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For nearly four decades, the Union of Concerned Scientists has been a nuclear power safety and security advocate. Neither anti- nor pro-nuclear power, UCS strives to ensure that the technology's inherent risks are minimized to the extent that is practically achievable.

The tragic events at the Fukushima Dai-Ichi nuclear plant in Japan have already revealed areas of elevated risk that should be rectified. Over the ensuing months and years, additional lessons will undoubtedly surface as workers conduct CSI Nuclear to assess what failed due to various causes, including the earthquake, the tsunami, the extended power outage, the hydrogen explosions, the torrents of water dropped from above and sprayed from below, and the submersion of equipment in water. Today, UCS would like to share six of the lessons already evident from Fukushima Dai-Ichi that are applicable to ensuring safer nuclear power plants in the United States:

- Better protection against extended power outages
- Adequate severe accident management guidance
- Safer storage of spent fuel
- Upgraded guidance for spent fuel pool events
- Additional regulatory requirements for defueled reactors

BETTER PROTECTION AGAINST EXTENDED POWER OUTAGES

Some may argue that what happened at Fukushima Dai-Ichi cannot happen here—that our nuclear power plants are not vulnerable to extended power outages caused by the one-two punch of an earthquake and tsunami. In June 1998, a tornado disabled the normal power supply for the Davis-Besse nuclear plant in Ohio, just as the earthquake had done for Fukushima Dai-Ichi. Outside air temperatures exceeding 90°F caused the backup power supply to overheat and fail, just as the tsunami had done at Fukushima Dai-Ichi. The difference was that workers restored the normal power supply for Davis-Besse an hour before the backup power supply failed while more extensive damage prevented workers at Fukushima Dai-Ichi from restoring its normal power supply for nearly a week, days too late to prevent fuel damage.

Enclosure 1 provides Tables B-1 and B-2 from a 2003 report issued by the NRC on power outages at U.S. nuclear power plants. When both the normal and backup power supplies are lost, a condition called station blackout occurs. As at Fukushima Dai-Ichi, the only source of power during a station blackout is a bank of batteries. The fourth column of data in Tables B-1 and B-2 provides the percentage of overall risk of reactor core damage (called core damage frequency or CDF) due to station blackouts as calculated by the plant owners themselves. For example, station blackouts constitute 80.6 percent of the overall core damage risk at the LaSalle nuclear plant in Illinois. In other words, the risk from station blackouts is roughly four times the risk from all other causes combined. And LaSalle is located far away from the earthquake faults of California and the tsunami risks of both coasts, so clearly an earthquake and tsunami is not the only path to a station blackout disaster.

The three reactors at Fukushima Dai-Ichi operating at the time of the earthquake were each equipped with banks of batteries having 8-hour capacities. As reflected by the data in the fifth column of Tables B-1 and B-2, the majority of U.S. reactors have equal or shorter station blackout coping durations. This means that workers at a U.S. reactor experiencing a station blackout would essentially be playing a very high stakes version of “Beat the Clock.” If they restore normal or backup power within a few hours, they win. If not, many may lose.

Requiring nuclear plants to have 16 hours of battery capacity would give workers a greater chance of bearing the clock. But what if, as at Fukushima Dai-Ichi, it takes longer than 16 hours to restore the normal and backup power supplies? The world has been watching what happens, and it isn't pretty or worth emulating.

UCS believes a better way to ensure victory in station blackout “Beat the Clock” is to evaluate how long it will likely take for replacement batteries and/or portable generators to be delivered to each nuclear power plant site. For some plant sites, the current situation is fine because nearby reinforcements exist and it will be possible to supply replacement batteries or portable generators within the existing 4-hour or 8-hour station blackout coping duration. However, for other plants reinforcements are not likely to arrive in time, and reactor owners should increase the battery capacity and/or pre-stage battery replacements and portable generators closer to the site.

ADEQUATE SEVERE ACCIDENT MANAGEMENT GUIDANCE

In NRC terminology, a severe accident is one in which at least some of the fuel melts. In testimony at Congressional hearings, NRC and nuclear industry representatives have claimed that the severe accident management guidelines (SAMGs) developed in the wake of reactor meltdown at Three Mile Island would provide reliable protection against the problems faced at Fukushima Dai-Ichi. They have not been telling the whole story. As newscaster Paul Harvey used to say, here's the rest of the story.

Enclosure 2 provides part of Table 2 from NRC Manual Chapter 0308 on its reactor oversight process (ROP). The fourth column for the severe accident management guidelines entry states:

The [NRC] staff concluded that regular inspection of SAMG was not appropriate because the guidelines are voluntary and have no regulatory basis.

The NRC never checks—repeat, never checks—the guidelines to see if they would be effective under severe accident conditions.

From March 2009 until March 2010, I worked for the NRC as a Boiling Water Reactor technology instructor at their Technical Training Center. My duties included teaching the severe accident management guidelines to NRC employees for their initial qualifications and re-qualifications. I and the other instructors emphasized that NRC inspectors were not authorized to evaluate the adequacy of the guidelines. Plant owners are required to have the guidelines while NRC inspectors are required not to assess their effectiveness. It's like maritime inspectors ensuring that passenger liners have lifeboats, but not checking to see that there's sufficient capacity for all passengers and crew members.

If NRC continues to rely on these guidelines to protect public health, it must evaluate their effectiveness.. It would be too late and too costly to find out after a U.S. nuclear plant disaster that the plant's severe accident management guideline was missing a few key steps or contained a handful of missteps.

SAFER STORAGE OF SPENT FUEL

Much has been reported about the problems with the fuel in the spent fuel pools at Fukushima Dai-Ichi Units 3 and 4. Helicopters dropped tons of water from above while water cannons on fire trucks sprayed water from below. And yet it appears that fuel in at least two spent fuel pools has been damaged.

