What's in an inspector's luggage?

A review of safeguards equipment

By Vincent Fournier

In-field inspections form the core of the IAEA's nuclear verification activities, and equipping inspectors with the appropriate tools is key to effective nuclear safeguards. Over a hundred types of equipment are used by IAEA inspectors to verify the form, isotopic composition and quantity of nuclear material.

Inspectors typically select three to five hand-held pieces of equipment for each inspection. "There is no such thing as a typical inspection," said Alain Lebrun, Head of the IAEA Non Destructive Assay Section that provides monitoring tools for inspector use. "Equipment is selected by inspectors on a case-by-case basis."

Technicians prepare, calibrate and pack up the devices, which are carried by inspectors or — if they are too bulky — are shipped to their destination ahead of time. The most widely used hand-held equipment is non-destructive analysis instruments. These detect the presence of nuclear material (uranium, plutonium and thorium) and its specific characteristics. Specialized instruments assess physical characteristics — temperature, weight, volume, thickness and light emission/absorption — of nuclear materials.

"The equipment needs to be technologically advanced, versatile, rugged, and user-friendly," Lebrun said. Equipment experts continuously review and optimize the instruments, keeping up with technological innovation and simplifying user interfaces.

Sometimes commercially available equipment can be used with minimal customization, while in other cases equipment is specifically developed for and/or by the IAEA. "Some of these tools cost more than a sports car," Lebrun said.

Radiation detectors

One of the most commonly used pieces of equipment is the **HM-5**. It is a commercial instrument customized to safeguards verification applications. It is carried by inspectors to detect the presence of radioactive material. It emits a “beeping” sound if there is radiation above a certain level and identifies the nuclide emitting the radiation. It can also measure the enrichment level of uranium. With such versatility, the HM-5 is used in virtually all IAEA inspections.

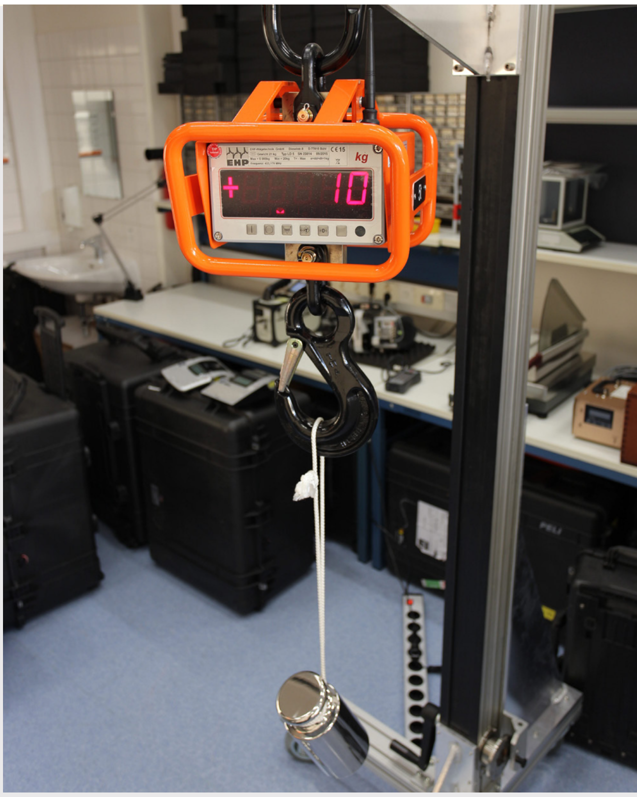
Enrichment matters

Uranium enriched in uranium-235 is required to sustain a nuclear chain reaction. However, the nuclear material and technology at enrichment plants can also be used to manufacture weapons-grade uranium. In facilities that process and/or store uranium, inspectors measure the weight and enrichment ratio of uranium in order to calculate the total amount of fissile material.

Inspectors use a big **load cell**, a sort of suspended scale, to weigh a cylinder to quantify the material it contains, such as uranium. It operates in two load ranges of up to 5000 and up to 20 000 kilograms.

To verify enrichment levels, inspectors often use high-tech detectors applying gamma spectrometry — a technique to monitor and assess gamma radiation released from a source — to take measurements. The **electrically cooled germanium system** (ECGS), for example, is a compact and portable high resolution detector that relies on an active germanium crystal, which, when cooled to -140 degrees Celsius, can detect gamma radiation released from uranium. It can be used in non-laboratory environments because, unlike conventional germanium detectors, it can be cooled using batteries, rather than with liquid nitrogen, which is difficult to handle and not always available.

As seen in the picture, the material that is analysed is sometimes contained in a bulky cylinder. To ensure that the ECGS — or other tools — can evaluate and analyse the data precisely, inspectors use an **ultrasonic thickness gauge** to adjust the detector’s sensitivity to gamma radiation based on the thickness of the cylinder walls.

