COST EFFECTIVE MEASURES FOR MEETING INTERNATIONAL ATOMIC ENERGY AGENCY REQUIREMENTS IN STORAGE OF SURPLUS PLUTONIUM

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ABSTRACT

The end of the Cold War created a legacy of surplus weapons-useable materials throughout the world. In keeping with its policy of nonproliferation the United States (U.S.) declared 200 metric tons of fissile material to be excess to national security needs and ordered it to be withdrawn from the nuclear material stockpile. The U.S. further began plans to submit this material to International Atomic Energy Agency (IAEA) safeguards and to develop a strategy for its eventual permanent disposition. Nuclear material from the former weapons program at two sites managed by the Office of Environmental Management is now under IAEA safeguards. A third site has been placed on the IAEA list of Eligible Facilities and soon will subjected to IAEA inspection. These sites are Rocky Flats Environmental Technology Site, Hanford Site, and the Savannah River Site. The U.S. Department of Energy, site personnel and the IAEA have developed a successful inspection regime at a cost which is reasonable for nuclear materials facilities. Several lessons were learned with each successive safeguards implementation which proved invaluable to the overall program.

INTRODUCTION

The end of the Cold War created a legacy of surplus weapons-useable materials throughout the world. On September 27, 1993 the United States (U.S.) stated it would submit fissile material no longer needed for military applications to inspection by the International Atomic Energy Agency (hereinafter referred to as the IAEA or Agency). In November 1994, the Nuclear Weapons Council declared over 200 tons of fissile material, approximately 38 metric tons of which are weapons-grade plutonium, excess to national security needs. The Council deferred to the National Security Council, however, any decision of how much of this material would be placed under IAEA safeguards. In March 1995 President Clinton declared that "…to further demonstrate our commitment to the goals of the Nonproliferation Treaty (NPT),…I have ordered that 200 tons of fissile material be permanently withdrawn from the United States nuclear stockpile". These decisions and directives instituted the surplus plutonium and uranium disposition initiative in the U.S. This paper will concentrate only on the surplus plutonium part of the initiative.

In January 1997, the Department of Energy (DOE or Department) announced the Record of Decision (ROD) on the *Storage and Disposition of Weapons-Useable Fissile Materials Final Programmatic Environmental Impact Statement.* To assure safe, secure, cost-effective and inspectable long-term storage of plutonium, the Department of Energy's strategy for disposition of plutonium consists of immobilizing some of the surplus plutonium in glass or ceramic material and burning the rest of the surplus plutonium as mixed oxide (MOX) fuel in existing

commercial reactors. Technology, complexity, timing, cost and other factors are involved in purifying certain plutonium materials to make them suitable for use in MOX fuel. Approximately 30 percent of the total quantity of plutonium, therefore, that has or may be declared surplus to defense needs would require extensive purification to use in MOX fuel. This material will likely be immobilized. DOE will immobilize at least 8 metric tons (MT) of currently declared surplus plutonium materials that DOE has already determined are not suitable for use in MOX fuel. DOE's program will be subject to the highest standards of safeguards and security throughout all aspects of storage, transportation, and processing, and ***are expected to include appropriate IAEA inspection.***

In accordance with the ROD, the Department has decided to reduce, over time, the number of locations where the various forms of plutonium are stored. This will be accomplished through a combination of storage alternatives in conjunction with a combination of disposition alternatives. These are

- Phase out storage of all weapons-usable plutonium at the Rocky Flats Environmental Technology Site (RFETS)
- Upgrade storage facilities at Pantex to store surplus pits from RFETS pending disposition
- Store Strategic Reserve pits already at Pantex in other upgraded facilities
- Expand storage at the Savannah River Site (SRS) to store non-pit plutonium materials currently at SRS and surplus non-pit plutonium materials from RFETS, pending disposition
- Continue current storage of surplus plutonium at the Hanford site and the Idaho National Environmental and Engineering Laboratory, pending disposition
- Continue current storage of plutonium at Los Alamos National Laboratory, pending disposition

Concurrent with the development of the Storage and Disposition of Weapons-Usable Fissile Materials Record of Decision, the Secretary of Energy of the United States, the Minister of Atomic Energy of the Russian Federation, and the Director General of the IAEA met in Vienna on September 17, 1995. The purpose of the meeting was to consider practical measures concerning IAEA verification of weapon origin fissile materials. The participants noted that this endeavor is parallel and complementary to the commitments made by Presidents Clinton and Yeltsin in September 1994 and May 1995, respectively, regarding the transparency and irreversibility of nuclear arms reductions. In this meeting

