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NUCLEAR REGULATORY COMMISSION

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ATOMIC SAFETY AND LICENSING BOARD

OFFICE OF SECRETARY
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Before Administrative Judges:

Dr. Robert M. Lazo, Chairman
Dr. Richard F. Cole
Dr. Emmeth A. Luebke

SERVED APR 20 1988

In the Matter of	Docket Nos. 50-250-OLA-2 50-251-OLA-2
FLORIDA POWER & LIGHT COMPANY	ASLBP No. 84-504-07 LA (Spent Fuel Pool Expansion)
(Turkey Point Plant, Units 3 & 4)	April 19, 1988

INITIAL DECISION
(Spent Fuel Pool Expansion)

Appearances

Joette Lorion, Miami, Florida, for the Intervenors Center For Nuclear Responsibility, Inc., and Joette Lorion.

Steven P. Frantz, Esq., Washington, D.C. and Norman A. Coll, Esq., Miami, Florida, for the Licensee, Florida Power & Light Company.

Mitzi A. Young, Esq., and Janice E. Moore, Esq., for the Nuclear Regulatory Commission Staff.

I. INTRODUCTION AND BACKGROUND

Florida Power & Light Company (FPL or Licensee) is licensed to possess, use and operate the Turkey Point Plant, Units 3 and 4, two pressurized water nuclear reactors located in Dade County, Florida.

On March 14, 1984, the Licensee applied for amendments to allow the expansion of the capacity of each unit's spent fuel pool from 621 fuel

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assemblies to approximately 1404 fuel assemblies.[1] This application was supported by a Safety Analysis Report which addressed various safety matters related to the expansion and concluded that the proposed modification of the Turkey Point spent fuel pools would continue to provide safe storage of spent fuel. On June 7, 1984, pursuant to 10 C.F.R. 2.105(a)(4)(i), the Nuclear Regulatory Commission published in the Federal Register a notice of consideration of the issuance of amendments to the facility operating licenses and offered the opportunity for a hearing on these amendments. 49 Fed. Reg. 23715 (1984). On July 9, 1984, the Center for Nuclear Responsibility, Inc. (Center) and Joette Lorion (collectively referred to herein as Intervenors) filed a timely request for a hearing and petition for leave to intervene in the license amendment proceeding.[2]

The NRC Staff applied the standards of 10 C.F.R. 50.92 and made a final determination that the amendments involved no significant hazards consideration. 49 Fed. Reg. 46832 (1984). Consequently, on November 21, 1984, the NRC issued the license amendments to allow the expansion of the capacity of the spent fuel pools notwithstanding the pendency of the Intervenors' petition to intervene. In conjunction with the

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1 Letter from Mr. J. W. Williams, Jr. (FPL) to Mr. D. G. Eisenhut (NRC) (March 14, 1984) (Turkey Point Units 3 and 4, Docket Nos. 50-250 and 50-251, Proposed Amendment to Spent Fuel Storage Facility Expansion).

2 Request For Hearing And Petition For Leave To Intervene, July 9, 1984.

issuance of the amendments, the NRC Office of Nuclear Reactor Regulation issued a Safety Evaluation for the expansion which concluded that there is reasonable assurance that the health and safety of the public will not be endangered by the expansion.[3]

On March 7, 1985, Intervenors submitted an Amended Petition to Intervene which included ten proposed contentions. On March 27, 1985, the Licensing Board held a prehearing conference in order to consider Intervenors' petition to intervene. By Order of September 16, 1985, the Licensing Board admitted the Intervenors as parties and seven of their proffered contentions (Contentions 3, 4, 5, 6, 7, 8, and 10) as issues to be litigated in the proceeding. Florida Power and Light Co. (Turkey Point Nuclear Generating Plant, Units 3 and 4), LBP-85-36, 22 NRC 590 (1985). Contention 1 was rejected because it sought to litigate an issue not cognizable by the Board, and Contentions 2 and 9 were rejected because Intervenors failed to specify an adequate basis for those contentions. In several cases, the Board noted that the admitted contentions were supported by only a "minimally sufficient basis." Id. at 596-599.

On October 28, 1985, the Licensee served interrogatories upon the Intervenors.[4] The Intervenors filed a response to these interrogatories

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3 NRC Staff Exh. 1.

4 Licensee Interrogatories to Center for Nuclear Responsibility and Joette Lorion, October 28, 1985.

on November 27, 1985.[5] The Intervenors did not conduct any discovery, and no other discovery was conducted in this proceeding.

On January 23, 1986, Licensee filed a motion for summary disposition of each contention raised by Intervenors.[6] Licensee's motion was supported by the NRC Staff with respect to every contention except for part of Contention 4.[7] Subsequently, the NRC Staff submitted its own motion for summary disposition of Contention 4.[8]

Intervenors did not file a response to the NRC Staff's motion for summary disposition. Intervenors' response to Licensee's motion for summary disposition was filed on March 19, 1986.[9] This response was not supported by an affidavit from any expert or by any other evidence. The only affidavit provided in support of Intervenors' response was that of Joette Lorion, who is one of the Intervenors.[10]

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5 Intervenors' Response to Licensee's Interrogatories to Center for Nuclear Responsibility and Joette Lorion, November 27, 1985.

6 Licensee's Motion For Summary Disposition Of Intervenors' Contentions, January 23, 1986.

7 NRC Staff Response to Licensee Motion for Summary Disposition of Contentions, February 18, 1986.

8 NRC Staff Motion for Summary Disposition of the Personnel Exposure Portion of Contention 4, July 14, 1986.

9 Intervenors' Response to Licensee's Motion for Summary Disposition of Intervenors' Contention 3, etc., March 19, 1986.

10 See Affidavit of Joette Lorion on Contentions 3, 4, 5, 6, 7, 8, and 10, March 19, 1986.

After considering the motions for summary disposition, the Licensing Board determined that there were no genuine issue of material fact to be litigated with respect to Contentions 3, 4, 7, 8, and 10 (unpublished). Florida Power and Light Co. (Turkey Point Nuclear Generating Plant, Units 3 & 4), slip. op. at 62 (March 25, 1987). The Licensee's motion for summary disposition of Intervenors' Contentions 5 and 6 was denied.

Hearings were held before the Board on Contentions 5 and 6 in Miami, Florida, on September 15, 1987 and September 16, 1987. During the hearing, the Licensee and Staff presented testimony from a series of witness panels. As discussed below, these witnesses generally were in agreement with respect to resolution of Contentions 5 and 6. Intervenors did not sponsor any testimony and did not offer any exhibits or other evidence. Furthermore, with respect to Contention 5, Intervenors did not cross-examine the direct testimony of the Licensee's panel of witnesses. Consequently, the evidence submitted by Licensee and Staff regarding Contentions 5 and 6 is essentially undisputed.

This initial decision is based upon the record developed at the hearing. The decision incorporates the Findings of Fact that follow. Any proposed findings submitted by the parties that are not incorporated directly or inferentially in this decision are rejected as being unsupportable in law or in fact or as being unnecessary to the rendering of this decision.

II. FINDINGS OF FACT

A. CONTENTION 5

1. Intervenors' Contention 5 states:

> That the main safety function of the spent fuel pool, which is to maintain the spent fuel assemblies in a safe configuration through all environmental and abnormal loadings, may not be met as a result of a recently brought to light unreviewed safety question involved in the current rerack design that allows racks whose outer rows overhang the support pads in the spent fuel pool. Thus, the amendments should be revoked.

Intervenors gave the following bases for the contention:

> In a February 1, 1985 letter from Williams, FPL, to Varga, NRC which describes the potential for rack lift off under seismic event conditions [sic]. This is clearly an unreviewed safety question that demands a safety analysis of all seismic and hurricane conditions and their potential impact on the racks in question before the license amendments are issued, because of the potential to increase the possibility of an accident previously evaluate [sic], or to create the possibility of a new or different kind of accident caused by loss of structural integrity. If integrity is lost, the damaged fuel rods could cause a criticality accident.

The Board admitted this contention by Memorandum and Order dated March 25, 1987 (unpublished) (hereafter "SD Order"). The contention questions whether there is a deficiency in the Turkey Point rack design and a necessity for a restriction on loading to prevent potential lift-off during seismic events. SD Order at 18. This concern is based on a Licensee letter which indicated that the structural design of the rack, whose outer rows overhang the support pad, could cause the racks to lift-off (or more likely tip-off) from the pool floor during seismic events. See Letter from J. W. Williams, Jr., Licensee, to Steven A. Varga, NRC, dated February 1, 1985. In our March 25, 1987 Order denying summary disposition, we found that there is no question that properly executed administrative controls would prevent rack lift-off during a seismic event but observed that "there are sufficient doubts as to the basis for issuance of the amendments, particularly the structural analysis involving the safe shutdown earthquake and various loading conditions other than fully loaded and involving the overhanging rows, conditions which the Staff apparently has not evaluated." SD Order at 21, 24.