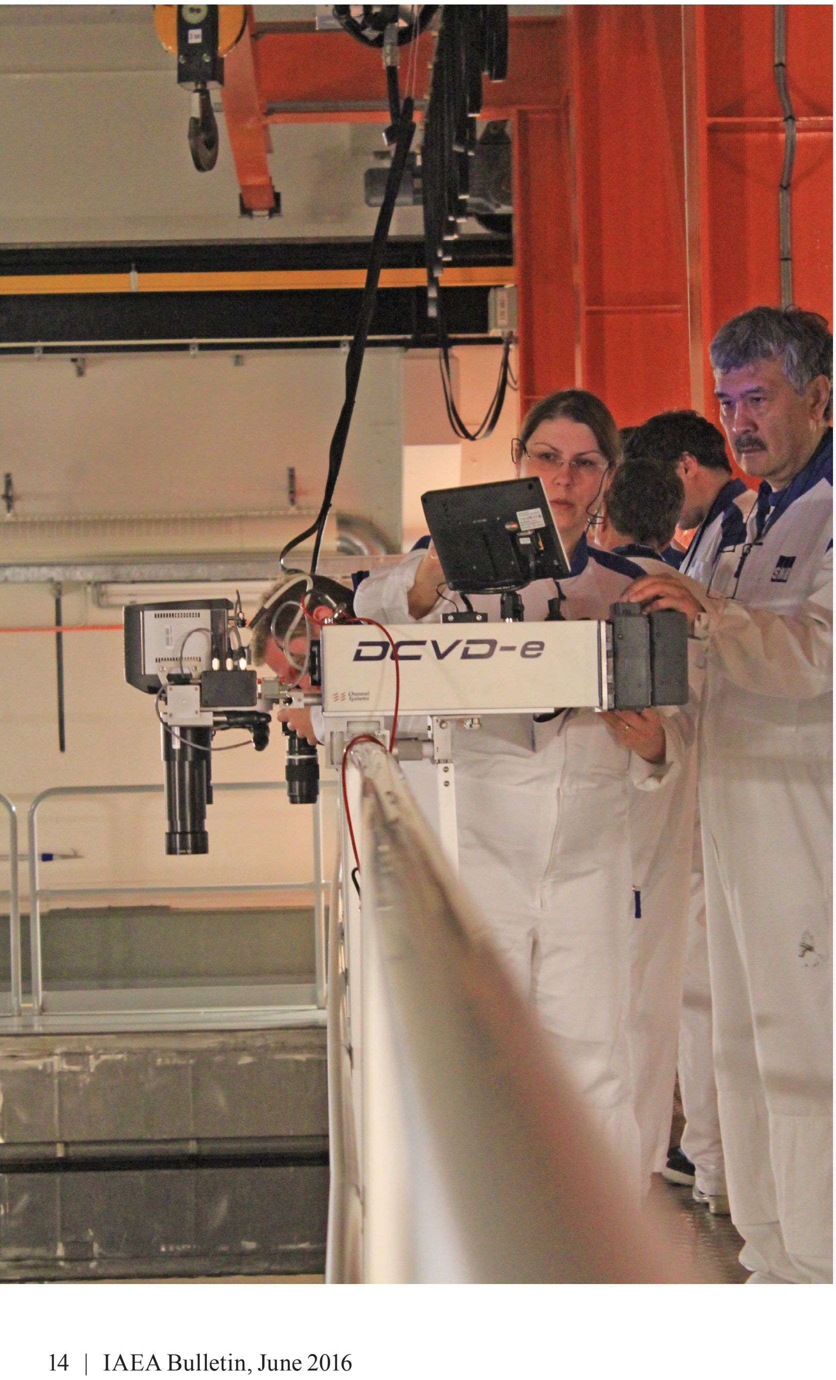


Under water

Inspectors use various types of detector systems to measure attributes of spent fuel, filters and waste in nuclear facilities.

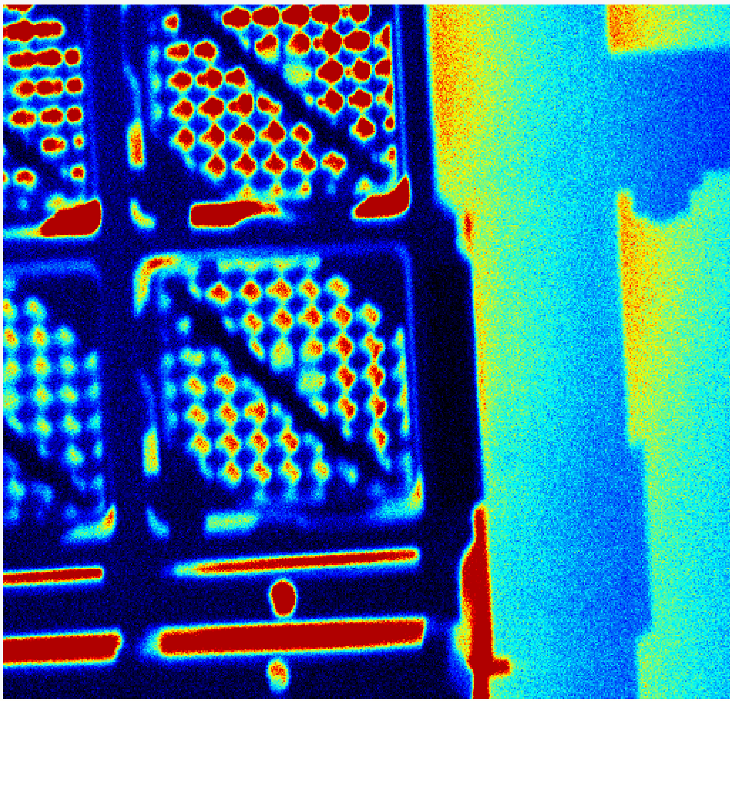
For instance, the **Irradiated Item Attribute Tester** is comprised of a small but sensitive gamma ray detector — the size of a small gemstone — contained in a protective tube, which is lowered into the spent fuel pond to measure items stored there. Cables connect it with an analyser that remains on the side of the fuel pond.

