September 24, 2008

Mr. Charles G. Pardee
Chief Nuclear Officer
and Senior Vice President
Exelon Generation Company, LLC
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: LASALLE COUNTY STATION, UNITS 1 AND 2 - REQUEST FOR ADDITIONAL INFORMATION RELATED TO SPENT FUEL POOL STORAGE REQUIREMENTS (TAC NOS. MD7900 AND MD7901)

Dear Mr. Pardee:

By letter to the Nuclear Regulatory Commission (NRC) dated December 13, 2007, Exelon Generation Company, LLC submitted a request to revise Technical Specification (TS) Section 4.3.1, "Criticality," to add a new requirement to use a blocking device in spent fuel pool storage rack cells that cannot maintain the effective neutron multiplication factor K_{eff}, requirements specified in TS Section 4.3.1.1.a, for the LaSalle County Station, Units 1 and 2.

The NRC staff has accepted your license amendment request tor review and has determined that additional information is required to complete the review. The specific information requested is addressed in the enclosure to this letter. During a discussion with your staff on July 22, 2008, it was agreed that you would provide your response to the questions 30 days from the date of this letter.

The NRC staff considers that timely responses to requests for additional information help ensure sufficient time is available for staff review and contribute toward the NRC's goal of efficient and effective use of staff resources. If circumstances result in the need to revise the requested response date, please contact me at (301) 415-3154.

Sincerely,

/RA/

Stephen P. Sands, Project Manager
Plant Licensing Branch III-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-373 and 50-374

Enclosure:
Request for Additional Information

cc w/encl: See next page

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Docket Nos. 50-373 and 50-374

Enclosure:
Request for Additional Information

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LaSalle County Station, Units 1 and 2

cc:

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REQUEST FOR ADDITIONAL INFORMATION

LASALLE COUNTY STATION, UNITS 1 AND 2

DOCKET NOS. 50-373 AND 50-374

In reviewing the Exelon Generation Company's (Exelon's) submittal dated December 13, 2007, related to a license amendment request to revise Technical Specification (TS) Section 4.3.1, "Criticality," to add a new requirement to use a blocking device in spent fuel pool (SFP) storage rack cells that cannot maintain the effective neutron multiplication factor K_{eff}, requirements specified in TS Section 4.3.1.1.a, for the LaSalle County Station (LSCS), Units 1 and 2, the Nuclear Regulatory Commission (NRC) staff has determined that the following information is needed in order to complete its review:

The LSCS Unit 2 SFP storage racks contain Boraflex. Boraflex is subject to known degradation mechanisms in SFP environments. The degradation at LSCS is reaching the point where Boraflex can no longer be credited for maintaining SFP sub-criticality requirements. SFP storage cells with an unusable Boraflex panel are unable to meet the LSCS TS, and Title 10 of the *Code of Federal Regulations* (10 CFR) Section 50.68 regulations. When a Boraflex panel lining a storage cell wall has degraded to a certain point, that cell and three others in a 2x2 array are declared unusable and any fuel is removed from those four cells. This significantly reduces the LSCS SFP storage capacity. Currently, only a few storage cells are affected; eventually all storage cells will be affected. The current license amendment request (LAR) has two parts. The first part is a request to add the requirement for unusable storage cells to be filled with a "blocking device." The second part is a dual criticality analysis in which storage is allowed in three cells of the 2x2 array mentioned previously, the fourth cell will contain a "blocking device."

10 CFR Part 50 Appendix A, Criterion 62, requires, "Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations."

10 CFR Section 50.68 (b)(1) requires, "Plant procedures shall prohibit the handling and storage at any one time of more fuel assemblies than have been determined to be safely subcritical under the most adverse moderation conditions feasible by unborated water."

10 CFR Part 50, Section 50.68 (b)(4), requires, "If no credit for soluble boron is taken, the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with unborated water. If credit is taken for soluble boron, the k-effective of the spent fuel storage racks loaded with fuel of the maximum fuel assembly reactivity must not exceed 0.95, at a 95 percent probability, 95 percent confidence level, if flooded with borated water, and the k-effective must remain below 1.0 (subcritical), at a 95 percent probability, 95 percent confidence level, if flooded with unborated water."

