UNITED STATES NUCLEAR REGULATORY COMMISSION
BACKGROUNDER
Office of Public Affairs
@NRCgov
301.415.8200
www.nrc.gov ■ opa.resource@nrc.gov

Chernobyl Nuclear Power Plant Accident

Background

On April 26, 1986, a sudden surge of power during a reactor systems test destroyed Unit 4 of the nuclear power station at Chernobyl, Ukraine, in the former Soviet Union. The accident and the fire that followed released massive amounts of radioactive material into the environment.

Emergency crews responding to the accident used helicopters to pour sand and boron on the reactor debris. The sand was to stop the fire and additional releases of radioactive material; the boron was to prevent additional nuclear reactions. A few weeks after the accident, the crews completely covered the damaged unit in a temporary concrete structure, called the “sarcophagus,” to limit further release of radioactive material. The Soviet government also cut down and buried about a square mile of pine forest near the plant to reduce radioactive contamination at and near the site. Chernobyl’s three other reactors were subsequently restarted but all eventually shut down for good, with the last reactor closing in December 2000. The Soviet nuclear power authorities presented their initial accident report to an International Atomic Energy Agency meeting in Vienna, Austria, in August 1986.

After the accident, officials closed off the area within 30 kilometers (18 miles) of the plant, except for persons with official business at the plant and those people evaluating and dealing with the consequences of the accident and operating the undamaged reactors. The Soviet (and later on, Russian) government evacuated about 115,000 people from the most heavily contaminated areas in 1986, and another 220,000 people in subsequent years (Source: UNSCEAR 2008, pg. 53).

Health Effects from the Accident

The Chernobyl accident’s severe radiation effects killed 28 of the site’s 600 workers in the first four months after the event. Another 106 workers received high enough doses to cause acute radiation sickness. Two workers died within hours of the reactor explosion from non-radiological causes. Another 200,000 cleanup workers in 1986 and 1987 received doses of between 1 and 100 rem (The average annual radiation dose for a U.S. citizen is about .6 rem). Chernobyl cleanup activities eventually required about 600,000 workers, although only a small fraction of these workers were exposed to elevated levels of radiation. Government agencies continue to monitor cleanup and recovery workers' health. (UNSCEAR 2008, pg. 47, 58, 107, and 119).

The Chernobyl accident contaminated wide areas of Belarus, the Russian Federation, and Ukraine inhabited by millions of residents. Agencies such as the World Health Organization have been concerned about radiation exposure to people evacuated from these areas. The majority of the five million residents living in contaminated areas, however, received very small radiation doses comparable to natural background levels (0.1 rem per year). (UNSCEAR 2008, pg. 124-25) Today the available evidence does not strongly connect the accident to radiation-induced increases of leukemia or solid cancer, other than thyroid cancer. Many children and adolescents in the area in 1986 drank milk contaminated with radioactive iodine, which delivered substantial doses to their thyroid glands. To date, about 6,000 thyroid cancer cases have been detected among these children. Ninety-nine percent of these children were successfully treated; 15 children and adolescents in the three countries died from thyroid cancer by 2005. The available evidence does not show any effect on the number of adverse pregnancy outcomes, delivery complications, stillbirths or overall health of children among the families living in the most contaminated areas. (UNSCEAR 2008, pg. 65).

Experts expected that some cancer deaths might eventually be attributed to Chernobyl over the lifetime of the emergency workers, evacuees and residents living in the most contaminated areas. While cancer deaths have generally been far lower than initial speculations of tens of thousands of radiation-related deaths, a recent study of a cohort of emergency workers found a statistically significant relative risk of solid cancer incidence and mortality. (Kaschcheev, 2015).

There are also psycho-social impacts on residents and evacuees from the disaster including higher rates of depression, alcoholism, and anxiety over potential health effects. Residents report very negative self-assessments of health, unexplained physical symptoms, and expectations of a short life. (IAEA, 2006, and World Health Organization, 2006).

U.S. Reactors and NRC's Response

The NRC continues to conclude that many factors protect U.S. reactors against the combination of lapses that led to the accident at Chernobyl. Differences in plant design, broader safe shutdown capabilities and strong structures to hold in radioactive materials all help ensure U.S. reactors can keep the public safe. When the NRC reviews new information it takes into account possible major accidents; these reviews consider whether safety requirements should be enhanced to ensure ongoing protection of the public and the environment.

The NRC's post-Chernobyl assessment emphasized the importance of several concepts, including:

- designing reactor systems properly on the drawing board and implementing them correctly during construction and maintenance;
- maintaining proper procedures and controls for normal operations and emergencies;

- having competent and motivated plant management and operating staff; and
- ensuring the availability of backup safety systems to deal with potential accidents.

The post-Chernobyl assessment also examined whether changes were needed to NRC regulations or guidance on accidents involving control of the chain reaction, accidents when the reactor is at low or zero power, operator training, and emergency planning.

The NRC's Chernobyl response included three major phases: (1) determining the facts of the accident, (2) assessing the accident's implications for regulating U.S. commercial nuclear power plants, and (3) conducting longer-term studies suggested by the assessment.

