From: Diane Curran <dcurran@harmoncurran.com> NRC
To: Alice Gordon <Gordonam@mindspring.com>, "G. Paul B... Board members & Parties
Date: Tue, Feb 20, 2001 10:30 AM
Subject: Comments on Technical Study

Dear Board and parties,
I am enclosing a cover letter and set of comments I sent to the NRC Commissioners today regarding its consideration of the NRC Staff's Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants.
Sincerely, Diane Curran

Cover Ltr.
Concerns.
1. Phenomenology of fire progress
2. Report does not consider land contamination & other impacts of (Relocation) SFP Fire.

Wants complete SFP study so that other methods of SF storage can be compared on valid risk/cost basis.

F/17

February 20, 2001

BY FAX

Richard A. Meserve, Chairman
Greta Joy Dicus, Commissioner
Nils J. Diaz, Commissioner
Edward McGaffigan, Jr., Commissioner
Jeffrey S. Merrifield, Commissioner
U.S. Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, Maryland

SUBJECT: *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants*

Dear NRC Commissioners:

On behalf of the Institute for Resource and Security Studies and the government of Orange County, North Carolina, I am enclosing a set of comments by Dr. Gordon Thompson regarding a recent report by the NRC Staff, *Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants* (October 2000). The comments are entitled *Comments on the NRC Staff's Technical Study of Spent Fuel Pool Accident Risks at Decommissioning Nuclear Power Plants* (February 19, 2001). We ask you to consider Dr. Thompson's comments in your meeting today regarding the NRC Staff report.

We are concerned that the report has major deficiencies, which should be addressed before the Commission relies on it for any regulatory decisions regarding high-density pool storage of spent nuclear power plant fuel. In particular, we are concerned that this report should not be relied on inappropriately for any regulatory decisions affecting the proposed expansion of spent fuel storage capacity at the Shearon Harris nuclear power plant. The Atomic Safety and Licensing Board is now in the process of deciding whether to grant a full evidentiary hearing on an environmental contention regarding spent fuel pool accident risks at Harris, and we anticipate that the Staff's study may be relevant in any hearing that is granted.

As discussed in Dr. Thompson's comments, the NRC Staff report shows an improved but incomplete understanding of the phenomena associated with a pool fire. The Staff now recognizes the significant implications of partial drainage of spent fuel pools. However, the Staff has not fully addressed this phenomenon. *See* Comments, Section 3.

In addition, the Staff seriously understates the potential impacts of a spent fuel pool fire. The Staff's study makes calculations regarding numbers of prompt fatalities and cancer fatalities, based on the assumptions that (a) people will be relocated if the projected dose to an individual exceeds four rem over five years; and (b) that they will return at a time when the projected dose for the five years after return is less than four rem. As presented by the report, "relocation" would be more aptly referred to as "disappearance." The report simply assumes that people in the area of a spent fuel pool release would disappear when radioactivity levels were high, and re-appear again when radioactivity declined to an acceptable level. The report contains no discussion whatsoever of the reasons for the relocation, *i.e.*, the impacts of radioactive contamination of a large land area, including contamination of agricultural land and water supplies; the forced abandonment of farms, factories and houses; or the economic and social upheaval caused by relocating large numbers of people. As Dr. Thompson points out, a spent fuel pool release would be a national disaster of historic proportions. *See* Comments at Sections 4, 5, and 6. Members of the public who live in the vicinity of high-density spent fuel storage pools are entitled to a much more candid and complete assessment of the risks they face. Moreover, an accurate assessment of the potential impacts of spent fuel pool fires is an essential tool for comparing the relative merits of other fuel storage technologies such as dry storage, which may cost more in dollars but would eliminate the risks of large-scale radioactive releases.

High-density spent fuel pool storage is one of the most common ways that nuclear power plant licensees are coping with their mounting inventory of spent fuel. Inquiry by the NRC Staff into the risks of this storage technology is an overdue and welcome event. However, in its present form, the Staff's study is seriously deficient. We urge you to require the Staff to continue its work on this issue and to perform a more thorough and accurate study.

