

April 12, 2003

The authors respond to Professor Peterson's original and "post-mortem" comments on, "Reducing the hazards from stored spent power-reactor fuel in the United States" (*Science & Global Security*, spring issue, 2003)

Background

It is unusual for authors to have to respond publicly to a peer review that was solicited by the editor of a journal to which they had submitted a manuscript. The circumstances are definitely unusual on this case, however.

On March 27, 2003, at a public meeting of the Nuclear Regulatory Commission, one of the Commissioners, Edward McGaffigan, attacked our paper and *Science & Global Security*, the journal in which it will be published, on the basis of a peer review that had been prepared by Professor Per D. Peterson, chair of the University of California Berkeley Department of Nuclear Engineering. (The journal is edited at Princeton University.) According to the published transcript of the meeting, Commissioner McGaffigan said:¹

"Apparently peer review at Princeton means you get somebody like Per Peterson, a distinguished professor at the University of California Berkeley, telling you it's not a very good paper and you say 'Thank you very much, and we're still going to publish it.' And that apparently is what peer review means in the house journals of some of these anti-nuclear activists, which I guess Princeton has become."

To us, peer review of a potentially controversial paper requires seeking out those reviewers likely to be most critical and carefully examining what they have to say. Better for both the editor and authors to hear the full range of views before a paper is published than afterwards. Peer review is not a popularity contest. However, not every part of a critique will be relevant. For some, an adequate response will only require authors to add additional supporting references. Response to other critiques may require deletions, revisions, and/or the preparation of entirely new sections. If the authors cannot modify the paper to deal reasonably with the relevant critiques, the editor must reject the paper. To complete the peer review process, reviewers not satisfied should have the opportunity to publish letters that become part of the archival record for all to examine. All of the steps essential to peer review have been carried out in this case, despite Commissioner McGaffigan's speculations.

Commissioner McGaffigan did not indicate the nature of Professor Peterson's criticisms so his listeners had no basis on which to judge his characterization of our paper, Professor Peterson's review of it, or the standards of *Science & Global Security*.

Because of Commissioner McGaffigan's attack, the editor of *Science & Global Security* requested and received Professor Peterson's permission to release his review and has asked the authors of the article to respond to the review publicly so that those who have heard Commissioner McGaffigan's characterizations can make their own judgments. Our response is given below.

¹ *Briefing on the status of Office of Research Programs, Performance, and Plans* (U.S. Nuclear Regulatory Commission, March 27, 2003, <http://www.nrc.gov/reading-rm/doc-collections/commission/tr/2003/20030327b.pdf>) p. 42.

We do not expect this to be the last of the matter, however, because in the same NRC meeting, Commissioner McGaffigan demanded of the Director of the NRC's Office of Nuclear Regulatory Research (RES) that his office produce "a hard-hitting critique" of our paper "that sort of undermines the study deeply." After some discussion the director agreed that, "certainly we can put together a critique."

Such a critique would presumably be based on unpublished work carried out by NRC that was reported at the same hearing. According to p. 10 of the transcript, the RES office had

"recently completed integral analysis of a spent fuel accident scenario. In general, the analyses show a significant departure from the previous generic studies that have been cited in the media as representative should a terrorist attack a spent fuel pool. The new analysis indicates that, for the scenario analyzed, spent fuel is much more easily cooled."

We look forward to seeing the new analysis, when it is completed.

The media attention referred to in the transcript had resulted in part from our release two months earlier of a preprint of our paper after it had been peer reviewed and accepted for publication by *Science & Global Security*. Our paper reviews and makes accessible to the larger technical community and the public the findings of 25 years of NRC studies of the risks of spent-fuel-pool fires. This media attention was enhanced by the fact that the NRC had a month before denied petitions by citizen's groups seeking enhanced protections from terrorist attacks against spent-fuel pools. The NRC justified its refusal to act on these petitions with the argument that "the possibility of a terrorist attack...is speculative and simply too far removed from the natural or expected consequences of agency action."²

Apparently, the attention has not died down. In the March 27 NRC hearing, Commissioner McGaffigan complained to RES about the impact of our article:

"Our staff is getting beat up with this study as they do the annual performance reviews at various reactor sites as part of the reactor oversight process at the moment. And without guidance, they're doing I think a decent job, you know, of fending it off and saying that 'we don't believe the study.'...But I don't know that they're doing it based on guidance. I haven't seen any guidance from you guys that the average branch chief from a region should use when this infamous study is brought up to them."

With this background, it is not surprising, although disappointing, that two months after release of our paper not a voice was raised at the Commission's meeting to question RES's public dismissal of 25 years of peer reviewed NRC studies of the risk of spent-fuel fires on the basis of an unpublished and unreviewed in-house analysis of one scenario.

We would welcome it if the new study was correct and the risks from spent-fuel fires were less than the previous NRC studies have found. However, this conclusion cannot be considered credible until the Office of Nuclear Regulatory Research publishes its new analysis and it has been reviewed by the NRC's own Advisory Committee on Reactor Safeguards, the national laboratory experts on whose analyses the NRC has previously depended, and interested independent analysts such as ourselves.

² *In the matter of Dominion Nuclear Connecticut, Inc (Millstone Nuclear Power Station, Unit No. 3)*, (U.S. Nuclear Regulatory Commission, Docket No. 50-423-LA-3, CLI-02-27, memorandum and order, Dec. 18, 2002).

