2. NUCLEAR CRISIS: Failures in storage pools, battery backups point to problems in U.S. fleet *(Greenwire, 03/15/2011)*

Hannah Northey and Jenny Mandel, E&E reporters

Spent fuel at Fukushima Daiichi Nuclear Power Station's Unit 4 caught fire last night and released radiation directly into the air before the fire was brought under control and extinguished, according to the International Atomic Energy Agency (IAEA).

The spent fuel pool, which stores used fuel rods submerged in water as they gradually cool over several years to a temperature at which they can be moved to other storage, is located next to the containment building and is normally under the roof of an outer building.

That outer building may have blown off, as the IAEA reported that the pool was open to the atmosphere and that "Japanese authorities are saying that there is a possibility that the fire was caused by a hydrogen explosion."

Hydrogen explosions have caused the reactor buildings to blow up at the Unit 1 and 3 reactors, and the IAEA also reported an explosion last night at the Unit 2 reactor. Authorities did not immediately report damage at any of the four sites to the reactor containment vessels, the concrete-and-steel structures around the reactors designed to hold in radiation in the event of an emergency.

Yesterday, some experts were assessing the radiation risk from spent storage pools as greater than the danger from the reactors themselves, as emergency crews appeared to be warding off further reactor meltdowns with pumped seawater, and at least one pool -- at the Unit 3 reactor -- showed signs in satellite images of potentially being compromised and emitting steam directly into the atmosphere.

In a call with reporters, Robert Alvarez, a senior scholar with the progressive Institute for Policy Studies and former deputy assistant secretary for national security and the environment with the Energy Department, said if cooling water in the pools is lost and the spent fuel becomes partially or fully exposed to air, it can overheat and the zirconium protection around it can catch fire. "Then you have the potential for very very significant, long-term land area contamination," Alvarez said.

Indeed, overnight, the IAEA reported that radiation dose rates as high as 400 millisieverts per hour -- enough to cause excess cancers in four out of 100 people in just one hour, according to a National Academy of Sciences analysis -- were reported at the site. Those levels fell to 0.6 millisievert per hour several hours later, IAEA reported, which they said suggested that local levels of radioactivity were decreasing.

Thomas Cochran, a nuclear physicist, senior scientist with the Natural Resources Defense Council and member of the Energy Department's nuclear energy advisory committee, said that under normal circumstances, the pools do not present a radiation risk even if exposed directly to the outside air.

"It's got a lot of water in it, and it's got several meters of water above [the spent fuel rods], so you can peer over the side and you're shielded from the radiation by the water," Cochran explained, adding that a reprocessing facility in the United Kingdom maintains open-air pools on which seagulls and other birds regularly land.

But he said the occurrence of a fire indicates some sort of damage to the pool itself, to have allowed the water level to so quickly fall low enough for the used fuel to overheat.

"We're days away from this accident; you'd have to walk away from that pool for a long time for that water to evaporate away. So something else has to have happened," he said.

"The problem with this particular design is that the pool -- it's like building a concrete swimming pool up on the fifth floor. And if you start having explosions in the building, you should start to worry about the pool leaking," Cochran added.

This group of reactors all share the elevated spent fuel pool design, meaning the entire group is vulnerable to the same design flaw.

Cochran said some other plant designs put the pool underground, which makes it less vulnerable to an explosion, though an earthquake could still cause structural damage and cause such a pool to leak, especially if the quake far surpassed the design specifications for the plant as occurred in this case.

Storage pools a known issue

U.S. nuclear regulators have considered the dangers posed by spent fuel pool vulnerabilities in the past.

Following the 2001 terrorist attacks in the United States, the National Academy of Sciences undertook a study, "Safety and Security of Commercial Spent Nuclear Fuel Storage," which focused primarily on the risks associated with a terrorist attack on a spent fuel pool and consequent radiation release.

The report concluded that spent fuel pools are needed at all operating nuclear power plants to store recently used fuel as it cools and that a fire of the zirconium protective layer around the spent fuel rods "could result in the release of large amounts of radioactive materials."

The report suggested certain relatively simple measures like rearranging the spent fuel assemblies in pools to more evenly disperse heat and putting in place redundant cooling measures. It also made other recommendations that were redacted on security grounds.

NRDC's Cochran criticized the decision by the Nuclear Regulatory Commission (NRC) to classify so much of the report, "ostensibly so you wouldn't assist potential terrorists," because "as a consequence you deny the public the chance to decide whether they agree with that analysis."

One finding of the report, echoed by several nuclear experts in recent days, is that "dry cask storage," in which partially cooled spent fuel is stored in concrete and steel structures, generally underground, is inherently safer than storage in pools.

