to be investigated for fatigue damage. The finite element code ANSYS is used to analyze the BVPS Unit No. 2 spent fuel racks.

b) For the given loading history, perform bounding stress analyses to establish peak stress amplitudes at the critical locations. The locations shall include all structural discontinuities.

c) Calculate the combined stress intensities by adding the peak stress results from each directional load (x, y, and z directions) and identify the stress intensity cycles that characterize the resulting pattern. The alternating stress amplitudes used for fatigue damage analysis are 50% of the stress intensity ranges that are found from the analysis, as defined in ASME Code Subsection NB.

d) Amplify the alternating stress intensities to account for plasticity effects and then use the appropriate fatigue curve from the code to obtain a damage factor. The peak stress intensity values are substituted for S_n in NB-3228.5 (b) to determine the plasticity factor, K_e.

For freestanding fuel racks, the geometry is such that the area of concern is the cellular region above a support pedestal. During a seismic event the freestanding rack is expected to slide, rock, etc., leading to the highest local loading near the pedestal. The maximum values for these local loads only occur during a limited period of time during a seismic event. During most of the event duration, the loading is significantly reduced. The time history results for the horizontal and vertical pedestal loads are calculated using the Holtec proprietary dynamics computer code DYNARACK. In the fatigue analysis, these time histories are used to develop the bounding stress intensities and also to establish the number of stress cycles.

The input time histories are chosen on the basis of the peak pedestal loads. In other words, the pedestals that experience the highest instantaneous forces, as determined by whole pool multi-rack analysis, are the source of the input time histories for fatigue analysis. The cumulative damage factor (CDF) for the spent fuel rack, which results from a combined load of one safe shutdown earthquake (SSE) event and five operating basis earthquake (OBE), must be below 1.0.

This method of analysis has been used for other spent fuel rack projects at Sequoyah (Tennessee Valley Authority), Kuosheng (Taiwan Power Company), Fort Calhoun Station (Omaha Public Power District), and Salem (Public Service of New Jersey), and at many other nuclear plants. The analysis is documented in Reference 23.

7. **Provide sufficient numerical information to support the stated factors of safety in Sections 5.7 through 5.9 of Enclosure A of the application.**

<u>Cask Pit Platform Analysis (Section 5.7 of Enclosure B)</u>

The cask pit platform analysis is carried out in two steps. First a single rack dynamic analysis is performed using DYNARACK in order to extract the maximum loads at the rack-platform interface. Then, after all loads are obtained, the Solidworks Computer-aided design (CAD) model of the cask pit platform is imported into ANSYS Workbench, meshed, and subject to the maximum loads. Solidworks is a commercially available CAD program, which has been validated under Holtec's 10 CFR Part 50 Appendix B QA Program (Reference 25). Holtec has also performed a QA validation of ANSYS (Reference 26), which is a commercial finite element program. Based on the finite element analysis (FEA) results, the stresses and safety factors are evaluated. The finite element model of the cask pit platform is shown below in Figure 7.

