RAS 1617

March 29, 2000

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT	)	Docket No. 50-400 -LA
(Shearon Harris Nuclear	)	ASLBP No. 99-762-02-LA
Power Plant)	)	
	)	

ORANGE COUNTY'S RESPONSE TO BOARD'S INFORMATION REQUEST

Introduction

Pursuant to the Board's Memorandum and Order (Requesting Additional Information) (March 21, 2000), Orange County hereby submits its views regarding the relevance of a recent NRC Staff draft study to the environmental issues raised by Orange County in this proceeding. The study, NRC Staff's Draft Final Technical Study of Spent Fuel Accident Risk at Decommissioning Plants ("Draft Study"), was noticed at 65 Fed. Reg. 8,752 (February 22, 2000). This response is supported by the Declaration of Dr. Gordon Thompson in Support of Orange County's Response to Board's Information Request (March 24, 2000), which is attached as Exhibit 1.

As discussed below, the Draft Study has limited relevance to the County's environmental contentions, but supports those contentions in important respects. The Draft Study narrowly focuses on the evaluation of spent fuel pool accidents that could occur during decommissioning, after a nuclear reactor has ceased operating. In contrast, the County's concerns relate to the accident risk when fuel pools -- specifically, Harris pools C and D -- operate in close proximity to an operating reactor and other fuel pools.

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SECY-02

Moreover, the Draft Study's analysis of the risks of spent fuel pool drain-down accidents is seriously deficient, principally because it ignores the phenomena associated with partial exposure of fuel assemblies. By ignoring these phenomena, the Draft Study significantly underestimates the overall risks of spent fuel pool accidents.

Despite its limitations, the Draft Study confirms the County's position in several key respects. First, the Study confirms that the consequences of a spent fuel pool accident could be catastrophic, causing significant and long-term health and environmental damage over a huge geographic area. Second, it is clear from the Draft Study that there are key aspects of spent fuel pool accident behavior that have yet to be properly investigated. This lack of complete information precludes any confident assertion that the risk of a spent fuel pool accident is too remote to warrant close investigation in an Environmental Impact Statement ("EIS"). Third, the Draft Study acknowledges the availability of an alternative that would completely avoid the risk of a fuel pool accident: dry cask storage. Although there may be disagreement regarding the likelihood of a spent fuel pool accident, it is sheer folly to ignore an alternative that would completely eliminate the risk of such a massive catastrophe.

DISCUSSION

A. Draft Study's Scope Gives It Limited Relevance

The Draft Study has limited relevance to the environmental contentions raised by Orange County, because it addresses the risks of spent fuel pool accidents in a plant that is being decommissioned, *i.e.*, where the reactor has been permanently shut down. Thus, the Draft Study does not address several features of an operating nuclear power plant that are relevant to the evaluation of risk at Harris.

First, the Draft Study does not address the relationship between degraded-core reactor accidents and the potential for severe accidents in fuel pools. An accident scenario of concern to Orange County involves a degraded-core reactor accident followed by a period during which the plant is inaccessible due to high radiation levels. As discussed in Contention EC-1 at pages 8-9, loss of water from the spent fuel pools by evaporation is virtually inevitable under these circumstances. During the process of evaporation, there will be a period when the fuel assemblies are partially exposed. There is a high probability that partial or total exposure of the fuel assemblies will lead to a runaway exothermic reaction (fire) in the pools.

Second, although the Draft Study gives some attention to the potential for propagation of exothermic reactions from "younger" fuel to "older" fuel, it does not make a thorough study of the accident risks at an operating plant, where a significant supply of younger fuel is always present. [1]

Third, although the Draft Study discusses some scenarios for criticality accidents, it does not address the risk of a criticality accident that arises from the placement of low-burnup fuel assemblies in a pool where the licensee relies on credit for burnup to prevent criticality. This class of event may be the most significant contributor to the risk of a criticality accident at the Harris plant. Thus, the Draft Study's conclusion that the risk of a criticality accident is "sufficiently small" (*see* page A3-1) does not take into consideration key characteristics of the Harris nuclear power plant.

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[1] Here "younger" and "older" refers to the age of spent fuel after its discharge from a reactor.

