Making the world more secure, one research reactor at a time

By Adem Mutluer

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>
> *— Petr Chakrov, Acting General Director, Institute of Nuclear Physics, Alatau, Kazakhstan*

During the night of 29 September 2014, a heavy transport plane took off from an air base in Kazakhstan after an operation to remove fuel and increase the security of a research reactor.

In its cargo bay sat four massive containers, provided by the IAEA, that had been filled with a total of 10.2 kilograms of highly enriched uranium (HEU), on its way to be diluted to a safe substance or securely stored at the flight's destination in Russia.

The Alatau research reactor, Kazakhstan
(Photo: P. Chakrov/Institute of Nuclear Physics)

The operation represented the latest achievement in a global programme involving the IAEA, the Russian Federation and the United States to assist several countries, including Kazakhstan, in eliminating the risks associated with HEU, while still maintaining the important scientific research conducted at the reactor. HEU is a security risk, as it is an ingredient that can be used to create a nuclear device intended for malicious use. It is not encouraged to use HEU in a research reactor as safer low enriched uranium (LEU) can be used instead (see box). In the 1960s and 1970s, when many of the world's research reactors were built, technology using LEU was not yet available, so in order to perform experiments HEU fuel was required. As of next year, less proliferation sensitive LEU will be used to fuel the light water research reactor in Alatau near Almaty, the largest city in Kazakhstan.

Research to continue

"I am very confident that the reactor will continue with its current work after the switch," said Petr Chakrov, Acting General Director of the Institute of Nuclear Physics, in Alatau. "Furthermore, we believe that the new core will have twice the capacity to produce various medical, as well as other, radioisotopes going forward," he said referring to the part of the reactor containing the nuclear fuel components where the nuclear reactions take place.

The Alatau 6 megawatt light water reactor is used for a number of purposes, including scientific research, isotope production for medicine, and testing material for use in industry. For example, the reactor produces molybdenum-99, an important medical radioisotope used in 70% of nuclear medicine procedures worldwide, and relied on for tens of millions of medical procedures a year (see related article, page 12).

Before the implementation of the conversion to LEU began, scientists at the reactor performed post-irradiation studies of LEU fuel to determine the suitability of the reactor for conversion to LEU. The IAEA provided the equipment for this research, Chakrov explained. By analysing specimens irradiated to different doses of radiation, modelling the conditions under which the LEU would be used in the reactor after the conversion, scientists confirmed that the reactor was suitable for using LEU in a safe and manageable way, he said.