2. To determine whether administrative controls on loading should be imposed by means of either a license condition or a technical specification requirement for Turkey Point, the Board has applied the guidance of the Appeal Board in Portland General Electric Co. (Trojan Nuclear Plant), ALAB-531, 9 NRC 263 (1979). There the Appeal Board stated:

> [T]here is neither a statutory nor regulatory requirement that every operational detail set forth in an applicant's safety analysis report (or the equivalent) be subject to a technical specification, to be included in the license as an absolute condition of operation which is legally binding upon the licensee when and until changed with specific Commission approval. Rather,...the contemplation of both the Act and the regulations is that technical specifications are to be reserved for those matters as to which the imposition of rigid conditions or limitations upon reactor operation is deemed necessary to obviate the possibility of an abnormal situation or event giving rise to an immediate threat to the public health and safety.

9 NRC at 273 (footnote omitted).[11]

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[11] See 10 C.F.R. § 50.36; Sacramento Municipal Utility District (Footnote Continued)

Consequently, we will determine whether the administrative controls are necessary to prevent an abnormal situation or event which poses an immediate threat to the public health and safety.

3. The Licensee's direct case consisted of the testimony of a panel of three witnesses: Edmund E. DeMario, an advisory engineer in the Commercial Nuclear Fuel Division of Westinghouse Electric Corporation (Westinghouse); Harry E. Flanders, Jr., a Principal Engineer for the Advanced Engineering Analysis Section of Westinghouse's Nuclear Components Division; and Russell Gouldy, a Senior Engineer in Licensee's Nuclear Licensing Department (ff. Tr. 103).

Description of the Spent Fuel Pool

4. The Turkey Point spent fuel pools have two storage regions, Region 1 and Region 2. The Region 1 storage racks consist of three major sections, which are the leveling pad assembly, the upper and lower grid assemblies, and individual storage cells made of stainless steel. The cells within a rack are interconnected by grid assemblies to form an integral structure. Each rack is provided with leveling pads connected to the lower grid assembly which contact the floor of the spent fuel pool and are remotely adjustable from above to level the racks during installation. The racks are free-standing and are not anchored to the

(Footnote Continued)
(Rancho Seco Nuclear Generating Station), ALAB-746, 18 NRC 749, 754 n.4 (1983); Commonwealth Edison Co. (Zion Station, Units 1 and 2), ALAB-616, 12 NRC 419, 422 (1980); Virginia Electric Power Co. (North Anna Nuclear Power Station, Units 1 and 2), ALAB-578, 11 NRC 189, 217 (1980).

floor or braced to the pool walls. Support pads for the new racks sit on the existing floor embedment plates which are located at various places along the bottom of the pool liner. Due to the location of the floor embedment plates, some of the support pads for some of the new racks in Region 1 cannot be situated at the corners of the racks. Therefore, some of the outer storage locations on these racks overhang (extend beyond) the support pad. Flanders, ff. Tr. 103, at 3-4; Kim, ff. Tr. 129, at 3-4.

5. The Region 2 storage racks consist of two major sections, which are the leveling pad base assembly and stainless steel cells. The cells are assembled in a checkerboard pattern, producing a honeycomb-type of structure. The cells are welded to a base support assembly and to one another to form an integral structure, without the use of grids of the type used for the Region 1 racks. The Region 2 storage racks, like the Region 1 racks, are provided with leveling pads connected to the base support assembly, which contact the pool floor/embedment plates, and which are remotely adjustable from above to level the rack during installation. The racks are free-standing and are not anchored to the floor or braced to the pool walls. Some of the storage locations in some of the Region 2 racks also overhang their support pads. Id., at 4.

Analyses

6. In support of its amendment application, the Licensee provided the NRC with the results of an analysis which showed that lift-off or

tilt of the storage racks would not occur during a seismic event. This analysis assumed that the Licensee would establish administrative controls to prohibit the loading of overhanging rows of a rack while the remaining rows of the rack were empty. The NRC issued the Turkey Point spent fuel pool expansion amendments in November 1984 on the basis that, with these administrative controls in place, rack lift-off would not occur. This procedure is currently in use at Turkey Point. It requires the preparation and use of a fuel handling data sheet which designates a specific location within a spent fuel rack for each spent fuel assembly identified by number. The fuel handling data sheets are prepared with the aid of fuel status boards which contain diagrams of the reactor and the spent fuel pool that show the locations of currently-stored fuel assemblies and the locations where fuel assemblies may be placed. By assigning a specific location for each assembly, the fuel handling data sheet controls the loading of the racks and prevents the loading of assemblies into overhanging locations until after fuel assemblies are placed into the other storage locations. Prior to their use, the fuel handling data sheets are subject to review and approval by the Plant Nuclear Safety Committee. These types of administrative controls are common in the nuclear industry and have been used successfully for loading assemblies in spent fuel racks as well as loading fuel assemblies into the reactor. Gouldy, ff. Tr. 103, at 4-6.

7. The Licensee's fuel rack seismic analysis was performed for two cases. Case 1 assumed that administrative controls are in place to prevent loading of fuel assemblies into the overhanging locations until

after assemblies are loaded into the other storage locations. Case 2 is an analysis performed by Westinghouse at the request of Licensee, after NRC approval of the license amendments, to determine the potential effect of loading fuel assemblies into overhanging locations while the remainder of the fuel rack is empty. Flanders, ff. Tr. 1(3, at 14.

8. Standard Review Plan (SRP) Section 9.1.2 states that the storage racks should be designed to Seismic Category I requirements (i.e., able to withstand the effects of a Safe Shutdown Earthquake (SSE) and remain functional). Section III of the "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications" (NRC Position Paper) identifies criteria for performing criticality analyses for spent fuel pools under accident conditions, and it states that the presence of soluble boron in the pool water may be taken into account when analyzing the effects of earthquakes. Section IV of the NRC Position Paper identifies criteria for performing evaluations of the mechanical and structural integrity of spent fuel racks. These criteria state that compliance with the American Society of Mechanical Engineers (ASME) Code provides an acceptable basis for deriving allowable stresses in spent fuel racks. The design of the storage racks is considered to be acceptable if the amplitudes of sliding motion are minimal, if impact between storage racks and the pool walls is prevented, and if the factors of safety against tilting of the racks are within specified values. These criteria are widely used in the nuclear industry for performing seismic analyses of spent fuel racks, and they are recognized as being conservative. Id., at 4-7.

The racks were designed in accordance with Seismic Category I requirements. The structural analysis of the storage racks was based upon the allowable stresses of the ASME Code, and the remainder of the mechanical and structural analysis of the racks was performed in accordance with Section IV of the NRC Position Paper. Id., at 7-8.

The Licensee's seismic analysis of the spent fuel stora racks used the following conservative assumptions:

a. The maximum seismic acceleration used in the analyses was the design basis Safe Shutdown Earthquake (SSE) acceleration for the Turkey Point Plant specified in the Updated Final Safety Analysis Report (FSAR) for Turkey Point.

b. The structural damping of the seismic acceleration provided by the storage racks was consistent with the value provided in the updated FSAR for welded steel frame structures, and damping provided by the spent fuel pool water was conservatively neglected.

c. A range of coefficients of friction between the racks and the pool floor embedments were used which bounded the maximum possible rack horizontal displacement (sliding) and the maximum rack horizontal overturning force (tilting).

d. The storage racks were assumed to be hydrodynamically coupled, thereby producing maximum deflections, loads, and stresses for sliding or tilting.

e. No loads on the racks were assumed as a result of sloshing of the pool water during a seismic event, because such sloshing would occur in the upper elevations of the pool above the top of the racks. Id., at 8-11.

9. The Licensee's seismic analysis was performed in two phases. The first phase used a two-dimensional nonlinear model of an individual rack cell. The results of the first phase provided input to the second phase of the analysis, which used a three-dimensional linear model for the purpose of calculating loads and stresses in the storage racks. Use of these two models enabled the Licensee to account for both the nonlinear and three-dimensional responses of the storage racks. In particular, the model used in the first phase directly accounted for nonlinearities and provided input for correcting the loads calculated by the linear model used in the second phase. Similarly, the model used in the second phase provided three-dimensional response data for loads and stresses. Use of a two-dimensional model in phase one to calculate displacements was appropriate because each fuel assembly and storage cell is structurally symmetric about either the x or y horizontal axis. Id., at 11-12.

10. This methodology was applied for both Case 1 and Case 2. The results of the analysis for Case 1, which considered full fuel loading (i.e., fuel assemblies in all storage locations) and various partial loading conditions were as follows:

a. The fuel rack support points did not lift off or lose contact with the floor of the spent fuel pool when subjected to the specific seismic ground accelerations. The factor of safety against overturning was much greater than the 1.5 value specified by Section 3.8.5.II.5 of the Standard Review Plan.

b. The maximum relative displacement of a fuel rack was calculated to be 0.256 inches. The relative displacement accounts for sliding, structural, and thermal movement of two adjacent racks toward each other. The gap between adjacent fuel racks is 1.11 inches, and the gap between a fuel rack and the spent fuel pool walls is even larger. Thus, impact between adjacent rack modules or between a rack module and the pool wall is prevented and the leveling screws will not slide off the embedment plates.

c. The fuel rack stresses are within ASME Code allowable limits, i.e., the minimum ratio of allowable stress divided by applied stress is greater than one. The minimum ratios of allowable stress divided by applied stress for the leveling pads, grid assemblies, and cell assemblies, are 1.27, 1.15, and 1.11, respectively. It should be noted that allowable stresses do not represent the point of material failure, but are values which include conservatisms inherent in the ASME Code.

