FPL

L-2004-133
10 CFR 50.90
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U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington D. C. 20555

Re: Turkey Point Nuclear Plant Units 3 and 4
Docket Nos. 50-250 and 50-251
Spent Fuel Pool Cask Area Racks
Response to NRC Request for Additional Information (RAI)

By letter L-2002-214 dated November 26, 2002, Florida Power and Light (FPL) submitted a license amendment application to revise the Turkey Point (PTN) Unit 3 and 4 Technical Specifications (TS) to add a spent fuel rack to each unit's spent fuel pool cask area.

By letter dated July 18, 2003, Nuclear Regulatory Commission (NRC) staff issued a request for additional information (RAI) to support their review of the application. The response was submitted by FPL letter L-2003-213 dated September 8, 2003. By letter dated October 23, 2003, the NRC staff requested further clarification of the RAI responses in several areas. FPL letter L-2003-239 dated October 30, 2003 was submitted to clarify the responses to RAI Questions 10a and 23.

The October 23, 2003 NRC letter also requested additional information related to the cask drop accident analysis. A response to those questions is attached. The no significant hazards consideration determination contained in our November 26, 2002 license amendment application remains valid with the information provided herein.

In accordance with 10 CFR 50.91(b)(1), a copy of this letter is being forwarded to the State Designee for the State of Florida.

If you should have any questions, please contact Mr. Walter Parker at 305-246-6632.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on. June 21, 2004

Terry Jones

T. O. Jones
Vice President
Turkey Point Nuclear Plant

Attachment

cc: Regional Administrator, Region II, USNRC
Senior Resident Inspector, USNRC, Turkey Point
USNRC Project Manager, Turkey Point
W. A. Passetti, Florida Department of Health

A001

Attachment to FPL Letter L-2004-133

RESPONSE TO

REQUEST FOR ADDITIONAL INFORMATION

ADDITION OF SPENT FUEL POOL CASK AREA RACKS

TURKEY POINT PLANT, UNITS 3 AND 4

DOCKET NOS. 50-250 AND 50-251

Background

In a letter dated October 23, 2003, the NRC staff requested additional information related to the proposed license amendments adding a cask area rack to each unit's spent fuel pool:

"1. Provide a discussion on the source term used to calculate the exclusion area boundary thyroid and whole body dose numbers contained in Table 14.2.1-5.

2. In the September 8, 2003 RAI reply letter, the reply to RAI #27 refers to a previously reviewed cask drop analysis back in the 1976 timeframe. This analysis is the justification that spent fuel pool integrity will be maintained. Discuss how the 1976 cask drop analysis conforms to Appendix A of NUREG-0612.

3. During a cask drop accident, discuss whether the liner will be preserved."

Questions 2 and 3 relate to the Turkey Point cask drop analysis. The Turkey Point cask drop analysis includes structural, radiological, and neutronic analyses described in the Turkey Point Updated Final Safety Analysis Report (UFSAR) and licensing correspondence (in particular FPL letter L-76-234 dated June 23, 1976).

Because the original analysis predates NUREG-0612, Appendix A by several years, the analysis did not specifically address the Appendix A considerations when it was prepared. To substantiate the current licensing basis, certain other analyses are referred to herein. Also, several new calculations were performed specifically to demonstrate conformance to the NUREG-0612, Appendix A guidelines as discussed in the appropriate sections below. These new calculations use previously approved methods and use assumptions that appropriately represent the physical characteristics of the load drop conditions. As addressed later, these new calculations impose no new operational restrictions or no new heavy load handling restrictions.

The FPL response to these RAI questions follows.

RAI Responses

RAI #1: "Provide a discussion on the source term used to calculate the exclusion area boundary thyroid and whole body dose numbers contained in Table 14.2.1-5."

FPL Response:

The following discussion expands on the factors found in UFSAR Table 14.2.1-4, "Assumptions used for Dropped Cask Dose Analysis":

(a) Spent fuel damaged by the cask drop is conservatively assumed to be a full core offload (157 assemblies) that has decayed 1525 hours. Turkey Point Technical Specification 3.9.12 requires that the spent fuel cask shall not be moved into the spent fuel pool (SFP) until all spent fuel in the pool has decayed for a minimum of 1525 hours. Damaging recently offloaded fuel that has decayed the minimum time allowed by technical specifications is a bounding assumption, because older fuel stored in the adjacent racks would contain relatively insignificant gap activity.