Responses to Professor Peterson's criticisms

Professor Peterson's primary criticism is that we did not write a paper quantitatively comparing the risks from spent-fuel fires to other potential terrorist risks. He stated, "If the purpose is to inform public policy for setting priorities toward the goal of combating terrorism, then enough information must be provided so one can compare the relative vulnerabilities of existing nuclear infrastructure to other civil infrastructure."

To insist that no paper can discuss the vulnerabilities of one industry without comparing with the vulnerabilities of all other civil activities is a formula for paralysis. Our focus was on understanding one risk and possible ways to mitigate it. Without papers like ours and the NRC-sponsored studies which it reviews there would be little substance on which to base comparative risk assessments.

We would guess that, over the next decade, at least a hundred billion dollars will be spent on reducing vulnerabilities within the US infrastructure and much more on military efforts against terrorism. Dealing with the obvious vulnerabilities of spent fuel pools are would not risk draining funds from other important protective actions even if the most costly measures that we discuss are fully implemented. Indeed, we propose that the funding come out of either the Nuclear Waste Fund or a trivial increase in the price of nuclear electricity.

In any case, we carefully examined the technical criticisms that Peterson made and carefully checked the challenged assumptions. A number of other expert reviews – some solicited by *Science & Global Security* and some by ourselves, some very critical, some very supportive -- provided many more technical comments and suggestions and contributed to our repeated and thorough reworks of our analyses. The editor of *Science & Global Security* only accepted our article for publication after he had concluded that none of the criticisms that we had received had identified a fundamental error in of our analysis, that we had corrected the minor errors that had been pointed out, and that we had responded to other suggestions by either incorporating them or pointing out that they were incorrect or irrelevant to the scope of our paper – as we believe Peterson's primary criticism was.

Below we respond to the other major specific criticisms made in Peterson's review:

Probabilities. Peterson complained that we do not discuss the probability of terrorists causing spent-fuel fires or the opportunities for reducing the probability of terrorist attacks. In his "post-mortem," he also complains that our final paper did not retain a sentence in the draft that he reviewed: "We therefore propose without probabilistic justification physical changes to spent-fuel arrangements..." We eliminated this sentence because we thought it was redundant after our quote of the NRC staff conclusion that "No established method exists for quantitatively estimating the likelihood of a sabotage event at a nuclear facility." Despite his complaints, Peterson does not himself suggest that such a methodology exists.

That said, we did respond to the probability conundrum in the final paper by approaching the problem from a new direction. We looked at the various estimates made in studies done by and for the NRC of the probability of a spent-fuel-pool fire being caused *accidentally*. Typically these probabilities are estimated to be on the order of 1 chance per million per pool-year, which is equivalent to one chance in 300 during a period of 30 years for the approximately 100 U.S. spent-fuel pools. We then point out that the most costly of our recommendations could be economically justified at between 1 and 15 times this

probability level, depending primarily upon the fractional release of a pool's inventory of ^{137}Cs (10-100%). The question then becomes one of whether terrorists could increase the probability of an accidental spent fuel fire by up to or even more than one order of magnitude. We think that is credible.

Comparison with other risks. As already noted, Peterson complained that we did not compare the risks from spent-fuel fires with other risks – in particular with terrorists deliberately crashing a jumbo jet into a filled stadium. Once again, the question is how either probability could be calculated.

Blocking hijackers from using a commercial aircraft as a suicide weapon. Peterson proposed that we compare the benefits of investing in dry-cask storage with the benefits of investing in anti-hijack systems for aircraft. In his "Postmortem" he states that he is angry that we did not use a reference he provided to work done at Berkeley on this subject. However, there is little need to educate anyone with the reasonableness of spending large amounts of money on anti-hijack systems. It is the spent-fuel problem that is unfamiliar. Furthermore, it should not be assumed that an attack with an airliner is the largest terrorist threat to a spent-fuel pool. The hijack problem and its possible solutions are therefore appropriately treated separately.

Fractional ^{137}Cs release from a spent-fuel fire. Peterson questioned the 10-100% range of releases that we assumed, following a Brookhaven National Lab analysis done for the NRC.³ He argued that the ^{137}Cs would not be released before the fuel reached a temperature of 2000 °C and that, by that time, the zirconium would have reached its melting point and the geometry of the spent-fuel would have changed. In reviewing this argument, we found that experiments show that "virtually all of the ^{137}Cs would be released from the spent fuel before the melting temperature of zirconium (1850 °C) is reached." (See the reference added to footnote 20 of our final paper.)

Damage from ground attack. Peterson argued that attacks by ground-based terrorists could not be damaging enough to prevent recovery of cooling before a spent-fuel fire could arise. We are not so sanguine but it would be unwise to debate this in public.

Safety of future-design power plants. Peterson suggested that future nuclear-power plant designs or fuel cycles could be made less susceptible to spent-fuel fires. We agree but this is beyond the compass of our article, which was focused on the possibilities for reducing the risks at *existing* plants.

Thanks to Professor Peterson and our other reviewers

Despite our disagreements with Professor Peterson, we benefited from his review. Although he doesn't think so, his comments helped to improve the final paper. We are similarly grateful to all the other reviewers for their comments, especially the hard-hitting comments that challenged our technical and policy arguments in ways that we hadn't thought of.

Robert Alvarez, Jan Beyea, Klaus Janberg, Jungmin Kang, Ed Lyman, Allison Macfarlane, Gordon Thompson and Frank von Hippel

³ *A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants* (Brookhaven National Laboratory, NUREG/CR-6451, 1997).