March 28, 2011

At U.S. Nuclear Sites, Preparing for the Unlikely

By JOHN M. BRODER, MATTHEW L. WALD and TOM ZELLER Jr.

WASHINGTON — American nuclear safety regulators, using a complex mathematical technique, determined that the simultaneous failure of both emergency shutdown systems that are designed to prevent a core meltdown was so unlikely that it would happen once every 17,000 years.

But 20 years ago, it happened twice in four days at a pair of nuclear reactors in southern New Jersey.

The American people, and the regulators whose job it is to protect them from a catastrophic nuclear accident, are watching the unfolding events at a complex of crippled reactors in Japan with foreboding and an overriding question: Can it happen here?

The answer — probably not — from the Nuclear Regulatory Commission is meant to reassure. But as the New Jersey accidents in 1983, which did not result in any core damage or release of radiation, show, no one can predict what might upend all the computer models, emergency planning and backup systems designed to eliminate those narrow theoretical probabilities or mitigate their effects.

“We can never say that that could never happen here,” said Anthony R. Pietrangelo, senior vice president and chief nuclear officer at the Nuclear Energy Institute, the industry’s main trade association. “It doesn’t matter how you get there, whether it’s a hurricane, whether it’s a tsunami, whether it’s a seismic event, whether it’s a terrorist attack, whether it’s a cyberattack, whether it’s operator error, or some other failure in the plant — it doesn’t matter. We have to be prepared to deal with those events.”

The threats considered most serious by nuclear engineers are problems that lead to a loss of power. Lack of power to run cooling systems for the reactor core and for spent-fuel ponds led to the explosions and release of radiation at the Fukushima Daiichi nuclear complex in Japan.

American nuclear facilities have backup power systems, and backups to those. All plants are required to have batteries to provide power in the event of a loss of power and failure of backup generators. In the United States, 93 of the 104 operating reactors have batteries capable of providing power for four hours; the other 11 have eight-hour batteries. Fukushima had eight-hour batteries. It wasn't enough.

No single analysis can discern which nuclear power plants in the United States are most at risk for a disaster, But the probabilities of an accident leading to damage to a reactor core have been roughly penciled out.

A 2003 Nuclear Regulatory Commission report, based on data submitted by plant owners, looked at the risk of equipment breakdowns, power failures and other factors that could lead to core damage.

It found that reactor No. 1 at Three Mile Island, near Harrisburg, Pa., would appear to be at greatest risk. (Three Mile Island is, of course, the plant that suffered a partial core meltdown in reactor No. 2 in 1979, the worst accident so far in the commercial nuclear power industry in the United States) By the commission's calculations, such an episode would occur there roughly once every 2,227 years. By contrast, the expected frequency of a core damage accident at the Quad Cities facility in Illinois is once every 833,000 years.

"These sorts of big numbers can tell you which plants need to take steps first to fix general problems, or which plants might have wider margins if a problem were to occur," said David Lochbaum, a nuclear engineer and the director of the Nuclear Safety Project of the Union of Concerned Scientists, an environmental and nuclear watchdog group. "They're not going to tell you when that bad day is going to arrive."

Regulators and federal courts have discounted the likelihood of multiple crises hitting a nuclear facility at the same time. One federal judge, ruling against opponents of the Diablo Canyon nuclear plant near San Luis Obispo, Calif., said that the odds of an earthquake setting off a nuclear accident at the plant were negligible.

"The commission has determined that the chance of such a bizarre concatenation of events occurring is extremely small," the court said.

But the crisis at Fukushima shows that such natural catastrophes can occur. The fact that the odds of a nuclear accident are unknowable and the risks hard to measure make it in some ways more frightening than the known — and greater — risks of driving without a seat belt or breathing the fumes from a coal-burning power plant.

"People are scared of certain things. It's part of our makeup," said Robert H. Socolow, a physicist at Princeton University. "The public is more afraid of radiation than the experts who work with it every day. But this is about irreducible irrationality, if you like. We are irrational, every last one of us."

