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Attribute Measurement Systems Prototypes And Equipment In The United States

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ABSTRACT

Since the fall of 1997, the United States has been developing prototypical attribute verification technology for potential use by the International Atomic Energy Agency (IAEA) under the Trilateral Initiative. The first attribute measurement equipment demonstration took place in December 1997 at the Lawrence Livermore National Laboratory. This demonstration led to a series of joint Russian Federation/US/IAEA technical discussions that focused on attribute measurement technology that could be applied to plutonium bearing items having classified characteristics. A first prototype attribute verification system with an information barrier was demonstrated at a Trilateral Technical Workshop in June 1999 at Los Alamos. This prototype nourished further fruitful discussions between the three parties that has in turn led to the documents discussed in a previous paper.[1]

Prototype development has continued in the US, under other initiatives, using an integrated approach that includes the Trilateral Initiative. Specifically for the Trilateral Initiative, US development has turned to some peripheral equipment that would support verifications by the IAEA. This equipment includes an authentication tool for measurement systems with information barriers and in situ probes that would facilitate inspections by reducing the need to move material out of storage locations for reverification. In this paper, we will first summarize the development of attribute verification measurement system technology in the US and then report on the status of the development of other equipment to support the Trilateral Initiative.

INTRODUCTION

The Trilateral Initiative has focused on IAEA verification of materials that are excess to defense needs in the United States and in the Russian Federation. For materials that are in unclassified forms, standard IAEA safeguards measurement equipment and methods can be applied. For materials that have classified characteristics, however, the use of such methods would result in the compromise of the classified information. To avoid this, an attribute verification approach has been discussed and adopted for such materials. This approach uses standard radiation measurement equipment behind an information barrier. The classified radiation data are compared to unclassified thresholds and a simple yes/no answer is passed through the barrier. This scheme requires that calibration of the radiation equipment must be possible using unclassified reference materials.

The design of the information barrier must also allow the inspector access for authentication of the measurement equipment during unclassified measurements.

Attribute Measurement Equipment Approaches

There have been three demonstrations of attribute measurement equipment since the idea was first formulated. Each of the three demonstrations has had specific goals. The first demonstration took place in December of 1997 at the Lawrence Livermore National Laboratory (LLNL). The goal of this demonstration was to present the concept of attribute measurements using standard radiation equipment. Figure 1 shows a neutron multiplicity counter being demonstrated for the measurement of mass. Figure 2 shows high-resolution gamma-ray spectroscopy being used to determine plutonium isotopic ratios. At this stage of development the "information barrier" was a fledgling concept and was implemented totally in software. Trilateral Initiative technical discussions that followed this demonstration over the next year focused on the pros and cons of this approach and resulted in the adoption of this measurement methodology. The need for a more robust approach to the "information barrier" was recognized and technical discussions turned to this development.

Fig. 1. A neutron multiplicity counter being demonstrated for the measurement of mass at the Trilateral Initiative Technical Workshop in December 1997.

Fig. 2. A high-resolution gamma-ray spectroscopy system being demonstrated for the measurement of plutonium isotopics at the Trilateral Initiative Technical Workshop in December 1997.

Two prototype attribute measurement systems with information barriers have since been constructed and demonstrated at Los Alamos National Laboratory (LANL). These efforts were undertaken jointly with technical specialists from LLNL. The hardware development of the information barrier was based on ideas put forth by specialists from all three parties to the Initiative. The concept reached sufficient maturity in the summer of 1998 to consider building a prototype. This first prototype was demonstrated in the summer of 1999. Figure 3 shows the prototype. The goal of this demonstration was to stimulate further discussions between the three parties to the Trilateral Initiative concerning the viability of the information barrier concept and various approaches that could be employed in such systems. Thus the first prototype employed a variety of solutions ranging from standard IAEA software running on a desktop computer platform to a customized microcomputer running minimal software. After this demonstration, the technical experts were charged with the development of general technical requirements (GTR) and functional specifications (FS) for attribute measurement equipment with information barriers. These were developed in the winter of 1999 and the spring of 2000 and have been provisionally agreed to.

