A Survey of the World's Radioactive No-Go Zones

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http://www.spiegel.de/

The Soviet nuclear testing site in present-day Kazakhstan is just one of many places in the world that remain dangerously radioactive to this day.

Everyone knows about Chernobyl, Three Mile Island and, now, Fukushima. But what about Semipalatinsk, Palomares and Kyshtym? The world is full of nuclear disaster zones -- showing just how dangerous the technology really is.

Wednesday, Mar. 28, 1979. In the Three Mile Island nuclear power station in Harrisburg, Pennsylvania, the nightmare scenario of nuclear physicists was about to unfold. At four in the morning, employees in the control room noticed the failure of a pump in the reactor's water cooling loop. When a bypass valve failed to trip, water stopped flowing to steam generators, resulting in an emergency reactor shutdown. But the reactor continued to generate so-called decay heat. A relief valve opened automatically but then failed to close, allowing coolant to flow out at a rate of one ton per minute. The control panel erroneously indicated that the cooling system was functioning normally, meaning technicians initially failed to recognize the problem.

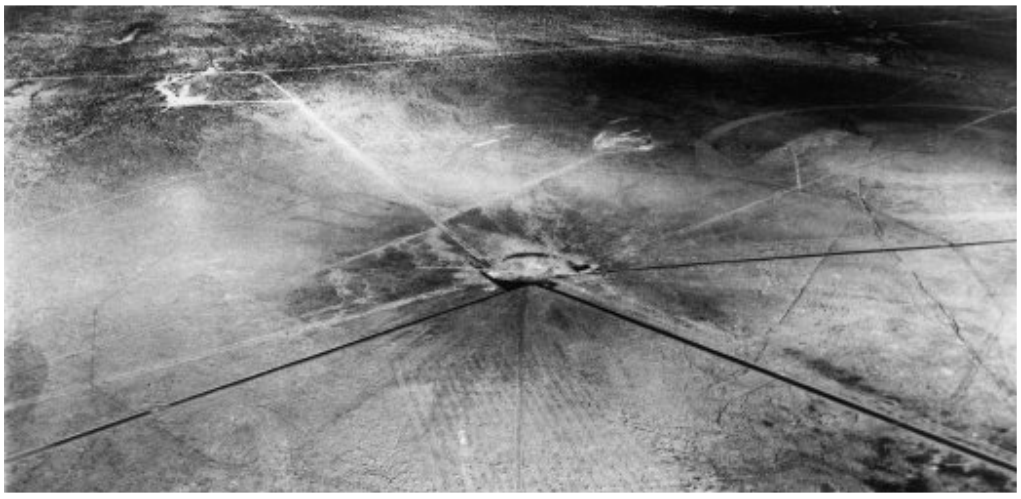
By 6 a.m., the top of the reactor core was no longer covered in cooling water -- and the fuel rods began to melt. At the last moment, a technician noticed the problem and closed the relief valve. A full-scale meltdown was only barely averted.

Still, the series of events had a devastating effect: Not only was radioactivity released into the atmosphere, but contaminated coolant escaped into the nearby river. Cancer rates in the local population later rose dramatically. In addition, large parts of the reactor and the power plant site were contaminated. The clean-up operation in Harrisburg took 14 years and cost more than $1 billion. And the reactor ruins are radioactive to this day.

The case is instructive. It was the result of tiny construction errors and a small dose of human error. And now, as the world watches on in horror as the catastrophe in Fukushima continues to unfold, the debate on the safety of nuclear power has been reignited. The area around Fukushima will likely remain contaminated for decades, if not centuries. And many are once again wondering if the returns from nuclear technology justifies the risks. How can anything be considered under control which can so quickly mutate into an apocalypse?

Sadly, though, disasters like Three Mile Island and Fukushima are not as rare as one would hope. There have been plenty of atomic accidents resulting in significant radioactive leaks, spills and explosions. And the Chernobly Exclusion Zone, for all the attention it gets, is far from the only nuclear no-go area on the planet. A look at some of the worst incidents is enough to demonstrate just how high the price of nuclear energy and nuclear weapons truly is.