Fresh Eye on American Plants

In the wake of the disaster in Japan, concerns were quickly raised at the Turkey Point nuclear power plant in Florida, on Biscayne Bay 24 miles south of Miami. Critics pointed to the potential for a hurricane to create a storm surge that could simultaneously sever grid power and inundate backup generators — precisely the recipe that crippled Fukushima.

In 1992, Turkey Point took a direct hit from Hurricane Andrew, causing a loss of off-site power for more than five days. Backup systems, however, allowed operators to keep the reactors cool until power could be restored. Paul Gunter, the director of the Reactor Oversight Project for the group Beyond Nuclear, which opposes nuclear energy, joined other critics in pointing to the Dresden nuclear facility in Morris, Ill., and the nearby Quad Cities plant in Cordova, both of which are north of the New Madrid seismic zone. The area registered quakes estimated to have exceeded 7.0 in magnitude in 1811 and 1812, and is known for somewhat more regular temblors of lesser intensity.

Exelon, the operator of both facilities, said that all of its plants are designed to withstand substantial earthquakes, but argued that none — including Dresden and Quad Cities, which are hundreds of miles from the New Madrid fault line — are actually considered to be in significant earthquake zones.

Still, the Nuclear Regulatory Commission announced last week that it would be conducting new seismic risk assessments next year at 17 plants — including Dresden.

The Diablo Canyon nuclear power plant is not on the commission's list. The plant, on an 85-foot bluff above the Pacific Ocean, is owned by Pacific Gas & Electric, about halfway between San Francisco and Los Angeles.

Opponents of that plant redoubled their efforts when PG&E began seeking early renewal on its two 40-year licenses — chiefly on the ground that the seismic studies that underwrote the original licensing in the 1970s were inadequate, and are now sorely out of date.

A fault line discovered in 2008, called the Shoreline Fault, runs about half a mile from the front door of Diablo Canyon. Opponents want new seismic studies before the plant's license

is renewed, but PG&E, the Nuclear Regulatory Commission and other experts argue that the fault poses no threat that the nuclear facility couldn't handle.

As at Diablo Canyon, fears of an earthquake near the Indian Point nuclear power facility, about 30 miles north of New York City, were stoked in 2008 when researchers at the Lamont -Doherty Earth Observatory at Columbia University discovered a pattern of small but active faults in the area, suggesting that earthquakes near the plant were more common than once thought.

Gov. Andrew M. Cuomo of New York has called a special meeting with federal regulators to discuss earthquake risks and preparedness at the facility. Among the concerns: how to execute an orderly evacuation of one of the most densely populated regions of the country — particularly given that the government mandates that officials plan only for a 10-mile escape radius.

How Risk Is Calculated

As part of its mission to ensure the safety of nuclear power, the Nuclear Regulatory Commission sets two goals: that the public's risk of death from acute radiation sickness from nuclear reactors should not exceed one-thousandth of the risk of accidental death from all sources, and that the risk of fatal cancer likewise should not exceed that amount.

The commission, looking at how much radiation it would take to kill people in accidents, and how much it would take to raise cancer rates, decided that reactors would meet that standard if there were meltdowns with off-site consequences only once per 100,000 years of operation.

With 104 American reactors now running, that would mean such an event once every 1,000 years or so. The commission asserts that all plants currently meet that safety standard, according to an analysis that looks at the chance that any piece of equipment will fail, and what other failures that might lead to, under a mathematical method called probabilistic risk assessment, Martin A. Stutzke, the commission's senior technical adviser for probabilistic risk assessment technologies, said in an interview.

To meet the government's goal, about 80 percent of the plants have made changes since the early 1990s, industry experts say. Many of the changes were to cope with new calculations of earthquake frequency and intensity. But while the safety goal of once in 100,000 years expresses a real number, the component failure numbers are yardsticks that may be wrong. "The numbers have tremendous uncertainty with them," he said. They could be off by a factor of 10, he said.

Earthquakes are a challenge, Mr. Stutzke said, because the historical record is so short. The Richter scale is 75 years old. For earlier records, he said, experts study old newspaper accounts — "church bells ringing, chimneys knocked over, this sort of thing," he said. Geologists also use carbon dating and other techniques to estimate the time and scale of older earthquakes.

