December 12, 2001

Mr. J. A. Stall
Senior Vice President, Nuclear and
Chief Nuclear Officer
Florida Power and Light Company
P.O. Box 14000
Juno Beach, Florida 33408-0420

SUBJECT: EXEMPTION FROM THE HYDROGEN CONTROL REQUIREMENTS OF 10 CFR SECTION 50.44 AND 10 CFR PART 50, APPENDIX A, GENERAL DESIGN CRITERIA 41, 42, AND 43 - TURKEY POINT PLANT, UNITS 3 AND 4 (TAC NOS. MB0332 AND MB0333)

Dear Mr. Stall:

The Commission has approved the enclosed exemption from the specific requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.44 and 10 CFR Part 50, Appendix A, General Design Criteria 41, 42, and 43, related to the hydrogen recombiners and the post-accident containment vent system. The exemption will remove the above requirements from the Turkey Point Plant design basis. This action is in response to your submittal dated October 23, 2000.

Your submittal also requested, among other things, an exemption from 10 CFR Part 50, Appendix E, Section IV related to the containment hydrogen monitors. The staff will act on this exemption request separately.

A copy of the exemption and the supporting safety evaluation are enclosed. The exemption has been forwarded to the Office of the Federal Register for publication.

Sincerely,

/RA/

Kahtan N. Jabbour, Senior Project Manager, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-250 and 50-251

Enclosures: As stated (2)

cc w/encls: See next page

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NUCLEAR REGULATORY COMMISSION

FLORIDA POWER AND LIGHT COMPANY

TURKEY POINT PLANT, UNITS 3 AND 4

DOCKET NOS. 50-250 AND 50-251

EXEMPTION

1.0 BACKGROUND

The Florida Power and Light Company (the licensee) is the holder of Facility Operating License Nos. DPR-31 and DPR-41, which authorize operation of the Turkey Point Plant, Units 3 and 4. The licenses provide, among other things, that the facilities are subject to all rules, regulations, and orders of the U.S. Nuclear Regulatory Commission (NRC, the Commission) now or hereafter in effect.

The facility consists of two pressurized water reactors located in Miami-Dade County in Florida.

2.0 REQUEST/ACTION

By letter dated October 23, 2000, Florida Power and Light, the licensee for Turkey Point Plant, requested, among other things, an exemption from certain requirements of 10 CFR 50.44; 10 CFR Part 50, Appendix A, General Design Criterion 41, 42, and 43; and 10 CFR Part 50, Appendix E, Section VI; related to the hydrogen control system (i.e., recombiners, hydrogen monitors, and post-accident containment vent system). The proposed exemption would remove the above requirements from the Turkey Point Plant design basis. The staff has reviewed the information provided and concludes that the requested exemption for the hydrogen recombiners

and the post-accident containment vent system are justified. The staff will act on the exemption request for the containment hydrogen monitors, the requested modification to the revised Confirmatory Order issued on October 5, 2000, and the revision to the Technical Specifications related to the post-accident containment vent system and the hydrogen monitors by separate correspondence.

The post-accident containment vent system is provided to facilitate controlled venting through adding air (Service Air backed by Instrument Air) to the reactor containment and venting air from the containment to effectively maintain hydrogen concentration below 4.0 volume percent. Regulatory requirements for the hydrogen control system are specified in 10 CFR 50.44 and 10 CFR Part 50, Appendix A, (General Design Criteria 41, 42, and 43). Additional staff guidance is provided in Regulatory Guide (RG) 1.7. Staff review and acceptance criteria are specified in Section 6.2.5 of the Standard Review Plan.

3.0 DISCUSSION

Pursuant to 10 CFR 50.12, the Commission may, upon application by any interested person or upon its own initiative, grant exemptions from the requirements of 10 CFR Part 50, when (1) the exemptions are authorized by law, will not present an undue risk to public health or safety, and are consistent with the common defense and security; and (2) when special circumstances are present.