(b) All fuel rods in all 157 assemblies are assumed to be damaged. The assumption of 157 damaged assemblies is a bounding number and is non-mechanistic, because the footprint of a dropped cask[1] tipping into the vacant cask area of the pool would not be expected to damage this number of assemblies in adjacent storage racks.

(c) The core power level prior to the offload is the uprated power level of 2346 MWt (102% of 2300 MWt). The nominal cycle length is assumed to be 24 months and assumes a two-region core. The 24-month cycle case corresponds to an equilibrium cycle length of 24,000 MWD/MTU.

(d) The fission product radiation source considered to be released from the damaged fuel consists of 100% of the gap activity from all of the fuel rods in all 157 assemblies. The gap activity consists of the following fuel rod gap fractions: 10% of all iodine, krypton, and xenon isotopes, except for krypton-85 (30%) and iodine-131 (12%). Iodine species in the fuel rod gap consist of 99.75% elemental iodine and 0.25% methyl iodine.

(e) For the total gap release, the specific halogen and noble gas nuclides and their corresponding activities in the total gap release are listed in a proprietary vendor calculation.

(f) The gap activity is released into the SFP a minimum of 23 feet below the pool surface. This water depth provides a decontamination factor of 133 for the elemental iodine and 1

[1] The analyzed 25-ton cask is a cylinder approximately three feet in diameter and 17 feet high. The maximum area impacted would be 3' x 17' if the cask tipped horizontally.

for the methyl iodine, giving an overall effective decontamination factor of 100 for the pool.

(g) No filtration of activity released from the pool is assumed in the calculation, because the pool area communicates directly with the outside environment through the open Auxiliary Building L-shaped door during cask handling operations.

RAI #2: "In the September 8, 2003 RAI reply letter, the reply to RAI #27 refers to a previously reviewed cask drop analysis back in the 1976 timeframe. This analysis is the justification that spent fuel pool integrity will be maintained. Discuss how the 1976 cask drop analysis conforms to Appendix A of NUREG-0612."

FPL Response:

The cask drop analysis in the plant licensing basis has been compared to NUREG-0612, Appendix A. Because the original analysis predates NUREG-0612 by several years, the analysis did not specifically address the Appendix A considerations when it was prepared. However, the applicable considerations are discussed below to demonstrate conformance with Appendix A.

Based on the cask drop presenting the greatest potential for damaging consequences (due primarily to it representing the limiting maximum weight that may be carried in accordance with Technical Specifications), the responses focus on the cask drop event rather than the rack drop event. Where appropriate in the responses below, the rack drop is also specifically discussed to reinforce that the cask drop analyses bound potential rack drop events.

NUREG-0612 Appendix A - Part 1, General Considerations

Appendix A, Part 1 consists of ten (10) subsections listed below as items (1) through (10). The NUREG guideline is transcribed verbatim. The conformance review of each subsection follows as the response.

The following should be considered for any load drop analysis, as appropriate:

(1) That the load is dropped in an orientation causing the most severe consequences.

FPL Response:

The cask drop analysis is a compilation of a structural evaluation of the impact and other evaluations of radiological and criticality consequences. In theory, the orientation of the load drop could affect the results of these analyses; however, from a practical standpoint, the analyses have been limited to a vertical orientation (i.e., the upright position) while showing conservatively bounding results. Other, non-vertical orientations are highly unlikely based on the symmetry and necessary safety factors for lifting equipment.

Nonetheless, the discussion below will show how other non-vertical orientations may be eliminated qualitatively and need not be specifically analyzed.

The structural analysis is composed of two parts; one that calculates the degree of pool liner damage, and one that determines whether the base mat will fail and propagate a fault that would allow passage of pool water through the mat. If the limiting load does not cause such a fault, then any degree of liner damage will cause no consequential leak. Thereby, the orientation of the dropped load – and the degree of liner damage – will be inconsequential to the amount of leakage. Furthermore, as discussed below, the response of the base mat to the impact load is not dependent upon the orientation of the dropped load.

Docketed information about the original cask drop analysis indicates that only vertical orientations were evaluated. As discussed below, the vertical orientation imparts the maximum impact energy.