Sincerely,

Diane Curran

Cc: Service list for Harris license amendment proceeding
Dr. Gordon Thompson
Orange County Commissioners

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COMMENTS ON THE NRC STAFF'S
TECHNICAL STUDY OF SPENT FUEL POOL
ACCIDENT RISK AT DECOMMISSIONING
NUCLEAR POWER PLANTS

by Gordon Thompson
19 February 2001

1. Introduction

In January 2001, the US Nuclear Regulatory Commission (NRC) released to the public a report, dated October 2000, that was prepared by the NRC Staff.[1] The report addresses the risk posed by storage of spent fuel in pools at nuclear power plants that are no longer licensed to operate (i.e., decommissioning plants). The NRC Commissioners have scheduled a public meeting for 20 February 2001, at which the report will be discussed.

Here, the Institute for Resource and Security Studies (IRSS) provides selected comments on the Staff's report. IRSS has a longstanding interest in the risk posed by high-density storage of spent fuel in pools. Since early 1999, IRSS has been assisting Orange County, North Carolina, in its intervention in license amendment proceedings related to activation of spent fuel pools at the Harris nuclear power plant.[1]

2. Pool fires and their context

The Staff's report indicates that the accident risk associated with a spent fuel pool arises from the potential for the zirconium cladding of the fuel to burn if water is lost from the pool. However, the report lacks a clear summary of the factors that have created the potential for a pool fire and the phenomena that would accompany a fire. This lack reflects the Staff's piecemeal and incomplete approach to the problem of pool risk.

The potential for a pool fire arises because the NRC has allowed plant licensees to adopt high-density storage of spent fuel in pools. When the present generation of nuclear plants first entered service, spent fuel pools employed low-density racks. If water were lost from such a pool, the fuel cladding would ignite only in rare conditions. By contrast, if water is lost from a high-density pool, the fuel cladding will ignite in most conditions. Contrary to NEI/Piazq ves

High-density pool storage is used because it is a comparatively cheap option. Dry storage offers a proven alternative but is more expensive. Thus, the risk of a pool fire is almost completely avoidable. This risk exists because licensees are unwilling to bear the cost of avoiding the risk, and because the NRC has allowed licensees to create the risk.

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1 Timothy Collins et al (authors are all from the NRC Staff), Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants, October 2000.
1 Two reports prepared by IRSS in support of Orange County's intervention are: (a) Gordon Thompson, Risks and Alternative Options Associated with Spent Fuel Storage at the Shearon Harris Nuclear Power Plant, February 1999; and (b) Gordon Thompson, The Potential for a Large, Atmospheric Release of Radioactive Material from Spent Fuel Pools at the Harris Nuclear Power Plant: The Case of a Pool Release Initiated by a Severe Reactor Accident, 20 November 2000.

The potential for a pool fire exists at operating plants as well as decommissioning plants. Indeed, the risk of a pool fire is greater at operating plants, for two reasons. First, operating plants always have a significant inventory of recently-discharged fuel which is more prone to ignition, given a loss of water, than older fuel. Second, there are potential interactions between operating reactors and adjacent spent fuel pools, whereby an accident at the reactor could lead to a pool fire or vice versa.

Since the late 1970s the NRC has released a number of reports that have addressed the potential for a pool fire at operating and decommissioning plants. These reports have been incomplete and technically deficient in a variety of ways, some of which are discussed in these comments. The Staff's latest report, to which these comments are directed, has corrected some, but not all, of the technical deficiencies in previous reports, and is incomplete in its analysis of pool risk.

3. Evolution of the Staff's understanding of pool fires

For two decades the Staff and its consultants assumed that the most severe case of loss of water from a spent fuel pool would be a total, instantaneous loss of water. That assumption has distorted and rendered incomplete every NRC analysis of pool accident risk until the Staff's latest report, which partially addresses the implications of a loss of water that is not total and instantaneous.1

Many scenarios for water loss from a pool would involve a comparatively slow loss of water, through either evaporation or leakage. Also, personnel could attempt to provide makeup water. Thus, at particular phases of a water-loss scenario the water level could be falling, rising or static. The fuel could be exposed to air along all or part of its height for varying periods of time.