B. The Draft Study Is Flawed.

The Draft Study has significant inadequacies with respect to the comprehensiveness of its treatment of a subject it purports to evaluate, *i.e.*, the risk of zirconium fires in decommissioning nuclear power plants. Most significantly, the Draft Study completely overlooks the implications of partial drainage of a pool. This omission is illogical, given that a state of partial drainage would always occur *before* a state of total drainage, and must be considered as an inevitable link in the chain of events involving loss of water from a spent fuel pool. The state of partial drainage should be examined thoroughly because it has different characteristics than a state of total drainage: (1) older fuel is more vulnerable to ignition in a state of partial drainage than in a state of total drainage, because convective heat transfer is suppressed by the presence of residual water at the base of the fuel assemblies (*see* Thompson Report at page D-6); (2) partial drainage will lead to a steam-zirconium reaction rather than the air-zirconium reaction that will occur following total drainage (*see id.* at page D-6.); and (3) a steam-zirconium reaction during partial drainage will produce hydrogen gas which could reach explosive concentrations in the atmosphere of the fuel handling building, potentially leading to a breach in that building (*see id.* at page D-1).

The County notes that its expert, Dr. Gordon Thompson, commented on the lack of a discussion of partial drain-down in an earlier version of the Draft Study that was issued in the summer of 1999. *See* letter from Gordon Thompson to Richard F. Dudley (September 30, 1999), attached as Exhibit 2. The Draft Study does not directly respond to Dr. Thompson's letter, but mentions the raising of the partial drain-down issue by an

un-named stakeholder. *Id.* at page A7-3. The Draft Study also claims to have addressed the partial drain-down issue as follows:

> The staff has also considered a scenario with a rapid partial draindown to a level at or below the top of active fuel with a slow boiloff of water after the draindown. This could occur if a large breech (sic) occurred in the liner at or below the top of active fuel. Section 5.1 of NUREG/CR-0649 analyzes the partial draindown problem. For the worst case draindown and a lower bound approximation for heat transfer to the water and the building the heatup time slightly less than the heatup time for the corresponding air cooled case. More accurate modeling could extend the heatup time to be comparable to or longer than the air cooled case.

Id. at page A1-9. In fact, NUREG/CR-0649 constitutes the *only* report in which the NRC Staff has ever looked at the issue of partial drainage. As discussed in the Thompson Report at pages D-7 and D-8, NUREG/CR-0649 is deficient in its treatment of the partial drainage case, but nevertheless supports Dr. Thompson's concerns.

NUREG/CR-0649 used a crude heat transfer model. It did not analyze radiative heat transfer along the axis of a fuel assembly. Therefore, it could not estimate the maximum cladding temperature, which would occur in the mid-height region of the exposed portion of the fuel rods. Also, it did not consider the steam-zirconium reaction, or address the potential for propagation of exothermic reactions to nearby assemblies. Finally, it assumed a larger center-center distance (13 inches) than would exist for PWR fuel in Harris pools C and D (9 inches). Nevertheless, NUREG/CR-0649 clearly shows that a state of partial drainage would be more conducive to the initiation of a runaway exothermic reaction than a state of total drainage. Correction of the analytic deficiencies in NUREG/CR-0649 would make this effect even more prominent.

The Draft Study is also inadequate with respect to its discussion of spent fuel pool accident consequences. The Draft Study acknowledges that zirconium fires in spent fuel

pools can have very severe consequences because they may involve releases from multiple reactor cores. *See id.* at 2, 3, 6. However, the Draft Study implies that the consequences of a spent fuel pool accident would ultimately be less than those of a reactor accident because there would be a long lead time to initiate and implement protective responses, including offsite responses such as evacuation and relocation of populations.[2] *Id.* at 30. This suggestion that the consequences of a spent fuel pool accident can be resolved by a leisurely evacuation ignores the fact that the consequences of a severe fuel pool accident include long-term contamination of a very large land area. The Draft Study completely sidesteps the question of where all the people who are relocated will be able to go for the decades that must pass while the land where they live recovers from radioactive contamination. This issue is graphically illustrated by the consequences of the Chernobyl accident, which rendered huge land areas uninhabitable and unsuitable for agriculture for an extended period of time.