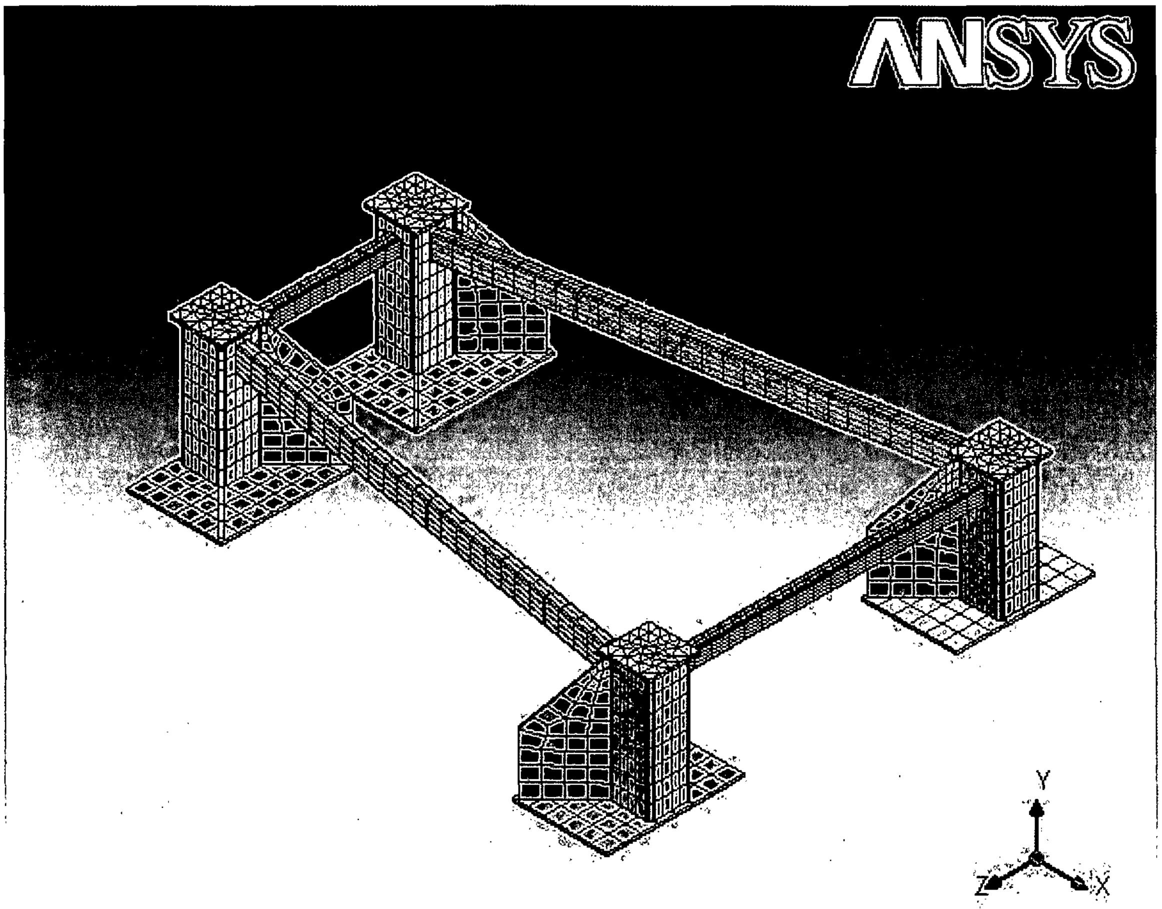


Figure 7 – Finite Element Model of Cask Pit Platform

The maximum loads applied at each pedestal support location are summarized in the tables below. The loads were produced from the single rack dynamic analysis.

Pedestal 1		Pedestal 2		Pedestal 3		Pedestal 4	
x	y	x	y	x	y	x	y
36200	64400	46700	50900	42500	63000	41500	88800

Shear loads (pound (force))

Pedestal 1	Pedestal 2	Pedestal 3	Pedestal 4
179900	232100	206000	172000

Compressive loads (pound (force))

The calculated stresses in the cask pit platform as determined by ANSYS are compared with the stress limits per ASME Subsection NF for linear type supports. The following table summarizes the minimum safety factor for various platform components under normal (Level A) and faulted (Level D) conditions. The analysis is documented in Reference 19

Component*	Safety factor	
	Level A	Level D
5989-01	N/A	1.31
5989-08	8.96	1.35
5989-11	N/A	6.51
5989-13	N/A	2.79
5989-14	N/A	4.11
Weld -5989-08 & 5989-11	N/A	2.48
Weld -5989-08 & 5989-13	N/A	1.12

* Component numbers are per Holtec drawing 5989.

Bearing Pad Analysis (Section 5.8 of Enclosure B)

The bearing pad analysis is performed using ANSYS. 3-D finite element models that include non-linear contact elements between the pedestal and the bearing pad and between the bearing pad and the existing, underlying concrete are developed. The load is vertically applied at the top of the pedestal. The peak load is obtained from the dynamic analyses of the spent fuel racks subject to seismic loads, which is performed using the program DYNARACK. The bearing pad is permitted to lose contact with the concrete under the load. The pedestal load is statically applied in increments until both the full load is applied and the analysis solution has converged. The average compressive stress in the concrete is computed based on the predicted contact area and then compared to the allowable stress. The average bearing stress on the pad is calculated by simply dividing the maximum pedestal load by the area of application.