The NRC coordinated the fact-finding phase with other U.S. government agencies and some private groups. The NRC published the results of this work in January 1987 as NUREG-1250.

The NRC published the second phase's results in April 1989 as NUREG-1251, "Implications of the Accident at Chernobyl for Safety Regulation of Commercial Nuclear Power Plants in the United States." The agency concluded that the lessons learned from Chernobyl fell short of requiring immediate changes in the NRC's regulations.

The NRC published its Chernobyl follow-up studies for U.S. reactors in June 1992 as NUREG-1422. While that report closed out the immediate Chernobyl follow-up research program, some topics continue to receive attention through the NRC's normal activities. For example, the NRC continues to examine Chernobyl's aftermath for lessons on decontaminating structures and land, as well as how people are returned to formerly contaminated areas. The NRC considers the Chernobyl experience a valuable piece of information for considering reactor safety issues in the future.

Discussion

The Chernobyl reactors, called RBMKs, were high-powered reactors that used graphite to help maintain the chain reaction and cooled the reactor cores with water. When the accident occurred, the Soviet Union was using 17 RBMKs and Lithuania was using two. Since the accident, the other three Chernobyl reactors, an additional Russian RMBK and both Lithuanian RBMKs have permanently shut down. Chernobyl's Unit 2 was shut down in 1991 after a serious turbine building fire; Unit 1 was closed in November 1996; and Unit 3 was closed in December 1999, as promised by Ukrainian President Leonid Kuchma. In Lithuania, Ignalina Unit 1 was shut down in December 2004 and Unit 2 in 2009 as a condition of the country joining the European Union.

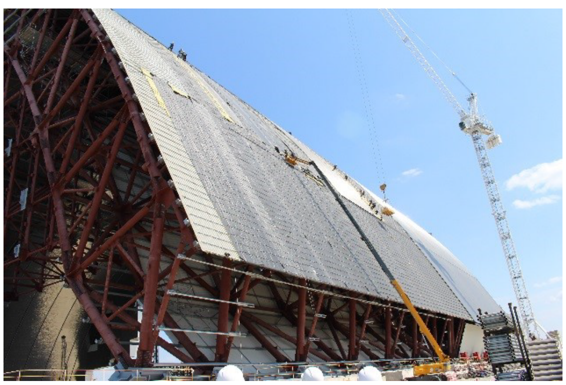
Closing Chernobyl's reactors required a combined effort from the world's seven largest economies (the G-7), the European Commission and Ukraine. This effort supported such things as short-term safety upgrades at Chernobyl Unit 3, decommissioning the entire Chernobyl site, developing ways to address shutdown impacts on workers and their families, and identifying investments needed to meet Ukraine's future electrical power needs.

On the accident's 10th anniversary, the Ukraine formally established the Chernobyl Center for Nuclear Safety, Radioactive Waste and Radio-ecology in the town of Slavutych. The center provides technical support to Ukraine's nuclear power industry, the academic community, and nuclear regulators.

Sarcophagus

The Soviet authorities started the concrete sarcophagus to cover the destroyed Chernobyl reactor in May 1986 and completed the extremely challenging job six months later. Officials considered the sarcophagus a temporary fix to filter radiation out of the gases from the destroyed reactor before the gas was released to the environment. After several years, experts became concerned that the high radiation levels could affect the stability of the sarcophagus.

In 1997, the G-7, the European Commission and Ukraine agreed to jointly fund the Chernobyl Shelter Implementation Plan to help Ukraine transform the existing sarcophagus into a stable and environmentally safe system. The European Bank for Reconstruction and Development manages funding for the plan, which will protect workers, the nearby population, and the environment for decades from the very large amounts of radioactive material still in the sarcophagus. The existing sarcophagus was stabilized before work began in late 2006 to replace it with a new safe shelter called the New Safe Confinement.



The New Safe Confinement structure was an unprecedented project to design a new building that would completely enclose the existing sarcophagus. To protect the construction workers from radiation, the arch-shaped steel structure was assembled away from the damaged reactor building and rolled into place across steel rails. Over 350 feet high and 840 feet wide it was the world's largest transportable building. In 2016, the New Safe Confinement was repositioned over the sarcophagus. Following finishing work and testing, it was transferred to Ukrainian authorities in 2020. This new structure is designed to last at least 100 years. In 2017, construction was completed on an Interim Spent Fuel Storage Facility. In 2021, Ukrainian regulators authorized the facility to accept Chernobyl's damaged fuel, which began arriving the same year. The facility will process and store the spent fuel assemblies from the undamaged units 1, 2, and 3 in dry, double-walled canisters designed to last at least 100 years. (EBRD, 2018, 2024).

Information Resources

United Nations Scientific Committee on the Effects of Atomic Radiation – Chernobyl

International Atomic Energy Agency – Chernobyl Forum

World Health Organization – Health Effects of the Chernobyl Accident

European Bank for Reconstruction and Development – Chernobyl: A Site Transformed

Kashcheev, V.V. and others, "Incidence and Mortality of Solid Cancer Among Emergency Workers of the Chernobyl Accident: Assessment of Radiation Risks for the Follow-Up Period of 1992-2009," Radiation and Environmental Biophysics 54 (2015): 13-23.

March 2024