The results of the Case 1 analysis conform with the acceptance criteria in the NRC Position Paper and demonstrate that the spent fuel storage racks will be maintained in a safe configuration during postulated seismic events. Id., at 15-16.

11. In Case 2, the Licensee analyzed the potential effects of loading fuel assemblies into overhanging locations. The models were

adjusted to account for the mass of the fuel in the overhanging rows, and the analysis was conducted for various partial fuel loading conditions with the appropriate seismic ground acceleration inputs. The results of the Case 2 analysis were as follows:

a. The rack module was predicted to rock and result in lift off of one side of the rack from the support point. The maximum lift off of 0.18 inches was produced by loading the three outboard rows on the side of the rack with the most overhanging storage locations. Lift off of support points is not uncommon for free-standing racks under seismic conditions and the structural members of the racks are designed to accommodate the stresses produced by lift off. The lift off distance was used in an overturn stability calculation, and it was shown that the rack is stable and will not overturn and that the minimum factor of safety against overturn is 8 (which is substantially greater than the 1.5 factor of safety against overturning recommended by Section 3.8.5.II.5 of the SRP).

b. The maximum relative displacement of a fuel rack is 0.709 inches. Relative displacement accounts for sliding, rocking, structural, and thermal movements of two adjacent racks toward each other. This is less than the gap between adjacent fuel racks and between the fuel racks and the spent fuel pool walls. Thus, impact between adjacent rack modules or between a rack module and the pool wall is prevented and the leveling screws will not slide off the embedment plates.

c. Structural loads and stresses are enveloped by the condition of a fully loaded rack. Thus, the maximum stresses produced by the partially loaded racks in Case 2 are less than the maximum stresses calculated in Case 1. Therefore, the applied stresses in Case 2 are also within the ASME Code allowable stresses. Id., at 16-17.

12. The results of the Case 2 analysis conform with the acceptance criteria in the NRC Position Paper and demonstrate that the spent fuel storage racks will be maintained in a safe configuration during postulated seismic events. The Case 2 analysis demonstrates this to be true without administrative controls to assure that spent fuel is not loaded into overhanging portions of the racks until other portions of the racks have been filled. Id., at 16-18.

13. The NRC Staff's direct case consisted of testimony by Sang Bo Kim, a structural engineer, and Daniel G. McDonald, Jr., the project manager for Turkey Point, ff. Tr. 129.

NRC Staff Review

14. The structural design of spent fuel pool racks as well as the spent fuel pool must satisfy General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena." GDC 2 provides that fuel storage be designed to withstand the effects of earthquakes without loss of capability to perform its safety function. In addition, the spent fuel pool and pool storage racks must be designed to assure adequate safety under normal and postulated accident conditions (GDC 61, "Fuel Storage and Handling and Radioactivity Control"). Geometrically safe

configurations of the fuel storage system should be used in order to prevent fuel criticality (GDC 62, "Prevention of Criticality in Fuel Storage and Handling"). Kim, ff. Tr. 129, at 4.

15. The NRC review scope and acceptance criteria are described in the "OT Position For Review and Acceptance of Spent Fuel Storage and Handling Applications," dated April 14, 1978, and later amended on January 18, 1979 (Operating Technology Position or OT Position). The OT Position specifies acceptable load combinations of weight, temperature and earthquake. Dead and live loads are considered for normal service conditions. Thermal and earthquake loads are added for accident conditions. Allowable stress levels increase with the severity of the service level. This is generally the industry practice. ASME Code, Section III. In addition, the OT Position specifies an allowable safety factor for overturning by referencing Section 3.8.5.11.5 of the Standard Review Plan (SRP), NUREG-0800. A range of the safety factors between 1.1 to 1.5 are specified depending on load combinations. The OT Position also states that total displacement, including thermal expansion due to temperature as well as movement of the rack due to earthquake (sliding and tilting), should be considered using a detailed non-linear dynamic analysis which demonstrates that displacement is minimal. Kim, ff. Tr. 129, at 5, 10-11; Flanders, ff. Tr. 103, at 4-6.

16. This Staff criteria allows lift-off or tilting of the racks provided that, as stated in the criteria, (a) the factors of safety against tilting (or overturning) are within the value permitted by Section 3.8.4.11.5 of the SRP and (b) it can be shown that any sliding

and tilting motion will be contained within suitable geometric constraints such as thermal clearances and that any impact due to clearance is incorporated. Thermal clearances are calculations of the space between the racks after expansion of the racks due to the heat transferred from the spent fuel assemblies. Kim, ff. Tr. 129, at 11; Flanders, ff. Tr. 103, at 4-6.

17. The Staff's evaluation of Licensee's rack design was performed with the assistance of Franklin Research Center (FRC), the Staff's technical consultant, and published in a safety evaluation supporting the amendments. The NRC Staff performed a review of Licensee's Case 1 analysis. The review consisted of an evaluation of the Licensee's description of the structural configuration of the spent fuel racks as well as the spent fuel storage pool, load combinations, calculations including rack response to an earthquake, resultant stresses in the rack, and comparison of final stresses with allowable stress limits prescribed in the OT Position. The Staff concluded in Section 2.3.6 of its Safety Evaluation that the design of the racks satisfied the structural aspects of the Appendix A requirements of 10 C.F.R. Part 50 (GDC 2, 4, 61 and 62) because: (a) the Licensee considered all the required loading conditions including earthquakes and accidents; (b) the analysis methods that calculate stresses and earthquake response were in accordance with industry practice and were acceptable as detailed in FRC's Technical Evaluation Report which is appended to the Staff's Safety Evaluation; and (c) the resultant stresses and overturning safety

factors satisfied the allowable limits specified in the Staff OT position. Kim, ff. Tr. 129, at 4-6; Staff Exhibit 1, § 2.3.6.

18. Subsequent to the Staff's November 21, 1984 Safety Evaluation, Licensee, by letter dated February 1, 1985, presented an additional rack earthquake response analysis concerning the loading of the overhanging outer rows. This additional analysis was done as a result of being informed by Westinghouse Electric Corporation, the rack vendor, (a) that lifting of a rack could occur during a seismic event if the outer rows are fully loaded while the rest of the rack is empty and (b) that administrative controls on fuel loading would be needed for those spent fuel racks whose outer rows overhang the support pads. Licensee stated that the analysis results demonstrated that the design of racks with fuel overhang continued to satisfy the OT Position in that there are adequate safety margins against overturning and stresses in the racks and pool. In addition, Licensee stated it would provide administrative controls on fuel placement in order to preclude the possibility of rack lift-off. Kim, ff. Tr. 129, at 6.

19. By letter dated February 26, 1985 (McDonald, ff. Tr. 129, at Attachment 3), the Staff responded to Licensee's February 1, 1985 request for NRC review of an analysis which showed that the results of lift-off would be acceptable. Licensee's request for review of the analysis represented a change in the NRC basis for issuing the amendments which authorized the pool expansions. The Staff stated that Licensee could make changes without prior NRC approval provided it performed a review pursuant to 10 C.F.R. § 50.59, "Changes, Tests, and

Experiments," and determined that neither a technical specification change nor an unreviewed safety question is involved. The Licensee withdrew its February 1, 1985 request in a letter dated November 13, 1985. Gouldy, ff. Tr. 103, at 4-5.

20. In addition to stating that Licensee could institute a change in the use of administrative controls pursuant to a 10 C.F.R. § 50.59 analysis, the Staff stated that the conclusions in its Safety Evaluation and supporting Technical Evaluation Report (TER) remained valid because administrative controls were initiated prior to any fuel being loaded in the SFP racks with overhanging rows and thus, precluded the possibility of any rack lift-off. McDonald, ff. Tr. 129, at 7-8 and Attachment 3.

21. Section 6. of the Turkey Point Technical Specifications, "Administrative Controls," generally require the use of procedures and administrative controls to assure that all safety-related structures, systems and components remain within their design basis and can perform their safety function. Section 6.8.1, "Procedures," requires that written procedures and administrative policies be established, implemented and maintained that meet or exceed the guidance of the American National Standards Institute (ANSI) N18.7-1972 as endorsed by Regulatory Guide 1.33, "Quality/Assurance Program Requirements (Operation)." Under ANSI N18.7-1972, Section 5.3.4.5, "Fuel Handling Procedures," fuel handling operations, which would include the movement of fuel in or about the spent fuel pools, must be performed in accordance with written procedures. Furthermore, Section 6.8.3 of the Technical Specifications governs the modification of procedures and

permits changes if: (1) the intent of the procedure is not altered; (2) the change is approved by two members of the plant management staff, at least one of whom holds a Senior Operator's License; and (3) the change is documented, reviewed by the Plant Nuclear Safety Committee and approved by the Plant Manager. Id., at 9-10.