In addition, the Staff does not explain the regulatory basis for its assumption of a threshold dose for relocation of 4 rem over a period of 5 years. Draft Study at A4-6. The Reactor Safety Study used, for rural areas, a lower threshold of 10 rem over a period of 30 years. *See* Thompson Report at page E-3. Dose rates at either level would produce a significant increase in cancer mortality in exposed populations. *See* Thompson Report at page E-5. Finally, the Draft Study fails entirely to address the social and economic

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[2] It is important to note that an assumption in the Draft Study -- namely that there is plenty of time for response measures following a loss of cooling to a spent fuel pool at a decommissioned nuclear plant -- would not be valid for in-plant response measures at an operating nuclear plant if a degraded-core reactor accident, with containment failure or bypass, were to occur. The high radiation fields that would immediately follow this event

implications of losing the use of thousands of square kilometers of land for several generations.

C. The Draft Study Acknowledges Significant Information Gaps.

There are a number of significant areas in which the Draft Study concedes that the NRC Staff lacks complete information regarding the risks of severe spent fuel pool accidents. Among the more stunning of these admissions is the Staff's statement that it "has not performed a sufficient amount of research to fully understand and predict the propagation of zirconium fires in a spent fuel pool." *Id.* at A1-9. Other similar admissions regarding significant information gaps abound. *See, e.g.*, Draft Study at A1-1 (lack of any realistic evaluation of melting and relocation of aluminum or aluminum/boron carbide eutectic); A1-4 (SHARP code used to calculate critical decay times "not significantly benchmarked, validated or verified"); A1-4 ("[m]any assumptions and modeling deficiencies exist in the current calculations" regarding spent fuel heatup); A1-5 (calculations performed "to date" assume that building, fuel and rack geometry remain intact, which may not be valid after the onset of zirconium oxidation); A1-5 (effects that inhibit air flow are not adequately modeled by available studies); A1-6 (important assumptions about air flow mixing are suspect); A3-1 (due to "processes involved and lack of data," it was "not possible to perform a quantitative risk assessment for criticality in the spent fuel pool").

Given the number, range and significance of the areas in which the Staff's understanding of spent fuel pool accidents is admittedly incomplete, spent fuel pool

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would preclude the implementation of in-plant response measures such as supplying water makeup to fuel pools.

accidents cannot justifiably be ruled out as remote and speculative events. These uncertainties and information gaps further demonstrate, in addition to the information provided in the County's contentions, that there are material factual disputed issues regarding the likelihood of a spent fuel pool accident. These disputed issues demand thorough examination in the context of a hearing.

D. Despite Its Limitations, the Draft Study Supports the County's Position in Important Respects

Despite its limited relevance and analytical inadequacies, the Draft Study does support the County's position in some significant respects. First, the Study acknowledges that "the consequences of a zirconium fire in a decommissioning plant can be very large."[3] *Id.* at 2. It also acknowledges that zirconium fires in spent fuel pools "potentially have more severe long term consequences than an operating reactor core damage accident, because there may be multiple cores involved, and because there is no containment surrounding the SFP to mitigate the consequences." *Id.* at 6.

The Draft Study confirms that the relationship between the age of fuel and the likelihood of a zirconium fire, given a loss of water, must be examined on a "case specific basis," and finds that the decay time required to preclude ignition may be as long as five years. *Id.* at 2. This estimate is for total drainage. For the same situation, Dr. Thompson makes an interim estimate of 3 years for Harris pools C and D. In this instance he is less conservative than the NRC Staff.

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[3] For instance, the Draft Study confirms that the consequences of a fuel pool accident could include thousands of cancer fatalities. For example, Table A4-7 indicates that about 26 thousand cancer fatalities, within a 500-mile radius, could be attributed to a hypothetical fuel pool accident at a generic site.

In addition, the Draft Study supports the County's concern regarding the potential for propagation of exothermic reactions from younger to older fuel.[4] *See* Draft Study at A1-1, Thompson Report at D-7. The Draft Study also shows that an increase in temperature of the atmosphere in the fuel handling building will increase the age at which fuel will ignite following pool drainage. This is a mechanism whereby a fire in Harris pools A and B could make the ignition of fuel in pools C and D more likely. *Id.* at A1-3. These effects call into question the NRC Staff's argument in opposition to the admission of Contention EC-1 that aged fuel is not subject to exothermic reaction. *See* NRC Staff's Response to Intervenors' Request for Admission of Late-Filed Environmental Contentions at 22 (March 3, 2000).