For this exemption, these special circumstances include consideration that the quantity of hydrogen prescribed by 10 CFR 50.44(d) and RG 1.7 which necessitated the need for hydrogen recombiners and the post-accident containment vent system would be bounded by the hydrogen generated during a severe accident. As shown in the attached safety evaluation, the staff has found that the relative importance of hydrogen combustion for large, dry containments with respect to containment failure is quite low. This finding supports the argument that the hydrogen recombiners are not risk significant from a containment integrity perspective and that the risk associated with hydrogen combustion is not from design basis

accidents but from severe accidents. Studies have shown that the majority of risk to the public is from accident sequences that lead to containment failure or bypass, and that the contribution to risk from accident sequences involving hydrogen combustion is actually quite small for large, dry containments such as Turkey Point's. This is true despite the fact that the hydrogen produced in these events is substantially larger than the hydrogen production postulated by 10 CFR 50.44(d) and RG 1.7. Hydrogen combustion sequences that could lead to early containment failure typically involve up to 75 percent core metal-water reaction. Hydrogen combustion sequences that could lead to late containment failure involve additional sources of hydrogen due to the interaction of corium and the concrete basemat after vessel breach. Although the recombiners and the post-accident containment vent system are effective in maintaining the RG 1.7 hydrogen concentration below the lower flammability limit of 4.0 volume percent (for a design basis loss-of-coolant accident (LOCA)), they are overwhelmed by the larger quantities of hydrogen associated with severe accidents that would typically be released over a much shorter time period (e.g., 2 hours). However, NUREG/CR-4551 states that hydrogen combustion in the period before containment failure is considered to present no threat to large, dry containments. Table A.4-5 of NUREG/CR-4551 shows that the contribution of hydrogen combustion to late containment failure is also very small. Therefore, the relative importance of hydrogen combustion for large, dry containments with respect to containment failure has been shown to be quite low.

The recombiners can, however, prevent a subsequent hydrogen burn, if needed, due to radiolytic decomposition of water and corrosion in the long term. Analysis performed in accordance with the methodology of RG 1.7 shows that the hydrogen concentration will not reach 4.0 volume percent for 15 days after initiation of a design basis LOCA. Additionally, as described in the attached safety evaluation, hydrogen concentrations on the order of 6.0 volume percent or less are bounded by hydrogen generated during a severe accident and would not be a threat to containment integrity since there is ample time between burns to

reduce elevated containment temperatures using the installed containment heat removal systems. The Turkey Point Individual Plant Examination (IPE) concluded that containment survival is almost certain following hydrogen combustion when the Reactor Building Cooling Units and the Reactor Building Spray System are operating.

The underlying purpose of 10 CFR 50.44 is to show that, following a LOCA, an uncontrolled hydrogen-oxygen recombination would not take place, or that the plant could withstand the consequences of uncontrolled hydrogen-oxygen recombination without loss of safety function. Based on the analysis, which includes the staff's evaluation of the risk from hydrogen combustion, resolution of Generic Issue 121, "Hydrogen Control for PWR [pressurized-water reactor] Dry Containments," and the Turkey Point IPE, the plant could withstand the consequences of uncontrolled hydrogen-oxygen recombination without loss of safety function and without credit for the hydrogen recombiners for not only the design basis case, but the more limiting severe accident with up to 100 percent metal-water reaction. Therefore, the requirements for hydrogen recombiners as part of the Turkey Point design basis are unnecessary and their removal from the design basis is justified. Additionally, elimination of the hydrogen recombiners from the Emergency Operating Procedures (EOPs) would simplify operator actions in the event of an accident and, therefore, would be a safety benefit.

The staff examined the licensee's rationale that supports the exemption request and concluded that the exemption requested for the recombiners and the post-accident containment vent system is justified as stated in the supporting safety evaluation. Additionally, elimination of the hydrogen recombiners and the post-accident containment vent system from the EOPs would be a simplification and a safety benefit. Consequently, pursuant to 10 CFR 50.12(a)(2)(ii), application of the regulation is not necessary to achieve the underlying purpose of the rule.

The safety evaluation may be examined, and/or copied for a fee at the NRC's Public Document Room, located at One White Flint North, 11555 Rockville Pike (first floor), Rockville,

Maryland. Publicly available records will be accessible electronically from the ADAMS Public Library component on the NRC Web site, http://www.nrc.gov (the Public Reading Room).