The inherent problem, risk experts say, is that it is hard to determine the size of the worst natural hazard, said Douglas E. True, of ERIN Engineering and Research in Walnut Creek, Calif.

American reactors may be better protected than those at the Japanese plant were, because of precautions taken after Sept. 11 for a terrorist or military attack, according to industry and government officials and academic experts. American nuclear plant operators are required to have diesel fuel and pumps on site or readily available nearby to provide backup power and cooling capacity. Right after the Fukushima crisis they were ordered to check that they had the required equipment on hand and in working order.

The details are classified, but the industry has emergency supplies of pumps, hoses and generators, and the plan assumes Air Force help in moving equipment when needed.

"We have military capability that's pretty impressive, a transport system that can move big pieces of equipment very quickly," said Dale Klein, a commission chairman in the second Bush administration. If the diesel generators fail, he said, it makes no difference whether the cause was attack, tsunami or earthquake; the remedy is the same.

Another former chairman, Richard Meserve, who was in that position at the time of the 2001 attacks, said, "The challenge that we confront is that external events obviously can occur that may be larger than you expected."

The commission will not discuss the precautions it has in place to contend with such events, citing security considerations.

Alternatives Carry Risks Too

There is no simple or single way to properly weigh the risks of nuclear power against other energy sources, or other risks of modern life, said David Ropeik, an instructor at Harvard University, consultant to industry and author of "How Risky Is It, Really? Why Our Fears Don't Always Match the Facts."

"What we're afraid of determines how we behave, and sometimes those behaviors become risks in themselves," he said. He cited a study by two researchers at the University of

Michigan who found that fear of flying after the Sept. 11 hijackings had caused an additional 1,018 highway deaths in just the first three months after the attacks.

Radiation is a real threat, nuclear physicists say, but not as great as many people believe it is, and not as great as other threats. Indeed, every energy source comes with dangers, from the mine or wellhead to the smokestack or tailpipe.

“One million people a year die prematurely in China from air pollution from energy and industrial sectors,” said Stefan Hirschberg, head of safety analysis at the Paul Scherrer Institute, an engineering research center in Switzerland. More than 10,000 Americans a year die prematurely from the health effects of breathing emissions from coal-burning power plants, according to the Environmental Protection Agency.

Coal mining accidents in China kill an estimated 6,000 people a year, according to China’s Mining Ministry. In just the past year in the United States, the Deepwater Horizon blowout killed 11 people, the Upper Big Branch coal mine blast killed 29 and a natural gas pipeline explosion in California killed 8.

But such statistics don’t alter the public’s view of nuclear accidents.

Michael A. Levi, senior fellow for energy and the environment at the Council on Foreign Relations, said there is no right way to gauge risk. It is an intensely personal matter affected by a lot of factors.

“When you hear these arguments that pollution from coal plants costs so many thousands of lives compared to minimal or no deaths from nuclear accidents, that may be technically true, but it leaves a lot of people cold. It’s like saying, ‘Don’t pay attention to the twin towers falling; more people die crossing the street,’ ” he said. “Experts should not say, ‘Here’s how you should feel about risk.’ They should be saying, ‘Here are the facts. You decide what matters to you.’ ”

A 2006 study of survivors of the 1986 Chernobyl accident, compiled by the International Atomic Energy Agency, the World Bank and a number of United Nations bodies, found that the biggest health impact was psychological.

“The mental health impact of Chernobyl is the largest public health problem unleashed by the accident to date,” according to the report, “Chernobyl’s Legacy: Health, Environmental and Socio-Economic Impacts.” “Psychological distress arising from the accident and its aftermath has had a profound impact on individual and community behavior,” including a

sense of fatalism and dependency that has been transferred to the next generation in the affected zone.

“There is no question we should be appropriately concerned about nuclear power,” Mr. Ropeik said. “But ‘appropriately’ is the important distinction. On a continuum, there is no question in my mind that the dangers from fossil fuel burning should worry us more.”