Nuclear safeguards technology 1982

by J. Lovett*

One of the best tests of a proposal's technical feasibility is how much research it stimulates. Scientists are often reluctant to make unequivocal public statements, but their opinions can be divined by noting their reluctance to carry out research on ideas that do not look as if they will work. Perceived workable solutions to perceived needs, attract researchers; problems that are already solved, or ones that are unsolvable, do not.

The International Atomic Energy Agency sponsors symposia on nuclear material safeguards about once every four years. These symposia are of interest not only for the papers presented, but also, and more importantly, for the areas of emphasis (or lack of emphasis) which can be identified. The invitation to submit papers is broadly worded, with the aim of bringing together as many people as possible to review and discuss all topics in safeguards. Authors can only submit papers in the subjects in which they are working, however; and areas of work correspond, at least roughly, with areas of perceived need to which it is expected that solutions can be found.

What then are the currently perceived needs in safeguards? Based on this symposium**, the first perceived need is practicability. Ideas for new and totally untested measurement methods or safeguards concepts were few. Practical studies on how to make the best use of instruments or concepts which had already been through initial development and evaluation stages were common.

It has been agreed for many years that IAEA safeguards should not be based on unverified data submitted by plant operators. Rather, the Agency's inspectors should verify that data. Historically this has meant independently redetermining a randomly selected fraction of it. But what if, as is becoming increasingly common, the operator's data was generated using a highly automated microprocessor-controlled non-destructive measurement instrument? Conceptually, the answer is to "authenticate" data produced by the instrument, i.e. to satisfy oneself that the instrument, or the material being measured by it, has not been tampered with in any way that would cause it to give false or inaccurate readings.

Several papers presented at the symposium suggested ways in which specific instruments might be authenticated. One paper in particular, by Augustson and co-workers in the IAEA's Division of Development and Technical Support, described the Agency's experience in the use of protected standards, blind samples or standards, replacement of kev components. containment and surveillance, and other measures.

One could identify several instruments worthy of discussion, but the K-edge densitometer is one of the most interesting. It measures the attenuation of gamma-rays at energies immediately above and below the K-absorption edge for plutonium. Since all elements except plutonium should have effectively constant absorption over the narrow energy range considered, the difference in absorption at the two energies can be used to calculate the concentration of plutonium. With care and proper corrections for secondary effects, accuracies approaching 0.5% can be achieved.

The K-edge densitometer was first proposed several years ago. What was new and interesting at this symposium was not the idea, but the demonstration that the instrument is now ready for routine use (and indeed is in routine use in at least one facility), and that it can maintain its claimed accuracy during routine use. The paper by Augustson describes the use of tantalum foils, occasional duplicate samples, and other means to authenticate K-edge data produced by plant operators.

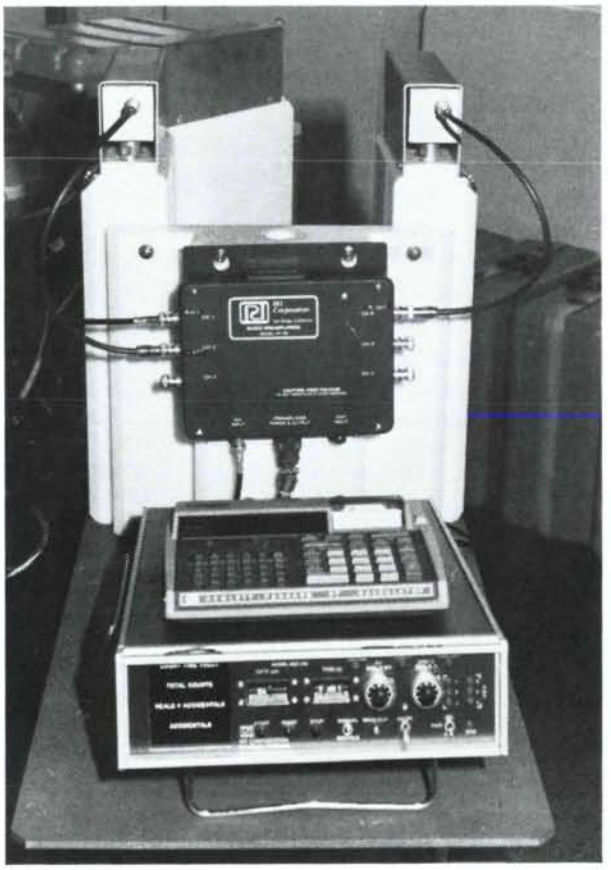
Two specific facility types received sufficient interest at the symposium to justify separate consideration in this article. One was uranium enrichment facilities; the other, as might have been predicted, was spent fuel reprocessing.