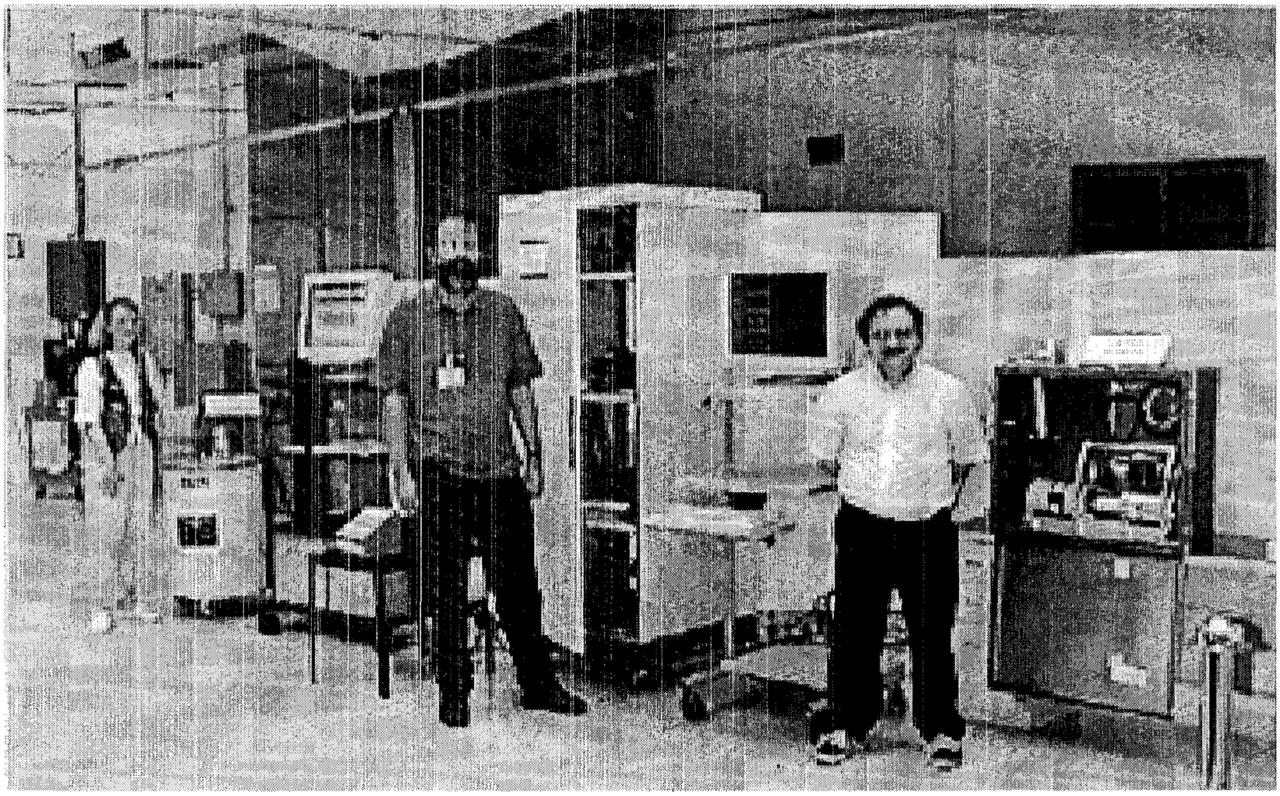

Fig. 3. The first prototype attribute measurement system with an information barrier for the Trilateral Initiaitive.

Attribute measurements with information barriers have since been discussed for other initiatives and this has warranted an integrated approach to development. A second prototype was developed and demonstrated in the summer of 2000. The goal for this second prototype, shown in Figure 4, was to demonstrate the concept using a classified item. This demonstration is described in more detail in reference 2. Although this demonstration was not done within the auspices of the Trilateral Initiative, the same technical experts from the US and from the Russian Federation were involved. In addition, to the extent possible for a demonstration system, the Trilateral Initiative GTR and FS were included in this second prototype. In particular, this system allowed for simultaneous neutron and gamma-ray measurements. This prototype measured six attributes including the three used in the Trilateral Initiative and thus also demonstrated the versatility of the information barrier concept.

