From: [redacted]
To: Vance Petrella
Cc: GIP Resource
Subject: [External_Sender] Re: Re: Blank Form for Proposed GI on Potential Spent Fuel Pool Criticality Excursions
Date: Monday, December 2, 2024 6:51:13 PM

All,

My Facebook ID is [redacted]. My postings there are few and easy to find. Nevertheless, here's the copied text:

As implied in my previous posting today, it is clear to me that the U.S. Nuclear Regulatory Commission (NRC, my employer 1992-2016) has long grossly over-regulated nuclear power reactors. It is thus ironic that the NRC has so badly failed to regulate what my analysis tells me is by far the largest hazard presented by nuclear power facilities. Let me explain:

I believe the NRC erred terribly in 2011 when its politically appointed commissioners rejected the recommendation of the NRC staff's Fukushima Near-Term Task Force to phase out high-density pool storage of spent fuel by accelerating the deployment of dry spent fuel casks. As I see it, two major misrepresentations in the NRC staff's analysis supporting that poor decision led to both the frequency and consequences of pool draining events being grossly understated.

1. Potential Events Leading to Spent Fuel Storage Pool Draining or Boil-off

First, and as noted by others, was the NRC staff's seemingly disingenuous selection of an extremely rare beyond design basis earthquake as the so-called "prototype event" for assessing the risks of pool draining leading to zirconium fires. There are obviously more likely events that could lead to pool boil-off or draining. These would include insider sabotage or missile attacks by domestic or foreign terrorists.

Relevant events would further include extended regional grid blackouts resulting from cyber attacks or from electromagnetic pulses (EMPs) as induced by either Carrington-scale solar storms or high-altitude thermonuclear blasts by an adversary. Note that the frequency of Carrington-scale solar storms has been estimated at 12% per decade (Yikes!). Such intense EMPs could fry large transformers that would take months to fix or replace. The result would be vast regionwide grid blackouts lasting several months or longer.

In the ensuing dystopian chaos, it is far from clear that mitigating actions could reliably be taken. Traffic chaos could make it extremely difficult for trained responders to reach affected reactor sites. And communication infrastructure failures could prevent responders from learning of the affected sites. Moreover, responders might understandably tend to prioritize defending home and family over all else. Such EMPs could thus result in unmitigated crises at many reactor sites in the blackout affected regions.

2. Progression and Consequences of Spent Fuel Fires in Storage Pools

As likewise noted in part by others, the NRC staff's analysis failed in two ways to adequately model the progression and consequences of fuel fires caused by pool draining or boil-off. First, the intensity of spent fuel burning seems to have been greatly underestimated due to the NRC MELCOR code's acknowledged inability to model exothermic zirconium nitriding reactions in air.

Similar concerns over spent fuel pool fires are further described in this recent journal article: https://thebulletin.org/2024/04/spent-nuclear-fuel-mismanagement-poses-a-major-threat-to-the-united-states-heres-how/.

And past attempts to get the NRC to finally do the right thing include (a) this 2.206 enforcement petition submitted to the NRC in 2023: https://www.nrc.gov/docs/ML2306/ML23061A054.pdf and (b) NRC rulemaking petition PRM-50-96.

3. Spent Fuel Pool Nuclear Criticality Excursions

Second, no consideration was given to the likelihood and consequences of potential criticality excursions that could occur during pool draining or boil-off or while refilling an extensively drained or boiled-off pool. Almost all high-density pool racks use aluminum-based neutron absorber plate materials (i.e., Boral, Metamic, Carborundum, and others) that, when no longer submerged, could readily disintegrate and/or melt from overheating by spent fuel nuclear decay heat and eventual zirconium burning. The absence of effective absorber plates could then give rise to pool criticality excursions.

Because the spent fuel pools at pressurized water reactors (PWRs) are heavily borated, criticality-induced local pool boiling would produce strongly positive feedback and, thus, highly destructive energetic excursions akin to the one that destroyed Chernobyl.

Because I seem to be the first person ever to recognize the potential for criticality excursions -- and certainly autocatalytic criticality excursions -- in conjunction with postulated spent fuel pool fires, especially the latter may bear explaining even to fellow nuclear experts. In particular, no one seems to understand that autocatalytic criticality excursions can occur when a PWR pool starts to refill after extensive draining or boil-off. Fuel storage rack temperatures in pool fires can readily exceed the melting points of the almost universally used aluminum-based rack neutron absorber plates that are required to prevent nuclear criticality.

Without neutron absorber plates separating the fuel assemblies, expected concentrations of soluble pool boron will clearly not suffice to keep the affected pool rack zones subcritical. The onset of a supercritical chain reaction of neutron-induced nuclear fission will then quickly heat the pool water, causing it to thermally expand and boil.

