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Wind and Rain Steer Radiation's Reach

By HENRY FOUNTAIN

So, how bad could it get?

Experts say it is impossible to forecast how events at Japan's stricken nuclear plant will unfold, whether there will be a meltdown or other crisis at one or more of the reactors that results in a large release of radioactivity into the environment. And even if such a release occurred, the impact in Japan and elsewhere would depend greatly on wind and rain and how long the release lasted.

"We're in uncharted territory here," said Robert Alvarez, a nuclear expert and adviser to the secretary of energy during the Clinton administration. "But in very general terms, the worst-case scenario would be a catastrophic release of radiation that will not necessarily happen all at once."

That would make the event similar to, and perhaps worse than, the Chernobyl accident in 1986, in which large amounts of radioactivity were released and hundreds of square miles of land in Ukraine were left uninhabitable. But without such a catastrophic release, the events would likely be closer in scale to the partial meltdown in 1979 at Three Mile Island in Pennsylvania, where the plant's containment structure held and a relatively small amount of radioactivity was released.

So far, the problems at the Fukushima Daiichi plant in Japan are more severe than at Three Mile Island but less so than in Chernobyl.

The Chernobyl reactor, which caught fire after electrical tests resulted in a series of explosions, was not surrounded by a containment structure, as the Japanese reactors are. So a key factor in Japan is whether, if one or more of the reactors has a full meltdown of its nuclear fuel, the containment barriers hold. Complicating matters is the presence of large amounts of spent fuel — which contain most of the same radioactive elements as the fuel in the reactor — in storage ponds that are outside any containment barrier.

Experts differ as to whether breaching of the containment is likely or not. "There's quite a lot of redundancy and barriers built into the system," said Mary Lou Dunzik-Gougar, an

assistant professor of nuclear engineering at Idaho State University. "A full-fledged meltdown might result in a breach of the pressure vessel, with the fuel dropping into the lower part of the plant. But it's not going to go very far."

But a breach would most likely be catastrophic.

"If there's a breach of containment and a significant release of radioactivity, I think it's safe to draw parallels to Chernobyl," said Kenneth L. Mossman, a professor of health physics at Arizona State University. But he described Chernobyl as an "upper bound" of what might happen in Japan.

Dr. Mossman said the impact of the radiation would be twofold. Workers would be at risk for illness or death because of high levels of gamma rays and other ionizing radiation. But the area around the plant would become a no-man's land, contaminated with radioactive elements like cesium, plutonium and iodine.

Just how large this area would be would depend on whether the poisons were released slowly and stayed close to the ground or were spewed into higher altitudes by explosions or fire. Wind would push the radiation in one direction, and tend to disperse it over a larger area. Rain would bring much of it to the surface.

The size of the contaminated area would also depend on how much of the radiation escaped. At Chernobyl, where the reactor burned for about a week, no one knows for certain how much of the radiation in the fuel was released — one estimate is about 40 percent. At the Japanese plants, unless the containment vessels were totally destroyed by explosions — which some nuclear engineers said was unlikely — some percentage of the radiation in the roughly 150 tons of fuel in each reactor would still be kept safe.

However large, the contaminated area would be uninhabitable for decades.

The spent-fuel pools represent another risk. They are designed to keep the old fuel rods, which are removed from the reactor regularly, submerged to prevent overheating as the radioactive elements in the fuel decays.

"Any of the pools at units 1 through 4 are problems," Mr. Alvarez said.

It is not clear how much spent fuel there is at each reactor. At the Vermont Yankee plant, a reactor in southern Vermont that is nearly identical to the crippled ones in Japan, close to 700 metric tons of spent fuel is stored. The Japanese plants probably do not have nearly as much — perhaps tens of tons at each reactor, Mr. Alvarez said.

If they overheat and the rods crack or, worse yet, the fuel burns — again, experts differ as to whether this is likely — radioactivity would be released. Because the fuel is older, iodine, an element with a relatively short half-life, would not be a problem. But cesium, plutonium and strontium would still be present in large quantities.

The plume might even be larger than that from a reactor meltdown, because of the lack of containment. But that is another of many unknowns, Mr. Alvarez said.

"The kinds of things that are happening have in very general terms been vaguely predicted," he said. "The phenomenon of multiple hydrogen explosions, for example — will there be more explosions, will they damage or otherwise compromise the primary containment?

"There are things we don't know but things we need to be concerned about."