In its latest report, the Staff recognizes that the flow of air to exposed fuel assemblies could be blocked by collapsed structures (as as result of a cask drop or an earthquake) or the presence of residual water. The Staff analyzed the heat transfer implications of flow blockage and concludes:1

> "While the February 2000 [draft] study indicated that for the cases analyzed a required decay time of 5 years would preclude a zirconium fire, the revised analyses show that it is not feasible, without numerous constraints, to define a generic decay heat level (and therefore decay time) beyond which a zirconium fire is not physically possible."

This conclusion represents an advance in the Staff's understanding of pool fires. However, the Staff has failed to analyze all of the implications of flow blockage for the onset and progression of a pool fire. Consider three examples. First, the role of residual water in blocking air flow has important implications for accident management, because there would be many scenarios in which the addition of water to a pool undergoing draining or evaporation would make the situation worse. Second, heatup of fuel that is partially submerged in water could lead to a fire that involves not a zirconium-air reaction but a zirconium-steam reaction, yielding hydrogen gas that could accumulate to explosive concentrations in surrounding buildings. Third, flow blockage could play an important role in the propagation of a fire from comparatively recently-discharged fuel to older fuel, because a fire in recently-discharged fuel could lead to debris falling to the base of the pool, thereby blocking air flow to nearby fuel channels.

The Staff has never made a systematic study of the potential for a reactor accident to cause a pool accident, the potential for a pool accident to cause a reactor accident, or the potential for a pool accident to cause another pool accident. The first two potentials are important for operating plants, while the third potential is important for operating or decommissioning plants that have more than one pool.

In the Harris license amendment proceedings, the Staff and the licensee, Carolina Power and Light (CP&L), have proffered analyses and arguments about the potential for a degraded-core accident at the

1 A brief review of previous NRC analyses is provided in: Thompson, 1999, Appendix D.
1 Collins et al, 2000, page 2-1.

Harris reactor to cause a pool fire. The Staff and CP&L both argue that the probability that a reactor accident will cause a pool fire is very low, although neither party supports its argument with the scope and level of analysis that is currently expected of a probabilistic risk assessment (PRA) for a nuclear power plant. Interestingly, CP&L and the Staff both assume that a fire at one of the Harris pools would inevitably cause a fire at the other Harris pools.1

Orange County has proffered an analysis of selected degraded-core accident sequences at the Harris reactor, concluding that these selected sequences would cause a pool fire.1 This analysis does not purport to be exhaustive, and Orange County has called for a comprehensive analysis of the risk of a pool fire at Harris, using best-practice PRA techniques.

A comprehensive analysis of pool accident risk would include a thorough assessment of the offsite consequences of a pool fire. The Staff has never made a thorough assessment of offsite consequences, as discussed in Section 4, below.

4. The Staff's analysis of the offsite consequences of a pool fire

In the report under review here, the Staff provides a limited analysis of offsite consequences.1 The Staff used the MACCS code to perform this analysis. The analysis assumed the occurrence of a pool fire either 30 days, 90 days or 1 year after the last discharge of spent fuel into the pool. A radionuclide release fraction (fraction of fuel inventory released to the atmosphere) of 100 percent was assumed for noble gases, iodines and cesiums, with smaller release fractions for other radionuclide groups. The assumed pool inventory of radionuclides included 20 million Curies of cesium-137.

For an assumed offsite population distribution, the MACCS code was used by the Staff to calculate the number of prompt fatalities and cancer fatalities, and the societal dose (in person-Sv). However, in these calculations the population in a sector was assumed to be relocated if the projected dose to an individual in that sector exceeded 4 rem over 5 years, and the relocated population was assumed to be returned at a time when the projected dose for the 5 years after return was less than 4 rem.

The Staff provides no estimate of the number of people relocated or the period for which they would be relocated. Nor does the Staff provide any estimate of the area of land that would be contaminated to a degree such that the population would be relocated from that land. The Staff's estimates of cancer fatalities and societal dose reflect an assumption that the relocated persons would receive, during their period of relocation, no radiation dose attributable to the pool fire.

