Training Nuclear Watchdogs

It is not the kind of enriched uranium for a nuclear bomb. But the powder and the pellets are key parts of the nuclear fuel process under IAEA safeguards. In Sweden, inspectors learn the ins and outs.

1 Fuel for most of the world's nuclear electricity plants is made from enriched uranium at "fuel fabrication" facilities.

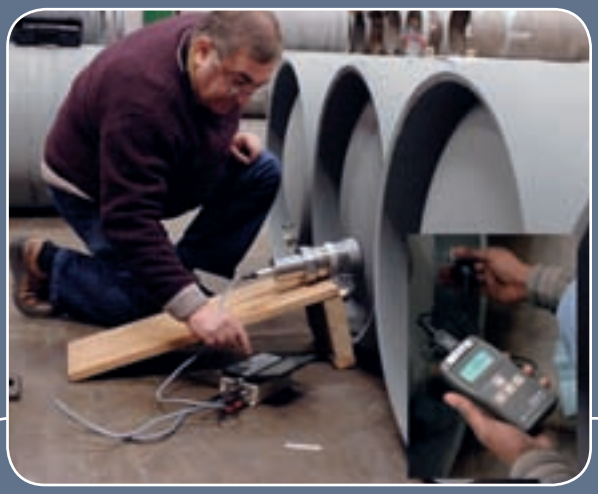
Each year, teams of IAEA inspectors verify the peaceful nature of civil nuclear programmes — their work includes some 41 fuel fabrication plants in 22 countries that are under international safeguards.

2 Natural uranium contains three different isotopes, U-238, U-235, and U-234. In industry, the isotopes are separated to increase the concentration of one isotope relative to another. The aim is to achieve higher — or "enriched" — concentrations of U-235, which can sustain a nuclear chain reaction.

By itself, low-enriched uranium used for nuclear fuel is not useful for making nuclear explosives. However the material could be diverted and become feedstock for developing them — prime reasons why IAEA safeguards it.

3 Once at the facility, inspectors test their new skills. To untrained eyes, the factory floor is a spaghetti of wires, tubes and pipes giving the impression of organized chaos. Inspectors must know about a variety of plant configurations so they can detect indications to divert sensitive material.

4 Inside a control room, inspectors eye screens displaying schematics of the plant's operational flow. Computer programs monitor key operations — temperatures in the pipes, conductivity measurements, batch weights, precipitation levels, Ph balance and chemical flows, among others. Closed circuit TV cameras zoom in on gauges giving the operator critical indicators from the control room.



5 Checking the cylinder is one thing. Checking what's inside is another. Inspectors rely on sophisticated instruments — such as germanium detectors and sodium iodide, pictured here, to detect enrichment levels — most enriched material emits gamma rays. These tools of the trade help inspectors verify the accuracy of the facilities' records.

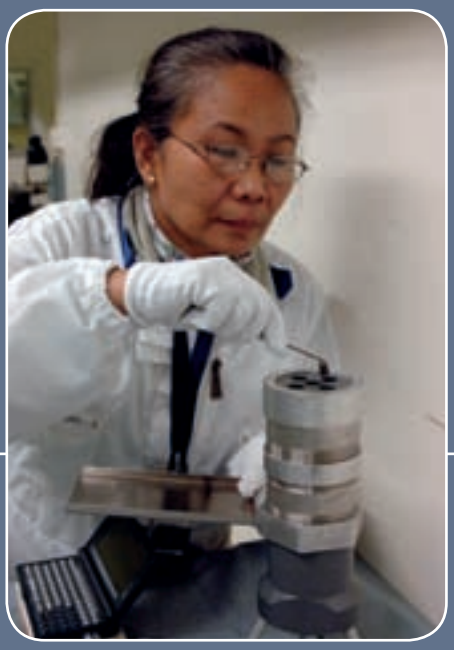
6 Once the cylinder's contents are verified, inspectors attach an IAEA metallic seal — commonly used to prevent tampering. The seals provide important evidence of any unauthorized attempt to gain access to the secured material.

7 Another step for inspectors is to verify levels of enrichment during the uranium conversion process. Here inspectors observe a plant operator carefully extracting a UF6 sample to be analyzed for isotopic composition.

8 The UF6 sampling process ends up with concentrated uranium dioxide, a form of "yellowcake". The sample is baked in a furnace for three hours to mimic the uranium conversion process. Thereafter, the sample is sent to the IAEA's Safeguards Analytical Laboratory in Seibersdorf, Austria, for analysis of enrichment levels.