10 CFR Section 50.36(c)(4) requires, "Design features. Design features to be included are those features of the facility such as materials of construction and geometric arrangements, which, if altered or modified, would have a significant effect on safety and are not covered in categories described in paragraphs (c) (1), (2), and (3) of this section."

There are essentially two criticality analyses in the LAR, one from Holtec and another from AREVA. Any issue identified for the Holtec analysis should be considered for the AREVA analysis as well. All issues should be considered in a generic sense, rather than just the specifics mentioned.

The staff request responses to the following questions in order to continue its review of the LSCS Unit 2 SFP LAR.

1) The LAR indicates that if a Boraflex panel reaches a certain amount of degradation, it can no longer be credited for reactivity control and the cell associated with that panel is declared "unusable." The above introduction states that the licensee's request to add the requirement for unusable storage cells to be filled with a "blocking device" to the TS to be an "apparently simple" request. "Apparently simple" because the LAR considers the "blocking device" to be an infallible means of preventing a fuel misloading into an unusable cell. However, the "blocking device" is not a permanent installation such as welding or locking a barrier in place. Rather, the "blocking device" is a movable object, as mobile as a fuel assembly (FA), and subject to essentially the same administrative controls as the FAs. The staff considers the misloading of a FA into an incorrect location in the SFP to be a creditable accident scenario. A recent event occurred at a boiling-water reactor (BWR) plant where two fuel assemblies were misloaded during a refueling outage. The LAR does not provide any justification for why misloading a FA into a cell instead of a "blocking device" is not a creditable event. Explain why misloading a FA into a cell instead of a "blocking" device' is not a creditable event.

2) The LAR Attachment 1 states, "The fully loaded array of stored fuel assemblies is calculated to maintain K_{eff} less than or equal to 0.95 assuming the pool is filled with unborated water at 39.2°F, under both normal and abnormal conditions. Analyses have been performed for each type of fuel stored in the Unit 2 SFP to assure compliance with the K_{eff} requirement." However, both the Holtec criticality analysis in the LAR Attachment 3 (HI-2073758) and the AREVA NP, Inc. (ANP) criticality analysis in the LAR Attachment 4 (ANP-2684) indicate that, in the absence of Boraflex, the maximum reactivity occurs at higher temperatures. Explain this apparent contradiction.

3) The Technical Analysis in the LAR Attachment 1 states, "The ATRIUM-10 fuel assembly in the Attachment 3 criticality analysis also bounds legacy fuel types used at LSCS prior to ATRIUM-10. The limiting lattice at LSCS, with respect to margin to spent fuel pool criticality, is currently an ATRIUM-10 lattice from Unit 1 Cycle 13. Exelon has evaluated this lattice and determined that it is bounded by the 2.45 wt percent U-235 uniform enriched ATRIUM-10 no Gadolinium lattice modeled in the criticality analysis." This appears to be justified by a table showing the in-core k_{∞} of limiting lattices. As described, the values in the table appear to have been calculated in standard cold core geometry (SCCG). The table shows the 2.45 wt percent U-235 uniform enriched ATRIUM-10 no

Gadolinium lattice maximum SCCG k_∞ exceeding that of the SCCG k_∞ attributed to the limiting legacy FA.

However, ANP-2684 (LAR Attachment 4) Table 6.1 shows the 2.45 wt percent U-235 uniform enriched ATRIUM-10 no Gadolinium lattice maximum in-rack k_∞ to be at least 0.0135 Δk lower than the maximum Unit 1 Cycle 13 in-rack k_∞.

a) Since the in-rack k_∞ for the 2.45 wt percent U-235 uniform enriched ATRIUM-10, and no Gadolinium lattice is lower than the maximum Unit 1 Cycle 13 in-rack k_∞, how can the 2.45 wt percent U-235 uniform enriched ATRIUM-10 no Gadolinium lattice be limiting?

b) How do the in-core reactivity calculations translate to in-rack reactivity?