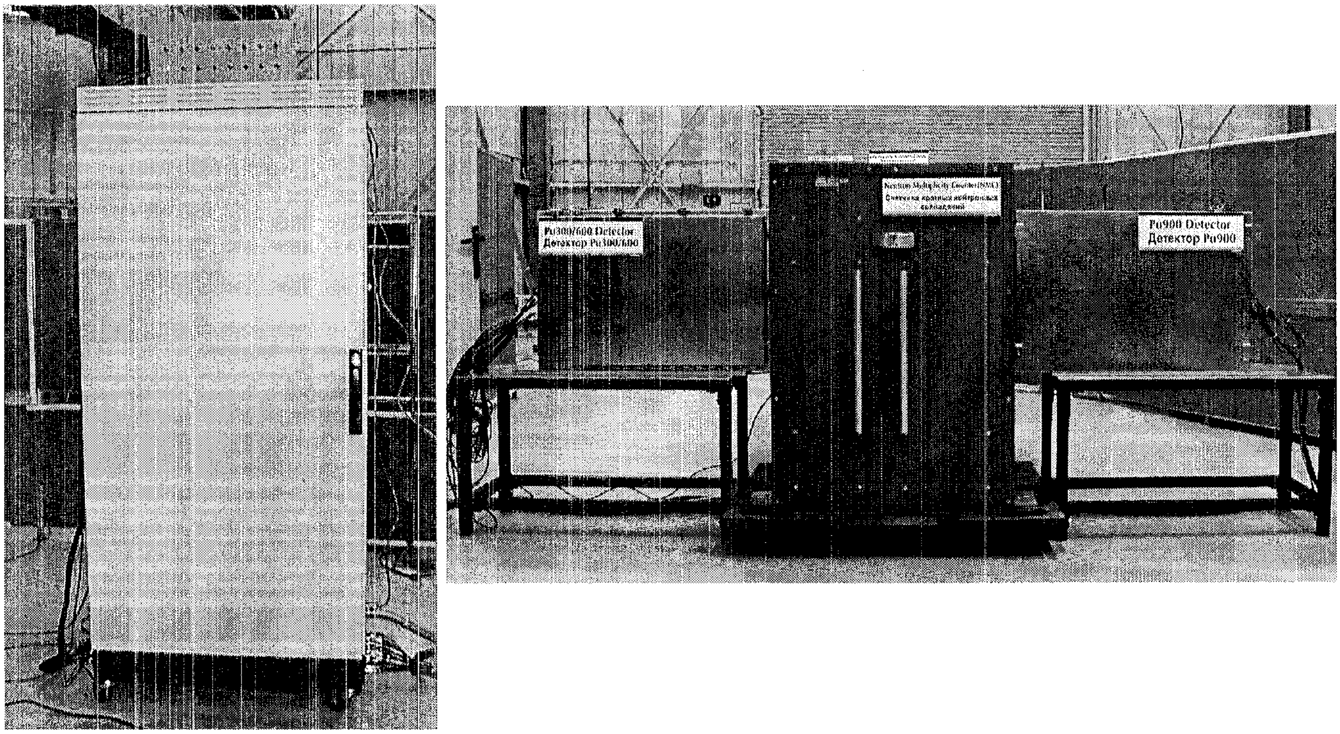

Fig. 4. The second protoype attribute measurement system with an information barrier.