22. The fuel movement procedure for Turkey Point has been revised to include a restriction which prevents loading of racks with overhanging rows while the remainder of a rack is empty. This procedure is currently being used at Turkey Point as described in ¶ 7.

23. Licensee's seismic analysis of the spent fuel storage rack was performed for two cases. See ¶¶ 7-12. Case 1, discussed earlier, is predicated on the use of administrative controls to prevent loading of overhanging rows while the remaining rows of the racks are empty. That analysis considered full fuel loading and various partial loading conditions. In Case 2, the fuel assemblies are loaded in the overhanging locations before the remaining locations are loaded. The results of Licensee's analysis of Case 2 are consistent with NRC Staff's OT Position. The methodology used to calculate overturning and stresses is the same as that reviewed by FRC and the Staff in connection with the issuance of the rerack amendments. The calculational methodology included a general purpose computer code which performs rack response analysis for the duration of an earthquake. The results of the analysis of the loading of overhanging rows in the absence of administrative controls satisfy the OT Position. Licensee's calculations and tabulated results show that the total displacements can be easily accommodated by

the gaps provided between the racks and between the rack and the pool wall. The results also show that the stresses in the rack and the pool are within the limits specified in the OT Position. Kim, ff. Tr. 129, at 11-12; Flanders, ff. Tr. 103, at 14-18.

24. Specifically, Licensee's calculated factor of safety of 8 against overturning is greater than the SRP minimum value of 1.1. Thus, the criteria is satisfied and the results indicate that overturning of a rack is unlikely during an earthquake. Licensee calculates a 0.72-inch total combined displacement between racks attributable to seismic motion and thermal growth. The space between the racks prior to insertion of spent fuel assembly and thermal expansion is designed to be not less than 1.10 inches. Kim, ff. Tr. 129, at 12-13; Flanders, ff. Tr. 103, at 16-18.

25. Consequently, the Staff concluded that administrative controls on fuel loading are no longer necessary for the Turkey Point spent fuel pools. Kim. ff. Tr. 129, at 13.

26. Intervenors did not put on a direct case or offer evidence at the hearing. Intervenors did not cross-examine the Licensee's panel of witnesses. Tr. 104. Referring to the bases for Contention 5, Intervenors point to a February 1, 1985 letter from Williams, Licensee, to Varga, NRC, which describes the potential for rack lift-off under seismic event conditions that raises an unreviewed safety question. Intervenors cite the NRC Staff conclusion in Section 2.3.6 of the November 21, 1984 Safety Evaluation that the fuel storage racks satisfied the structural aspects of the Appendix A requirements of 10

C.F.R. part 50 (GDC 2, 4, 61 and 62). Kim and McDonald, at 5, Tr. 126. Intervenors summarize a series of correspondence between the Licensee and Staff regarding the analyses and reviews concerning the loading of the overhanging outer rows with fuel rods. This ends by citing the NRC Staff testimony that it had completed the reviews, including the Case 2 analysis, and determined that administrative controls were no longer necessary. Kim, Tr. 144.

27. Based on the evidence presented, the Board concludes that Licensee's seismic analysis for the new Turkey Point spent fuel pool racks, and the results of those analyses, comply with applicable NRC criteria. The record shows that the Staff adequately reviewed Licensee's Case 2 analysis against the pertinent acceptance criteria and acted in accordance with the regulations by permitting Licensee to perform a 10 C.F.R. § 50.59 analysis. There is no evidence or record that Licensee has abused this provision. Intervenors did not put on a direct case with evidence. The Licensee's lift-off analysis shows that the fuel rack stresses would be within ASME code limits, the safety factors for overturning are sufficiently larger than the Staff acceptance criteria, and the total displacement due to seismic motion and thermal growth is less than the cold gap between the fuel racks. Thus, the rack design satisfies the structural aspects of GDC 2, 4, 61, and 62; and there is reasonable assurance of safe storage of the fuel in the event of an earthquake. We find that the sworn testimony regarding the Licensee's analysis and NRC Staff's review supports the conclusion that loading controls are no longer necessary.

B. CONTENTION 6

28. Contention 6 states:

> The Licensee and Staff have not adequately considered or analyzed materials deterioration or failure in materials integrity resulting from the increased generation and heat and radioactivity, as a result of increased capacity and long term storage, in the spent fuel pool.[12]
>
> The bases for the contention are:
>
> The spent fuel facility at Turkey Point was originally designed to store a lesser amount of fuel for a short period of time. Some of the problems that have not been analyzed properly are:
>
> (a) deterioration of fuel cladding as a result of increased exposure and decay heat and radiation levels during extended periods of pool storage.
>
> (b) loss of materials integrity of storage rack and pool liner as a result of exposure to higher levels of radiation over longer periods.
>
> (c) deterioration of concrete pool structure as a result of exposure to increased heat over extended periods of time.

29. In a March 25, 1987 Order, the Board denied summary disposition of Contention 6 and raised an issue as to "the modes and effectiveness of surveillance of materials and the monitoring of the fuel storage pool and contents to provide a measured basis for safety during the extended period of use." SD Order, at 33. The question derived from Intervenors arguments concerning publications by A. B.

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12 In admitting this contention, the phrase "long term storage" was limited to the storage period authorized by the amendments. LBP-85-36, 22 NRC 590, 598 (1985).

Johnson entitled "Behavior of Spent Nuclear Fuel in Water Storage" (BNWL 2256, September 1977) and "Spent Fuel Storage Experience" (Nuclear Technology, Volume 43, mid-April, 1979). While Johnson stated that the technology for handling spent fuel has developed over 35 years and has largely been satisfactory, Johnson concluded that expected spent fuel storage of 20-to-100 years would be an incentive to determine whether any slow degradation mechanisms are operative. The Board also acknowledged the Intervenor's observation that spent fuel presently stored at Turkey Point did not exceed 39,000 MWD/MTU but that under the amendments the plant could operate until burnup of 55,000 MWD/MTU. SD Order, at 32, 33.

30. A few months after the Board issued the summary disposition order, the Staff issued new information concerning Boraflex, a neutron absorber material used in the Turkey Point spent fuel pools. BN-87-11, "Board Notification regarding Anomalies in Boraflex Neutron Absorbing Material," dated July 15, 1987.[13] Boraflex is a relatively new material and will be discussed separately after the other spent fuel pool materials.

31. The Licensee's direct case on Contention 6 consisted of two witness panels: (1) William C. Hopkins and Eugene W. Thomas from

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13 The Staff stated that it would evaluate whether its response favoring summary disposition of Contention 10 was affected by the new information. BN-87-11, at 2. Staff counsel stated that Staff's position on summary disposition of Contention 10 was not changed by the new information. Young, Tr. 276-77.

Bechtel Eastern Power Company (Bechtel), and (2) Russell Gouldy from Licensee and William A. Boyd and Dr. Gerald R. Kilp from Westinghouse. Mr. Hopkins addressed the impacts of radiation on the spent-fuel pool liner and concrete structure. Mr. Thomas addressed the impacts of heat on the spent fuel pool liner and concrete structure. Mr. Boyd addressed the impacts on K-effective of postulated gaps in the Boraflex poison material in the spent fuel racks. Hopkins, Thomas and Boyd, ff. Tr. 222, at 9-14. Mr. Gouldy addressed the potential for degradation of Boraflex and Licensee's surveillance program for Boraflex. Dr. Kilp addressed the integrity of the materials in the fuel assemblies and storage racks. Kilp and Gouldy, ff. Tr. 222, at 45-49.

32. The Staff's witness on the first portion of Contention 6, materials other than Boraflex, was Clifford David Sellers, a Senior Metallurgist at NRC. Sellers, ff. Tr. 188. The Staff panel on Boraflex consisted of Dr. James Wing, Conrad E. McCracken and Dr. Laurence I. Kopp. Wing, McCracken and Kopp, ff. Tr. 339, Professional Qualifications. Dr. Wing and Mr. McCracken testified on materials integrity of Boraflex. Dr. Kopp testified on the criticality aspects of Boraflex.

33. Ms. Lorion for Intervenors, presented no direct case or evidence.

Materials Other Than Boraflex

34. The new spent fuel storage racks are constructed of Type 304 stainless steel as the load carrying structure and use sheets of

Boraflex as a neutron absorbing material held in place by a thin-walled stainless steel wrapper on the outer surface of the storage cells and between the cells. Type 304 stainless steel is used in the pool liner. The rack feet consist of 17-4 PH stainless steel. The pool structure is concrete composed of cement and aggregate with reinforcing bars of carbon steel. The fuel assemblies are constructed of Zircaloy fuel cladding, Inconel 718 springs, and stainless steel nozzles and bands. Sellers, ff. Tr. 188, at 3; Kilp and Gouldy, ff. Tr. 222, at 4.

35. Redesign of the spent fuel pool racks increases only the storage capacity of the pool and not the frequency or the amount of newly discharged fuel to be placed in the pool during each fuel reload cycle. The rerack design does not change the radioactivity of the newly discharged fuel placed in the storage pool. Sellers, ff. Tr. 188, at 3.