Part 2: A New Age Dawns



Corbis

On Jul. 16, 1945, at 05:29:45 local time, the atomic era began as the first ever nuclear bomb, called "The Gadget", was detonated at the White Sands missile testing grounds in New Mexico. A similar device exploded over Nagasaki just a few weeks later. Beforehand, some of those involved in the test expressed fears that the explosion might ignite the atmosphere and destroy all life on the planet -- or completely incinerate New Mexico. But despite these concerns, the 18 kiloton bomb was detonated, creating a twelve-kilometer high mushroom cloud and a blast heard 320 kilometers away. Sand at the site of the explosion turned into green, radioactive glass -- also called Trinitit.

Part 3: 'Now I Am Become Death'

Corbis

The scientific director of the project, Dr. J. Robert Oppenheimer, said later the explosion had reminded him of a line from the Hindu scripture Bhagavad Gita: "Now I am become Death, the destroyer of worlds." In 1952, the bomb crater was filled in and most of the Trinitit removed. More than 60 years after the "Trinity" test, radiation at the site is still 10 times higher than normal. The site was declared a historic monument in 1965 and can be visited -- but only on two days a year.

Part 4: Uninhabitable to This Day

Corbis

The worst nuclear accident the world has so far seen occurred on Apr. 26, 1986 at the Chernoybl power plant near the town of Pripyat, in what was then the USSR (now Ukraine). The testing of a new voltage regulator led to an explosion in reactor 4 which destroyed the roof, exposing the melting core and hurling radiation into the air.

The Soviet authorities tried to cover up the incident for as long as possible. On the morning after the explosion, area residents were requested to stay indoors and to keep their windows closed. One day later, all 50,000 residents of Pripyat were evacuated. They were told they would be able to return home after three days, but they were never allowed back.

It was weeks before the full extent of the disaster became known outside of the Soviet Union as radioactivity reached large parts of Europe. An exclusion zone was set up prohibiting entry into an area 30 kilometers on all sides of the stricken reactor. Some say that as many as 110,000 people lost their lives with hundreds of thousands more still suffering from the effects of the radiation, but other estimates are much lower. The International Atomic Energy Agency (IAEA) said in 2006 that fewer than 50 people died from initial exposure to radiation from the reactor. At the scene of the accident, radiation exposure is still 700 times higher than permissible levels, and Pripyat remains uninhabitable.

Part 5: The Radioactive Dilemma

DPA

Above ground, Germany has not yet suffered a nuclear disaster, despite numerous incidents in German nuclear power plants. Underground, however, is a different story: Electricity has been produced from nuclear fission in Germany for more than 60 years -- but there is no final repository for the resulting waste. Since the 1960s, much of the waste has ended up at the Asse storage facility (pictured), a salt mine which was to protect the radioactive garbage for the next 100,000 years.

But just 40 years later, massive problems with the site have become apparent. Despite assurances to the contrary, 12,000 liters of water are leaking into the site each day, rusting the drums and resulting in a release of radioactivity. As yet, there is no proposal for what to do with the resulting sludge nor is there a plan in place for solving the Asse problem. Many of the waste drums were simply piled up, instead of neatly stacked. It is impossible to get close enough to begin a clean up program.

Part 6: Unrelenting Bombardment

Corbis

During the Cold War's nuclear arms race, a total of 119 atomic devices were detonated at the Nevada Proving Grounds, northwest of Las Vegas. This image is from a test in 1953. After 1962, more than a thousand nuclear tests were conducted underground. The site -- about the size of Germany's Saarland region -- was finally decommissioned in 1992.

Part 7: A Deadly Legacy

Getty Images

The lion's share of the plutonium used for the US nuclear arsenal during the Cold War came from the Hanford plant on the Columbia River in the US state of Washington. The plutonium used in the first atomic bomb test in July 1945 came from Hanford as did the material used in "Fat Man," the bomb which destroyed Nagasaki on Aug. 9, 1945.