4.0 CONCLUSION

Accordingly, the Commission has determined that, pursuant to 10 CFR 50.12(a), the exemption pertaining to the recombiners and the post-accident containment vent system is authorized by law, will not present an undue risk to the public health and safety, and is consistent with the common defense and security. Also, pursuant to 10 CFR 50.12(a)(2)(ii), special circumstances are present. Therefore, the Commission hereby grants Florida Power and Light Company an exemption from the requirements for the recombiners and the post-accident containment vent system as stated in 10 CFR 50.44 and 10 CFR Part 50, Appendix A, General Design Criteria 41, 42 and 43 for the Turkey Point Plant, Units 3 and 4.

Pursuant to 10 CFR 51.32, the Commission has determined that the granting of this exemption will not have a significant effect on the quality of the human environment (66 FR 59266).

This exemption is effective upon issuance.

Dated at Rockville, Maryland, this 12th day of December 2001.

FOR THE NUCLEAR REGULATORY COMMISSION

/RA/
John A. Zwolinski, Director
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FLORIDA POWER AND LIGHT COMPANY

TURKEY POINT UNIT NOS. 3 AND 4

DOCKET NOS. 50-250 AND 50-251

1. INTRODUCTION

By letters dated October 23, 2000, Florida Power and Light Company, the licensee for Turkey Point Plant, Units 3 and 4, requested, among other things, an exemption from the requirements of Title 10*, Code of Federal Regulations* (10 CFR), Section 50.44; Part 50, Appendix A, General Design Criteria 41, 42, and 43; and Part 50, Appendix E, Section VI. The purpose of the exemption request was to remove the requirements for the hydrogen control system (i.e., recombiners, hydrogen monitors, and post-accident containment vent system) from the Turkey Point Plant design basis. The request for exemption included amendment applications which would remove the hydrogen monitors and the post-accident containment vent system from the plant Technical Specifications, and a request to modify the revised Confirmatory Order issued on October 5, 2000.

2. DISCUSSION AND EVALUATION

2.1 Turkey Point Plant Hydrogen Control System

The Turkey Point Plant combustible gas control system consists of the hydrogen recombiner system, hydrogen monitoring system and the post-accident containment vent system. This safety evaluation will address the necessity of requirements for the hydrogen recombiners and the post-accident containment vent system as part of the design basis for Turkey Point Plant. The staff will act on the other issues included in the October 23, 2000, submittal separately.

The hydrogen recombiner system consists of two safety-related thermal recombiners. Air flows by natural convection through the unit at a rate of 50 standard cubic feet per minute. Heating elements cause the hydrogen to chemically combine with atmospheric oxygen. As presently described in the Turkey Point Plant Emergency Operating Procedures (EOPs) , the hydrogen recombiners are manually started by the control room operators before the hydrogen concentration reaches 3.0 volume percent. Following the methodology of Regulatory Guide (RG) 1.7, a hydrogen concentration of 3.0 volume percent is not reached for at least 8 days after the start of the accident.

As a backup to the hydrogen recombiners, the post-accident containment vent system is designed to maintain the hydrogen concentration of the reactor building below the lower flammability limit of 4.0 volume percent. This is accomplished by introducing fresh outside air

into the reactor building and allowing the displaced containment atmosphere to be discharged in a controlled manner to the plant vent through exhaust filters. The hydrogen vent system is placed in service if the hydrogen monitoring system indicates that the reactor building hydrogen concentration has reached 2.5 volume percent and the hydrogen recombiners are not available. At this time preparation for purging the reactor building would begin.

2.2 Regulatory Requirements For Combustible Gas Control Systems

Regulatory requirements for the hydrogen control system are specified in 10 CFR 50.44 and 10 CFR Part 50, Appendix A, (General Design Criterion 41, 42, and 43). Additional staff guidance is provided in RG 1.7. Staff review and acceptance criteria are specified in Section 6.2.5 of the Standard Review Plan. Different requirements apply to facilities according to the date of publication of the Notice of Hearing for the Construction Permit. With regard to combustible gas control system requirements, Turkey Point Plant is subject to the requirements of 10 CFR 50.44(g).