ANSYS SOLID45 elements (8-noded brick elements) are used to model the pedestal, the bearing pad and the concrete. The concrete slab is big enough in dimensions (length/width/height) so that the confined slab boundary does not affect the local stress distribution under the bearing pad. The length, width and depth of the modeled concrete slab are 20 inches, 20 inches and 30 inches, respectively. Slab boundary conditions are set to simulate the fully constrained concrete condition. Accordingly, the maximum pedestal load is applied to the top surface of the pedestal as a uniform pressure. To allow for the development of accurate contact load distribution and potential lift-off of the corners of the bearing pad, the interfaces between the pedestal and the bearing pad, and between the bearing pad and the concrete floor, are modeled using contact pairs TARGE170 and CONTA173 elements, which are the standard element pairing used to define surface-to-surface contact in ANSYS. Figure 8 below shows the ANSYS model that is used to qualify Type 1 bearing pads.

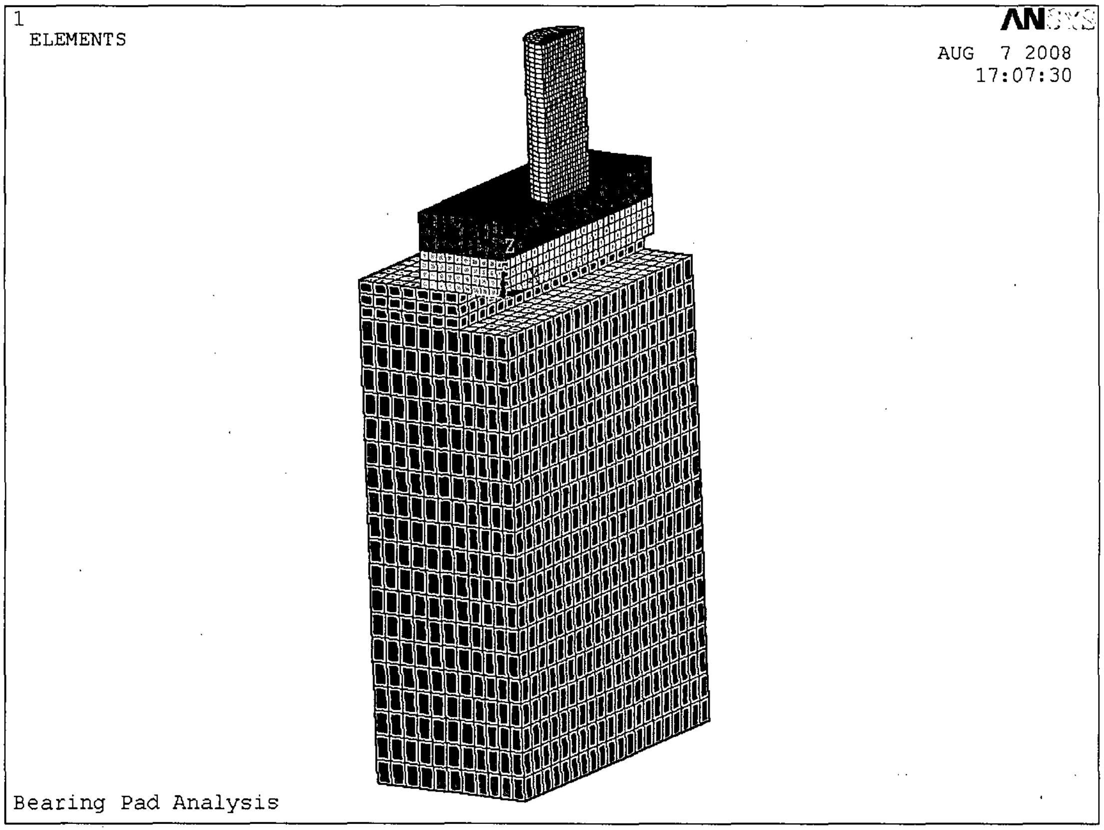


Figure 8 – Finite Element Model of Type 1 Bearing Pad Configuration

In accordance with the ACI-318-77, the bearing stress (f_b) in the concrete is limited to:

$f_b = \phi(0.85\ f_c')\varepsilon$

where: $\phi = 0.7$
$\varepsilon = (A_2/A_1)\ 0.5 \leq 2.0$
A_1 = Actual loaded area
$A_2 \geq A_1$

For $\varepsilon = 2$, the maximum permitted for full confinement, and $f_c' = 4{,}000$ pounds per square inch (psi), the above calculated bearing stress limit is 4,760 psi.

The yield stress of the bearing pad material (SA240-304) at 200°F is 25,000 psi. The bearing stress on the pad should be less than this yield strength (25,000 psi), and it is calculated as follows:

Maximum pedestal load P = 326,000 pound (force)

Diameter of the pedestal D = 4.5 inches

Area of the pedestal $A = \frac{\pi \times D^2}{4}$ =15.90 inches squared

Stress in the bearing pad $\sigma = \frac{P}{A}$ = 20,503 psi

The above calculated stress is less than the yield strength (25,000 psi) of the bearing pad.

Based on the ANSYS results, the average compressive stresses in concrete are 4,690 psi and 3,554 psi for Type 1 pad and Type 2 (and Type 4) pad, respectively, which are below the allowable value (4,760 psi) for confined concrete per the ACI Code. The compressive stresses in concrete underneath Type 3 bearing pads are bounded by the above stresses. The analysis is documented in Reference 20.

Interface Loads on Spent Fuel Pool Structure (Section 5.9 of Enclosure B)

The reinforced concrete spent fuel pool (SFP) structure at BVPS Unit No. 2 is qualified based on a comparative analysis using the existing strength qualification of the BVPS Unit No. 1 SFP, which was performed by Holtec International in 1990. Such an analysis is possible because the BVPS Unit No. 2 SFP is a mirror image of the BVPS Unit No. 1 SFP, and the loads are similar. While there are some variations in wall thicknesses and steel reinforcement patterns between the BVPS SFP structures, these are addressed in the analysis by re-computing the ultimate shear and moment capacities for the BVPS Unit No. 2 SFP walls and slab as necessary. Based on the results of the previous analysis for the BVPS Unit No. 1 SFP, the following governing load combinations are considered for the evaluation of BVPS Unit No. 2 SFP.

1) $1.4D + 1.9E$

2) $0.75\,(1.4D + 1.9E + 1.7T_o)$

3) $D + T_o + E'$

where:

D = Dead Load

E' = Design Basis Earthquake

E = Operating Basis Earthquake

T_o = Steady State Thermal Load during Normal Operation or Shutdown Conditions. To be conservative use $T_o = T_a$.

T_a = Abnormal Thermal load

The internal forces and moments on the BVPS Unit No. 2 SFP due to dead and seismic loads are calculated by scaling the shear and moment results for the BVPS Unit No. 1 SFP according to the applicable mechanical load ratios.

Since the thermal load (moment)[†] is directly proportional to the square of the entity (slab/wall) thickness and the corresponding temperature gradient, an adjustment factor is also calculated as shown in Table 1 to account for the change (increase/decrease) of the thermal load in the BVPS Unit No. 2 SFP.

Table 1: Change in Thermal Load

Entity Name	Thickness BVPS Unit No. 2 SFP (inches)	Thickness BVPS Unit No. 2 SFP (inches)	Temperature Gradient BVPS Unit No. 2 SFP (°F)	Temperature Gradient BVPS Unit No. 1 SFP (°F)	Moment Factor BVPS Unit No. 2 SFP	Moment Factor BVPS Unit No. 1 SFP	Change in Thermal Load %
West Wall	72	72	95.5	59	495072	305856	62
South Wall	88	72	93.6	59	724838	305856	137
South-East Wall	48	48	96.8	59	223027	135936	64
East-South Wall	54	54	97.6	59	284602	172044	65
East Wall	24	24	99.5	59	57312	33984	69
North Wall	90	72	93.3	59	755730	305856	147
Slab	120	78	94.8	59	1365120	358956	280