As a result of these demonstrations and the development of a GTR and FS for an attribute measurement system, Trilateral Initiative technical discussions have turned to the development of a system that could be deployed in a storage facility such as the Russian Fissile Material Storage Facility (RFMSF) at Mayak. Deployment of an actual system presents some new challenges. First, the system must be very robust. The US demonstration systems have only had to perform for relatively short periods of time compared to the length of time that an actual field system would need to operate. A lesson learned from the demonstrations is that troubleshooting the equipment behind an information barrier can be very difficult. For an actual field system, this problem needs to be overcome. Finally, the technical experts have begun to focus on the new challenges that authentication of such equipment will present. Discussions are also focusing on chain-of-custody of this equipment, spare parts and maintenance of the equipment.

Other Equipment Development

The attribute measurement system with an information barrier is an essential part of the verification approach envisioned for the Trilateral Initiative, but it is also just one part of a toolkit that an inspector might employ. US technical experts have begun the development of some other equipment that could be used to facilitate inspections of this scale. In particular the US experts have begun development of active splitters, in situ probes, and an electronic authentication tool.

For a storage facility of the scale of the RFMSF or any facility that is envisaged for long term storage of plutonium, it may be desirable for the attribute measurement equipment to be used jointly by the operator for material control and accountability as well as by the inspector for verifications. This equipment is generally large and the initial investment costly. Space for such equipment may be limited as well. Thus sharing of equipment may be an efficient and cost-effective approach. Such joint use, however, presents its own challenges.

General technical requirements for active splitters for neutron-pulse output from a junction box and for gamma-ray signal output from a high-resolution gamma-ray spectrometer are being developed. Factors such as signal isolation, power supply, and noise control are all being considered. The latter is especially important for a gamma-ray pulse splitter, where the source signal is small. A neutron splitter was designed and used in the second demonstration of an attribute measurement system with an information barrier. This splitter is shown in Figure 5. Current work is focused on developing a splitter for high-resolution gamma-ray systems and upgrading the neutron splitter to be more robust.

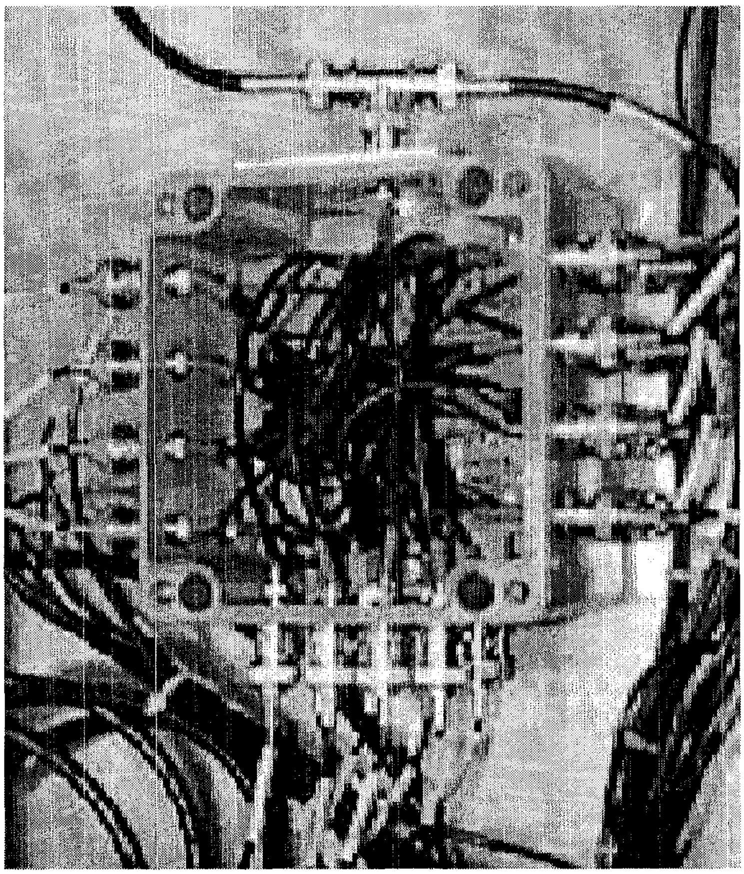

Fig 5. An active splitter for an 8 channel neutron multiplicity counter.