Using NRC-approved methods (based on Bechtel Topical Report BC-TOP-9A) a 1989 structural evaluation also analyzed a vertical cask drop orientation for the purpose of imparting the highest possible kinetic energy to the base mat. Other non-vertical drop orientations that impacted side-walls or adjacent racks would distribute the energy to those structures and impart less energy to the base mat. Thereby, the limiting vertical drop results in a maximum impact energy. The evaluation demonstrates that this impact energy is less than the "reserve energy" of the mat, meaning that no through-cracking of the base mat occurs. For illustrative purposes, the original floor penetration analysis also used a vertically-dropped cask that penetrates the floor to a depth of 0.89 inches (around the cask periphery). Similar penetration (0.9 inches) was calculated in the 1989 structural evaluation that used the BC-TOP-9A methodology. Other drop orientations may result in different local penetration characteristics; however, the integrity of the base mat is maintained because the impact energy is less than the mat reserve energy. A recent calculation using a simplified representation of the pool floor and the methodology of the Bechtel Topical Report confirmed that the base mat, while sustaining some local damage, would not suffer a gross failure under the impact loading associated with a dropped cask, by demonstrating that the entire energy of impact is absorbed by the bending of the slab with a substantial margin to the available strain energy.

The Turkey Point radiological evaluation of a cask drop is non-mechanistic in that it assumes that each stored fuel assembly from a recently discharged (1525 hours after shutdown) full core offload is damaged and releases fission products, as discussed in UFSAR Section 14.2.1.3. Therefore, the consequences of this evaluation are independent of the drop orientation. Nevertheless, for illustrative purposes, UFSAR Appendix 14D, Figure 4.4-A shows the loci of potential cask tip impact points in the adjacent storage racks based on a postulated accidental release from its lifting yoke. A dropped cask would only damage a portion of this semicircular area because the cask footprint and the crane travel path are limited such that a cask tipped into the vacant cask area of the pool cannot realistically impact as many fuel assemblies as assumed.

Also, as discussed later in compliance with NUREG-0612, Appendix A, Section 4.1 for neutronics analyses, the potential for causing fuel criticality is independent of the cask drop orientation. The neutronics analyses considered the non-mechanistic crushing of individual fuel assemblies (compacting the fuel rods) and storage racks (compacting the fuel assemblies) to produce worst-case reactivity values without regard to the cask drop orientation. As a result, cask drop orientations have no bearing on the neutronics evaluation.

In summary, the analyses adequately consider the limiting orientations of cask drops in determining the most severe consequences of the accident. Therefore, the analyses conform to general consideration (1) of NUREG-0612, Appendix A.

(2) That fuel impacted is 100 hours subcritical (or whatever the minimum that is allowed in facility technical specifications prior to fuel handling).

FPL Response:

Technical Specification 3.9.12 does not allow cask movement near the spent fuel pool until at least 1525 hours (~64 days) of decay time for all stored fuel. UFSAR Section 14.2.1.3 considers this time limit for the analysis of cask drop radiological consequences. As stated in the license amendment request, the decay time limit of Technical Specification 3.9.12 will also apply to cask area rack installation and removal operations, thereby limiting the potential radiological effects of a rack drop to those of the cask drop.

The Technical Specifications and analyses consistently consider the appropriate minimum value of 1525 hours subcritical for impacted fuel. Therefore, the analyses conform to general consideration (2) of NUREG-0612, Appendix A.

(3) That the load may be dropped at any location in the crane travel area where movement is not restricted by mechanical stops or electrical interlocks.

FPL Response:

For load movements over the spent fuel pool, the cask handling crane is provided with interlocks that restrict the movement of the crane hook and load to a narrow corridor necessary to bring the cask into the Auxiliary Building, and place it in the cask area of the SFP. Outside the building, the crane load path is also restricted by mechanical stops and interlocks. The 1976 evaluation transmitted to NRC in FPL letter L-76-234 considered the consequences of several cask drop locations within the limits of the stops and interlocks, both inside and outside the Auxiliary Building. Also see the response to Guideline Part 3, item 3(e).

Previous NUREG-0612 reviews and the NUREG-0612 Heavy Loads Program for Turkey Point ensure that heavy load paths are established and that the commensurate drop analyses have been performed. This includes the safe load paths in and around the fuel handling building. Therefore, the analyses conform to general consideration (3) of NUREG-0612, Appendix A.

