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New tomb will make Chernobyl site safe for 100 years

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Thirty years after the Chernobyl nuclear accident, there's still a significant threat of radiation from the crumbling remains of Reactor 4. But an innovative, €1.5 billion super-structure is being built to prevent further releases, giving an elegant engineering solution to one of the ugliest disasters known to man.

Since the disaster that directly killed at least 31 people and released large quantities of radiation, the reactor has been encased in a tomb of steel-reinforced concrete. Usually buildings of this kind can be protected from corrosion and environmental damage through regular maintenance. But because of the hundreds of tonnes of highly radioactive material inside the structure, maintenance hasn't been possible.

Water dripping from the sarcophagus roof has become radioactive and leaks into the soil on the reactor floor, birds have been sighted in the roof space. Every day, the risk of the sarcophagus collapsing increases, along with the risk of another widespread release of radioactivity to the environment.

Thanks to the sarcophagus, up to 80% of the original radioactive material left after the meltdown remains in the reactor. If it were to collapse, some of the melted core, a lava-like material called corium, could be ejected into the surrounding area in a dust cloud, as a mixture of highly radioactive vapour and tiny particles blown in the wind. The key substances in this mixture are iodine-131, which has been linked to thyroid cancer, and cesium-137, which can be absorbed into the body, with effects ranging from radiation sickness to death depending on the quantity inhaled or ingested.

Metal tomb. Credit: Arne Müseler/Wikimedia, CC BY-SA

With repair of the existing sarcophagus deemed impossible because of the radiation risks, a new structure designed to last 100 years is now being built. This "new safe confinement" will not only safely contain the radioactivity from Reactor 4, but also enable the sarcophagus and the reactor building within to be safely taken apart. This is essential if potential future releases of radioactivity, 100 years or more into the future, are to be prevented.

Construction of the steel arch-shaped structure began in 2010 and is currently scheduled for completion in 2017. At 110 metres tall with a span of 260 metres, the confinement structure will be large enough to house St Paul's Cathedral or two Statues of Liberty on top of one another. But the major construction challenges are not down to size alone.

The close-fitting arch structure is designed to completely entomb Reactor 4. It will be hermetically sealed to prevent the release of radioactive particles should the structures beneath collapse. Triple-layered, radiation-resistant panels made from polycarbonate-coated stainless steel will clad the arch to provide shielding that will be crucial for allowing people to safely return to the area in ongoing resettlement programmes.

Innovative engineering solutions

Operating a building site at the world's most radioactively hazardous site has inevitably led to a number of engineering innovations. Before work could start, a construction site was prepared 300 metres west of the reactor building, so workers could build the structure without being exposed to radiation. Hundreds of tonnes of radioactive soil had to be removed from the area, and great slabs of concrete laid to provide extra radiation protection.

Inconveniently for a 110 metre-high construction, working above 30 metres is impossible – the higher you go, the closer you get to the top of the exposed reactor core, where radiation dose rates are high enough to pose a significant threat to life. The solution? Build from the top down. After each section of the structure was built, starting with the top of the arch, it was hoisted into the air, 30 metres at a time, and then horizontal supports were added. This was done using jacks that were once used to raise the Russian nuclear submarine, the Kursk, from the bottom of the Barents Sea. The process was repeated until the giant structure reached 110 metres into the air. The two halves of the arch were also constructed separately and have recently been joined together.

The next challenge is to make sure the confinement structure lasts 100 years. In the old sarcophagus, "roof rain" condensation formed when the inside surface of the roof was cooler than the atmosphere outside, corroding any metal structures it came into contact with. To prevent this in the new structure, a complex ventilation system will heat the inner part of the confinement structure roof to avoid any temperature or humidity differences.

Finally, a state-of-the-art solution is required to move the confinement structure, which weighs more than 30,000 tonnes, from its construction site to the final resting place above Reactor 4. The giant building will slide 300 metres along rail tracks, furnished with specially developed Teflon bearings, which will minimise friction and allow accurate positioning.

Future safety

Once the new structure finally confines the radiation, deconstruction of the previous sarcophagus and Reactor 4 within can begin bit by bit. This will be done using a remotely operated heavy-duty crane and robotic tools suspended from the new confinement roof. However, the high levels of radioactivity may damage these remote systems, much like the robots that entered the stricken Fukushima core and "died trying" to capture the damage on camera.

At the very least, building a new confinement structure buys the Ukrainian government more time to develop new radiation-resistant clean-up solutions and undertake the clean-up as safely as possible, all while the radioactive material is decaying. This is an enforced lesson in patience. Only constant innovation in engineering, robotics and materials will allow nuclear disaster sites like Chernobyl and Fukushima to be made safe, once and for all.

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