Removing storage containers from large storage arrays for inspection is a time-consuming, costly operation. Such operations expose personnel to additional radiation. From a material protection perspective, minimizing such material movement is also desirable. A method that is being explored that could minimize the requirement for such material movement, while still allowing an inspector to verify the presence of material in a storage array, is the use of in-situ probes. Such probes could be comprised of a hand-held neutron detector, a gamma-ray detector, or some combination of both. They might also be used for a low level attribute verification, although such an application would likely require an information barrier. Independent calculations by US and Russian specialists have verified the viability of this approach. Development is underway at LANL with the goal of demonstrating the technique this fall.

A third initiative that is underway is development of an electronic tool that could be used to simulate a neutron or gamma-ray pulse stream. Such a tool would have multiple uses including authentication and training. As an authentication tool, this would allow the inspector to exercise a system with an information barrier independently from host owned reference materials. The use of a correlated, neutron pulse simulator developed by Bourret and Krick[3] as an authentication tool was demonstrated at a Trilateral technical workshop last fall (Figure 6). The current pulser, however, is rate limited and cannot currently be used to simulate large, bulk plutonium sources. It also does not simulate detector deadtime. An upgrade of the pulser is currently underway. A gamma-ray pulse simulator is also currently being independently developed by both LANL and LLNL.

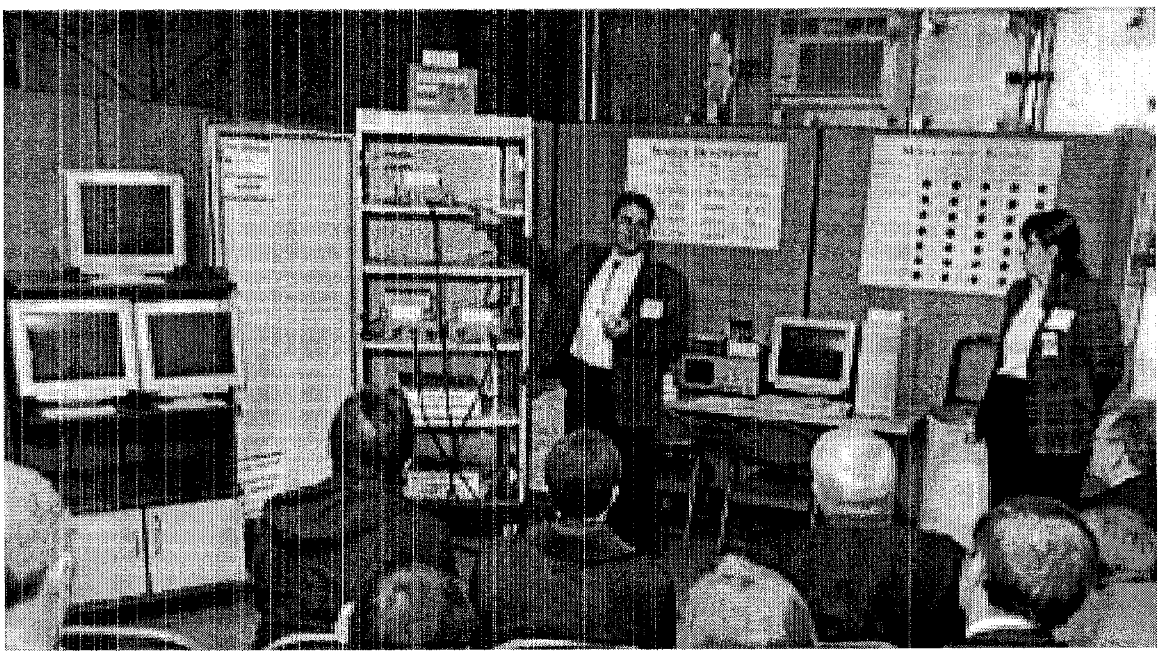

Fig. 6. A neutron pulse simultator demonstrated as part of a Trilateral Technical Workshop in November 2000.

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