(4) That credit may not be taken for spent fuel pool charcoal filters if hatches, wall, or roof sections are removed during the handling of the heavy load being analyzed, or whenever the building negative pressure rises above (-) 1/8 inch (-3 mm) water gauge.

FPL Response:

No credit is taken in the radiological analysis for filtering radioactive releases, because the spent fuel pool area communicates with the outside environment through the open Auxiliary Building L-shaped door during cask handling operations and also because other cask drops are postulated to occur outside the building. Therefore, the analyses conform to general consideration (4) of NUREG-0612, Appendix A.

(5) Analyses that rely on results in Table 2.1-1 or Figures 2.1-1 or 2.1-2 for potential offsite doses or safe decay times should verify that the assumptions of Table 2.1-2 are conservative for the facility under review. X/Q values should be derived from analysis of on-site meteorological measurements based on 5% worst meteorological conditions.

FPL Response:

The Turkey Point cask drop radiological analyses do not rely on the results of Table 2.1-1 or Figures 2.1-1 or 2.1-2 for offsite doses and decay times. Therefore, the first part of general consideration (5) of NUREG-0612, Appendix A does not apply to the analyses.

X/Q values used in the radiological analyses are described in UFSAR Table 14.3.5-4 and have been previously approved for use in analyzing other plant accidents including Loss of Coolant. The values are derived from on-site meteorological conditions. As discussed in UFSAR Appendix 14D (Section 5.3.1.2.2), the model for calculating the thyroid and whole-body site boundary doses incorporated the conservative assumptions specified in the Standard Review Plan (SRP) Section 15.7.5 and Regulatory Guide 1.25. Therefore, the X/Q values used in the radiological analyses conform to general consideration (5) of NUREG-0612, Appendix A.

(6) Analyses should be based on an elastic-plastic curve that represents a true stress-strain relationship.

FPL Response:

As discussed in letter L-76-234 to the NRC, the structural analysis methodology uses the Petry formula and compares the impact stresses to an allowable compressive strength of 3000 psi. The drop analysis concluded that the impact stress was less than this allowable stress limit and, therefore, the SFP floor slab did not through-crack. As stated previously, subsequent calculations substantiated the results of the structural evaluation described in L-76-234. Based on the fact that the analysis considers the true stress-strain relationship, the cask drop structural analyses conform to general consideration (6) of NUREG-0612, Appendix A.

(7) The analysis should postulate the "maximum damage" that could result, i.e., the analysis should consider that all energy is absorbed by the structure and/or equipment that is impacted.

FPL Response:

The cask drop structural analysis discussed in letter L-76-234 to NRC took no credit for energy absorption by deformation of the dropped cask or absorption by adjacent structures. Similarly, a 1989 structural analysis performed for pool re-racking did not assume any energy absorption by the cask or rack, and yielded similar cask penetration depth results to those in the previous analysis. Therefore, the structural analyses conform to general consideration (7) of NUREG-0612, Appendix A.

(8) Loads need not be analyzed if their load paths and consequences are scoped by the analysis of some other load.

FPL Response:

As discussed in UFSAR Appendix 14D, Section 3.4.3, the structural damage consequences of a rack drop are bounded by the cask drop. The radiological consequences of a rack drop are also bounded by the cask drop due to the lesser rack weight (approximately 18 tons) and honeycomb construction of an empty rack compared to a 25-ton cask. As confirmation of this position, the 1989 structural analysis compared the structural damage resulting from a cask drop and a rack drop. The evaluation concluded that the cask drop bounds the rack drop, except for the penetration depth into the pool floor. The five-inch diameter rack feet that were evaluated would penetrate to a depth of 2 inches, which is greater than the 0.9 inch depth of the cask drop. However, neither drop causes through-cracking of the floor slab, and the cask drop energy is bounding for the slab impact consequences.

As described in the license amendment request, the cask area rack installation will use the same safe load paths as those designated for cask handling.

General consideration (8) of NUREG-0612, Appendix A is permissive in nature rather than restrictive offering the licensee the opportunity to forego drop analyses for those loads bounded by other loads. As discussed above, Turkey Point has previously exercised this option for evaluating rack drops. As these racks will use the same safe load paths as a spent fuel cask, and the rack drop consequences can be shown to be bounded by the cask drop, the structural analyses conform to general consideration (8) of NUREG-0612, Appendix A.

(9) To overcome water leakage due to damage from a load drop, credit may be taken for borated water makeup of adequate concentration that is required to be available by the technical specifications.