By ignoring the issues of land contamination and population relocation, and their attendant impacts, the Staff has failed to address highly signifcant impacts of a pool fire. As a result, the Staff's report does not provide a credible basis for decision making on policy or regulatory issues.

5. Land contamination from a pool fire

An indication of the extent of land contamination that could be caused by a pool fire is provided by an analysis that IRSS has performed, to estimate the area of land that would be contaminated by cesium-137 following a pool fire at the Harris plant.1 The analysis drew upon calculations by Jan Beyea using a straight-line Gaussian plume model. The threshold of contamination in these calculations was a whole-body groundshine dose of 10 rem over 30 years, assuming a shielding factor of 0.25.

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1 At the Harris plant, four pools are located in one fuel handling building. Two pools, at one end of the building, are now licensed for use. CP&L seeks a license amendment so that it can activate two hitherto-unused pools at the other end of the building.
1 Thompson, 2000.
1 Collins et al, 2000, Appendix 4.
1 Thompson, 1999, Appendix E.

At the Harris plant, a release of 20 million Curies of cesium-137 -- the release of cesium-137 that is assumed in the Staff's report -- would represent the inventory of cesium-137 in spent fuel aged up to 3 years. The inventory of cesium-137 in spent fuel aged up to 9 years would be 70 million Curies.

A release to the atmosphere of 20 million Curies of cesium-137 would -- in typical meteorological conditions -- contaminate 50,000-60,000 square kilometers of land. A release of 70 million Curies would contaminate about 150,000 square kilometers of land, an area slightly larger than the area of North Carolina.[1]

If people were not relocated from the contaminated area, they would receive a whole-body groundshine dose, from deposited cesium-137, that would exceed 10 rem over 30 years. Radionuclides other than cesium-137 would cause some additional exposure. Ingestion of cesium-137 in contaminated food and water would -- unless food and water were supplied entirely from outside sources -- cause an additional radiation exposure that could be of a magnitude comparable to the groundshine dose from deposited cesium-137.

A groundshine dose of 10 rem over 30 years was used in the 1975 Reactor Safety Study (WASH-1400) as a threshold for relocation of populations from rural areas. A relocation threshold of 25 rem over 30 years was used for urban areas, to reflect the assumed greater expense of relocating urban inhabitants.

The public health implications of radiation doses of this magnitude can be estimated using the findings of the BEIR V study.[1] One finding was that a continuous lifetime exposure of 0.1 rem per year will yield a 2.5 percent excess of cancer mortality for males and a 3.4 percent excess for females.[1]

Thus, one can say that the populations who receive a groundshine dose just below 10 rem over 30 years -- and who therefore would not qualify for relocation -- could experience an excess of cancer mortality -- an increase above the normal expectation -- of roughly 10 percent.[1] The normal expectation of cancer mortality -- the fraction of the population who die of cancer -- in a typical US population is about 21 per hundred for males and 18 per hundred for females. The excess cancer mortality due to radiation can be regarded as a reduction in the lifespan of an affected person, with an average reduction in lifespan of about 17 years per excess death.[1] Thus, a 10 percent excess of cancer mortality would mean, on average, that about 2 persons per hundred would have their lifespans reduced by about 17 years.

In other words, a pool fire could lead to the relocation of populations from an area of tens of thousands of square kilometers. The affected area could be larger than the area of North Carolina. The farms, factories and houses in the affected area would be abandoned for decades, and the inhabitants would be obliged to make new lives elsewhere. Populations in the surrounding area, who would not be relocated, could experience an excess of cancer mortality of up to 10 percent. The use of a little imagination shows that this event would be a national disaster of historic proportions, with major impacts of a social, economic and political nature.

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1 The total area of North Carolina is 136,000 square kilometers, and the state's land area is 127,000 square kilometers (Thompson, 1999, page E-4).

1 National Research Council, Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V (Washington, DC: National Academy Press, 1990).

