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What about the spent fuel?

By Robert Alvarez

Until recently, concerns about attacks on commercial nuclear power plants focused mainly on the vulnerability of reactor containment buildings. But nuclear power plants may have a weaker link—spent fuel ponds. “Reactors are inside steel vessels surrounded by heavy structures and containment buildings,” says Gordon Thompson, senior scientist at the Institute for Resource and Security Studies. “Spent fuel pools, containing some of the largest concentrations of radioactivity on the planet, can catch fire and are in much more vulnerable buildings.”

Public officials share Thompson’s concern. “I’m not so worried about the core; I’m worried about the spent fuel pool,” Gov. Howard Dean of Vermont told the *New York Times* (November 2). “There’s basically no protection there.”

The ponds, typically rectangular or L-shaped basins about 40 feet deep, are made of reinforced concrete walls four to five feet thick and stainless steel liners. Basins without steel liners are more susceptible to cracks and corrosion. Most of the spent fuel ponds at boiling water reactors are housed in reactor buildings several stories above ground. Pools at pressurized water reactors—representing about two-thirds of all ponds—are partially or fully embedded in the ground, sometimes above tunnels or underground rooms.

Fire and water

Over the past 25 years, Thompson, a physicist and engineer, has worked on behalf of citizen groups and state and local governments to convince nuclear regulators in the United States and Europe that spent fuel pools pose severe risks. The most serious risk, he says, is loss of the pool water that cools and shields the highly radioactive spent fuel assemblies. Water loss could expose spent fuel, leading to a catastrophic fire with consequences potentially worse than a reactor meltdown. Most U.S. reactors store spent fuel in high-density pools. If that fuel were exposed to air and steam, the zirconium cladding would react exothermically, catching fire at about 1,000 degrees Celsius. A fuel pond building would probably not survive, and the fire would likely spread to nearby pools. The Nuclear Regulatory Commission (NRC) concedes that such a fire cannot be extinguished; it could rage for days.

On average, spent fuel ponds hold five to 10 times more long-lived radioactivity than a reactor core. Particularly worrisome is the large amount of cesium 137 in fuel ponds, which contain anywhere from 20 to 50 million curies of this dangerous isotope. With a half-life of 30 years, cesium 137 gives off highly penetrating radiation and is absorbed in the food chain as if it were potassium. According to the NRC, as much as 100 percent of a pool’s cesium 137 would be released into the environment in a fire.

In comparison, the 1986 Chernobyl accident released about 40 percent of the reactor core’s 6 million curies of cesium 137 into the atmosphere, resulting in massive off-site radiation exposures. A single spent fuel pond holds more cesium 137 than was deposited by all atmospheric nuclear weapons tests in the Northern Hemisphere combined.

If a fire were to break out at the Millstone Reactor Unit 3 spent fuel pond in Connecticut, it would result in a three-fold increase in background exposures. This level triggers the NRC's evacuation requirement, and could render about 29,000 square miles of land uninhabitable, according to Thompson. Connecticut covers only about 5,000 square miles; an accident at Millstone could severely affect Long Island and even New York City.

A 1997 report for the NRC by Brookhaven National Laboratory also found that a severe pool fire could render about 188 square miles uninhabitable, cause as many as 28,000 cancer fatalities, and cost $59 billion in damage. (The Brookhaven study relied on a different standard of uninhabitability than Thompson.) While estimates vary, "the use of a little imagination," says Thompson, "shows that a pool fire would be a regional and national disaster of historic proportions."

Several events could cause a loss of pool water, including leakage, evaporation, siphoning, pumping, aircraft impact, earthquake, accidental or deliberate drop of a fuel transport cask, reactor failure, or an explosion inside or outside the pool building. Industry officials maintain that personnel would have sufficient time to provide an alternative cooling system before the spent fuel caught fire. But if the water level dropped to just a few feet above the spent fuel, the radiation doses in the pool building would be lethal.

The procedures fuel handlers need to follow to recognize problems, repair heavily damaged equipment, and command off-site resources have yet to be formalized, much less tested. But if routine operations are any indication, not all reactors would pass muster: By the NRC's own admission, significant temperature rises in fuel ponds have gone undetected for days.

Old policy, older problems

Over the years, Thompson's persistence has paid off, and the NRC has grudgingly made important concessions. For 20 years, the NRC assumed that aged spent fuel, which has had several years for radioactive isotopes to decay, was at little risk of catching fire. But in an October 2000 study of spent fuel risks at sites where reactors were being decommissioned, the NRC conceded that "the possibility of a zirconium fire cannot be dismissed even many years after a final reactor shutdown."

Equipment installed to make high-density ponds safe actually exacerbates the fire danger, particularly with aged spent fuel. In high-density pools at pressurized water reactors, fuel assemblies are packed about nine to 10.5 inches apart—slightly more than the spacing inside a reactor. To compensate for the increased risk of criticality, pools have been retrofitted with enhanced water chemistry controls and neutron-absorbing panels between assemblies. The extra equipment restricts water and air circulation, creating vulnerability to systemic failures. If the equipment collapses or fails, as might occur during a terrorist attack, for example, air and water flow to exposed fuel assemblies would be obstructed, causing a fire, according to the NRC's report. Heat would turn the remaining water into steam, which would interact with the zirconium, making the problem worse by yielding flammable and explosive hydrogen. As a result, the NRC concluded 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."