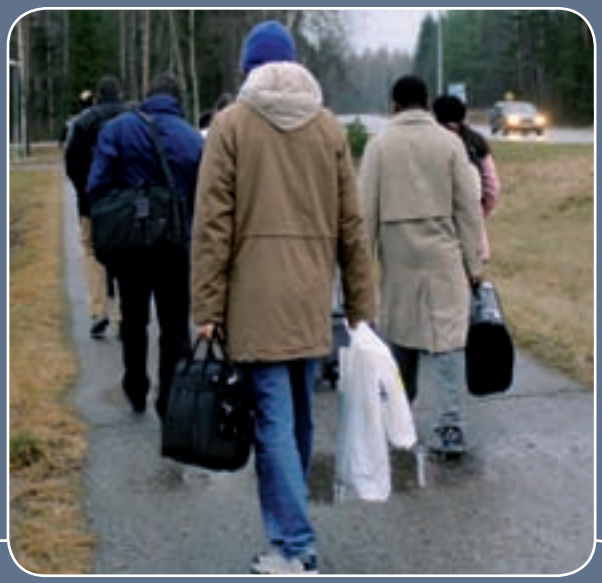
9 A facility operator carefully takes a sample from the tilted hopper. The powder sample is poured into two small glass bottles (inset).

10 Metal boxes hold trays of finished fuel pellets. Each pellet, slightly larger then a pencil eraser, contains enriched uranium dioxide that will be used at nuclear power plants.



11 An inspector verifies the pellet's enrichment using an instrument called a Mini-Multichannel Analyzer that attaches to a palm-sized computer.

12 Going up to the source is sometimes the only way to access the assemblies for critical measurements. In this case, an inspector is hoisted into the air on a crane to get an active length measurement.



13 Once fully trained, inspector teams can spend over 100 days a year on the road at various sites throughout the world, to help make sure that peaceful nuclear materials and activities stay peaceful.

The photos were taken during a safeguards training exercise at the Westinghouse Atom AB, a fuel fabrication facility in Västerås, Sweden in November 2005. Site visit was made possible in cooperation with the Swedish Nuclear Power Inspectorate (SKI) and the IAEA Section for Safeguards Training.
Photos: Dean Calma; Text: Linda Lodding

by John Bohannon

Staying One Step Ahead

An IAEA Safeguards Inspector Fits The Picture

Paulus Nangonya remembers the moment when his career finally made sense to him. It was last December in Japan when a friend came up and said, "You won." In response to his confused look, the friend exclaimed, "The Nobel Prize!"

At 29, Nangonya, an engineer, is the nuclear inspector at the International Atomic Energy Agency (IAEA). Nangonya and his colleagues at the Vienna-based organisation (along with IAEA's Director General, Mohamed ElBaradei) were the winners of the 2005 Nobel Peace Prize. When Nangonya started three years ago, he says, he felt unsure whether the job was really for him. Like any scientific research discipline, nuclear inspection requires a blend of science and technical knowledge and a sceptical mindset. But a career in nuclear inspection also demands detective and diplomatic skills sharp enough to handle sensitive political issues. To reap the full rewards of the job, says Nangonya, "you have to see how you fit into the big picture. And now I see it."

Nangonya lives and works a long way from Oshakati, his hometown in Namibia, in southern Africa. After winning a scholarship in 1996 to study engineering in China at Shanghai University, he thought he was on his way to an industrial career. At Shanghai, he completed his undergraduate degree in applied electronics while also becoming fluent in Mandarin Chinese. His career took an unexpected turn when one of his mentors noticed his that final-year research project—a system to control heavy machinery from a distance by radio—would be very useful during a nuclear meltdown. "Have you ever considered working for the IAEA?" asked the professor.

He hadn't. In spite of Namibia's significance to the nuclear industry—the country is the world's fifth largest producer of uranium ore and is expected to move into third place by next year—fewer than a dozen Namibians have significant nuclear expertise.

Intense Training

Nangonya joined the IAEA in 2002 by taking the Agency's Safeguards Traineeship Programme, a foundation course on nuclear technology open only to nationals from developing countries. After finishing the year-long programme, Nangonya applied for an IAEA nuclear inspector position—he got it—and then undertook the three-month training course that all newly hired inspectors complete.

At 29, Paulus Nangonya, an engineer from Namibia, is the youngest-ever nuclear inspector at the IAEA.

Most of Nangonya's training covered the subjects that might be expected: the ins and outs of the nuclear fuel cycle, how to verify that each and every reported gram of plutonium and uranium are where they are supposed to be, and how to spot signs of illicit activity. The training, he says, is "intense."

Every year, IAEA hires 15 to 30 nuclear inspectors, typically in their 30s, many with backgrounds far removed from nuclear physics. It is difficult to predict exactly what the Agency is looking in a given year, says Perpetua Rodriguez, IAEA senior training officer, because it depends on "what specific backgrounds are needed from the Operations Division." An inspection team needs a combination of backgrounds, she says. Inspectors come with a range of expertise, from physics, engineering, and chemistry to computer science and even biology; samples from plants and animals often play a role in detecting unreported nuclear materials. "My strength is in understanding instruments," says Nangonya, "how they function and malfunction." His expertise was in demand the year he applied.