FPL Response:

No postulated drop analysis has required a borated water makeup supply to the spent fuel pool. Accordingly, Technical Specifications do not require a borated water makeup source for the SFP. The original plant SER and letter L-76-234 both concluded that no significant leakage would result; i.e., the leakage rate would be significantly less than the available makeup rate of 100 gallons per minute via the spent fuel pool cooling system. SFP makeup may be either borated or non-borated, depending on the source.

General consideration (9) of NUREG-0612, Appendix A is permissive rather than restrictive offering the licensee the opportunity to take credit for borated water makeup sources if necessary. As discussed above, drop analyses do not result in leakage that would require borated water makeup. Because no borated makeup water is credited in the analyses, general consideration (9) of NUREG-0612, Appendix A is not applicable.

(10) Credit may not be taken for equipment to operate that may mitigate the effects of the load drop if the equipment is not required to be operable by the technical specifications when the load could be dropped.

FPL Response:

The analyses do not take credit for any equipment not required to be operable by Technical Specifications to limit either the structural, radiological, or neutronic consequences of a cask drop. Therefore, the analyses conform to general consideration (10) of NUREG-0612, Appendix A.

NUREG-0612 Appendix A - Part 3, Spent Fuel Cask Drop Analysis

Appendix A, Part 3 consists of seven (7) subsections listed below as items (1) through (7). The guideline is transcribed verbatim. The conformance review of each subsection follows as the response.

(1) Applying a single-failure to the lifting assembly, consider that the cask is dropped in an orientation that will result in the most severe consequences.

FPL Response:

The cask drop analysis in conjunction with the 1989 rack drop analysis considered both vertical and tipped drops. In most cases, a single failure to the lifting assembly was not specifically analyzed, but rather, the worst-case non-mechanistic drops were postulated from the highest postulated lift heights. As discussed previously, the drop orientations were chosen to cause the most severe consequences.

The geometry of the proposed rack (as well as the existing racks) promotes a vertical drop orientation. The rack design is an array of axial flow conduits with a large flow hole in the baseplate of each cell. A descending rack will channel the water along its axial cells, resulting in hydrodynamic forces that act to right any rack obliqueness with respect to the vertical. Because of this distinguishing characteristic of a fuel rack's fall, assuming a uniformly vertical collision with the liner has been standard industry practice dating back to the 1980s.

The analyses conform to Part 3 guideline (1) of NUREG-0612, Appendix A.

(2) Impact loads should include a fully loaded cask (with water, where applicable) and all equipment required for lifting and set down such as baseplates, lifting yokes, wire ropes and crane blocks.

FPL Response:

Technical Specification 3.9.12 limits Turkey Point to use of a single-element cask. As described in UFSAR Appendix 14D Section 5.3.1.2.1, the cask drop analysis considered a fully-loaded cask weight of 51,200 lbs, which includes a single fuel assembly, water, and lifting devices. Therefore, the analysis conforms to Part 3 guideline (2) of NUREG-0612, Appendix A.

(3) Restricted path travel of the spent fuel cask (defined by electrical interlocks, mechanical stops, and crane travel capability) should be evaluated to determine the locations and probable accident cases along the path where damage could occur to:

(a) the floor and walls of the Spent Fuel Pool (SFP);
(b) racks within the SFP which support the spent fuel;
(c) the spent fuel itself;

(d) the refueling channel gate; or
(e) safety related systems, components and structures beneath or adjacent to the travel path of the cask.

FPL Response:

(a) Damage to the pool floor was evaluated in the original 1972 SER, again in the 1976 letter L-76-234, and in UFSAR Appendix 14D, Section 3.4.3. Although wall damage was not quantitatively evaluated, any pool wall liner damage would not result in a significant leak because the leakage would be stopped either by the undamaged base mat, or be diverted into the SFP leak chases which are normally isolated by valves.

(b) The radiological analysis assumes non-mechanistic damage to recently-discharged fuel assemblies (as discussed previously) without any specific calculation of rack damage. However, for illustrative purposes, UFSAR Figure 4.4-A in Appendix 14D shows the loci of potential cask tip impact points in storage racks adjacent to the cask area. Although the degree of rack damage has not been specifically analyzed, the worst-case radiological consequences of a cask drop have been evaluated. In the case of neutronics analyses and radiological analyses, the degree of rack damage has no bearing on the results because the evaluations are non-mechanistic in nature.