Cochran said dry cask storage becomes possible two to four years after the fuel is retired from use, when the temperature drops enough that with proper ventilation, the zirconium cladding will not melt. "It would be extremely hot both thermally and radioactively at that point, but it wouldn't be hot enough to melt the cladding," he said.

Because dry cask storage does not require active cooling, it is inherently safer than a system that relies on power-dependent water cooling systems that can fail, as has happened at the Daiichi plants.

U.S. fleet

According to General Electric Co., 32 boiling water reactor (BWR) Mark 1 units like those in use at the Daiichi plants are in operation worldwide, and experts say there are 23 comparable plants in the United States.

"The BWR Mark 1 reactor is the industry's workhorse with a proven track record of safety and reliability for more than 40 years. ...There has never been a breach of a Mark 1 containment system," the company said yesterday.

But Cochran believes the elevated pools are just one design element of the Daiichi plant setup that clearly needs further review in the United States.

"I think there are a lot of problems with these BWRs and Mark 1 and 2 containments, and there's a lot of work to be done to repair the safety deficiencies in the U.S. plants. Otherwise, they should be phased out," Cochran said.

"You don't design a reactor so that every time you get a partial-core melt you would blow the top off the reactor. There's obviously a design flaw in the hydrogen management. ... You don't have to be very smart to figure out that there was some failure in the design for managing that type of an event," Cochran said.

He said another clear design flaw lies with the regulatory requirements governing backup power for the reactors. It was an initial grid power outage to the plant from the earthquake, followed by failure of the backup diesel generators due to damage in the tsunami and depletion of four-hour backup batteries, that led to the cooling system failures in Fukushima.

4 to 12 hours of battery backup

Indeed, many scientists and environmental groups are pointing to the unfolding events as a wake-up call for U.S. regulators to go further in ensuring the country's 104 reactors have sufficient battery power to continue operating if power is lost and backup diesel generators fail.

The country's nuclear plants could lose independent off-site power sources and backup generators and slowly come to rely on batteries that only run for four to eight hours, said David Lochbaum, a nuclear engineer and director of the Union of Concerned Scientists' (UCS) nuclear safety program. Only a smaller group has batteries that can produce power for up to 10 hours, he said.

Lochbaum acknowledged that many plants are better prepared for disasters in the aftermath of the terrorist attacks of Sept. 11, 2001, both in terms of backup generation and personnel to fight fires, and "those might be sufficient to deal with what happened in Japan," he said.

Nuclear Energy Institute (NEI) Senior Vice President Tony Pietrangelo said today that nuclear reactors in the United States are in compliance with NRC's "station blackout rule," which requires nuclear facilities to develop plans and practices to continue operating when power is lost.

On a call with reporters today, Pietrangelo conceded that the loss of power factored into the situation at Japan's Fukushima Daiichi plant. Operators at the reactor lost power and three units "tripped" or shut down after the earthquake struck on March 11, at which time emergency diesel generators worked for about an hour until they were washed away by the tsunami and batteries were brought in.

But in the United States, some reactors -- Pietrangelo could not confirm how many -- install diesel generators underground for protection and, depending on the plant, have batteries that can last up to 12 hours. All U.S. nuclear plants, he said, are designed to sustain the most severe earthquakes for the region within which the plant is located.

When asked how the industry would feel about reactors being required to have more backup battery power, Pietrangelo said, "That's the kind of review we do to apply the lessons learned going forward."

Environmental groups have raised concerns about the "standard blackout rule" since it was implemented in the 1980s, calling into question whether the agency confirmed that all U.S. plants can cope with a total loss of power "at any time." Industry groups like NEI, on the other hand, submitted comments making clear that any requirements beyond the rule would prompt further formal rulemaking activities.

NRC conducted a study in 2003 that found all plants were complying with the rule, generally by adding diesel or gas turbine generators, and confirmed that all facilities reviewed had a "4- or 8-hour coping capability."

Lochbaum yesterday pointed to a handful of events in which nuclear power plants in the United States were knocked offline, generators failed and batteries were used as a last resort.

In 1998, a tornado struck the Davis-Besse nuclear power station, a pressurized water reactor in Ohio, and damaged the facility's access to external power. The plant was shut down and emergency diesel generators powered the safety system until external power could be restored, according to NRC.

In 1992, the Turkey Point nuclear reactor in Florida was damaged by Hurricane Andrew's winds of up to 145 miles per hour, causing a loss of power, according to NRC. In that situation, the backup diesel generators failed because of problems with moisture in the equipment, and remaining emergency diesel generators carried the load. The NRC report notes that the backup generators were crucial to pumping power into the facility.

"To say that this never happens" is wrong, said Jim Riccio, a nuclear policy analyst for Greenpeace. "There are examples ... even with a robust grid like ours, you're going to have problems."

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