4) Based on the following excerpts from the LAR Attachment 1, the licensee's proposed identification and control of the 3-of-4 storage configuration appears to be inadequate. From the Interfaces Between Areas of 3-of-4 and 4-of-4 Storage section of the Technical Analysis of the LAR Attachment 1, the following controls are proposed to ensure the criticality analysis remains valid.

a) "Each cluster of four storage cells (i.e., 2x2) must meet either the criteria for 4-of-4 storage or the criteria for 3-of-4 storage."

b) "In each cluster of four storage cells (i.e., 2x2), if one storage cell is considered unusable (i.e., one or more of the four surrounding Boraflex panels is degraded beyond acceptable levels), then one of the four cells must contain a blocking device."

It is unclear how these controls will ensure the criticality analysis remains valid, as they could be satisfied with an arrangement that would leave a fuel assembly in the cell with the actual degraded Boraflex panels while having the empty cell be some other cell. This would allow the storage cells with the degraded Boraflex panels to be part of a 4-of-4 storage configuration with other fuel assemblies, a scenario the licensee has indicated does not meet their TS or 10 CFR 50.68. Explain why that would be acceptable.

5) It is not clear that all of the affected 2x2 arrays are being identified. A storage cell is not part of just one 2x2 array. Unless it is on the periphery, each storage cell is at the center of a 3x3 array which comprises four different 2x2 arrays. Additionally, from the description in the LAR, it appears that the Boraflex panels are shared by two cells, meaning the degradation of one panel actually affects two cells, creating a 4-by-3 array of cells with six separate 2x2 arrays. It is not clear whether the adjacent cell is also being identified as 'unusable' and its associated 2x2 arrays being controlled. Provide a description of how the affected 2x2 arrays are being identified and controlled so that the staff may make a reasonable assurance decision that all of the appropriate affected 2x2 arrays are being included.

6) The licensee is proposing the following requirement be added to TS 4.3.1.1 which states, "For Unit 2 only, a blocking device shall be installed in spent fuel storage rack cells that cannot maintain the requirements of 4.3.1.1.a." According to the LAR, a cell that has

even one degraded Boraflex panel, cannot maintain the requirements of 4.3.1.1.a. Eventually all SFP storage cells will have at least one degraded Boraflex panel. This proposed TS would require those cells to have blocking devices. This requirement would prevent the removal of the blocking device from a storage cell so that the storage cell could hold a FA. Explain how the 3-of-4 storage configuration is compatible with the proposed TS requirement.

7) Provide a rationale as to why none of the interface requirements or definitions are being placed into the LSCS TS. 10 CFR 50.36(d)(4) which states, "Design features to be included are those features of the facility such as materials of construction and geometric arrangements, which, if altered or modified, would have a significant effect on safety and are not covered in categories described in paragraphs (c) (1), (2), and (3) of this section." Provide a revised TS proposal that includes these items in the LSCS Unit 2 TS.

8) In the No Significant Hazards Consideration (NSHC) section of the Regulatory Analysis of the LAR Attachment 1, it indicates there is no possibility of a new or different kind of an accident from any accident previously evaluated stating, "This change does not create the possibility of a misloaded assembly into a blocked cell. Placing a spent fuel assembly into a location containing a blocking device is not a credible event since there are diverse and redundant administrative and physical barriers to prevent that." The NRC staff disagrees with this conclusion. The NRC staff does not view the use of typical SFP items such as "…e.g., fuel channel, blade guide, etc.…" as blocking devices and "…controls for movement of a blocking device that are similar to the controls that govern fuel movement…" to be sufficiently robust to preclude the misloading of a FA since misloadings do occur despite the controls that govern fuel movement. Additionally, the process as described in the LAR is dynamic in that it appears likely that the empty cell in the 3-of-4 storage configuration will change over time as different Boraflex panels are identified as degraded. Labeling cells as "unusable" when in fact they may be used in the 3-of-4 storage configuration is a misnomer and may lead to confusion with respect to the actual use of the cell and increase the possibility of a misloading event. Therefore, the NRC staff considers the misloading of a FA into a cell that is unusable as a creditable event and as an accident different from those previously evaluated at LSCS. Provide a revised NSHC that includes a misloaded fuel assembly as an accident not previously analyzed at LSCS.