Fifty-two buildings at Hanford remain contaminated to this day, and 240 square miles are uninhabitable due to the radioactivity that has seeped into the soil and ground water:

uranium, cesium, strontium, plutonium and other deadly radio-nuclides. Altogether, more than 204,000 cubic meters of highly radioactive waste remain on site -- two-thirds of the total for the entire US. In one area, discharges of more than 216 million liters of radioactive, liquid waste and cooling water have flowed out of leaky tanks. More than 100,000 spent fuel rods -- 2,300 tons of them -- still sit in leaky basins close to the Columbia River.

The plant is also notorious for the so-called "Green Run" -- the deliberate release of a highly radioactive cloud from the T-plant, the world's largest plutonium factory at the time. The radiation was almost 1,000 times worse than that released during the 1979 meltdown at Three Mile Island in Pennsylvania, the worst nuclear accident in American history. Fallout from the experiment drifted all the way to California. People wondered why they suddenly got sick. Studies would eventually show that some babies at Hanford were radiated twice as much as the children of Chernobyl.

Part 8: A Nuclear No Man's Land

Semipalatinsk in Kazakhstan, now known as Semey, was host to the main nuclear test site of the former Soviet Union. Some 506 nuclear tests were carried out there during the Cold War. Since the closure of the site, the United States has invested more than $600 million (€420 million) in cleaning up the contaminated 18,500 square kilometers (7,142 square miles). The US has also invested $100 million (€70 million) in trying to better secure the site -- there are fears terrorists could obtain radioactive material there in order to build so-called dirty bombs.

The Kazakh government had hoped to make the site available for agricultural use once again. But some areas are still so contaminated with plutonium that they have to be covered with huge, two-meter thick steel plates to contain the radiation.

Part 9: Unfathomable Destruction

AP

On Aug. 6, 1945, the US bomber *Enola Gay* dropped an atomic bomb on Hiroshima, Japan. Within seconds, much of the city was destroyed and 90 percent of the people in a half-kilometer (0.3 mile) radius were killed. Many others died in the aftermath of the bomb. By 1946, it is estimated that between 90,000 and 166,000 people had died from the immediate after-effects.

Part 10: Long-Term Effects

DPA

In later years, countless people died from the effects of radiation. Its full magnitude is still being studied.

Part 11: The Irradiated Buddha

REUTERS

On May 18, 1974, a new member joined the global nuclear family. In the Thar Desert in Rajasthan, near the border with Pakistan, and with expertise gained from a Canadian-built reactor, the first Indian atomic bomb -- called "Smiling Buddha" -- was detonated 107 meters below the ground. India insisted the explosion was for "peaceful" purposes.

In 1998, the site was used for five additional atomic weapons tests. It is unknown whether any radiation leaked to the surface -- officials have claimed that none was detected. To date, India has still not signed the Nuclear Non-Proliferation Treaty but has pledged never to strike first with nuclear weapons.

Part 12: Underground Time Bomb

AP

East Germany stored its radioactive waste at a facility at Morsleben, in the eastern German state of Saxony-Anhalt. Shortly after the fall of the Berlin Wall, Angela Merkel,

then the environment minister, allowed considerable amounts of radioactive waste from the affluent West to be dumped in the Morsleben salt deposits -- despite the concerns of the Federal Authority for Radiation Protection and the opposition of local politicians. Because the facility is now classed as severely structurally damaged, it must be stabilized at great cost -- some €2 billion is needed for permanent closure.

Part 13: The First Big Accident

AP

The first large nuclear power plant accident -- and the largest until Chernobyl -- took place at Windscale, now Sellafield, in October 1957. There, by the Irish Sea, the British had hurriedly built two atomic reactors after World War II for power production and to make weapons-grade plutonium.