36. There will be a small increase in radiation exposure and radiation heating to spent fuel pool mat--ials as a result of the expanded storage capacity. As the old fuel elements continue to age, they contribute less and less to the heat load of the pool. The maximum pool temperature after refueling is not expected to rise above 143°F and will decrease thereafter. This is within NRC guidelines for maximum exposure temperature to concrete. Sellers, ff. Tr. 188, at 10, 11; Kilp and Gouldy, ff. Tr. 222, at 4-5.

37. Licensee performed two sets of calculations to determine the cumulative gamma and neutron exposures of materials stored for over 40 years in the Turkey Point spent fuel pools. One set assumed each fuel assembly has an average burnup level of 36,000 MWd/MTU. The second set

assumed a future average burn-up of 55,000 MWd/MTU. The results for 36,000 and 55,000 MWd/MTU showe. that pool materials would receive cumulative gamma radiation doses of 1.9×10^{10} rads and 2.9×10^{10} rads, respectively. The cumulative neutron radiation dose of the two burn-up levels was 4.8×10^{13} neutrons/cm^2 and 1.7×10^{14} neutrons/cm^2, respectively. Kilp and Gouldy, ff. Tr. 222, at 5-10.

38. Licensee analyzed the effect of thermal stresses on the pool structure resulting from the temperature differential between the pool water and outside conditions. Pool water temperatures up to 212°F were considered. Licensee assumed ambient temperature as low as 30°F outside the pool. The analysis showed that the pool structure would maintain its integrity even under severe thermal stress conditions of postulated boiling combined with the effects of the design basis earthquake. Thomas, ff. Tr. 163, at 4-7.

39. The Staff and its consultant, Franklin Research Center (FRC), reviewed Licensee's analysis of temperature-induced stresses on the pool structure and liner and concluded that the stresses were acceptable. Staff Exhibit 1 (Safety Evaluation at 10, 15; Technical Evaluation Report at 25-26).

40. The temperatures associated with radiation due to the increased fuel storage capacity will not result in significant deterioration of the concrete pool structures or steel liner. Temperatures below 300°F have little effect on the concrete and reinforcing steel. The pool liner plate made of Type 304 stainless steel, maintains its stability and integrity in temperatures in excess

of 1000°F, which is far above pool temperatures. Sellers, ff. Tr. 188, at 10; Thomas, ff. Tr. 163, at 8-10.

41. Tests show that stress corrosion cracking of sensitized steels adjacent to welds in the fuel pool liner would be highly localized and would not lead to gross degradation of the liner. Chloride caused stress corrosion cracking is prevented in the stainless steels at Turkey Point by the controls on chloride levels in the fuel pools. Sellers, ff. Tr. 188, at 6-7.

42. The expanded storage capacity will not result in deterioration of the spent fuel concrete structure and steel liner due to radiation. The radiation is attenuated by distance and the water. Such attenuated exposure would be well below the threshold for radiation damage to the carbon steel in the pool structure and the stainless steel, which is the order of 10^{17} to 10^{18} neutrons/cm^2. Concrete is used throughout a nuclear power plant for its structural support and radiation shielding characteristics. Gamma radiation has a negligible effect on the mechanical properties of concrete. A concrete structure can withstand neutron fluences up to 10^{21} neutrons/cm^2 without loss of material integrity. This is many orders of magnitude higher than the fluence expected in the Turkey Point spent fuel pool. Reports on the irradiation of concrete have not identified any defects in concrete which can be traced directly to radiation damage. Sellers, ff. Tr. 188, at 5, 10, 14-15; Hopkins, ff. Tr. 163, at 5-7.

43. There will be no loss of integrity of the pool liner due to gamma radiation. Tests have shown that stainless steel can withstand

neutron radiation levels which are orders of magnitude higher than those predicted in the Turkey Point spent fuel pools without loss of integrity. The effect of nuclear heating on stainless steel is negligible at the levels of radiation in the spent fuel pool. Hopkins, ff. Tr. 163, at 3-5, 7; Sellers, ff. Tr. 188, at 5.

44. Zircaloy, Inconel and stainless steel are used for fuel assemblies. These materials are essentially unaffected by the alpha, beta and gamma radiation which comprise the major fraction of the radiation in the spent fuel pool. The primary effect of gamma radiation at the levels expected at Turkey Point on these materials is heating and not structural damage. Kilp and Gouldy, ff. Tr. 222, at 5, 11-12.

45. The racks containing the first discharged fuel assemblies can be expected to receive the maximum radiation in the pool. The assemblies are exposed to approximately 10^{22} neutrons/cm^2 while in the reactor. This is approximately 8 orders of magnitude greater than the 1.7×10^{14} neutrons/cm^2 exposures during 40 year storage of fuel with burn-up of 55,000 MWd/MTU. Stated another way, a 40-year storage dose is similar to one second in the operating reactor. Sellers, ff. Tr. 188, at 5; Kilp and Gouldy, ff. Tr. 222, at 10-12, 15-16; Sellers, Tr. 211-12.

46. Little or no microstructural changes would occur in the spent fuel pool materials which is attributable to the extended storage. The NRC Staff does not anticipate a significant increase in the corrosion occurring in the pool because the rates of most corrosion reactions tend to decrease with time as protective oxide films form on the metals.

Microstructural change can occur with Zircaloy-clad fuel when the hydrogen produced by the reaction between zirconium and water diffuses into metal, forming hydride particles or a hydride phase within the Zircaloy cladding. Microstructural changes from solid state diffusion processes do not occur below 500°F in stainless steels. Sellers, ff. Tr. 188, at 5-6; Kilp and Gouldy, ff. Tr. 222, at 12-14.

47. Stress corrosion cracking and intergranular corrosion can occur in the storage racks steels adjacent to welds but it would be highly localized and would not lead to gross degradation of the steel. Test reactors use Type 17-4 PH stainless steel in control rod drive mechanisms. Inservice surveillance has shown no degradation at all of this material after many years of service in water of similar quality to that in the Turkey Point pools, and a temperature of 145°F. In addition, chloride caused stress corrosion cracking and intergranular stress corrosion is prevented in the stainless steel at Turkey Point by controls on chloride levels in the fuel pools. Sellers, ff. Tr. 188, at 6-7; Tr. 193-94; Kilp and Gouldy, ff. Tr. 222, at 12-14.

48. Radioactive crud enters the pool with the freshly discharged fuel. It is subsequently removed by the pool water purification system well before the next refueling. There is no evidence that such crud deposits influence the corrosion of stainless steel or degrade the fuel itself. Sellers, ff. Tr. 188, at 7-8.

49. Leakage and disintegration of spent fuel and its cladding while in pool storage is highly unlikely. In the Battelle Pacific Northwest Laboratories Report BNWL-2256, Dr. Johnson surveyed the

information on behavior of spent fuel in pool storage and found no evidence of degradation of spent nuclear fuel during pool storage after times up to 18 years for Zircaloy-clad fuel and 12 years for stainless steel-clad fuel (as of 1977). The results of surveys for the Nuclear Regulatory Commission, performed by Dr. J. R. Weeks of Brookhaven National Labs, since issuance of Dr. Johnson's report show that stainless steel-clad fuel has been continuously stored in spent fuel pools since the early 1970's with no evidence of any failures developing in fuel cladding. Sellers, ff. Tr. 188, at 8.

50. While leaking fuel has been stored in a number of fuel pools, uranium oxide fuel pellets have displayed excellent corrosion resistance. Should a defect develop in a fuel cladding in the reactor, the volatile and soluble fission products, normally the alkalis and the halogens, would be released to the reactor coolant and removed by the reactor coolant purification system. Some small amounts of these materials may enter the pool from fuel that developed defects in the reactor, during the first few months after the fuel enters the pool. These (except for the inert gases) would readily be removed by the spent fuel pool water purification system. Fuel elements are tested for their leak tightness before being placed in the pool so that the plant staff can determine which fuel elements to be placed in the pool have defects. Sellers, ff. Tr. 188, at 9.

51. The proposed long-term storage does not affect the probability that degradation of the fuel will occur in the pool or that significant amounts of fission products would be released to the pool. In the

unlikely event that a defect should develop in the fuel cladding during the first few months of pool storage, gaseous and alkali radioactive fission products could be released to the pool and the pool environment. The spent fuel pool radioactivity monitors and the cleanup system monitors would detect such a release. Should a leak develop in a fuel cladding several months after it has been placed in the pool (an unlikely occurrence) and after most of the gaseous fission product activity has decayed, the consequences would be less and would differ little from those associated with stored fuel elements containing known defects. Sellers, ff. Tr. 188, at 9-10.

52. The 40 years of industry experience with wet fuel storage illustrates that it is a fully-developed technology with no associated major technological problems. Fuel elements have been stored continuously for as many as 25 years without evidence that Zircaloy-clad fuel or stainless steel structural elements degrade significantly during wet storage. Sellers, ff. Tr. 188, at 4; Tr. 195; Kilp and Gouldy, ff. Tr. 222, at 14-17.