9) In the Section 2.1, Code Validation, the Holtec criticality analysis states, "As stated, CASMO-4 was used for criticality calculations of tolerance and temperature effects. As proof of its acceptability in this application, CASMO-4 has been verified [3, 4] against Monte Carlo calculations and critical experiments." References 3 and 4 are not provided nor are they publicly available. There is no generic Topical Report for CASMO-4, for either in-core analyses or in-rack analyses. All current approvals for using CASMO-4 are based on a site specific acceptance. There was no site specific justification for using CASMO-4 provided. Therefore, the staff needs the following:

   a) LCSC site specific justification for using CASMO-4.

b) No code validation for the use of CASMO-4 was provided. It does not appear that CASMO-4 code bias and uncertainty were determined or applied. Provide these in accordance with references 2 and 3.

10) In the Section 4.0, Assumptions, the Holtec criticality analysis states, “To assure that the true reactivity will always be less than the calculated reactivity, the following conservative assumptions were made:”

One assumption is that, “Neutron absorption in minor structural members is neglected, i.e., spacer grids are replaced by water.” This appears to be incongruent with the subsequent statement in a later section that, “Therefore, MCNP-4A calculations were performed to verify that including the channel in the final analysis is conservative.” Both the conclusion that it is conservative to model the FA channeled and the assumption that it is conservative to not model the FA grids and end fittings appear to be balancing the absorption of structural components against increasing the amount of over moderation. Explain why both assumptions are conservative at the same time.

11) In Section 5.1, Fuel Assembly Specifications, of the Holtec criticality analysis, the vendor has used the ATRIUM-10 FA with a reactivity equivalent uniform enrichment of 2.45 w/o 235U as the limiting assembly. This is what is referred to as the reactivity equivalent fresh fuel enrichment (REFFE). The REFFE is intended to represent the maximum reactivity state. BWR fuel typically has higher enrichments than 2.45 w/o, but they also typically have Gadolinium burnable absorber included. As the Gadolinium depletes with burnup, the reactivity increases to a maximum. The REFFE equates the maximum reactivity of the Gadolinium depleted fuel with a low enriched fresh FA. Care must be used with the REFFE as changes in the model, such as using a REFFE determined in a 4-of-4 storage configuration in a 3-of-4 storage configuration, can create non-conservative results. NUREG/CR-6683, A Critical Review of the Practice of Equating the Reactivity of Spent Fuel to Fresh Fuel in Burnup Credit Criticality Safety Analysis for pressurized-water reactor (PWR) Spent Fuel Pool Storage, (Reference 5) addresses these concerns. The REFFE was provided by the licensee. The ANP criticality analysis in LAR Attachment 4 is the justification for the 2.45 wt percent U-235 uniform enriched ATRIUM-10 no Gadolinium lattice REFFE. It is not clear that these issues have been adequately addressed. Describe how this potential non-conservatism has been avoided.

12) In Section 7.1, Manufacturing Tolerances, of the Holtec criticality analysis discusses the uncertainties associated with manufacturing tolerances associated with the fuel assemblies and storage racks. The section states, in part, “To determine the Δk associated with a specific manufacturing tolerance, the reference k_{inf} was compared to the k_{inf} from a calculation with the positive and negative value of the tolerance included.” While this is the appropriate application of the tolerances to determine the reactivity uncertainty associated with the tolerances, this description is only applied to two of the dozen or so manufacturing tolerances which affect reactivity. Not all of the manufacturing tolerances which affect reactivity are discussed. The other tolerances, which are discussed, are lumped together in a single value in Table 7.2 with no discussion of where it came from, how it was derived, or its basis. Provide the

justification and basis for this value. Include sufficient detail for the staff to independently reach a reasonable assurance determination regarding its use.

13) The Holtec criticality analysis has no discussion about the burnup (BU) uncertainty. This is reasonable for the Holtec analysis as the REFFE is given to them by the licensee as an input and the REFFE is fresh fuel. The BU uncertainty should be included in determining the REFFE. But there is no discussion regarding BU in the ANP criticality analysis in LAR Attachment 4.