Because highly borated pool water acts predominantly as a neutron absorber, its thermal expansion and boiling inserts positive neutronic reactivity, resulting in autocatalytic positive feedback. This is what we call positive void reactivity.

The resulting fission power surge will spike after the pool boiling steam bubble fraction (a.k.a. "void fraction") grows to the point where its neutron-slowing effect no longer suffices to support criticality. This may occur only after several dollars or more of reactivity have been inserted, resulting in a so-called super prompt critical reactor period of milliseconds or less. The violent fission power surge then resumes when the water collapses. Rinse and repeat.

To my knowledge, no one has ever tried to apply neutron kinetics code models to calculating the progression of such PWR pool criticality scenarios

That said, I should mention having been a minor contributor to the NRC staff's independent calculations of positive void reactivity effects in Atomic Energy of Canada's (AECL's) proposed CANDU-3 reactor design in the early 1990s. At the time, we used AECL's Powderpuffs kinetics code to show the onset of fuel melting within 4 seconds after a sudden header break with scram failure. This is described in a NUREG report available from the NRC online archives.

In fact, few seem to know that, unlike the Chernobyl RBMK reactors, all CANDU reactors have strongly positive coolant void reactivity under all normal and off-normal operating conditions.

It's instructive to note that AECL returned to the NRC in 2006 with an advanced CANDU reactor design called ACR-700. They specifically asked the NRC staff to confirm that their new design, which used light water instead of heavy water in the coolant channels, reduced the channel spacing, and used slightly enriched uranium instead of natural uranium, had indeed achieved negative coolant void reactivity.

With code modeling help from my long standing friend and collaborator Professor Tom Downar and his devoted graduate students, I took the lead in performing the staff's independent confirmatory calculations of ACR-700 coolant void reactivity. To everyone's surprise, our results were extremely non-confirmatory.

Our calculations revealed a major error on the part of AECL, concluding that coolant void reactivity could in fact be strongly positive throughout the initial seconds-long "checkerboard voiding" phase of unscrammed coolant header break events. I described this in Chapter 8 of the NRC ACR-700 Pre-Application Safety Assessment Report (available in the NRC online archives).

Given that high-density spent fuel storage pools generally contain many core inventories of cesium and strontium and are located outside containment, it is clear to me that such events have far larger potential consequences than any conceivable reactor events.

Bottom Line: Until the NRC finally does the right thing, we should be very, very concerned.
...

That's all. Looking forward to your next reply.

[redacted]

On Mon, Dec 2, 2024, 16:12 Vance Petrella <Vance.Petrella@nrc.gov> wrote:

> Hello [redacted],
>
> We are still not able to see your concern because the Facebook site will not let us see your post. The error is not with the NRC, but with Facebook. Could you send us a screen shot or copy and paste the information from your post into an email so that we can view all of the text that you have provided? If you are unable to copy and paste the information, can you write out your concern in an email? If it is not text, then can you send us whatever you can

describing the issue of concern?

From,

Vance Petrella

From: Vance Petrella
Sent: Monday, December 2, 2024 10:38 AM
To: [redacted]
Subject: RE: Re: Blank Form for Proposed GI on Potential Spent Fuel Pool Criticality Excursions

Hello [redacted],

Thank you for your safety concern. Unfortunately, we are not able to see the safety concern that you have provided through the Facebook link that you provided. Can you describe the safety concern and send it to use so that we can process it?

From,

Vance Petrella

From: [redacted]
Sent: Wednesday, November 27, 2024 2:20 PM
To: Vance Petrella <Vance.Petrella@nrc.gov>
Cc: GIP Resource <GIP.Resource@nrc.gov>
Subject: [External_Sender] Re: Blank Form for Proposed GI on Potential Spent Fuel Pool Criticality Excursions

Hello Vance Petrella,

I apologize for having overlooked your email below until now.

I've now confirmed that the Form 833 that I emailed on October 30th was complete and correctly transmitted. As proof, please see the attached screenshots of the sent email and its attachment. The Form 833 pdf is also attached to this email.

If you again see a blank form, the problem is at your end. In which case you should seek IT support.

I left you a voice mail about this. Please phone me to discuss further.

Sincerely,

[redacted]

[redacted]

On Wed, Oct 30, 2024, 12:15 Vance Petrella <Vance.Petrella@nrc.gov> wrote:

> Hello [redacted],
>
> We received a blank NRC form 833 from you. Can you resubmit the form so that we can process your safety concern.
>
> From,
>
> Vance Petrella
>
> Professional Engineer
>
> U.S. Nuclear Regulatory Commission