(c) The radiological analysis (UFSAR Tables 14.2.1-4 and 5) assumes 157 assemblies are non-mechanistically damaged by a cask drop. Although the degree of fuel damage resulting from a cask drop has not been specifically analyzed, the worst-case consequences of such an event have been evaluated. In the case of neutronics analyses and radiological analyses, the actual extent of fuel damage has no bearing on the results because the evaluations are non-mechanistic in nature.

(d) Not applicable. The refueling channel gate (referred to as the "keyway gate" at Turkey Point) is not within the cask drop zone.

(e) FPL letter to NRC L-76-234 discussed buried pipes and duct banks in the cask load path between the units. Restricting the cask lift elevation along the load path to one foot above the ground limits the damage potential. FPL letter to NRC L-96-121 (FPL's response to NRC Bulletin 96-02, "Movement of Heavy Loads Over Spent Fuel, Over Fuel in the Reactor Core, or Over Safety-Related Equipment") stated that plant procedures (e.g., Procedure 0-ADM-717, "Heavy Load Handling") are used to control handling of heavy loads. 0-ADM-717 identifies the safe load paths defined under the Phase I implementation to satisfy NUREG-0612 guideline 5.1.1(1). This includes the safe load paths in and around the fuel handling building.

Outside the Auxiliary Building, the safe load path of the cask area racks will traverse the "cask washdown area" that was previously evaluated as the path for "normal refueling cask handling." In FPL letter to NRC L-76-234, the only significant consequences from a drop in this area stemmed from damaged piping associated with either the spent fuel pool cooling (SFPC) system (high and low suction lines) or the component cooling water (CCW) system (supply and return lines to the spent fuel pool cooling system). The SFPC system malfunction created the potential for a partial loss of SFP water inventory and the CCW system malfunction created the potential for interruption of cooling to non-essential equipment. The consequences were evaluated therein and the appropriate preventive measures were proceduralized.

A recent walkdown confirmed that no new safety-significant components that could be impacted by a heavy load drop were introduced to the safe load paths. Any subsequent configuration changes that could affect this safe load path would be subject to 10 CFR 50.59 to maintain compliance with the UFSAR and Technical Specifications.

Based on evaluation of the five travel path targets discussed above, the analyses conform to Part 3 guideline (3) of NUREG-0612, Appendix A.

(4) In the analysis consideration may be given to drag forces caused by the environment of the postulated accident case, e.g., when the spent fuel cask is postulated to drop into the SFP, credit may be taken for drag forces caused by the water in the SFP. Water level assumed for such analyses should be the minimum level allowed by technical specifications.

FPL Response:

Drag forces through 40 feet of water were considered in the L-76-234 drop analysis. The minimum level allowed by Turkey Point Technical Specification 3.9.11 is 38 feet 4 inches, which is derived from a minimum TS pool surface elevation of 56'-10" minus a floor elevation of 18'-6". Therefore, the original analysis allowed for approximately an additional foot of water drag beyond the above consideration. However, a 1989 structural analysis evaluated a cask drop through 39 feet of water, with liner/base mat impact results similar to the original analysis (i.e., no base mat through-crack). For this reason, the one-foot variation in assumed water depth from this consideration is not considered significant. Therefore, the analyses conform to Part 3 guideline (4) of NUREG-0612, Appendix A.

(5) Credit may be taken for energy absorbing devices integral to the cask if attached during the handling operations in determining the amount of energy imparted to the spent fuel or safety related systems, components or structures.

FPL Response:

General consideration (5) of NUREG-0612 Appendix A is permissive rather than restrictive offering the licensee the opportunity to take credit for energy absorbing devices if necessary. No energy absorbing devices are considered in the cask drop analysis. Therefore, the analyses conform to Part 3 guideline (5) of NUREG-0612 Appendix A.

(6) For the purpose of the analysis, the cask should be considered rigid (except for devices and appurtenances specifically designed for energy absorption and in place) and not to experience deformation during impact.

FPL Response:

The cask was assumed to be rigid. No deformation was assumed that would absorb impact energy and reduce the structural damage consequences. Therefore, the analyses conform to Part 3 guideline (6) of NUREG-0612, Appendix A.

(7) In calculating the center of gravity, consideration should be given to modifications made to cask configuration after purchase, e.g., addition of a perforated metal basket within the cask.

