LA-UR-98-2084

Title:

Instrument Recommendations for Trilateral Initiative Attribute Verification Measurement Technologies

Author(s):

N. J. Nicholas, M. W. Johnson, D. G. Langner,
B. L. Fearey and J. W. Tape

T. B. Gosnell and S. J. Luke

H. R. Martin, B. W. Smith

D. J. Mitchell and K. W. Marlow

Submitted to:

http://lib-www.lanl.gov/la-pubs/00412891.pdf

Los Alamos
NATIONAL LABORATORY

LA-UR-98-2084

Instrument Recommendations for Trilateral Initiative Attribute Verification Measurement Technologies

N. J. Nicholas, M. W. Johnson, D. G. Langner,
B. L. Fearey and J. W. Tape
Los Alamos National Laboratory, Los Alamos, NM 87545

T. B. Gosnell and S. J. Luke
Lawrence Livermore National Laboratory, Livermore, CA 94551

H. R. Martin, B. W. Smith
Pacific Northwest National Laboratory, Richland, WA 99352

D. J. Mitchell and K. W. Marlow
Sandia National Laboratories, Albuquerque, NM 87185

Executive Summary

This report documents the efforts of the U.S. team of technical experts to identify and recommend measurement technologies for use in support of the Trilateral Initiative for International Atomic Energy Agency (IAEA) verification of weapon-origin fissile materials in the United States and Russia. The verification approach being pursued is based on measuring unclassified attributes of fissile material in a sensitive form to provide confidence that the material is consistent with its declarations without revealing sensitive information. Attribute measuring could then be followed by nonintrusive monitoring designed to ensure that the material has not been returned to weapon programs. Measurements of multiple attributes, or multiple measurements of different signatures relating to the same attribute, could, in principal, be used to provide robustness and anomaly resolution options. Selection criteria for attribute measurement methods have been developed internally by a team of U.S. technical experts, and discussed and refined in trilateral fora. U.S. technical experts have begun testing and evaluating several candidate measurement approaches which meet these criteria; however, the recommendations of the U.S. technical experts are not exclusive of Russian-built instruments.

I. Introduction and Background

This report documents the efforts of the U.S. team of technical experts (the attribute verification team) to identify and recommend measurement technologies for use in support of the Trilateral Initiative for IAEA verification of weapon-origin fissile materials in the United States and Russia. The most important consideration in the development of technology for the verification of excess nuclear materials is the requirement to protect sensitive nuclear weapon design and other classified information from release to unauthorized parties. Unfortunately, the attribute verification team believes that all standard nondestructive methods for performing measurement and monitoring functions will reveal classified information. However, we also believe that it will be possible to construct instruments to analyze sensitive measurement data that would, using “information barriers,” present only unclassified results to the inspector. This activity is on-going, while significant progress has been made, much remains to be done. The primary challenge will be to develop potential measurement approaches and “information barriers” that permit meaningful verification conclusions regarding fissile materials removed from nuclear weapons while protecting sensitive information.

II. Attribute Verification

The verification approach being pursued is based on measuring unclassified attributes of fissile material in sensitive form to provide confidence that the material is consistent with its declarations without revealing sensitive information. Attribute measuring could then be followed by nonintrusive monitoring designed to ensure that the material has not been returned to weapon programs. Measurements of multiple attributes, or multiple measurements of different signatures relating to the same attribute, could be used to provide robustness and anomaly resolution options. [1, 2] To analyze verification options, it is necessary to define which attributes would provide the most confidence that the material is worth monitoring. A regime based on a combination of methods could be especially robust if the technologies are complementary to each other.

III. Selection of Measurement Approaches

Selection criteria for attribute measurement methods have been put forward by a team of U.S. technical experts, and discussed and refined in trilateral fora; these criteria are discussed in the following sections.

A. U.S. Preliminary Selection Criteria

The final design of candidate measurement and monitoring instruments will be driven by the location, physical form, and size of the items containing the nuclear materials. However, it is possible to consider a number of criteria that might influence the selection of verification methods and to make preliminary recommendation on general measurement approaches. These selection criteria considerations, described in Table 1, were developed by a multi-laboratory team and include whether the techniques are used by the IAEA in classical safeguards regimes or have been used for prior verification of weapon components, as well as criteria such as reliability, measurement time, cost, etc. [3] For a more complete discussion of the aatribute verification team’s thinking on applicable technologies based on the criteria in Table 1, see reference 1. Because the focus of the technical work to date has been on plutonium, only passive mesurement technologies were considered.