53. Stainless steel clad spent fuel has been stored in PWR spent fuel pools more than 18 years. The exposure in the reactor, which is much greater than radiation levels in the storage pools, represents the maximum radiation exposure any stainless steel can accumulate in a spent fuel pool since the steel is directly against the fuel as the cladding material. Destructive and visual examination of this material produced no evidence of significant degradation of the stainless steel. Relating these observations to the materials of construction for the storage

racks, demonstrates that they would also not be subject to any significant degradation over long term use, far beyond the present storage time. Sellers, ff. Tr. 188, at 11; Kilp and Gouldy, ff. Tr. 222, at 14-17.

54. Zircaloy-clad rods were examined after nearly 21 years of water storage. A comparison of cladding properties with those measured 20 years earlier on rods from the same fuel assembly showed that no detectable changes had occurred in corrosion film thickness, cladding mechanical properties and fission gas thickness, cladding mechanical properties and fission gas release. Zircaloy-clad fuel elements which were loaded into Canada's NPD reactor in 1962 are continuing to operate satisfactorily, with no apparent degradation, after 22 years of exposure to far greater radiation than any element in the Turkey Point spent fuel pools will receive from being in the pools. Sellers, ff. Tr. 188, at 11-12; Kilp and Gouldy, ff. Tr. 222, at 14-17.

55. Surveillance, as used in the context of materials engineering, means the installation of specifically prepared test specimens which are nondestructively removable for testing after exposure to an environment which may degrade certain material properties. As such, no surveillance of spent fuel pool materials is planned. However, in the broader sense, spent fuel pool materials are subject to surveillance. There is monitoring of radioactivity in the spent fuel pool building atmosphere and the spent fuel pool cleanup system which is capable of determining the condition of stored spent fuel. The Licensee also periodically performs routine visual observations inside the fuel storage building

and subjects the fuel to inventory by underwater television. The condition of the liner is monitored by the installed leak chase system and procedures exist which require a daily check of the system to determine whether leakage has occurred. In addition, the Licensee maintains spent fuel pool area monitors to continuously monitor the pool areas and the plant's vent monitoring system to monitor total plant airborne radioactivity released (noble gas, iodine and particulates). Sellers, ff. Tr. 188, at 12-13; Kilp and Gouldy, ff. Tr. 222, at 17-19, 43; Gouldy, Tr. 301.

56. Intervenors argued at hearing and in their findings that Licensee and Staff witnesses base their conclusions regarding the ability of the pool materials to withstand radiation based upon assumptions and engineering judgment rather than field experience. They further assert that because predictors regarding extended storage are based on limited operational experience, an extensive materials surveillance program is needed to adequately protect the public health and safety. Tr. 93; Intervenors' Proposed Findings at ¶¶ 17-21. A similar argument was rejected by the Commission in the Waste Confidence Rulemaking proceeding. The Commission agreed that the basis for confidence that spent fuel will maintain its integrity during extended storage was based on an extrapolation for storage thirty-years beyond a facility's license from current experience. It found that "the extrapolation is made for conditions in which corrosion mechanisms are well understood" and "[the] extrapolation is reasonable and consistent with standard engineering practice." 20 NRC at 356-57. The Commission

has concluded that spent fuel can be safely stored in reactor spent fuel storage pool for at least 30 years beyond the expiration of a reactor's operating license. For example, the Commission found that the cladding which encases spent fuel is highly resistant to fuel failure under pool storage conditions and that corrosion would have a negligible effect during several decades of extended storage. Rulemaking On The Storage And Disposal of Nuclear Waste (Waste Confidence Rulemaking), CLI-84-15, 20 NRC 288, 353-57, 366 (1984).

57. The record in this proceeding shows that the mechanisms for spent fuel material degradation are sufficiently understood and the small increases in spent fuel pool radiation exposures and radiation heating will not significantly affect the integrity of spent fuel pool materials.

58. The evidence shows that the materials in the spent fuel pools will not degrade significantly because of the increased pool storage capacity over any term of years foreseeable for storage at individual plants. Stainless steel racks can be used to the end of life of the plant and experiments have shown that stainless steel, as well as the Inconel and Zircaloy in the aged fuel assemblies can be exposed to many orders of magnitude of radiation greater than can be reasonably expected in spent fuel pool racks without significant degradation. In addition, there is no evidence that degradation would occur due to the small increases in radiation or heat to storage pool liners or the concrete structure in spent fuel pools as a result of the increased storage. The Licensee and Staff have adequately considered and analyzed degradation

in materials integrity as a result of the increased capacity and the Board concludes that no additional monitoring or surveillance of materials is needed to provide reasonable assurance of safe storage during the extended storage authorized by the amendments.

59. The Board finds that the routine surveillance or monitoring currently performed by the Licensee is adequate to assure safety of the fuel storage pool and its contents during the extended storage period authorized by the amendments.

60. Based upon the evidence presented by the Staff and Licensee, the Licensing Board finds that the heat-induced stresses in the Turkey Point spent fuel pool concrete structures and stainless steel liners are acceptable, and that the temperature and radiation levels in the spent fuel pool will not result in any loss of integrity or degradation of the pool concrete or liner.

BORAFLEX

61. Boraflex is a neutron absorbing material or poison used in the spent fuel storage racks. It is made by uniformly dispersing fine particles of boron carbide in a homogenous, stable matrix of a methylated polysiloxane elastomer (a polymer). The boron dissolved in the spent fuel pool water, and the use of Boraflex or other poison material in the racks are each redundant and independent methods of preventing spent fuel pools from becoming critical. Kilp and Gouldy, ff. Tr. 222, at 23; Boyd, Tr. 330-32.

62. There are two regions in the Turkey Point spent fuel pools. The Region I racks are designed to hold fuel assemblies with a maximum

enrichment of 4.5%. The Region II racks are designed to hold fuel assemblies with a maximum reactivity equivalent to the reactivity of assemblies having an initial enrichment of 1.5%. The Region I spent fuel storage rack modules at Turkey Point are each composed of a number of cells with Boraflex panels which run along the length of each of the four sides of the cell. The Region II rack modules have a somewhat similar structure, but spacing between individual cells is smaller and the density of the Boraflex panels is lower than in the Region I racks. Boyd, ff. Tr. 222, at 4-5.

63. The regulatory requirements to prevent criticality is found in General Design Criterion (GDC) 62, "Prevention of Criticality in Fuel Storage and Handling." GDC 62 states that criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations. The NRC's acceptance criterion for assuring that GDC 62 is met is found in the Standard Review Plan (SRP), Section 9.1.2, which requires maintaining a storage array neutron multiplication factor (k_{eff}) less than or equal to 0.95 in spent fuel pools during normal and accident conditions. Kopp, ff. Tr. 339, at 3.

64. The Boraflex captures neutrons which would have otherwise been available for fission and therefore provides the required subcriticality margin. The total subcriticality margin with the Boraflex panels and the Technical Specification concentration of 1950 ppm boron in the spent fuel pool water, is approximately 25 percent (k_{eff} = 0.75). Kopp, ff. Tr. 339, at 3-4.

65. Boraflex has undergone extensive testing to determine the effects of gamma irradiation in various environments and to verify its structural integrity and suitability as a neutron absorbing material. The evaluation tests have shown that Boraflex was unaffected by the pool water environment and would not be degraded by corrosion. Tests were performed at the University of Michigan, exposing Boraflex up to 1.03 x 10^{11} rads of gamma radiation with substantial concurrent neutron flux in borated water. These tests showed that Boraflex maintained its neutron attenuation capabilities after being subjected to an environment of borated water and gamma irradiation. Irradiation caused some loss of flexibility, but did not lead to breakup of the Boraflex. Long-term borated water soak tests at high temperatures also showed that Boraflex withstands a borated water immersion at 240°F for 251 days without visible distortion or softening. The Boraflex showed no evidence of swelling or loss of ability to maintain a uniform distribution of boron carbide. Wing, ff. .r. 339, at 4-5; Staff Exhibit 1, § 2.2 at 7; Kilp and Gouldy, ff. Tr. 222, at 23-24.

66. At the Turkey Point Nuclear Plant, the spent fuel pool water temperatures under normal operating condit. s are not expected to exceed 143°F, which is well below the 240°F test temperature. In general, the rate of a chemical reaction, which could cause material deterioration, decreases exponentially with decreasing temperature. On the basis of these tests, the Staff did not anticipate any significant deterioration of the Boraflex at the pool under normal operating

conditions over the design life of the spent fuel racks. Wing, ff. Tr. 339, at 5.

67. Experience with Boraflex in spent fuel pools at some operating nuclear power plants has shown some materials deterioration or failure in integrity of Boraflex. The Staff issued Board Notification BN-87-11 subsequent to the Staff's review and acceptance of the Turkey Point spent fuel pool racks. It reported that some physical changes or gaps were identified in some spent fuel pools using Boraflex. The surveillance program for Boraflex used in the spent fuel pools at Point Beach Nuclear Plant, Units 1 and 2, showed that the 2-inch by 2-inch surveillance coupons, which had a maximum exposure of 1.6×10^{10} rads of gamma radiation, experienced some physical changes in color, size, hardness and brittleness. A full-length Boraflex assembly, which had a maximum exposure of about 10^{10} rads of gamma radiation, showed far less physical changes than the surveillance coupons. Neither the coupons nor the full-length Boraflex assembly showed any unexpected change in neutron attenuation properties. Inspections at Quad Cities Station, Units 1 and 2, revealed numerous gaps in some Boraflex panels which had been exposed to an estimated radiation dose of 10^9 rads. The Boraflex assemblies showed anomalies in the neutron attenuation profiles. One of the Boraflex surveillance coupons (8-inch by 12-inch) at the Prairie Island Nuclear Generating Plant, Units 1 and 2, showed some slight physical changes or degradations similar to the full-length Boraflex panels at the Point Beach Nuclear Plant. Wing, ff. Tr. 339, at 5-6; Kilp and Gouldy, ff. Tr. 222, at 25-26.