Virtually nothing has been reported about the fuel stored in dry casks at Fukushima Dai-Ichi. It experienced the earthquake. It experienced the tsunami. It experienced the prolonged power outage. It did not overheat. It was not damaged. It did not produce hydrogen that later exploded. It did not cause the evacuation of a single member of the public. It did not cause a single worker to receive radiation over-exposure.

The spent fuel pools at nuclear plants in the United States are significantly fuller than those in Japan. As a result, the chances of a spent fuel accident are higher and the consequences would be greater.

For the first five years after being taken out of the reactor core, spent fuel generates too much heat to be placed into dry casks. After five years, the heat generation rates have dropped low enough to permit dry cask storage.

It takes no pumps, no power, no switches, and no forced circulation of water to protect spent fuel in dry casks from damage. Instead, air enters an inlet in the bottom of the dry cask, gets warmed by the heat from the spent fuel, and flows out an outlet in the top of the dry cask via the chimney

effect. It's the "passive" safety system that worked at Fukushima Dai-Ichi and would work here, if we bothered to use it.

Instead, spent fuel pools in America are filled nearly to capacity. Then and only then is spent fuel transferred into dry casks. But the amount of spent fuel transferred is just enough to free up the space needed for the next fuel discharged from the reactor core. This practice maintains the spent fuel pool risk at a level about as high as can be achieved, and exposes millions of Americans to elevated and undue risk.

The safer way to store spent fuel is to transfer it into dry casks as soon as possible following the five year cooling off period in a spent fuel pool. That's the "passive" safety system Americans need most.

UPGRADED GUIDANCE FOR SPENT FUEL POOL EVENTS

Following the March 1979 accident at Three Mile Island Unit 2 in Pennsylvania, the NRC and the nuclear industry significantly upgraded the procedures used by operators during reactor core accidents. The upgraded procedures provide the operators with the full array of options available to deal with a reactor core accident, not just those relying on emergency equipment. In addition, the upgraded procedures would help the operators handle problems like unavailable or misleading instrument readings.

No such procedures, and associated training, are available to help operators deal with spent fuel pool accidents. After the water level in the Unit 4 spent fuel pool at Fukushima Dai-Ichi dropped below the top of the fuel assemblies, the fuel rods heated up, producing large amounts of hydrogen gas. That hydrogen exploded, destroying the reactor buildings walls and roof and creating a pathway for radioactivity to freely escape to the environment. To lessen the likelihood of similar explosions, workers cut openings in the roofs and walls of the reactor buildings on Units 2, 5, and 6. Their efforts were ad hoc and reactive.

The NRC should require robust procedures for spent fuel pool problems, comparable to those for reactor core problems, to help operators either prevent fuel damage or mitigate its consequences should such damage occur.

ADDITIONAL REGULATORY REQUIREMENTS FOR DEFUELED REACTORS

When the earthquake and tsunami happened, the reactor core on Fukushima Dai-Ichi Unit 4 was empty of fuel, with the fuel having been transferred to its spent fuel pool. That configuration is termed a defueled operating condition. There's a gaping hole in the regulatory safety net when reactors are defueled.

Enclosure 3 contains pages excerpted from the NRC's Standard Technical Specifications for boiling water reactors. When the NRC issues, or renews, licenses to operate nuclear power reactors, Appendix A to these licenses are the technical specifications. These specifications establish "the lowest functional capability or performance levels of equipment required for safe

operation of the facility”¹ along with the scope and frequency of testing required to verify that capability. The operational condition of the reactor (also called its MODE and defined by the Reactor Mode Switch Position and the temperature of the reactor cooling water) determines which requirements are applicable when. However, technical specification requirements only apply when one or more fuel assemblies are located in the reactor core. When the entire reactor core inventory has been offloaded to the spent fuel pool, almost no technical specification requirements still apply.

For example, technical specification 3.6.4.1 no longer requires secondary containment to be intact. Secondary containment, which is the reactor building, houses the spent fuel pool and acts as a barrier to prevent any radioactivity released from fuel in the spent fuel pool from reaching the environment—but only when it is intact. Likewise, technical specification 3.8.2 does not require normal or backup power supplies to be available. And technical specification 3.8.5 does not even require battery power to be available.

When one or more fuel assemblies is in the reactor core, the technical specifications mandate safety measures to protect Americans from that hazard. But when that hazard is entirely relocated to the spent fuel pool, the technical specifications allow all of those safety measures to be taken away. Technical specification 3.7.8 would even allow all the water to be drained from the spent fuel pool with all the irradiated fuel in it.

The NRC must fix this technical specification deficiency to provide adequate protection of public health when reactor cores are defueled.

CONCLUSION

The measures we have recommended will lessen the chance of a disaster at a U.S. nuclear power plant. But if it happens anyway, the federal government would be able to look Americans in the eye and say, “we took every reasonable measure to protect you.” Americans expect that protection. We urge the Congress to ensure the NRC provides Americans the protection they deserve.

Enclosures:

1. Pages from NRC NUREG-1776, “Regulatory Effectiveness of the Station Blackout Rule, August 2003.
2. Pages from NRC Inspection Manual Chapter 0308, “Reactor Oversight Process (ROP) Basis Document,” October 16, 2006.
3. Pages from NRC NUREG-1433, Volume 1, Rev. 3, “Standard Technical Specifications General Electric Plants, BWR/4,” December 2005.
4. Executive Summary from UCS’s report “Nuclear Power: Still Not Viable without Subsidies,” February 2011.

¹ 10 CFR 50.36, Technical Specifications. Available online at <http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-0036.html>