Table 1. Definitions of Criteria Used in Technology Assessments

SELECTION CRITERIA	DESCRIPTIONS / DEFINITIONS
Reliability/reproducibility	Evaluation of the precision and repeatability of any specific measurement
Low inspectorate impact	Ease of use by inspecting party
Developed technology	Technological maturity of measurement instrumentation
Info-barrier compatibility	Ease of adaptation of a robust information barrier to measurement technology
Ease of authentication	Ability for IAEA to independently confirm instrument operation and performance
Universality	Ability to measure full range of inventory (e.g., classified/unclassified, item/bulk)
Package compatibility	Ability to measure full range of package types (e.g., AT400, AL-R8)
Robustness	Ability to obtain the correct result under various and potentially adverse conditions
Remotely operable	Ability to operate in an unattended mode
IAEA familiarity	IAEA knowledge, acceptance, and use of technology
MPC&A familiarity	Russian knowledge, acceptance, and use of technology
Measurement time	Ability to make valid measurements in reasonable timeframe
Facility impact	Minimize impact to facility (e.g., small footprint, shielding requirements)
Resistance to spoofing	Assessment of the technology's resistance to spoofing (e.g., inappropriate material types)
Cost	Cost of procurement, installation, and operation
Power requirements	Necessity of special power requirements (V, A, and W)
Portability	Ability to carry or transport instrument on- and off-site
Independence	Nonreliance on other measurements (e.g., isotopics)

B. Trilateral Efforts to Refine Selection Criteria

December 1997 Trilateral Technical Workshop at LLNL

Technical experts from the United States, Russia, and the IAEA met to exchange views and demonstrate verification and monitoring technologies that might be used for IAEA inspections of sensitive components containing plutonium, without revealing classified information. The focus of the discussions was on measurement physics approaches and information barriers to protect classified information while permitting the IAEA to draw independent conclusions. One key technical objective pursued was development of independent measurements of attributes related to excess fissile materials of weapons origin that do not reveal classified information and that provide confidence that the materials are consistent with a quantity of weapons-grade plutonium above a mutually agreedthreshold level. The focus was on plutonium in storage.

Trilateral technical dialogue resulted in the development of an outline of a possible matrix for down-selecting attributes and measurement techniques (Table 2). After this matrix was outlined, the U.S. technical experts distributed earlier versions of Table 1 and related information on the criteria for selection of technologies from the selection criteria paper (reference 3). These issues were discussed at some length. The Russians noted that we only included U.S. technologies in our preliminary down selection. We offered to examine any they would like to propose, but they decided to defer until we attended the workshop they were planning to host.

Table 2. Outline of Possible/Potential Criteria for Measurement Technologies

Declaration	Attributes (Signatures)	Measurement Methods	Measurement Results to IAEA	IAEA Verification Conclusions	Selection Criteria (Pros/Cons)
Number of containers	-number of items -ID (bar code) -type of containers (AT400, ALR8)	-item count -barcode reader			
Number of containers with plutonium	-number of items -ID (bar code) -type of containers (AT400, ALR8) -presence of Pu	-item count -barcode reader -gammas, neutrons, heat			
Number of containers with weapon-origin plutonium	-number of items -ID (bar code) -type of containers (AT400, ALR8) -presence of w.o.-Pu				
Number of containers with > X grams weapon-origin plutonium					

March 1998 Trilateral Technical Workshop at Obninsk

A technical meeting in the context of the Trilateral Initiative was held by experts from the Russian Federation, the United States, and the IAEA on March 10-13, 1998.[4] The purpose of the meeting was to prepare recommendations on fissile material attributes and the next steps required to examine technical issues related to possible methods for IAEA verification of weapon-origin fissile materials in sensitive forms.

The participants reached a common understanding on technical issues related to attribute measurement approaches to be used in accepting containers containing weapon-origin plutonium in classified form for monitoring. It was agreed that it is important to make progress this year on technical work required to develop verification methods for the following attributes while allowing that other attributes may be considered in the future as deemed appropriate to support the objectives of the Trilateral Initiative:

- presence of plutonium,
- weapon-grade plutonium,
- threshold mass of plutonium.

At Obninsk the technical experts noted that several techniques existed that could be adapted to measure plutonium attributes (see Tables 3a-c). Moreover, several techniques appear capable of being used to create templates. If successfully developed and agreed such templates might be used to increase the speed and reduce the costs of IAEA verification (see Table 3d).