The speed of construction carried a great cost. In 1955, 251 workers were exposed to radiation during repair work. Then, on Oct. 10 1957, a reactor core began to burn. In an attempt to extinguish the fire, a radioactive cloud was released, followed by a second one the next day. The radiation reached as far as Switzerland. The fires were only brought under control after two days.

The authorities attempted to cover up the accident, initially saying only that there had been an incident, but that the workers involved had been able to scrub away the radiation with soap and water. The only warning was that cow's milk in a radius of 200 miles from the reactor should not be consumed. In reality, the population surrounding the reactor received radiation doses 10 times higher than that seen as permissible for a lifetime.

According to official figures, 33 people were killed by the after-effects of the disaster, with more than 200 diagnosed with thyroid cancer. To this day, 15 tons of damage fuel rods are still stored on site as is radioactive ash and mud, leftover from the fire. The reactor is now to be dismantled using a robot built exclusively for the project. In all, it is set to cost some 500 million pounds.

Part 14: The Desert Rats

AFP

France was also determined not to get left behind in the nuclear arms race. The first French atomic bomb was called "Gerboise Bleue," named after a desert rodent, and was detonated on the morning of Feb. 13, 1960 in the Reggane district of Algeria, then a French colony. At 70 kilotons, it was bigger than the first nuclear tests of the UK, USSR and USA combined. Three more bombs were exploded soon thereafter. France moved its testing grounds to remote areas of the South Pacific after Algeria gained its independence in 1962.

Part 15: An Ill-Advised Test

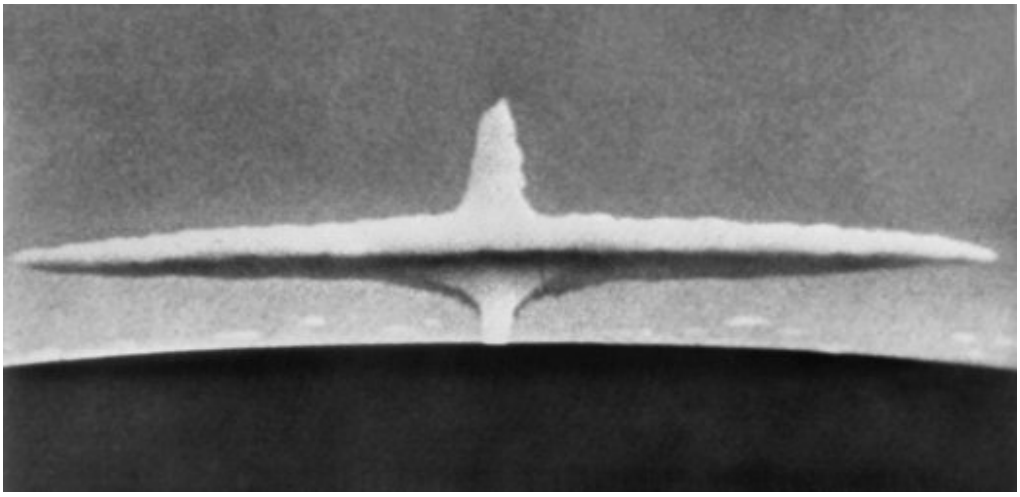
DPA

It was only in 2010, the 50th anniversary of that first French test, that the French paper *Le Parisien* published secret papers from the French Defense Ministry revealing that 300 soldiers were purposefully exposed to radiation during the last test to see what effect it would have on the human body. Most of the soldiers were later diagnosed with cancer,

and the survivors still suffer from the effects of the radiation. The scandal prompted the French government to provide €10 million in compensation for those affected by the 210 nuclear bomb tests it has carried out.

A report completed by the IAEA in 2005 at the request of the Algerian government found that no further measures were necessary to clean up the Sahara testing grounds. Radiation levels, the report found, were very weak. But Algerian victims' groups complain that France never carried out a decontamination program They say that cancer rates in the region are high and that children are often born with abnormalities.