A combustible gas control system is defined by 10CFR 50.44(h) as a system that operates after a loss of coolant accident (LOCA) to maintain the concentrations of combustible gases within the containment, such as hydrogen, below flammability limits. Combustible gas control systems are of two types: (1) systems that allow controlled release from containment such as a purge or vent system, and (2) systems that do not result in a significant release from containment such as recombiners. The purpose of this exemption request is to remove requirements for hydrogen recombiners and the post-accident containment vent system from the Turkey Point Plant design basis.

Turkey Point Plant is also subject to 10 CFR 50.44(d) which states:

> For facilities that are in compliance with § 50.46(b), the amount of hydrogen contributed by core metal-water reaction (percentage of fuel cladding that reacts with water), as a result of degradation, but not total failure, of emergency core cooling functioning shall be assumed either to be five times the total amount of hydrogen calculated in demonstrating compliance with § 50.46(b)(3), or to be the amount that would result from reaction of all the metal in the outside surfaces of the cladding cylinders surrounding the fuel (excluding the cladding surrounding the plenum volume) to a depth of 0.00023 inch (0.0058 mm), whichever amount is greater.

The amount of hydrogen described by 10 CFR 50.44(d) was clearly an attempt to address accident sequences beyond the design basis. As stated in the statement of considerations, 41 FR 46467, and RG 1.7, the factor of five is intended to provide an appropriate safety margin against unpredicted events during the course of accidents. More specifically, it is to account for a more degraded condition of the reactor than the Emergency Core Cooling Systems (ECCS) design-basis permits. RG 1.7 assumes oxidation of up to 5.0 volume percent of the zircalloy surrounding the active fuel. The amount of hydrogen due to radiolysis as recommended by RG 1.7 includes: 50 percent of the halogens, 1.0 volume percent of the solids present in the core are intimately mixed with the coolant water, all noble gases are released to the containment, and all other fission products remain in the fuel rods.

Subsequent risk studies have shown that the majority of risk to the public is from accident sequences that lead to containment failure or bypass, and that the contribution to risk from accident sequences involving hydrogen combustion is actually quite small for large, dry

containments. This is true despite the fact that the hydrogen produced in these events is substantially larger than the hydrogen production postulated by 10 CFR 50.44(d) and RG 1.7. Hydrogen combustion sequences that could lead to early containment failure typically involve up to 75 percent core metal-water reaction. Hydrogen combustion sequences that could lead to late containment failure involve additional sources of hydrogen due to the interaction of corium and the concrete basemat after vessel breach. Although the recombiners are effective in maintaining the RG 1.7 (post LOCA) hydrogen concentration below the lower flammability limit of 4.0 volume percent, they are overwhelmed by the larger quantities of hydrogen associated with severe accidents which are typically released over a much shorter time period (e.g., 2 hours).

The staff evaluated the risk from hydrogen combustion as part of NUREG-1150. Because the Zion containment was found to be quite strong by the structural experts who considered the issue, early containment failure due to hydrogen burns was not modeled for Zion. Figure 7.3 of NUREG-1150, Volume 1, dated December 1990, provides information in which the conditional probabilities of four accident progression bins (e.g., early containment failure) are presented for the Zion plant, which has a large, dry containment similar to Turkey Point Plant. This information indicates that, on a plant damage state frequency-weighted average, the mean conditional probabilities from internal events of: (1) early containment failure from a combination of in-vessel steam explosions, overpressurization, and containment isolation failures is 0.014, (2) late containment failure, mainly from basemat melt through is 0.24, (3) containment bypass from interfacing-system LOCA and induced steam generator tube rupture is 0.006, and (4) probability of no containment failure is 0.73. The accident progression event trees used to generate these bins are described in NUREG/CR-4551, Volume 7, Revision 1, Part 1. NUREG/CR-4551 goes on to state that hydrogen combustion in the period before vessel failure is now generally considered to present no threat to large, dry containments. Table A.4-5 of NUREG/CR-4551 shows that the contribution of hydrogen combustion to late containment failure is also very small (only 0.5 volume percent of the late containment failure bin, 8.376E-4, is from hydrogen combustion). Although the modeling of the accident progression event trees may have changed since 1990, the relative importance of hydrogen combustion for large, dry containments with respect to containment failure has not changed and continues to be quite low.