    It is not clear what uncertainties are included in the ANP criticality analysis in LAR Attachment 4. Provide the uncertainties that are included in the ANP criticality analysis.

14) Section 7.3, Effect of the Channel and Eccentric Fuel Positioning, of the Holtec criticality analysis discusses the uncertainties associated with the flow channel and eccentric positioning of the FA within a SFP storage cell.

    a) The nominal calculations have the FA centered in the cell. For the eccentric positioning determination the analysis states, "MCNP-4A calculations were made with the fuel assemblies assumed to be in the corner of the storage rack cell. These calculations indicate that eccentric positioning results in a decrease in reactivity." The discussion leaves out several pertinent details. Are they all pushed into the same corner? That would essentially keep the distance between them constant. Are they all pushed into the corner which brings them closest together? Since it is a 2x2 array modeled as infinite, even that essentially keeps the net separation the same. What if not all of the assemblies are pushed into the corner? Does it matter which ones are? What if the 3-of-4 storage configuration is surrounded by 4-of-4 storage configurations, or vice versa? Provide the necessary details for the staff to independently reach a reasonable assurance determination regarding eccentric fuel positioning.

    b) The analysis concludes that centering the fuel assemblies in the cells is the most reactive configuration. Since the channel takes up space in the cell it effectively reduces the amount of eccentricity that can be achieved by the model. Would increased eccentricity affect the conclusion? Are these independent parameters?

15) Section 7.4, Effect of Fuel Assembly Orientation, of the Holtec criticality analysis discusses whether the orientation of the FA in the storage cells affects the reactivity. The ATRIUM-10 FA is asymmetric, in that the water hole is off center. The nominal analysis orients the water hole in the same place for all cells. This portion of the analysis indicates that sensitivity studies were performed to determine whether or not this had an effect. Provide the results from the sensitivity studies.

16) Section 7.7, Abnormal and Accident Conditions, of the Holtec criticality analysis discusses which accidents are creditable and which are not.

    a) According to the analysis, dropping one FA on top of another may result in small compression of the bottom FA. It comes with this statement, "Such a vertical impact on an assembly would at most cause a small compression of the stored assembly, reducing the water-to-fuel ratio and thereby reducing reactivity." Elsewhere they have determined that hotter water is more reactive. Hotter water reduces the water-to-fuel ratio. Why is a reduction in water-to-fuel ratio more reactive for the temperature increase but less reactive for the FA compression?

b) There is no reactivity discussion associated with this accident, just the potential damage to the rack or FA. Why would this accident have no reactivity impact?

17) Section 7.8, Misloading a Fuel Assembly in a Location Intended to be Empty, of the Holtec criticality analysis discusses the reactivity affect of misloading a FA into a cell intended to have a blocking device. This section of the analysis shows that if a fuel assembly is loaded into a cell designated for a blocking device, then the regulatory requirement is exceeded.

a) Why is it creditable to drop a FA into an empty cell but not misload a FA into an empty cell?

b) As discussed previously, the staff considers misloading a fuel assembly in the SFP a creditable event. This analysis does not consider it a creditabe event. Explain why misloading a FA into a cell instead of a "blocking device" is not a creditable event.

18) Section 1.0, Introduction, of the ANP criticality analysis (ANP-2684) states, "Reference 1 contains an evaluation of the spent fuel storage pool of the LSCS Unit 2 Nuclear Power Station with AREVA NP Inc.* ATRIUM™-10† fuel assemblies in a repeated 2x2 array with one assembly removed (i.e., 75 percent checker-board loading) and no credit for Boraflex. The Reference 1 evaluation included the worst credible conditions and uncertainties." The analysis in ANP-2684 does not stand alone, rather it depends heavily on the work done in Reference 1, in several instances taking directly from the earlier work and applying them to the current work. As ANP-2684 develops the REFFE used in the Holtec analysis, ANP-2684 is essential to the review of the current LAR. Therefore, the information in ANP-2684 Reference 1 is critical for review of the current LAR. Provide ANP-2684 Reference 1.