[†] The thermal moment (M) across the plate with thickness h is given by Reference 2.

$$M := \frac{E}{1-\nu}\cdot\int_{-0.5\cdot h}^{0.5\cdot h} \alpha\cdot\eta T\, d\eta$$

where α = coefficient of thermal expansion , h = Wall thickness and T = Temperature gradient

The internal forces and moments due to mechanical and thermal loads are then combined to form the final adjusted loads on the BVPS Unit No. 2 SFP structure per the above load combinations. Finally, the safety factors for the BVPS Unit No. 2 SFP structure are calculated by comparing the factored shear force and moment loads with the ultimate section capacities for the BVPS Unit No. 2 SFP structure. The analysis is documented in Reference 21.

8. Please provide the following information for Section 5.6 of Enclosure A of the application:

i. This section contains a verbal description for assessing damage to mechanical accidents. Provide an analytical description and present the basis of the factors entering the given equations for incident impact velocity and how they are evaluated.

The mechanical accident analysis is a two-part process. First the incident impact velocity is calculated for each of the postulated drop events based on the methodology provided in Appendix A. Then a 3-D finite element model is developed for each of the postulated drop events using the commercial program LS-DYNA, which has been QA validated by Holtec (Reference 27). The LS-DYNA model includes both the impactor (dropped fuel assembly) and the target (fuel rack). At time zero, the impactor is positioned as it would be just prior to impact, and it is given an initial velocity equal to the incident impact velocity from Table 7.4.1 of Enclosure B of Reference 1. The target object is meshed in LS-DYNA using a combination of solid and shell elements having true stress-true strain, elastic-plastic material properties. For each drop event, the finite element solution proceeds until the kinetic energy of the impactor diminishes to zero or the target object experiences the maximum possible damage. The final damage assessment is based on visual examination of the finite element results in LS-DYNA. This two-part analysis process has been used by Holtec for numerous spent fuel rack license applications, including Waterford, V.C. Summer, Clinton, and Diablo Canyon. The analysis is documented in Reference 22.

ii. The basis for the plastic deformation criterion of 19.75 inches from the top.

The plastic deformation of the rack cell wall resulting from a fuel assembly drop event must not extend down into the neutron absorber zone that shadows the entire length of the active fuel. Based on the rack design drawings, the minimum distance measured from the top of the rack to the upper boundary of the neutron absorber zone is 19.75 inches. The analysis is documented in Reference 22.

iii. Numerical analyses to support the results stated in Section 7.5, "Results."

The results stated in Section 7.5 of Enclosure B are obtained from the LS-DYNA finite element analyses, which are discussed above in the response to Item 8.i. For example, the maximum depth of plastic deformation experienced by the spent fuel rack as a result of the shallow drop event is obtained directly from Figure 7.5.1 of Enclosure B, which shows a maximum depth of 17.912 inches (less than 18 inches). Similarly, Figures 7.5.2 through 7.5.5 support other LS-DYNA results stated in Section 7.5. The details of the numerical analyses supporting the results in Section 7.5 are documented in Reference 22.

9. **The rack in motion is either the old spent fuel storage racks while they are connected to the temporary crane or the new spent fuel storage racks while they are connected to the temporary crane. The licensing report states that the racks will be moved along "safe load paths," but the report provides no detail regarding what constitutes a safe load path while removing or installing the racks. Also, the report specifies neither how the temporary crane was assessed to retain its integrity during and following credible seismic events or how the crane will be tested to ensure it is erected per design. These elements are necessary to demonstrate the crane would not be subject to collapse while transporting a rack. Inadequate safe load paths or inadequate crane fabrication and design could allow a rack in motion (or a portion of the crane) to impact another rack containing stored fuel.**

   Provide an evaluation of interaction between a rack in motion and a rack containing stored fuel nor the basis for excluding this type of event from consideration.