68. The exact mechanisms that caused the observed physical degradations of Boraflex have not been confirmed. The Staff postulated that gamma radiation from the spent fuel initially induced crosslinking of the polymer in Boraflex and produced shrinkage of the Boraflex material. When crosslinking became saturated, scissioning (a process in which bonds between atoms are broken) of the polymer predominated as the accumulated radiation dose increased. Scissioning produced porosity which allowed the spent fuel pool water to permeate the Boraflex material. Scissioning and water permeation could embrittle the Boraflex material. Gamma radiation from spent fuel is considered to be the most probable cause of the physical degradations, such as changes in color, size, hardness, and brittleness, that were found in the Boraflex material at the Point Beach plant. While the Staff could not pinpoint the cause of the gap formation in some Boraflex panels at the Quad Cities Station, the Staff thought it conceivable that full-length Boraflex panels which are physically restrained could experience shrinkage caused by gamma radiation which could lead to gap formation. Wing, ff. Tr. 339, at 7.

69. Licensee attributed the gap formation in Quad Cities' Boraflex to a rack design and fabrication process which did not allow the Boraflex material to shrink without cracking. Licensee testified that the fabrication process, which required the Boraflex material to be glued along the entire axial length and firmly clamped in place to the stainless steel fuel rack walls, did not allow for shrinkage of Boraflex, and therefore the gaps developed.

70. Commonwealth Edison Company (CECo) hypothesized that Boraflex shrinkage caused by irradiation resulted in sufficient tensile stress to lead to breakage when it was restrained as in the Quad Cities spent fuel rack. BN-87-11, enclosure letter dated May 5, 1987. Bisco Products, Inc., the manufacturer of Boraflex material, informed the Staff that the failure of the neutron absorber may be due to the material's properties or, in the case of the Quad Cities racks, some manufacturing deficiencies such as the tearing of the Boraflex panels during handling. Based on this information, the Staff inferred that gaps may have been formed at Quad Cities before the panels were exposed to any radiation. Wing, ff. Tr. 339, at 8-9, In the Turkey Point racks, Boraflex is held to the stainless steel wall by enclosing it in a wrapper. The wrapper is an enclosure which protects the Boraflex from the flow of water and maintains a clearance between the Boraflex and the rack cell wall which is large enough to allow shrinkage, but small enough to prevent dislocation of the panel should it become brittle or crack. Short lengths of adhesive were used to attach the panels to the wrapper for panels produced by an automated process to provide temporary support during the spot welding process. None of the Region I racks, and only some of the Region II racks, were fabricated using adhesive to attach the Boraflex panel to the wrapper or storage cell. Kilp and Gouldy, ff. Tr. 222, at 39-40, as corrected; Gouldy, Tr. 242-44.

71. Gamma radiation-induced crosslinking and scissioning of the polymer in Boraflex can take place in the spent fuel pool racks of the Turkey Point plant in the presence of spent fuels. Because water can

permeate into the Boraflex, especially at the edges of the panel, minor degradations, such as changes in color, size, hardness, and brittleness, can be expected. However, the Staff could not predict with certainty whether or not gap formation will occur. Testing at Point Beach and Turkey Point indicates there are no gaps at accumulated levels of irradiation higher than at Quad Cities and there is information which suggests that the Quad Cities gaps may be related to fabrication and design of the racks. Thus, it may be inferred that gap formation may result from a combination of shrinkage due to irradiation and fabrication or rack design deficiencies. In addition, the Staff was not certain whether physical restraints exist in the Boraflex panels at Turkey Point which are sufficient to cause gap formation. Because the Boraflex panels at the Turkey Point plant were constructed from single sheets, the Staff testified that it did not expect that there were gaps in all the Boraflex panels prior to exposure to radiation from spent fuels, unless the panels were damaged by some means. Wing, ff. Tr. 339, at 10, 12.

72. Similarly, Licensee testified that since the design and fabrication process used for Turkey Point is more similar to that used for Point Beach (rather than Quad Cities) and those panels were not restrained from shrinking and did not develop any gaps, it would not expect gaps of significant size or extent to develop at Turkey Point. Kilp and Gouldy, ff. Tr. 222, at 40.

73. The Staff is collecting operating experience about Boraflex from plants that use Boraflex, additional test data from the vendor, and

fabrication information from spent fuel rack contractors. The Staff will evaluate the information to arrive at the cause(s) of the observed gap formation. McCracken, ff. Tr. 339, at 10.

74. The Licensee tested 54 Boraflex panels from storage cells in both Region I and Region II of the spent fuel pool. They were representative of those storage locations which have received an estimated radiation dose of 7.8 x 10^9 rads, the highest cumulated exposure to date. The testing had the capability to detect gaps of 1" to 1½" or greater. No indication of gaps, voids, or other spatial distribution anomalies was observed. The results of this testing also verifies that no gaps existed in these 54 Boraflex panels prior to exposure to spent fuel. No physical restraints are expected to exist in these panels. Therefore, on the basis of these data and information, the Staff believes that gaps will not likely form in the Turkey Point Boraflex panels. Kilp and Gouldy, ff. Tr. 222, at 33, 39; Wing, ff. Tr. 339, at 11.

75. Substantial physical degradation can alter the neutron attenuation properties of Boraflex and decrease the margin of subcriticality of the fuel pool. Neutron attenuation of Boraflex is mainly due to boron mass number 10 that is present in the boron carbide powder in Boraflex. If the spatial distribution of boron-10 is not disturbed, the neutron attenuation properties of Boraflex should remain unchanged. Physical degradations, such as changes in color, size (shrinkage), hardness and brittleness, that do not disturb the spatial distribution of boron-10, should not alter the neutron attenuation

properties of Boraflex. Large gap formation in a Boraflex sheet could alter the neutron attenuation profile. Of the 203 Boraflex panels examined at Quad Cities, 31 gaps were found in 28 panels, and two three-to four-inch gaps were found among the 31 gaps. If the conditions which resulted in gap formation at Quad Cities are present at Turkey Point, the Staff concluded that Turkey Point will not likely have gaps greater than four inches in approximately one percent of its Boraflex panels. Wing, ff. Tr. 339, at 11-13.

76. At the Staff's request, Licensee performed a sensitivity study to determine the effect of possible gaps in the Boraflex at Turkey Point on the margin of subcriticality. Since Region I of the spent fuel pool contains the higher Boraflex loading as well as the smaller subcriticality margin, the sensitivity study conservatively used the Region I spent fuel rack configuration. As an additional conservatism, the calculations did not take credit for the boron in the pool water, i.e., the racks are assumed to be flooded with pure water. The results indicate that for fuel enriched to 4.5 weight percent U-235, the acceptance criterion of k_{eff} less than or equal to 0.95 is met for the case of a 2-inch gap at the same elevation in all of the Boraflex panels in the rack. The acceptance criterion is also met for the case of almost a 4-inch gap at the same elevation in one-half of the Boraflex panels (2 of 4 panels in each storage cell in Region I) in the rack. Kopp, ff.. Tr. 339, at 13-14; Boyd, ff. Tr. 222, at 6-9.

77. The maximum enrichment of the fuel currently used at Turkey Point is only 3.6 weight percent U-235. Licensee estimates that in

approximately three years, the maximum fuel enrichment at Turkey Point will be less than 4.1 weight percent U-235. For fuel of 4.1 weight percent enrichment, the 0.95 acceptance criterion would be met for a 3.5 inch gap in all the Boraflex panels and a 7-inch gap in one-half of the panels in the rack. Kopp. ff. Tr. 339, at [illegible] Boyd, ff. Tr. 222, at 6-9.

78. The Staff considers Licensee's assumptions regarding the distribution of gaps to be conservative since if gaps were to develop, they would probably not all occur at the same elevation nor throughout the entire storage location within the racks. In Quad Cities, for example, the distribution of gap sizes ranged from 0 to about 4 inches with the maximum size (between 3 to 4 inches) observed in only one percent of the Boraflex panels tested. Therefore, conservatively assuming that the maximum gap size of 4 inches observed at Quad Cities occurs in 50 percent of the panels at Turkey Point, k_{eff} for the storage rack would be 0.93 for 4.1 weight percent enriched fuel at Turkey Point. The acceptance criterion of 0.95 would be met with as much as a 7-inch gap in 50 percent of the Boraflex panels for 4.1 weight percent fuel. Kopp, ff. Tr. 339, at 14-15.