Finally, and perhaps most importantly, the Draft Study acknowledges that the use of dry cask storage largely eliminates the risk of a zirconium fire, "by limiting the maximum fuel cladding temperature and minimizing the oxygen available." *Id.* at 2, note 1. Given the significant admitted uncertainties and information gaps in the NRC Staff's understanding of spent fuel pool accidents, given the relationship between degraded reactor core accidents and spent fuel pool drain-down events that is demonstrated in the Thompson Report, and given the potentially catastrophic consequences of a severe spent fuel pool accident, there is no rational justification for refusing to consider the dry cask storage alternative in the context of an Environmental Impact Statement.

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[4] The Draft Study notes that the propagation of a fire from younger to older fuel may occur not only by direct heat transfer, but also as a result of flow blockage caused by a loss of structural integrity in boral plates or racks. In this regard, it is notable that the Draft Study admits the lack of any "realistic evaluation of melting and relocation of aluminum or aluminum/boron carbide eutectic." Draft Study at A1-1.

CONCLUSION

As discussed above, the Draft Study has significant limitations and deficiencies that prevent it from being relied on for the purpose of dismissing Orange County's environmental contentions. In some significant respects however, it confirms Orange County's concerns and supports the admissibility of the County's contentions.

Respectfully submitted,

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March 29, 2000

EXHIBIT 1

March 24, 2000

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
CAROLINA POWER & LIGHT	)	Docket No. 50-400 -LA
(Shearon Harris Nuclear	)	
Power Plant)	)	
	)	

DECLARATION OF DR. GORDON THOMPSON IN SUPPORT OF ORANGE COUNTY'S RESPONSE TO BOARD'S INFORMATION REQUEST

I, Gordon Thompson, declare as follows:

1. I am the executive director of the Institute for Resource and Security Studies (IRSS), a nonprofit, tax-exempt corporation based in Massachusetts. On January 31, 2000, I submitted a declaration of my expert opinion in support of Orange County's environmental contentions in this proceeding.

2. I participated in the preparation of Orange County's Response to Board's Request for Information, which is to be filed on March 29, 2000. The technical factual statements in that Response are true and correct to the best of my knowledge, and the technical opinions expressed therein are based on my best professional judgment.

3. If Orange County's environmental contentions are admitted, I am prepared to testify as an expert witness regarding the information and opinions provided in the Response.

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I declare, under penalty of perjury, that the foregoing facts provided in my Declaration are true and correct to the best of my knowledge and belief, and that the opinions expressed herein are based on my best professional judgment.

Executed on 24 March 2000.

G. R. Thompson

Gordon Thompson

EXHIBIT 2

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30 September 1999

Richard F Dudley
Senior Project Manager, Decommissioning Section
Project Directorate IV and Decommissioning
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Office of Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Mr Dudley:

Re: Spent Fuel Pool Accidents

I write to comment upon Enclosure #2 to your 17 June 1999 memorandum titled "Summary of Meeting with the Nuclear Energy Institute". Enclosure #2 was titled "Draft Technical Study of Spent Fuel Pool Accidents for Decommissioning Plants".

This Draft Technical Study is deficient in at least two respects. First, it does not address the implications of partial drainage of a spent fuel pool. Second, it does not address the potential for an exothermic reaction between steam and zirconium. Both deficiencies are significant, and must be corrected if this Study is to provide useful guidance for regulatory action.

Please find enclosed a report which provides information on the implications and significance of partial drainage and the steam-zirconium reaction in connection with spent fuel pool accidents (see especially Appendices C, D and E). This report addresses an operating nuclear power plant (the Harris plant), but many of its findings are relevant to spent fuel pools at nuclear power plants which have been shut down.

If you and your colleagues wish to discuss the implications and significance of partial drainage and the steam-zirconium reaction, I would be pleased to do so.

I would like to be informed about future meetings that relate to the safety of spent fuel pools.

Thank you for your attention.

Sincerely,

G. R. Thompson

Gordon Thompson
Executive Director

Enclosure: "Risks and alternative options associated with spent fuel storage at the Shearon Harris nuclear power plant", a report prepared by Gordon Thompson for Orange County, NC, February 1999

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CAROLINA POWER & LIGHT	)	Docket No. 50-400 -OLA
(Shearon Harris Nuclear	)	ASLBP No. 99-762-02-LA
Power Plant)	)	
	)	

CERTIFICATE OF SERVICE

I certify that on March 29, 2000, copies of the foregoing ORANGE COUNTY'S RESPONSE TO BOARD'S INFORMATION REQUEST were served on the following by e-mail and/or first class mail as indicated below:

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