   Safe Load Paths

   In compliance with NUREG 0612, “Control of Heavy Loads at Nuclear Power Plants,” safe load paths will be included in project specific procedures to ensure that heavy loads shall not be carried over stored fuel in the SFP. Safe load paths will maximize the benefits of strategic fuel shuffles that allow for the greatest distance between a suspended rack and stored fuel while the suspended load is at a height above the top of the installed spent fuel racks. A minimum horizontal distance of three feet will be maintained between lifted racks and stored fuel. Suspended racks or any other heavy loads that are handled as part of the rerack operation will never be moved directly over stored fuel assemblies in the SFP. New racks will be carried over fuel in the cask pit. However, a cask pit cover, which has been qualified by analysis, will be in place to protect the fuel during such handling operations. Additionally, new racks being installed into the SFP will be lowered to a minimal height just above the SFP floor as soon as the rack safely clears the pool perimeter and any pool wall protrusions. As part of the defense-in-depth approach, the action of lowering the rack to a height just above the pool floor prior to commencing any horizontal movement reduces the amount of time that the rack is in a position that could cause potential damage to stored spent fuel.

Training will also be performed with the rack installation crew on many subjects in order to educate them on the many tasks and their associated governing procedures and regulations. Crane operators will get a training session on the functions of the cranes and the new parameters that are introduced by the allowance of travel over the spent fuel pool. In addition to this, and along with the rest of the rack installation crew, a training session will be given to offer a general overview of the tasks, associated safe load paths, and the applications of NUREG-0612 with respect to the many tasks that will be completed during the project.

Temporary Crane Design

The temporary crane is designed to meet the requirements of NUREG-0612, Section 5.1.1(7), which include the applicable criteria and guidelines of Chapter 2-1 of ANSI/ASME B30.2-1983, "Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)," and of CMAA-70, "Specifications for Electric Overhead Traveling Cranes".

The applicability of Chapter 2-1 of ANSI/ASME B30.2 to the temporary crane is discussed below with the section notations taken from ANSI/ASME B30.2. Those sections that are not applicable are omitted for clarity.

2.1.1 Marking

The temporary crane is designed for maximum lifted load and will only be used during reracking. This maximum lifted load will be painted on the crane and will also be marked on the control panel. The hoist has a higher load capacity than needed for the reracking.

2.1.2 Clearances

2.1.2.2 Clearance between the existing fuel handling crane and the temporary crane is maintained by mechanical linkage of the two units during rack installation/removal. During fuel shuffles in the spent fuel pool, the temporary crane is parked over the cask pit.

2.1.3 General Construction - Runways and Supporting Structure

2.1.3.2 Crane Runways

The temporary crane will use the existing fuel handling crane rails. These rails are adequate to support the loads.

2.1.4 Crane Construction

2.1.4.1 Welding - The appropriate American Welding Society Code Sections are specified for welding procedures involving crane structural members.

2.1.4.2 Girders - The crane meets the requirements of CMAA-70 design formulas where applicable. In addition, finite element analysis has been carried out. Safety margins meet the intent of ANSI N14.6 for heavy loads over critical areas. That is, the design margins are higher than those required by CMAA-70.

2.1.5 Cabs

Not applicable.

2.1.6 Lubrication

Lubricating points are in the hoist and the crane wheels. Access to the wheels is at walkway level. Access to the hoist is by means of a ladder at each end of the crane.

2.1.7 Footwalks and Ladders

There are no service platforms required. Ladders meeting ANSI A14.3 are provided at each end of the crane, and a footwalk with appropriate measures to protect workers from falling is provided along the top of the crane.

2.1.8 Stops, Bumpers, Rail Sweeps, Girders

The temporary crane travels on existing rails which have bumpers in-place (east-west travel). Trolley bumpers will be attached at the end of the girder carrying the motorized hoist (north-south travel). However, in accordance with the rack installation procedure, the trolley will not be operated near the ends of trolley travel.

2.1.9 Brakes

The hoist unit of the temporary crane is supplied by Ingersoll Rand Co. and meets the requirements of ANSI/ASME B30.2. The temporary crane is physically attached to the fuel bridge crane and travels at the same speed as the fuel bridge crane.