The device measures the intensity of gamma radiation at distinct energy levels. Each isotope of each atom has a characteristic gamma ray emission, so gamma spectrometry can be used to verify the contents of items in the spent fuel pond. If spent fuel had been removed or replaced in the pond, the spectrometry information will reveal this to the inspector.



Looking in spent fuel ponds while staying dry

One alternative to the Irradiated Item Attribute Tester for the verification of spent fuel is the **digital Cerenkov viewing device**, which is based on an ultra-sensitive camera detecting ultraviolet light. The camera is connected to a computer that uses specialized software to analyse the image. This device was custom-developed for the IAEA from astronomy equipment. But instead of looking at the stars, this camera's specialized lens and sensor capture ultraviolet light emitted from spent fuel assemblies, and the light patterns reveal key details about their characteristics. This is used to verify spent fuel ponds, ensuring that spent fuel was not diverted and substituted with a non-fuel assembly. Importantly, this device does not get immersed in the fuel pond, so it does not get contaminated with radioactive elements.



Additional protocol in action

The additional protocol grants the IAEA expanded rights of access to information and locations, helping to provide greater assurance of the absence of undeclared nuclear material and activities in those States with comprehensive safeguards agreements in place (see article, page 4).

To assess the completeness of States' declarations under the additional protocol, inspectors may perform complementary access visits with the **complementary access kit**. The toolkit equips them with multiple tools to collect information and verify declarations. The items include a camera, a laser distance meter, a GPS tool, a voice recorder, a flashlight, a general purpose radiation measurement system such as the HM-5, and an environmental sampling kit (see article, page 14.) These tools help the IAEA to confirm the absence of undeclared nuclear material and activities in those States.

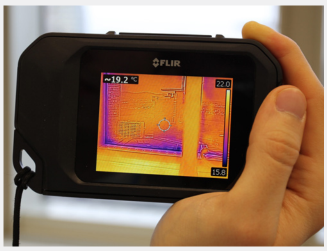
Planning for the future

Technological progress continues to offer new opportunities and efficiency gains for monitoring and verification work. Equipment has an average life span of about ten years, after which its reliability decreases. The IAEA, with critical support from several Member States, works to keep pace with the evolution of new technology.

"Improving inspection efficiency is a priority for the IAEA. We are aiming to do what we do today faster and better without disturbing the workflow," said Dimitri Finker, technology foresight specialist at the IAEA. "We are doing this by implementing incremental changes and by customizing tools and technologies that already exist on the market."

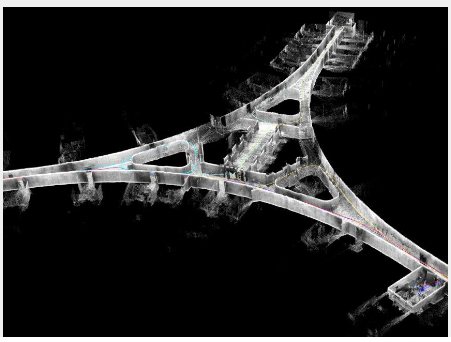
For instance, improvements to the complementary access toolkit will allow the inspectors in the near future to work faster, more accurately and generate reports with less effort upon their return to Vienna.

They will use an **electronic pen** to take notes in the field, an **autonomous positioning system** based on an inertial unit fixed on the foot of the inspector to keep track of where the inspector has been, different cameras including **infra-red cameras** combined with a **range-meter** and a new **miniaturized radiation detector** able to both detect and identify various sources of radiation. The data collected in the field is uploaded into a software and the information is put together to create a highly accurate geo-localized inspection report with the time, radiation value, picture and exact location of sampling throughout the duration of the inspection.



"Instead of having the inspectors spend half their time compiling information for the report, we provide them with technological solutions that then free up most of their time for analysis instead," said Finker.

The IAEA is also evaluating the benefit of using 3D laser technology for verification, as it can quickly map out buildings when the inspector walks through them with the tool in hand. The resulting 3D plans are more efficient than standard photographs for verifying States' declarations of facilities.



Photos: IAEA