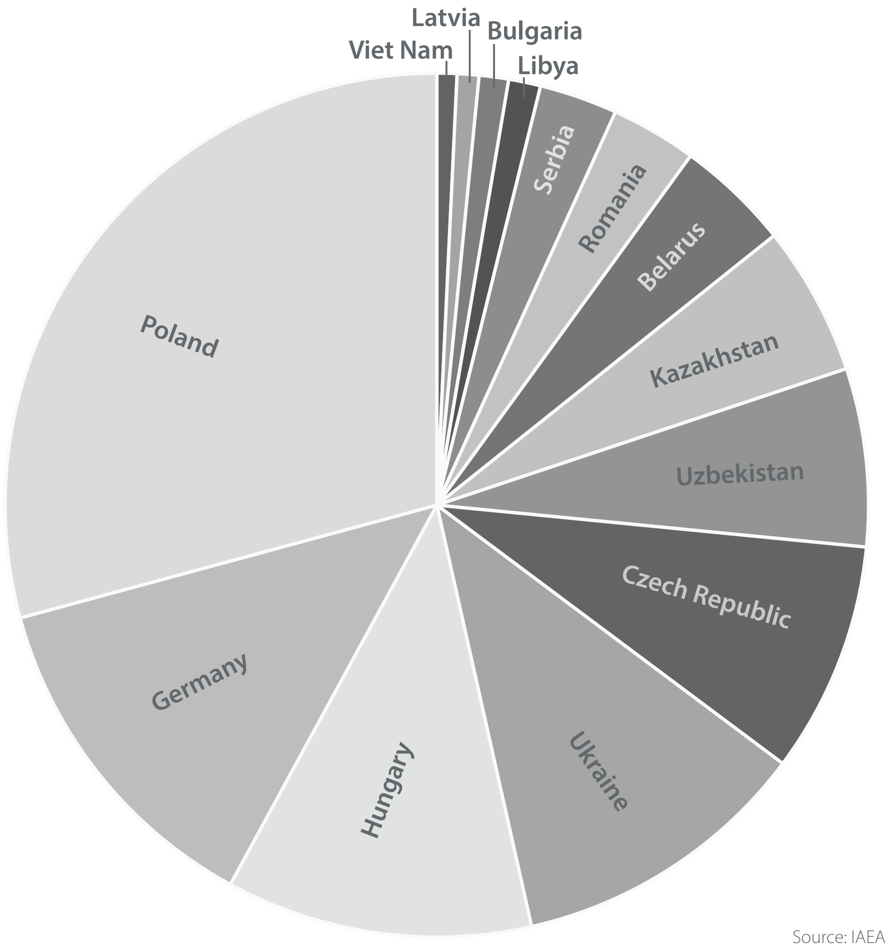
"The procurement of this equipment by the IAEA was absolutely necessary for the project to take place and to give us the confidence to move forward," Chakrov said.

Step-by-step removal

The containers of fuel on the plane in September represent one of several batches of fuel to be repatriated from Alatau. In July 2015, the reactor will be temporarily turned off to allow for a cooling off period of six months. During this time, the reactor's instrumentation and control system will be replaced in advance of the switch in fuel. In January 2016, the reactor will restart, using LEU.

"Because of the risks HEU poses, more than 2150 kilograms of HEU, supplied by the former Soviet Union, has been repatriated to the Russian Federation in 60 shipments from 14 countries under the Tripartite Initiative between Russia, the United States and the IAEA, often called the Russian Research Reactor Fuel Return (RRRFR) Programme (see chart)," said Sandor Tozser, a nuclear engineer at the IAEA's Research Reactor Section. The IAEA acts as an administrator and provides technical knowledge and equipment, he explained. The repatriation of HEU fuel from the Alatau reactor is part of this programme.

Peter Rickwood also contributed to this article.



The country breakdown of HEU repatriated to Russia under the Research Reactor Fuel Return Programme as of the end of 2014.

THE SCIENCE

Uranium enrichment

Highly enriched uranium has historically been used in research reactors for scientific purposes. Uranium is a naturally occurring element, and uranium-235 (^{235}U) and uranium-238 (^{238}U) are isotopes of uranium, meaning they share the same number of protons as uranium, but have a different number of neutrons. When uranium is mined from the ground, the mass contains only 0.7% ^{235}U, the fissionable element, and 99.3% ^{238}U, which is stable and does not undergo nuclear reactions. Enriching uranium means increasing the percentage of ^{235}U in the mass. Nuclear power plants in operation around the world typically use uranium enriched to between 4% and 7%.

Enriching can be done in several ways, each using a method called isotope separation. Isotope separation is the process of concentrating specific isotopes of a chemical element by removing other isotopes. In this case, isotope separation is used to increase the concentration of ^{235}U in a mass of uranium. The most common and effective method for doing this is by using a centrifuge, a specialized device that puts an object in rotation around a fixed axis, taking advantage of the difference in atomic mass between ^{238}U and ^{235}U. When centrifuges spin, they separate ^{235}U from ^{238}U, allowing ^{235}U to be further concentrated, or enriched, for use. The enrichment process can be done to create different levels of enriched ^{235}U; however, it is not an easy process and requires time, expertise and expense. Uranium enriched to contain over 20% of ^{235}U is considered HEU.