2.1.10 Electrical

The only electrical components are associated with the hoist itself; these meet the ANSI requirements.

2.1.11 Hoisting Equipment

The supplied main hoist is certified by Ingersoll Rand to meet applicable ANSI/ASME B30.2 requirements, OSHA requirements, and ANSI B16 which pertains specifically to hoists. The hoist is rated at 37.5 metric tons with a hoist design safety factor of five. In the event of loss of power, the hoist will hold the load.

In order to ensure that the temporary crane will maintain its integrity during and following a design basis earthquake, the temporary crane is designed to have a safety factor of 10, as compared to its collapse load, when it is supporting the maximum lifted load. Also, there are several design features that keep the temporary crane from separating from the fuel bridge crane rails during a design basis seismic event.

a) Calculations have shown that the crane wheel flange will not be lifted above the crane rail during an earthquake. This provides assurance that the wheels will not move laterally off of the crane rails.

b) The temporary crane will be physically connected to the fuel handling crane at four locations: at each side, top and bottom.

c) The temporary crane utilizes restraints at the wheels which are designed to catch the underside of the rail.

Testing of Temporary Crane

The temporary crane that will be used for the spent fuel rack installation at BVPS Unit No. 2 is the same crane that was originally designed and fabricated to support the spent fuel rack installation at BVPS Unit No. 1 (circa 1993). In order to verify its continuing compliance with ASME B30.2, the temporary crane will be removed from storage, fully erected at Holtec Manufacturing Division, and load tested to 125% of its rated capacity. Upon successful testing, the temporary crane will be disassembled, packaged, and shipped to site. The temporary crane will then be erected outside the fuel handling building before it is brought inside and mounted on the fuel handling crane rails over the SFP. Once it is installed on the rails, several functional checks will be completed as directed by procedure.

References:

1. FENOC Letter L-09-086, "License Amendment Request No. 08-027, Unit 2 Spent Fuel Pool Rerack," dated April 9, 2009 (ADAMS Accession No. ML091210251)
2. Mechanical Design of Heat Exchangers and Pressure Vessel Components, K.P. Singh and A.I. Soler
3. Levy, S. and Wilkinson, J.P.D., "The Component Element Method in Dynamics with Application to Earthquake and Vehicle Engineering," McGraw Hill, 1976
4. Seismic Response of a Free Standing Fuel Rack Construction to 3-D Floor Motion (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 9)
5. Holtec International Proprietary Position Paper WS-115 (3-D Single Rack Analysis of Fuel Racks), (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 1)
6. Planar View of a 16 Rack Array (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 2)
7. Evaluation of Fluid Flow for In-Phase and Out-of-Phase Rack Motions (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 3)
8. Estimated Effects of Vertical Flow Between Racks and Between Fuel Cell Assemblies (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 4)
9. Study of Non-Linear Coupling Effects (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 5)
10. Fluid Flow in Narrow Channels Surrounding Moving Rigid Bodies (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 6)
11. Chin Shan Analyses show advantages of whole pool multi-rack approach (Docket No. 50-382, Letter from Waterford 3 to NRC, January 29, 1998, Attachment 8)
12. SIMQKE: A Program for Artificial Motion Generation
13. Fritz, R.J., "The Effects of Liquid on the Dynamic Motions of Immersed Solids," Journal of Engineering for Industry, Trans. Of the ASME, February 1972, pp 167-172
14. Holtec International Report HI-91700, DYNARACK Validation Manual – Comparisons with Alternate Solutions
15. Entergy Operations, Inc., letter W3F1-98-0016 to the NRC, dated January 29, 1998