1 Ibid, Table 4-2.

1 A cesium-137 groundshine dose of 10 rem over 30 years represents an average dose of 0.33 rem per year. The dose rate falls exponentially due to weathering and the decay of cesium-137, whose half-life is 30 years. Additional doses would arise from ingestion and from radionuclides other than cesium-137. Table 4-2 of the BEIR V study (op cit) shows that a lifetime exposure of 0.1 rem per year will yield an excess of cancer mortality of 2.5 percent for males and 3.4 percent for females. The relationship between annual dose and aggregate mortality is approximately linear. Thus, one can say -- for purposes of illustration -- that a groundshine dose of 10 rem over 30 years will be associated with an excess of cancer mortality of roughly 10 percent.

1 BEIR V study (op cit), Table 4-2.

6. NRC safety goals

In 1986 the NRC issued its "Policy Statement on Safety Goals for the Operation of Nuclear Power Plants". The safety goals articulated in that policy statement -- together with the quantitative health objectives (QHOs) that the NRC uses to determine compliance with the safety goals -- are set forth in the Staff's report.[1] The safety goals are:

- Individual members of the public should be provided a level of protection from the consequences of nuclear power plant operation such that individuals bear no significant additional risk to life and health.

- Societal risks to life and health from nuclear power plant operation should be comparable to or less than the risks of generating electricity by viable competing technologies and should not be a significant addition to other societal risks.

In considering the application of these safety goals to pool fires, two points must be borne in mind. First, a pool fire would render uninhabitable a vast area of land and would have severe impacts on health, the environment, the economy and society. Second, the risk of a pool fire is almost completely avoidable, and the present risk exists only because licensees are unwilling to bear the cost of dry storage, a proven alternative.

The QHOs are expressed in terms of the risk of prompt fatality and cancer fatality in the surrounding populations. Nothing is said in the QHOs about the risks of land contamination and population relocation. Thus, the present QHOs do not provide a credible basis for determining if a spent fuel pool complies with the NRC safety goals.

The Staff's report employs a pool performance guideline (PPG) as a criterion for the acceptability of the risk of a pool fire. The PPG is expressed in terms of the annual probability of a pool fire at a particular plant, and the Staff recommends a numerical value for the PPG of 1 x 10-5 per year. According to the Staff, the risk of a pool fire at a nuclear plant is acceptable if the probability of the fire is less than 1 x 10-5 per year.

There are about 100 nuclear plants in the United States. If the probability of a pool fire at each plant were 1 x 10-5 per year, then the probability of a pool fire somewhere in the United States would be about 1 percent per decade. According to the Staff, this would be an acceptable risk. However, the Staff has never provided a credible analysis of the consequences of a pool fire. The analysis described in Section 5, above, shows that a pool fire would be a national disaster of historic proportions. One must wonder what a typical citizen would think about the Staff's notion of an acceptable risk, if the full consequences of a pool fire were spelled out to that citizen in plain language.

A citizen could reasonably conclude, given that the risk of a pool fire is almost completely avoidable, that the Staff's notion of an acceptable risk should be summarily rejected. Moreover, a citizen could further conclude that any use of high-density storage of spent fuel in pools violates the NRC safety goals.

7. Conclusions

C1. The Staff's understanding of the phenomena associated with a pool fire has improved, but remains incomplete.

C2. The Staff has never made a thorough analysis of the offsite consequences of a pool fire; notably, the Staff has ignored land contamination and population relocation and their attendant impacts.

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1 Collins et al, 2000, pp 4-2 to 4-3.

C3. The offsite consequences of a pool fire would amount to a national disaster of historic proportions.

C4. The Staff's notion of an acceptable risk means that the risk of a pool fire is acceptable if this event -- a national disaster -- has a probability of less than 1 percent per decade; this notion might not be shared by citizens if they were fully informed.

C5. The risk of a pool fire is almost completely avoidable, and the present risk exists only because licensees are unwilling to bear the cost of dry storage, a proven alternative.

C6. The Staff's report does not provide a credible basis for decision making on policy or regulatory issues.

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