Part 16: Mushroom Clouds in the South Pacific



AFP

In the 1960s, France moved all of its nuclear testing to the Mururoa and Fangataufa atolls and ultimately conducted 41 atmospheric tests and 147 underground tests at the site. Testing at the site was the periodic target of official protest, most notably by the New Zealand government, which sent ships to the atoll in the 1970s to protest for a nuclear free pacific. The site was abandoned as a nuclear test area in 1996, but is still guarded by French forces. There is concern that underwater cracks discovered in the atoll may ultimately allow under ground radiation to escape.

France wasn't the only country to test nuclear devices in the South Pacific. The US detonated 23 nuclear bombs at Bikini Atoll, starting in 1946. One of the blasts contaminated 23 crew members of a Japanese fishing boat, an event which angered Japan and provided the inspiration for the 1954 film "Godzilla." Some 200 inhabitants of the islands were relocated, but several were returned in the 1960s once the US declared the islands safe for habitation. They were, however, removed once again when failed pregnancies and birth deffects began to mount. Fish caught in the atoll's lagoon are still not safe to eat.

The US also conducted nuclear tests at Enewetak Atoll. The photo above shows a Hydrogen bomb blast on Enewetak Atoll in 1952.

Part 17: Dangerous Negligence

In 1997, highly toxic uranium escaped from around 2,000 barrels of nuclear waste at the Tokai atomic power plant in Japan after rainwater seeped into the shafts where they were stored, causing them to rust. As early as 1982, the authorities had told the firm responsible to fix the problem.

In March of 1997, 35 workers were contaminated with radiation at a nuclear reprocessing facility nearby, at the time, the worst nuclear accident in Japan's history. Just two years later at a uranium reprocessing facility in Tokaimura, 80 workers were contaminated and two died in an accident.

Part 18: Hydrogen Drama in Spain

DPA

On Jan. 17, 1966, an American B-52 bomber and a tanker plane collided over the Spanish coast near Almeria during a refueling maneuver. The bomber, which had been on a routine patrol flight, was carrying four hydrogen bombs. Three fell to the ground near the

Andalusian village of Palomares where it required an eight-week clean up operation by US forces to remove several thousand tons of contaminated soil and take it to the US for storage. The photo shows barrels containing the radioactive earth. The fourth bomb was recovered intact from the bottom of the ocean on April 7 that year.

Forty-five years later, the Palomares region still faces aftereffects of the accident. The Spanish government in Madrid has recently promised that cleaning up remaining contamination was a priority and a US team of experts was dispatched to help advise the effort. An estimated half a kilogram of plutonium is believed to still be in the soil.

Part 19: Harrisburg Horror

AP

In March 1979, the area around Three Mile Island in Harrisburg, Pennsylvania was contaminated with radioactivity. Technicians released irradiated gas and water into the environment in order to prevent a full reactor meltdown. The clean-up operation of the surrounding area lasted 12 years and cost around €1 billion.

Part 20: The Unknown Catastrophe

 DPA

One of the worst nuclear accidents took place on Sep. 29, 1957, but was only made public years later. On that day, a tank containing 80 tons of highly-radioactive liquid waste exploded at the Mayak plutonium plant in the southern Urals, 15 kilometers east of the Russian city of Kyshtym. The blast produced a radioactive cloud that was about 300 kilometers long and 40 kilometers wide, and which traveled northeast. The radiation did not reach Europe, but was at the same level of that released during the Chernobyl disaster in 1986. About 15,000 people who lived in the area were evacuated, and the houses located in a 25-kilometer zone surrounding the location were destroyed. No one was allowed to go back. The plutonium production at the plant, which also delivered the material for the Soviet Union's first atomic bomb, was not discontinued.

It wasn't until the 1970s that information about the catastrophe leaked to the West. The Soviet regime first admitted it in 1989. The number of deaths and details of the long-term effects remain unknown. The 150-square-kilometer area over which the radioactive cloud dispersed remains closed off to this day and entry is forbidden.