16. Holtec Proprietary Report HI-92811, QA Validation Manual
17. Holtec Proprietary Report HI-2083915, Artificial Time Histories, Revision 3
18. Holtec Proprietary Report HI-2084123, Rack Structural Seismic Analysis, Revision 2
19. Holtec Proprietary Report HI-2084165, Cask Pit Platform Calc, Revision 1
20. Holtec Proprietary Report HI-2084099, Bearing Pad Analysis, Revision 1
21. Holtec Proprietary Report HI-2084131, Pool Structural Analysis, Revision 3
22. Holtec Proprietary Report HI-2084010, Mechanical Drop Accident Analysis, Revision 1
23. Holtec Proprietary Report HI-2084079, Rack Fatigue Analysis, Revision 1
24. Holtec Proprietary Report HI-971648, QA Validation of Program DYNAPOST
25. Holtec Proprietary Report HI-2012761, Validation of SolidWorks
26. Holtec Proprietary Report HI-2012627, QA Documentation Package for ANSYS (Versions 5.3 and Higher)
27. Holtec Proprietary Report HI-961519, QA Validation DYNA3D

Enclosure B

L-09-162

Holtec Affidavit 1702-AFFI-2 (Holtec Report HI-2094370) Pursuant to 10 CFR 2.390

HOLTEC
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AFFIDAVIT PURSUANT TO 10 CFR 2.390

I, Matthew T. McGinley, state as follows:

(1) I am the Holtec International Adjunct Project Manager for the Beaver Valley Unit 2 Fuel Storage Racks Project and have reviewed the information described in paragraph (2) which is sought to be withheld, and am authorized to apply for its withholding.

(2) The information sought to be withheld is Revision 0 of Holtec Report HI-2094370, which contains Holtec Proprietary information and is appropriately marked as such.

(3) In making this application for withholding of proprietary information of which it is the owner, Holtec International relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by Holtec's competitors without license from Holtec International constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information which reveals cost or price information, production, capacities, budget levels, or commercial strategies of Holtec International, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future Holtec International customer-funded development plans and programs of potential commercial value to Holtec International;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reason set forth in paragraph 4.a and 4.b, above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information (including that compiled from many sources) is of a sort customarily held in confidence by Holtec International, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by Holtec International. No public disclosure has been made, and it is not available in public sources. All disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within Holtec International is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his designee), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside Holtec International are limited to regulatory bodies,

customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information classified as proprietary was developed and compiled by Holtec International at a significant cost to Holtec International. This information is classified as proprietary because it contains detailed descriptions of analytical approaches and methodologies not available elsewhere. This information would provide other parties, including competitors, with information from Holtec International's technical database and the results of evaluations performed by Holtec International. A substantial effort has been expended by Holtec International to develop this information. Release of this information would improve a competitor's position because it would enable Holtec's competitor to copy our technology and offer it for sale in competition with our company, causing us financial injury.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to Holtec International's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of Holtec International's comprehensive spent fuel storage technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology, and includes development of the expertise to determine and apply the appropriate evaluation process.

The research, development, engineering, and analytical costs comprise a substantial investment of time and money by Holtec International.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

Holtec International's competitive advantage will be lost if its competitors are able to use the results of the Holtec International experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

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The value of this information to Holtec International would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive Holtec International of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

Executed at Marlton, New Jersey, this 12th day of June, 2009.

Matthew T. McGinley
Holtec International

Enclosure C

L-09-162

Holtec Affidavit 1702-AFFI-3 (Holtec Report HI-2084010, Appendix B) Pursuant to 10 CFR 2.390

HOLTEC
INTERNATIONAL

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I, Matthew T. McGinley, state as follows:

(1) I am the Holtec International Adjunct Project Manager for the Beaver Valley Unit 2 Fuel Storage Racks Project and have reviewed the information described in paragraph (2) which is sought to be withheld, and am authorized to apply for its withholding.

(2) The information sought to be withheld is Appendix B of Holtec Report HI-2084010, which contains Holtec Proprietary information.

(3) In making this application for withholding of proprietary information of which it is the owner, Holtec International relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by Holtec's competitors without license from Holtec International constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

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c. Information which reveals cost or price information, production, capacities, budget levels, or commercial strategies of Holtec International, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future Holtec International customer-funded development plans and programs of potential commercial value to Holtec International;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

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Executed at Marlton, New Jersey, this 12th day of June, 2009.

Matthew T. McGinley
Holtec International