The Turkey Point Individual Plant Examination (IPE) concluded that containment survival is almost certain following hydrogen combustion when the containment heat removal systems are operating. The licensee estimates a limiting pressure for containment failure of 145 psig (Turkey Point Plant Probabilistic Risk Assessment, Level 2, Appendix 1). This estimate is reasonable when compared to Table 6.1 of NUREG/CR-6338, “Resolution of the Direct Containment Heating Issue for Westinghouse Plants with Large Dry Containments.” A safety margin exists for containment integrity even for conservative hydrogen concentration levels. The staff estimates the pressure for an adiabatic and complete hydrogen burn involving up to 75 percent core metal-water reaction to be 109 psig. Sequences involving up to 75 percent core metal-water reaction are expected to bound the majority of severe accident sequences including almost all that remain in-vessel. For sequences involving up to 100 percent core metal-water reaction, the staff estimates a pressure of 135 psig. The staff is using the methodology in Section 2.6 of NUREG/CR-5662, “Hydrogen Combustion, Control, and Value-Impact Analysis for PWR Dry Containments,” June 1991, a containment free volume of 43,900 cubic meters, and the inventory of zirconium in the core to be 16,500 Kg, to estimate the

pressure. These estimates are considered conservative because of the adiabatic assumption and the hydrogen burn is expected at much lower hydrogen concentrations than those assumed in the estimate, 13.0 and 16.0 volume percent, respectively. For example, the hydrogen burn during the accident at Three Mile Island, Unit 2, resulted from a hydrogen concentration of 8.1 volume percent. Therefore, the licensee's estimated limiting pressure for containment failure bounds conservative estimates of the most likely hydrogen combustion modes.

Although hydrogen igniter systems would provide some added margin that containment integrity can be maintained during hydrogen burns, Generic Issue (GI)-121, "Hydrogen Control for PWR [pressurized-water reactor] Dry Containments," found that hydrogen combustion was not a significant threat to dry containments and concluded there was no basis for new generic hydrogen control measures (i.e., igniters).

From this information, the staff concludes that the quantity of hydrogen, prescribed by 10 CFR 50.44(d) and RG 1.7, which necessitates the need for hydrogen recombiners is bounded by the hydrogen generated during a severe accident. The staff finds that the relative importance of hydrogen combustion for large, dry containments with respect to containment failure to be quite low. This finding supports the argument that the hydrogen recombiners are not risk significant from a containment integrity perspective.

2.3 Analysis

As mentioned in the previous section, the risk associated with hydrogen combustion is not from design-basis accidents but from severe accidents. The hydrogen recombiners are overwhelmed by the metal-water reaction and are incapable of removing appreciable amounts of hydrogen in the time period prior to spurious ignition. The Turkey Point Plant probabilistic risk assessment indicates that none of the analyzed sequences that could threaten containment due to hydrogen combustion are impacted by the hydrogen recombiner system. The recombiners are, however, capable of preventing a subsequent hydrogen burn due to radiolytic decomposition of water and corrosion in the long term.

The staff has performed analyses of a plant with a large, dry containment similar to that at Turkey Point Plant. The purpose of these analyses was to ascertain the value of the hydrogen recombiners in preventing the uncontrolled burning of hydrogen in the long term under best-estimate severe accident conditions versus the design-basis case. The staff used its confirmatory code COGAP to estimate the amount of hydrogen due to radiolytic decomposition of water and corrosion. COGAP was developed by the staff for determining hydrogen concentrations within reactor containments following a design basis LOCA. The following are some of the input assumptions the staff changed to make the calculations more appropriate for a best-estimate severe accident analysis: (1) the amount of solid fission product decay energy absorbed by the sump water solution was increased from 1.0 volume percent to 8.0 volume percent, (2) the iodine isotope decay energy absorbed by the sump water solution was increased from 50 percent to 75 percent, (3) the hydrogen yield was reduced from 0.5 molecule/100 ev to 0.4 molecule/100 ev, and (4) best estimate corrosion rates. The amount of solid fission product and iodine isotope decay energy were based on the release fractions in NUREG-1465 and the decay energy in NUREG/CR-4169. The corrosion rates were based on the proceedings of the Second International Conference on the Impact of Hydrogen on Water

Reactor Safety, Albuquerque, New Mexico, October 1982. The analysis calculated the hydrogen concentration to be 5.4 volume percent at 30 days and did not exceed the lower flammability limit of 4.0 volume percent for 16 days.