It has been shown that highly accurate material balances, approaching 0.1% of total feed over an extended period of time, can be prepared for uranium enrichment plants which use the centrifuge process. During the symposium the practical problems of working at this level of accuracy were discussed. A paper by Fainberg, Gordon, Dermendjiev, and Terrey, and a companion paper by Lauppe, Dermendjiev, and Schinzer described the development and field-testing of a load-cell weighing device for 2.5 t UF_6 cylinders with a claimed accuracy of ±1 kg. At that weight, and at that level of accuracy, it was necessary to investigate several possible corrections. Since the UF_6 cylinders are frequently stored out of doors and rarely in heated warehouses, temperature effects were of particular concern.

Other papers on safeguards for enrichment facilities dealt with the measurement or verification of uranium

* Mr Lovett is a staff member in the System Studies Section of the Division of Development and Technical Support, IAEA Department of Safeguards.

** International symposium on recent advances in nuclear material safeguards, organized by the IAEA and held in Vienna, from 8 to 12 November 1982.



The neutron collar shown in this photograph is used to determine the uranium-235 content of fresh fuel for light water reactors. A neutron source (californium) causes the uranium-235 to fission whereupon it emits two or more neutrons at the same time. These coincident neutrons coming from the fission of uranium are detected in the collar which, in normal operation, would surround the fuel assembly. The detectors are capable of distinguishing the coincident fission neutrons from those originating from the californium source or from elsewhere. The device is shown here under test in the Agency's laboratory, and so no fuel assembly is present.

in traps, with the concept of limited unannounced access to the cascade area itself, and with materials' accountancy. Again, the emphasis was on practical data rather than theory. Two sessions on safeguards for reprocessing plants drew considerable interest. This was especially the case for a paper by Koizumi and others in Japan, describing materials' accountancy experience in the Tokai reprocessing plant. It was also true for a group of papers dealing with near-real-time materials' accountancy.

Only one paper at the symposium dealt with the theoretical evaluation of simulated data, and even that paper yielded an interesting practical conclusion. Reprocessing plants are commonly described as being "flow dominated", meaning that the uncertainties in flow measurements are the most important. A paper by Sellinschegg showed that measurements are more accurate if in-process inventories are taken at ten-day intervals, rather than either one-day or twenty-day intervals. The comparison with twenty-day intervals was expected, the comparison with one-day periods was not. The explanation, the participants agreed, lies in the fact that if in-process physical inventories are taken every day, the hypothetical facility would become *inventory dominated.* It was also agreed that more theoretical work is needed to define the optimum inventory frequency.

If field-testing and practical demonstrations were common subjects at the symposium, what was disappointing by its absence? Participants in a panel discussion held on the last day of the symposium agreed that the biggest disappointment was the absence of papers demonstrating the routine applicability of containment-surveillance technology. Ultrasonic seals, fibre-optic remotely verifiable seals, video surveillance systems: these and other ideas that looked promising some years ago are in fact progresssing very slowly.

In 1978 an advanced concept *extended containment and surveillance* was widely advocated. Its principle, stated simply, was that, "nuclear material reliably known to have entered an area and similarly reliably believed not to have left that area must necessarily still be in the area". That was in 1978. The concept was remarkable in 1982 for its almost total absence. It would have been totally absent but for a single Agency paper reviewing its status and pointing out problems, some difficult to imagine solutions for, standing in the way of further progress.

Participants in the panel discussion were asked to identify future problems which in their opinion required concentrated study. A greater attention to the operator-inspector interface was one suggestion; the long standing need for a means of verifying the integrity of light-water reactor fuel assemblies was another. It will be interesting to see, presumably in November 1986, where the research and development effort of the next four years is actually directed.