79. Licensee had originally planned to perform an initial surveillance of Boraflex specimens after about five years of exposure in the spent fuel pool environment, as described in Section 4.8 of the Turkey Point Units 3 and 4 Spent Fuel Storage Facility Modification Safety Analysis Report, dated March 14, 1984. This program will be increased. Two types of examinations will be conducted on Boraflex to

examine and evaluate its physical and nuclear characteristics. First, an in-service surveillance program will evaluate the Boraflex specimens in both Region I and Region II of the spent fuel pool for physical and nuclear characteristics, including the determination of uniformity of boron distribution and neutron attenuation measurements. Second, a surveillance program will detect any spatial distribution anomalies in the full-length Boraflex panels. Wing, ff. Tr. 339, at 15; Kilp and Gouldy, ff. Tr. 222, at 30-33.

80. The second surveillance program is referred to as "blackness testing." These tests are performed using a fast neutron source and thermal neutron detectors. Any gaps in the Boraflex will be detectable by an increase in the number of thermal neutrons reflected back to the detectors. This method has been used satisfactorily in other spent fuel pool facilities such as the Quad Cities Station Units 1 and 2 to detect spatial anomalies in Boraflex. By retesting at regular intervals, any changes in the neutron attenuation properties or in the spatial distribution of the boron-10 in Boraflex should be detected and corrective actions taken should it be determined that gaps large enough to violate the k_{eff} acceptance criterion may occur. Kopp, ff. Tr. 339, at 16; Gouldy, ff. Tr. 222, at 31-32.

81. In early August, 1987, Licensee performed baseline blackness testing on the Boraflex panels that have received the highest cumulated radiation exposure to date. Licensee expects to perform future surveillance testing of the Boraflex panels within approximately three years, or sooner if industry experience indicates a shorter period for

surveillance is warranted. In addition, Licensee made a commitment not to store any fuel with an enrichment greater than 4.1 weight percent U-235 prior to completion of the next surveillance. Kopp. ff. Tr. 339, at 16; McCracken, Tr. 375-76; Gouldy, ff. Tr. 222, at 30-33.

82. Initial surveillance testing was performed by Licensee during the first week of August 1987 in the Turkey Point Unit 3 spent fuel racks. Storage locations were chosen in which the Boraflex panels would have experienced the highest accumulated gamma doses to date and, therefore, the largest percentage of shrinkage. No indication of gaps or other spatial anomalies were observed. The maximum accumulated gamma dose during this testing was estimated by Westinghouse Electric Corporation, the fuel vendor, to be 7.8×10^9 rads. The next surveillance testing of the Boraflex panels at Turkey Point is scheduled in approximately three years (December 1989) when the maximum accumulated gamma dose is estimated by Westinghouse to be 1.2×10^{10} rads. The Staff believes that the next surveillance should include a representative sample of panels subjected to a range of radiation exposures to provide reasonable assurance that fuel with enrichment up to 4.5 weight percent U-235 can be stored at Turkey Point and maintain the 0.95 k_{eff} acceptance criterion. McCracken, ff. Tr. 339, at 17. Wing, McCracken & Kopp, ff. Tr. 339, at 17; Kilp and Gouldy, ff. Tr. 222, at 36; Gouldy, Tr. 310-12.

83. Bisco Products, Inc. submitted additional test data for Boraflex on June 25, 1987 and August 26, 1987. The data showed that shrinkage in the Boraflex samples at the dose levels of 5×10^9 and 10^{10}

rads of gamma radiation was essentially the same, averaging about 2.1 percent. Irradiation at 2.5×10^{10} rads showed an average shrinkage of 2.4 percent. The data indicated that no appreciable change in shrinkage of Boraflex material occurred between 5×10^{9} and 2.5×10^{10} rads. The 54 Boraflex panels tested at Turkey Point had an estimated radiation dose of 7.8×10^{9} rads and an estimated maximum dose of 1.2×10^{10} rads in three years. These dose levels are within the range of 5×10^{9} and 2.5×10^{10} rads where no appreciable change in shrinkage was found. The Staff believes that the proposed Turkey Point surveillance interval is adequate. However, the Staff will continually monitor industry experience with Boraflex to determine whether a shorter time interval is warranted. Wing, ff. Tr. 339, at 17-18.

84. Intervenors argue that because the blackness tests performed by Licensee do not establish that no gaps exist in the panels since the test could not detect gaps smaller than 1.5 inches (Dr. Turner, Tr. 254), the amendments should be suspended until the absence of gaps is proven by an in-depth testing program. The record is clear that the K-effective limit for either 4.1 or 4.5 percent fuel enrichment would not be exceeded even if gaps smaller than 1.5 inches exist in all the panels in the pool (Kopp, ff. Tr. 339, at 13-15; Boyd, ff. Tr. 222, at 6-9) and that the presence of dissolved boron in the pool water alone is enough to maintain the subcriticality margin. Kopp, ff. Tr. 339, at 18; Boyd, Tr. 267-69. The Board finds no safety reason for suspending the amendments.

85. Intervenors also recommend that the Board direct the Staff to determine if Boraflex is "an unproven material" for spent fuel pool usage and if the use of Boraflex in the expanded storage capacity amendment involves a significant hazard. Intervenors Proposed Findings at ¶ 31. The record shows that no safety significant degradation of Boraflex is expected at Turkey Point and there is an adequate surveillance program to monitor its performance. The Staff's determination as to whether an amendment involves significant hazards pursuant to 10 C.F.R. § 50.92 determines the timing of any potential hearing either before or after the action is taken. This hearing has established that the Boraflex panels do not pose a significant safety concern.

86. In addition to the Boraflex surveillance, Turkey Point Technical Specification 3.17 requires the minimum boron concentration in the pool water while fuel is stored in the spent fuel pool to be 1950 ppm and Table 4.1-2 requires that the boron concentration be sampled monthly. NRC calculations have shown that under normal storage conditions at Turkey Point with the pool water borated to 1950 ppm of boron, all of the Boraflex panels could be removed and the 0.95 k_{eff} acceptance criterion would be met, even with 4.5 weight percent enriched fuel. Therefore, the boron concentration and sampling requirements provide additional assurance of safe fuel storage between surveillances of the Boraflex. The borated water and the Boraflex panels are independent and redundant safety measures. Kopp, ff. Tr. 339, at 18; Boyd, Tr. 267-69, 271, 328-29.

87. The Board finds that, based on the evidence presented by the Licensee and Staff, no safety significant degradation in the Turkey Point Boraflex panels at Turkey Point is expected to occur. The Licensee's surveillance programs include blackness testing on Boraflex specimens and panels at specified schedules which are adequate to detect physical degradations, including gaps, and will provide reasonable assurance that gap formation will be detected in sufficient time to enable Licensee to take corrective actions such that the NRC acceptance criterion of k_{eff} less than or equal to 0.95 is met. Licensee and Staff have adequately analyzed the materials integrity of Boraflex and the material continues to be acceptable for use in safe storage of the spent fuel at the Turkey Point Nuclear Plant.

III. CONCLUSION

Based upon the entire evidentiary record in this proceeding, and upon the foregoing findings of fact, the Board concludes the following:

1. The Licensee's seismic analysis for the new Turkey Point spent fuel pool racks shows that the rack design satisfies the structural aspects of GDC 2, 4, 61 and 62 and thus, there is reasonable assurance of safe storage of fuel in the event of an earthquake.

2. Contrary to Intervenors' assertion in Contention 6, the Licensee and Staff have adequately considered materials spent fuel pool integrity during the storage under the expanded capacity.

IV. ORDER

WHEREFORE, in accordance with the Atomic Energy Act of 1954, as amended, and the Rules of Practice of the Commission, and based on the foregoing findings of fact and conclusions of law, IT IS ORDERED THAT License Amendment Nos. 111 and 105 to License Nos. DPR-31 and DPR-41, respectively, issued by the Office of Nuclear Reactor Regulation on November 21, 1984 shall remain in full force and effect without modification.

IT IS FURTHER ORDERED, pursuant to 10 C.F.R. § 2.760, that this Initial Decision shall constitute the final decision of the Commission thirty (30) days from its date of issuance, unless an appeal is taken in accordance with 10 C.F.R. § 2.762 or the Commission directs otherwise. See also 10 C.F.R. §§ 2.785 and 2.786. Any party may take an appeal from this Decision by filing a Notice of Appeal within ten (10) days after service of this Decision. A brief in support of such appeal shall be filed within thirty (30) days after the filing of the Notice of Appeal (forty (40) days if the appellant is the Staff). Within thirty (30) days after the period has expired for the filing and service of the briefs of all appellants (forty (40) days in the case of the Staff), any party who is not an appellant may file a brief in support of, or in opposition to, any such appeal(s). A responding party shall file a single responsive brief, regardless of the number of appellants' briefs filed.

THE ATOMIC SAFETY AND LICENSING BOARD

Robert M. Lazo

Robert M. Lazo, Chairman
ADMINISTRATIVE JUDGE

Richard F. Cole

Richard F. Cole
ADMINISTRATIVE JUDGE

Emmeth A. Luebke

Emmeth A. Luebke
ADMINISTRATIVE JUDGE

Dated at Bethesda, Maryland
this 19th day of April 1988.