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Nuclear Mishap or Meltdown?: It's All a Matter of Degree

An obscure scale helps communicate the relative severity of a nuclear accident

Earthquake stories are incomplete without information from the Richter scale. Without the measurement of magnitude 6.8, for instance, few could grasp the relative severity of the recent earthquake off the western coast of Japan. Scales are also essential to any weather report—from hurricane intensity (measured on the Saffir-Simpson hurricane scale from categories 1 to 5) to the temperature.

An analogous scale exists for portraying the broad range of potential danger from a nuclear accident—whether it be a small leak of radioactive material or the meltdown of a reactor—though it lingers in relative obscurity. But with plans to build many more nuclear reactors worldwide, including as many as 30 in the U.S. alone over the next few decades, the International Nuclear Event Scale (INES) may become more familiar.

The scale ranges from level 0 (a "deviation" of "no safety significance") to level 7 (a "major accident"). No major nuclear accidents have occurred since it was implemented in 1992, but it has been used to assess damage from previous events. Only one event, the 1986 meltdown of the Chernobyl nuclear plant in Ukraine, has merited its most serious degree, level 7. The explosion in the reactor core spread both short- and long-lived radioactive material as far as the U.K. Therefore, it fulfilled all three of the scale's criteria: on-site impact, off-site impact and so-called "defense in depth."

The latter concept refers to the numerous safeguards designed to limit the impact of potentially deadly accidents. "How did the safety provisions function and how close the event was to causing a problem," says Cynthia Jones, the U.S. Nuclear Regulatory Commission's (NRC) senior technical advisor for nuclear security. "It's like if you had a car accident and you broke your turn signal. Can you still drive the car? Yes, but you've lost one of your defenses. It's a degradation of warning."

In the case of Chernobyl, all such preventive measures failed. In the case of the 1979 accident at the Three Mile Island nuclear plant near Middletown, Pa., radioactivity spread but was limited to a 10-mile radius, which led to it being downgraded to level 5, even though it had the makings of a full-scale catastrophe due to human error.

In all, there were 10 incidents at U.S. nuclear plants last year that merited ratings of 2—"significant spread of contamination / overexposure of a worker" and "incidents with significant failures in safety provisions," as the INES handbook puts it—or above, Jones says. "Two reactor events and eight nonreactor events."

Among the eight nonreactor events was a spill at the Nuclear Fuel Services, Inc., fuel production plant in Erwin, Tenn., in March 2006. More than eight gallons (31 liters) of highly enriched, weapons-grade uranyl nitrate, the liquid form of transportable uranium, nearly pooled in a sufficient quantity to achieve the conditions necessary for a spontaneous chain reaction—uncontrolled fission, otherwise known as a criticality.

"Nothing did happen in terms of a criticality event," says NRC commissioner Gregory Jaczko. "That would have been the kind of event that would have been a potential." Because such fission was avoided, the incident was reported to the International Atomic Energy Agency (IAEA) by the NRC as a level 2 event on the INES scale. Subsequently, the plant was closed for seven months and a major reorganization has been undertaken by Nuclear Fuel Services, according to notes from a meeting with NRC commissioners.

The INES scale notwithstanding, word of this near-fission event did not reach the public until this year due to secrecy provisions put in place by the Bush administration to stop would-be terrorists and others from getting information about nuclear power plants. "Certainly, in my view, this was something we should have reported initially," Jaczko says.

Notes Rejane Spiegelberg Planer, who is in charge of incident reporting at the IAEA: "There is no obligation to report." So far, 63 countries have agreed to voluntarily report and rank incidents on the scale. Each country has its own internal reporting requirements; the NRC requires that all licensed U.S. nuclear operators promptly notify it of any incidents.



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The information, of course, can only be as good as the reporting—and the scale itself. The leaks of nuclear fuel rod cooling water, a burning transformer and other problems at the world's largest nuclear reactor—Kashiwazaki-Kariwa in Japan—caused by the earthquake this past week have yet to rise above INES level 0. The coolant's radioactivity has been reported as 16,000 becquerels per liter in the roughly liter-and-a-half (0.39-gallon) spill. (One becquerel is the measure of a material's radioactive decay equal to one nucleus disintegration per second.) To merit a 2 on the scale, for example, would require the leak of material emitting several gigabecquerels. "We can't even measure that [Japanese spill] with any kind of device that we have," Jones says.

A malfunction in the water pump at the Oyster Creek nuclear power plant in New Jersey caused it to shut down on July 17 and release one curie of tritium (an isotope of hydrogen) in vented steam, according to the NRC. One curie equals 37 billion becquerels, "just half the radiological exposure of living with a household smoke detector," according to Exelon, the power company that runs the plant. As a result, this incident at the oldest operating nuclear reactor in the U.S. also does not merit inclusion on INES.

But with more nuclear power plants being built and planned (there are licenses pending at the NRC to build 30 plants in the U.S.), the aging of those currently on line as well as the proliferation of radioactive materials used in other applications, the INES scale may yet become more familiar. "I like to compare it with a very simple scale that is a thermometer," IAEA's Spiegelberg Planer says. Level 0 is equivalent to the human body at its normal temperature. Level 2 might be a slight rise in temperature that prompts taking an aspirin. "You don't go to the emergency room if you can take an aspirin," she says, whereas at level 7 "you are already in the hospital."

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