19) The ANP criticality analysis indicates CASMO-4 was used for in-rack SFP storage rack analysis. ANP has a vendor specific topical report regarding the use of CASMO-4 for BWR analysis, EMF-2158 (P)(A), Revision 0, "Siemens Power Corporation Methodology for Boiling-Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2", Siemens Power Corporation, (Reference 6). This topical report is part of the LSCS list of approved methodologies. However, this topical report appears to be limiting to in-core analyzes.

a) Provide a LSCS site-specific justification for using CASMO-4 for SFP in-rack criticality analysis.

b) No code validation for the use of CASMO-4 was provided. It does not appear that CASMO-4 code bias and uncertainty were determined or applied. Provide these in accordance with References 2 and 3.

20) The ANP criticality analysis indicates there is no significant difference with the FA channeled or not. This is opposite to the conclusion drawn in the Holtec analysis for the same fuel assembly in the same configuration. Explain this difference.

21) The ANP criticality analysis makes no attempt to establish uncertainties as specified in references 2 and 3. As the ANP criticality analysis is determining the REFFE those uncertainties are important and can and will change with different fuel assembly parameters. Provide the uncertainties and their basis. Include sufficient detail for the staff to independently reach a reasonable assurance determination regarding each uncertainty.

22) The ANP criticality analysis makes no attempt to establish biases as specified in references 2 and 3. As the ANP criticality analysis is determining the REFFE, those biases are important and can and will change with different fuel assembly parameters. Provide the uncertainties and their basis. Include sufficient detail for the staff to independently reach a reasonable assurance determination regarding each uncertainty.

23) The ANP criticality analysis provides no evidence to support the conclusions in Items 5 and 6 of Table 2.1. Provide the evidence to support these conclusions. Include sufficient detail for the staff to independently reach a reasonable assurance determination.

24) The LAR does not describe how the limitations inherent in conclusions in Items 5 and 6 of Table 2.1 of the ANP criticality analysis are captured and controlled. These restrictions appear to be similar in function to burnup/enrichment loading curves that are included in PWR TSs. Explain how the proposed LSCS TS ensures these limitations are not exceeded.

25) Table 6.1 of the ANP criticality analysis indicates the maximum in-rack reactivity of lattice A10T-4444L-12G40 exceeds that of REBOL A10B-245L-0G0 and A10B-245L-0G0. How can the ATRUIM-10 2.45 uniform planar enrichment with no gadolinium be limiting?

26) Describe the process used to determine that fuel assemblies have attained proper BU for storage in the BU dependent racks.

27) Describe the process used to control movement of items within the SFP.

<u>REFERENCES</u>

1. Exelon Generation Company, LLC, Patrick R. Simpson, Manager-Licensing, LaSalle County Station, to USNRC document control desk, re: "License Amendment Request Regarding Spent Fuel Storage Pool Criticality," December 13, 2007. (ADAMS Accession No. ML073511781).

2. NRC Memorandum from L. Kopp to T. Collins, Guidance on the Regulatory Requirements for Holtec criticality analysis of Fuel Storage at Light-Water Reactor Power Plants," August 19, 1998. (ADAMS Accession No. ML003728001).

3. Nuclear Regulatory Commission, Letter to All Power Reactor Licensees from B. K. Grimes. OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications. April 14, 1978, as amended by letter dated January 18, 1979.

4. U.S. NRC letter to Duke Energy Corporation “FINAL SAFETY EVALUATION FOR DUKE TOPICAL REPORT DPC-NE-1005P”, “NUCLEAR DESIGN METHODOLOGY USING CASMO-4/SIMULATE-3 MOX” dated August 20, 2004 (ADAMS Accession No. ML042370178).

5. NUREG/CR-6683, A Critical Review of the Practice of Equating the Reactivity of Spent Fuel to Fresh Fuel in Burnup Credit Criticality Safety Analysis for PWR Spent Fuel Pool Storage, September 2000, (ADAMS Accession No. ML003751298).

6. EMF-2158 (P)(A), Revision 0, "Siemens Power Corporation Methodology for Boiling-Water Reactors: Evaluation and Validation of CASMO-4/MICROBURN-B2", Siemens Power Corporation, October 1999.