Perhaps the most important concession was made in June 2001, when the NRC staff reported that terrorist threats against spent fuel ponds are credible and cannot be ruled out. "Until recently, the staff believed that the [design basis threat] of radiological sabotage could not cause a zirconium fire. However, [NRC's safety policy for spent fuel storage] does not support the assertion of a lesser hazard to the public health and safety, given the possible consequences of sabotage."

Despite acknowledging spent fuel pond dangers, the NRC's ability to adapt to a much more dangerous world remains to be seen. It took 10 days after the September 11 attacks before the NRC admitted that "nuclear power plants were not designed to withstand [jet airliner] crashes." Although this statement was widely covered by the media, the NRC was just restating the results of old policy.

In 1982, the NRC's Atomic Safety and Licensing Board ruled that reactor owners "are not required to design against such things as . . . kamikaze dives by large airplanes. Reactors could not be effectively protected against such attacks without turning them into virtually impregnable fortresses at much higher cost." This view is buttressed by NRC's equally long-standing policy blocking consideration of terrorist acts in licensing proceedings. Because acts of terrorism are unpredictable, the NRC reasons, they are not germane to safety requirements. Incredibly, a day after the September 11 attacks, the NRC ruled that concerns about terrorists raised by Georgians Against Nuclear Energy (GANE) regarding the mixing of plutonium in nuclear fuel at the Energy Department's Savannah River Site were not valid because "GANE does not establish that terrorist acts . . . fall within the realm of 'reasonably foreseeable' events."

Running out of room

The NRC is now reviewing from "top to bottom" its safety and security policies, "working around the clock to ensure protection of nuclear power plants and nuclear fuel facilities," NRC spokesman Victor Dricks told the *Washington Post* on November 1. "Everything's on the table. I'd like to tell you that everything's going to be okay, but I can't do that."

Will more gates, guards, and guns be enough? About 40,000 tons of spent nuclear fuel are stored in pools at 110 operating and closed reactor sites across the United States, with over 2 billion curies of long-lived radioactivity. Over the next several years, the Energy Department estimates that storage space for an additional 11,000 tons of spent fuel will be needed.

Plant owners are already lobbying for more space. For example, Connecticut's Millstone plant has 585 fuel assemblies in its reactor Unit 3 pond. But Millstone's owner, Dominion Nuclear Connecticut Inc., wants permission from the NRC to expand the pool's capacity to hold 1,860 assemblies.

Spent fuel ponds were designed to be temporary—and to store only a small fraction of what they currently hold. "Neither the AEC [now the Energy Department] nor utilities anticipated the need to store large amounts of spent fuel at operating sites," said Millstone's owner last October. "Large-scale commercial reprocessing never materialized in the United States. As a result, operating nuclear sites were required to cope with ever-increasing amounts of irradiated fuel. . . . This has become a fact of life for nuclear power stations."

The underlying assumption of NRC's policy allowing for expanded pool storage is that some day the government will permanently dispose of it all, as required under the 1982 Nuclear Waste Policy Act. But the Energy Department will not accept custody of spent fuel until 2010 at the earliest—if at all. Even if Energy and the Bush administration are able to overcome the formidable opposition to opening the proposed repository at Yucca Mountain in Nevada, there could be considerable risk in transporting thousands of shipments of highly radioactive waste.

Storage solutions

In light of the NRC's admissions about spent fuel vulnerabilities, it seems it would be easier to cause an accident at a spent fuel pond than to breach and release the radioactive contents of multiple hardened concrete and steel dry storage casks. Casks and other storage alternatives would greatly reduce, or even eliminate, the risk of a pond fire. A handful of reactor owners have put only about 4 percent of the nation's spent fuel into dry storage.

Today, the pressure felt by reactor owners from electricity deregulation works against nuclear safety. According to a report on utility deregulation and nuclear power by the Nukem Corporation, "In an era of deregulation there will be no pool of captive customers to shoulder uneconomic operating costs or massive capital additions." Because of deregulation, the owners of many reactors are limited liability companies with little or no cash reserves. There is no financial incentive to move wastes to safer dry storage.

Other nations are taking spent fuel vulnerabilities very seriously. Germany is seeking ways to harden its dry-stored spent fuel in even more robust containers. France has installed anti-aircraft missiles around its spent fuel ponds at the La Hague reprocessing facility, where some 100 million curies of cesium 137 are stored. What the United States will do to protect the public from this serious nuclear vulnerability remains to be seen.

The permanent disposal of spent fuel from commercial reactors now seems a greater abstraction than does a terrorist strike against a nuclear power plant. Safely securing the spent fuel in crowded pools should be a public safety priority of the highest degree. If the events of September 11 have taught us anything, it is that the war against terrorism will be an unpredictable struggle. The cost of fixing America's nuclear vulnerabilities may be high, but the price of doing too little is incalculable.

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