FPL Response:

The evaluations do not identify any modifications made to the 25-ton cask configuration that would have an effect on the drop analysis parameters and consequences. For a vertical drop resulting in the maximum impact energy to the mat, the center of gravity of the cask is not a drop consideration. Therefore, the analyses conform to Part 3 guideline (7) of NUREG-0612, Appendix A.

NUREG-0612 Appendix A – Part 4, Criticality Considerations
Part 4.1, Spent Fuel Pool Neutronics Analysis

Appendix A, Part 4.1 consists of several unnumbered paragraphs. The applicable neutronics analysis guidelines for a cask drop into the spent fuel pool are excerpted below. The conformance review follows as the response.

[Excerpt from Part 4.1] In this neutronics analysis the licensee must demonstrate that the fuel remains subcritical in the optimum crushed configuration. It is adequate to assume that the optimum configuration is with the rack crushed to uniformly reduce the separation between assemblies and the spacing between fuel pins uniformly reduced to maximize k_{eff}. ... The neutronics analysis for the spent fuel pool should consider the case where it has become necessary to off-load the entire core into the spent fuel pool and a heavy load is dropped on fuel in the pool.

FPL Response:

As demonstrated in the FPL docketed evaluations, the stored fuel will remain subcritical for the postulated cask drop. As supplemented by more current neutronic calculations, Turkey Point stored nuclear fuel will remain subcritical if crushed to its optimally moderated configuration. The recent calculations providing a basis for this conclusion considered both Region 1 and Region 2 style racks and fuel loadings that provide bounding results. For the Region 1 rack case, a loading of fresh fuel is more reactive than the full-core offload condition recommended in the guidance. Results of these calculations, which were performed using the CASMO-4[2] and MCNP-4A[3] computer codes, are summarized below.

Reactivity Effect of Reduced Fuel Rod Spacing within an Assembly

The effect on reactivity of tolerances in fuel parameters has recently been calculated for Turkey Point fuel as part of an activity to justify elimination of credit for the neutron absorption properties of Boraflex. These calculations, which were performed at soluble boron concentrations of up to 800 ppm, consistently demonstrate that, at a constant cell interior dimension (ID), reactivity of the rod lattice decreases if spacing between individual fuel rods is decreased. Although these calculations were not performed for the purpose of demonstrating compliance with NUREG-0612, Appendix A, they show that PWR fuel is under-moderated in water containing no or moderate levels of soluble boron, and that further crushing of the lattice will not increase its reactivity. Tolerance effects were not calculated at boron concentrations above 800 ppm, so the effect of reduced rod spacing on reactivity at higher soluble boron concentrations is separately considered in the discussion of Region 1 racks presented below.

Reactivity Effect of Reduced Fuel Assembly Spacing in Region 2 Racks

Fuel stored at Turkey Point in Region 2 style racks is part of a close-packed array; this rack design does not rely solely on the physical separation of fuel for reactivity control. Instead, Region 2 racks typically use neutron absorber material placed between storage cells and fuel assembly depletion as control measures. As rack cells already constitute a close-packed array, the only means of increasing the density of fuel storage is through a reduction in the storage cell ID. Based on a typical cell dimension of 8.8 inches and an assembly cross-section of approximately 8.4 inches, the maximum achievable cell ID

[2] M. Edenius, K. Ekberg, B.H. Forssen, and D. Knott, CASMO-4 A Fuel Assembly Burnup Program User's Manual, Studsvik/SOA-95/1, Studsvik of America, Inc. and Studsvik Core Analysis AB

[3] J.F. Briesmeister, Editor, MCNP- A General Monte Carlo N-Particle Transport Code, Version 4A, LA-12625, Los Alamos National Laboratory (1993)

reduction is about 0.4 inches. Recent uncertainty analyses performed as part of the effort to eliminate credit for Boraflex absorber material at Turkey Point produce an effect on delta-k of about 0.002 for a change in storage cell ID of 0.025 inches at 0 ppm. If a linear relationship between delta-k and storage cell ID is assumed, then a change in cell ID of 0.4 inches yields an effect on delta-k of about 0.032, or less than 400 ppm when converted to an equivalent boron concentration. At a soluble boron concentration of 800 ppm, this effect is about 0.052 delta-k, or 650 ppm when using the same boron worth conversion factor. Adding this crushed rack soluble boron requirement to the normal condition soluble boron requirement derived from 10CFR 50.68(b)(4) yields a total soluble boron requirement of about 1300 ppm for the crushed rack accident condition. As this soluble boron requirement is much less than the minimum required TS soluble boron concentration of 1950 ppm for the Turkey Point spent fuel pool, any crushed array of fuel in Region 2 will remain sub-critical by a substantial margin.