Hydrogen concentrations on the order of 6.0 volume percent or less are clearly bounded by hydrogen generated during a severe accident and would not be a threat to containment integrity as discussed in the previous section. Such a burn would impose a temperature transient to available instrumentation and equipment. In the range of 4.0 to 6.0 volume percent, the temperature transient is fairly benign because the rate of flame propagation is less than the rate of rise of the flammable mixture. Therefore, the flame can propagate upward, but not horizontally or downward. In this case, complete combustion will not occur until the concentration is increased above 6.0 volume percent.

Equipment survivability in concentrations greater than 6.0 volume percent was addressed as part of GI-121 which references NUREG/CR-5662 which assessed the benefits of hydrogen igniters. NUREG/CR-5662 concluded that simulated equipment can withstand a LOCA and single burn resulting from a 75 percent metal-water reaction in a large, dry containment. However, the multiple containment burns due to the operation of ignition systems could pose a serious threat to safety-related equipment located in the source compartment. The multiple burn environment was found potentially to be a threat because the source compartment temperature remains elevated from the previous burn. However, for Turkey Point Plant this is not a concern for the above radiolysis and corrosion case because there is ample time between burns to reduce elevated containment temperatures via containment heat removal systems. Therefore, an additional burn in the long term due to radiolysis and corrosion would not have a similar impact on equipment survivability at Turkey Point Plant.

2.4 Risk Reduction Due to Instruction Simplification

In a postulated LOCA, the Turkey Point Plant EOPs direct the control room operators to monitor and control the hydrogen concentration inside the containment after they have carried out the steps to maintain and control the higher priority critical safety functions. Key operator actions associated with the control of hydrogen include placing the hydrogen recombiners or the post-accident containment vent system in operation at very low hydrogen concentration levels. These hydrogen control activities could distract operators from more important tasks in the early phases of accident mitigation and could have a negative impact on the higher priority critical operator actions. An exemption from hydrogen recombiner and post-accident containment vent system requirements will eliminate the need for these systems in the EOPs and hence simplify the EOPs. The staff still expects the licensee's severe accident management guidelines to address combustible gas control. The staff concludes that this simplification would be a safety benefit and, therefore, is acceptable.

3.0 CONCLUSION

The staff has established certain criteria which permit any license holder to request specific exemptions to its rules and regulations provided special circumstances exist. Special circumstances are identified in 10 CFR 50.12(a)(2). It states in 10 CFR 50.12(a)(2)(ii) that, "Application of the regulation in the particular circumstances would not serve the underlying purpose of the rule or is not necessary to achieve the underlying purpose of the rule." The

underlying purpose of 10 CFR 50.44 is to show that following a LOCA an uncontrolled hydrogen-oxygen recombination would not take place, or that the plant could withstand the consequences of uncontrolled hydrogen-oxygen recombination without loss of safety function. Based on the above, which includes the staff's evaluation of the risk from hydrogen combustion, resolution of GI -121, "Hydrogen Control for PWR Dry Containments," and the Turkey Point Plant IPE, it has been successfully demonstrated by the licensee that the plant could withstand the consequences of uncontrolled hydrogen-oxygen recombination without loss of safety function without credit for the hydrogen recombiners and the post-accident containment vent system for not only the design basis case but more limiting severe accident sequences. Therefore, the staff finds that the requirements for hydrogen recombiners and the post-accident containment vent system capability as part of the Turkey Point Plant design basis are unnecessary and their removal from the design basis is justified. Therefore, the exemptions requested and the associated license amendments for these systems are justified. Additionally, elimination of the hydrogen recombiners and the post-accident containment vent system from the EOPs would be a simplification and a safety benefit.

Principal Contributor: Michael Snodderly, NRR

Date: December 12, 2001

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