Verifying the research

Implementing safeguards at research reactors

By Adem Mutluer

IAEA safeguards inspectors are trained to check all nuclear material at a research reactor facility.
(Photo: D. Calma/IAEA)

Verifying the peaceful use of nuclear material and technology at research reactors constitutes a significant part of the IAEA's work in nuclear verification. While only 30 countries have nuclear power plants and fuel cycle installations, over 50 operate research reactors. In 2018, IAEA safeguards were implemented at around 150 facilities with research reactors. These facilities pose a challenge for safeguards, as unlike nuclear power reactors, research reactor designs vary widely, and the safeguards measures applied need to be tailored to each type of reactor.

"Low power does not mean low concern," said Djamel Tadjer, Senior Inspector for State Level Coordination at the IAEA. "While research reactors provide major benefits in health and development, the potential for the diversion of nuclear material from peaceful use or misuse of the reactor is still there. As such, applying safeguards at research reactors is a critical part of the IAEA's verification work."

A by-product of using research reactors is plutonium — a material than can be used for nuclear power and research but is also an ingredient used to produce nuclear weapons. Although only a small amount of plutonium is produced by a single research reactor, it is still a safeguards concern.

During verification, the IAEA considers the amount of time it takes for a research reactor to produce one significant quantity of nuclear material, i.e. the approximate amount of nuclear material for which the possibility of manufacturing a nuclear explosive device cannot be excluded. The IAEA also receives information from the host State about the facility's design and layout, as well as the form, quantity, location and flow of the material in use. Using this information, the IAEA sets out a safeguards approach that is tailored to the facility's specifications. The IAEA can then verify the correctness and completeness of the design information provided by the State and confirm that the facility and the nuclear material at the facility are being used as reported.

Different uses and designs

Many research reactor facilities contain hot cells. These containment chambers shield workers from nuclear radiation; the worker stands outside the cell and uses manipulator arms to safely handle the equipment and nuclear materials located inside the chamber.

Hot cells are most often used for isotope separation for medical purposes, but they can also be used for small-scale plutonium extraction from the irradiated fuel produced by a research reactor. IAEA safeguards inspectors are trained to detect plutonium extraction.

A smaller number of research reactors use high enriched uranium (HEU) — uranium enriched to greater than 20% uranium-235 — which is another material that can be used to produce nuclear weapons. Although many research reactors are already converted to use low enriched uranium (LEU) — which is not directly usable for nuclear weapons — IAEA safeguards inspectors still check all nuclear material at a research reactor facility in order to verify the correctness and completeness of the State's declaration.

"Due to the differences in the design and use of research reactors, there is no general checklist to satisfy safeguards requirements at such facilities," said Tadjer. "Instead, we train our inspectors to look for any signs of misuse at research reactors and the diversion of nuclear material. For inspectors, it's about spotting inconsistencies and then knowing the right questions to ask."

Meeting safeguards obligations

However, it is not solely the work of the IAEA inspectors to apply safeguards, as States also have certain requirements they have to meet. The IAEA offers States assistance in meeting these requirements in terms of incorporating safeguards into the design of a facility, implementing nuclear material accountancy and meeting the legal requirements of implementing safeguards. Such assistance includes guidance on building safeguards considerations into the design of research reactors. The IAEA also offers in-country advisory missions to support State systems of accounting for and control of nuclear material (SSAC) in meeting their obligations.

By considering safeguards requirements early in the research reactor design process, future demands on the facility operator for nuclear material verification can be reduced. For instance, the possibility of applying remote monitoring is cost effective and maintains safeguards effectiveness while reducing the need for inspector activity on-site. One example of remote monitoring is the use of an advanced thermohydraulic power monitor that assesses coolant flow and heat extraction to calculate the reactor's plutonium production. By knowing how much plutonium is produced by the reactor over a specific time period, inspectors can amend the frequency of inspection accordingly, thereby saving time for both the inspector and the operator.

"To apply safeguards at research reactors, as with applying safeguards at any nuclear facility, cooperation between the State and the IAEA is very important," said Tadjer. "By working together and applying modern technology, such as the advanced thermohydraulic power monitor, the IAEA can more effectively and efficiently verify that nuclear material remains in peaceful use."

"We train our inspectors to look for any signs of misuse at research reactors and the diversion of nuclear material. For inspectors, it's about spotting inconsistencies and then knowing the right questions to ask."

— Djamel Tadjer, Senior Inspector for State Level Coordination, IAEA

A hot cell is a containment chamber that shields workers from nuclear radiation.
(Photo: IAEA)