Reactivity Effect of Reduced Fuel Assembly Spacing in Region 1 Racks

Region 1 fuel storage racks are intended to accommodate fresh fuel. The Region 1 rack design relies on neutron absorber material and the physical separation of stored assemblies to comply with limits on effective neutron multiplication. Region 1 racks at Turkey Point use a water-filled flux trap of approximately 1.5 inches to provide this physical separation. When the rack is in the crushed condition, this flux trap gap is assumed closed. Similar to the situation described for Region 2 racks, the crushed rack condition also reduces the Region 1 cell ID. As these two effects cause a greater reduction in separation distance between adjacent Region 1 fuel assemblies than for the Region 2 crushed rack condition, a higher soluble boron concentration is required to control neutron multiplication. The higher soluble boron concentration requirement means that the effect on reactivity of reductions in fuel rod spacing must be examined for boron concentrations greater than 800 ppm.

Crushed rack calculations have been performed for Region 1 racks at Turkey Point, considering an array of fuel assemblies having an initial enrichment of 4.5 weight percent (w/o) U-235 and a fuel pool soluble boron concentration of 1950 ppm.

A three-dimensional MCNP model was used to calculate k-effective for a crushed Region 1 rack while accounting for the potential gaps, shrinkage and thinning of installed Boraflex panels. To represent the full-core offload condition recommended by the above Appendix A guideline, a conservative fuel loading in Region 1 racks is considered that is more reactive than a full core offload. In this loading condition, Region 1 contains fresh fuel, with all assemblies having an initial enrichment of 4.5 w/o U-235. The storage condition is modeled in a 2x2 array of crushed Region 1 cells with periodic X and Y boundary conditions (i.e., infinite in the X and Y direction). Biases and uncertainties were applied in order to quantify a maximum value of the neutron multiplication factor.

Results of these calculations indicate:

- The array of fresh fuel produces a maximum calculated neutron multiplication factor of 0.9666 at a fuel rod spacing of 0.52" (~1.32 cm). This rod spacing is only slightly less than the undamaged fuel rod pitch.
- CASMO calculations quantifying temperature bias effects for the crushed Region 1 array, considering the presence of soluble boron, produce a bias value of 0.0013 delta-k at 4°C.
- Variations in the assumed thickness of Boraflex panels produced the largest single parameter reactivity effect. Specific calculations performed at 4°C using the crushed rack geometry and with 1950 ppm soluble boron produced a maximum effect of 0.0127 delta-k.
- Uncertainties and biases applied to the MCNP calculated results totaled 0.0224 delta-k. Including these effects produces a maximum k-effective value of 0.9890 for the array of fresh fuel.

Summary of Results

Calculations demonstrate that a crushed array of fuel in Region 1 and Region 2 racks remains sub-critical when these racks are loaded with fuel of the limiting reactivity permitted for storage and when considering the presence of soluble boron.

Therefore, current evaluations of Turkey Point Region 1 and 2 fuel storage racks conform to Part 4.1 guidelines of NUREG-0612, Appendix A.

RAI #3: "During a cask drop accident, discuss whether the liner will be preserved."

FPL Response:

As discussed in the previous section, the original Turkey Point cask drop structural evaluation concluded that the cask would penetrate the pool floor to a depth of 0.9 inches. A 1989 structural analysis determined that on a rack drop, the rack feet would penetrate the floor to a depth of 2.0 inches. Floor penetration to these depths would penetrate the ¼ inch thick stainless steel liner plate. Therefore, liner plate integrity could be lost following a vertical cask drop or rack drop.

However, although liner plate integrity would be breached by the above load drops, leakage from the SFP through the penetrated liner will be small, because the pool base mat will not through-crack. Any pool water that leaks through the tear will be stopped either by the underlying concrete, or be diverted into the SFP leak chases, which are normally isolated by valves. For these reasons, leakage from the pool through the damaged liner plate due to a load drop is expected to be insignificant.