But apart from technical expertise, there are also crucial social and psychological skills to be learned, and this is where nuclear inspection diverges most from academic science, says Rodriguez, an inspector since 1987. When you are a scientist

working in a university laboratory, "you can disappear into your own private world," she says. "But when the team needs something done during inspection," such as verifying whether a canister really contains a certain amount of uranium hexafluoride, "it must be done right then and there." Teamwork is one of the big perks of the job, says Nangonya, and it's a responsibility he takes seriously. "You're dealing with deadly materials, so you're putting your life in your team members' hands every day. You grow very close."

Nuclear inspectors must learn to trust their colleagues, but during their training they must learn not to trust others. You have to think like a cop, says Nangonya, doubting everything until you have proved it for yourself. "This change in worldview can be difficult for the new arrivals," says Rodriguez, because science is an enterprise built on trust. In the world of nuclear inspection, you never know who might be siphoning off nuclear material to build a bomb or sell on the black market, so it helps to suspect everyone and everything until proven otherwise.

Nangonya had no trouble getting into the sceptical mindset. "You just have to stay one step ahead of potential cheaters," he says. And one thing that enables Nangonya, and other inspectors, to keep ahead of nuclear crooks is coupling his detective work with experimentation. It is often the nuclear inspectors in the field who first identify security weaknesses in a fuel cycle. But confirming a previously unknown method of cheating—and finding a practical way of detecting it—often requires inspectors to regularly interact with IAEA's research laboratories in Seibersdorf, Austria, to test their ideas and improve the inspection process. Having a PhD is not a necessity, but it certainly can be a strength, says Rodriguez.

Working as a nuclear inspector delights Nangonya's inner gadget geek: "When we need a piece of equipment, we get it. Period. We have to stay on the cutting edge." From custom-made hand-held computers to instruments that can detect the faintest radioactivity from a piece of dust, the nuclear inspector's tool kit would make James Bond envious.

But "we are definitely not like James Bond," says Nangonya. Careful diplomacy, not covert intrigue, is the modus operandi. Even when nuclear inspectors turn up bad news, such as the recent discovery of what may be a secret nuclear programme in Iran, inspectors are not enforcers. "When findings have been confirmed, the IAEA Director General reports to the Board of Governors, who decides whether the finding(s) should be reported to the [U.N.] Security Council," says Rodriguez. "In a sense, our job is to help countries to comply with international obligations."

Keep a Low Profile

This provides some tense moments. Inspectors in Iraq in the lead-up to the first Gulf War received death threats, says Rodriguez. Besides your team members, "you're out there on your own," she says—no security force is along to protect you, and no company of medics to care for you. "I keep a low profile," says Rodriguez. "I never use cars with big U.N. signs on them. And when I meet local people, I don't discuss my job."

So far, Nangonya says he has never felt in danger. Nor does he see a significant radiation exposure risk with the job. Inspectors are routinely monitored at IAEA's research laboratories in Austria, and dangerous doses are very rare, he says.

The job's real drawbacks are more mundane, such as the frequent travel. The agency's 250 inspectors are divided into three sections, each with responsibility for one-third of the globe. Nangonya covers East Asia. Japan alone has more than 50 nuclear sites. But for Nangonya, the travel isn't a drawback at all. "Many inspectors knew what they were getting into from the start, and they love it. Like me." But others have a tougher time adapting, like one of Nangonya's colleagues who has children; she was able to shift within the agency to stay planted in Vienna more often. So there is room to adapt, Nangonya says, but not much. As a nuclear inspector, "your middle name should be life-on-the-road," he says.

Nangonya's work requires an unusual degree of care and precision, so it comes with some unusual technological rituals. During this interview, a fellow inspector stopped by Nangonya's office to drop off some documents. Like a scene from a futuristic movie, Nangonya pulled out a laser to scan a bar code on the other inspector's wrist and then his own. Each time sensitive documents are passed, the time and identity of the sender and receiver is recorded by a central computer system. "It's just how the job must be done. I don't mind that," he says. After all, a mistake can mean political disaster.

It is possible to remain a nuclear inspector for life, but returning to industry or academia is always an option, Nangonya says—although many from the developing world find it hard to match their very specific expertise with a job back home. Not so in Nangonya's case. "I will have no trouble finding a use for my nuclear training in Namibia," he says.

But he's not yet ready to start looking. Beyond the globetrotting and gadgetry, nuclear inspection also means being part of an organisation that makes a positive difference in the world, says Nangonya: "The nuclear black market is bad, but it would be much worse without the IAEA." The fact that last year's Nobel Prize went to IAEA and its Director General is recognition of the work's importance. "Now that's job satisfaction," he says.

John Bohannon is a contributing correspondent for Science Magazine. *This article first appeared in* Science Careers, *May 5, 2006; reprinted with permission from AAAS (American Association for the Advancement of Science).*