- The ministers of the U.S. and the Russian Federation (RF) agreed to discuss technical methods designed to protect sensitive nuclear weapons information and to prevent its disclosure, and to hold appropriate consultations with the IAEA on this matter.
- The participants agreed that, to address the various technical, legal and financial issues associated with implementing IAEA verification of relevant fissile materials, a joint group should be formed and report on progress in addressing these issues.
- All parties agreed that within six weeks of this meeting, representatives from the IAEA, the RF and the U.S. would participate in a trilateral visit to the RFETS and Hanford Site. The purpose of the meeting would be to examine how IAEA safeguards have been implemented at plutonium facilities under the existing U.S. Voluntary Offer Agreement.

The consultations began with visits to Argonne National Laboratory (November 4, 1996), Hanford (November 5, 1996), RFETS (November 6-7, 1996), and Washington DC (November 8, 1996). A core group of participants who agreed to pursue the trilateral initiative consultations resulted from these meetings. Trilateral Initiative consultations are ongoing and have produced a working draft of a "Model Agreement Between a Nuclear-Weapon State Party to the Treaty on the Nonproliferation of Nuclear Weapons and the IAEA for the Verification of Weapon-Origin Fissile Material or Other Fissile Material No Longer Required for Defence Purposes".

K-AREA NUCLEAR MATERIAL STORAGE (KAMS) PROJECT DESCRIPTION

The 105-K Reactor at the Savannah River Site (SRS), South Carolina, was formerly used for tritium and plutonium production. Operations ceased in 1988 and the facility was placed in a cold shutdown mode in 1992 with no provision for restart. DOE decided in 1996 to accelerate closure of the RFETS with the new closure date being 2006. K-Area was studied with the thought that non-pit plutonium currently stored at RFETS could be stored in building 105-K in a cost efficient way. DOE determined, therefore, to modify the 105-K Building for storage of non-pit plutonium during an interim period of approximately 10 years until disposition of this material.

In March 1998 the U.S. informed the IAEA that there was a possibility of utilizing the reactor building at K area for the storage of excess non-pit plutonium. At this time and later during the June-August time frame, the KAMS facility and safety limitations were discussed with and explained to the IAEA. The U.S. also envisioned use of the KAMS facility as an appropriate storage facility within the framework of the Trilateral Initiative, and an IAEA nuclear material verification approach was drafted by the U. S. as well as the IAEA.

(Fig. 1: Typical Shipping Container)

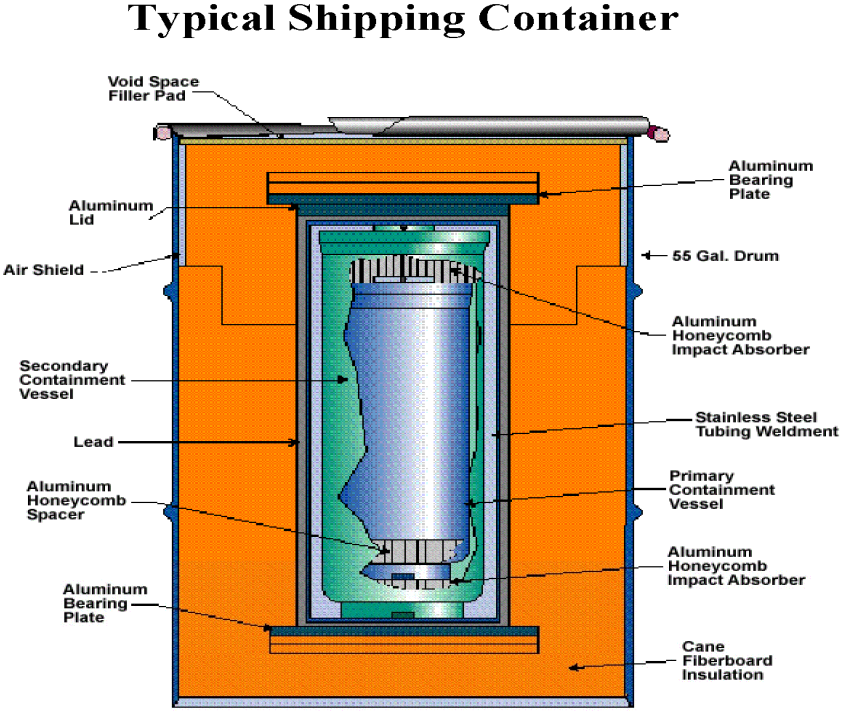
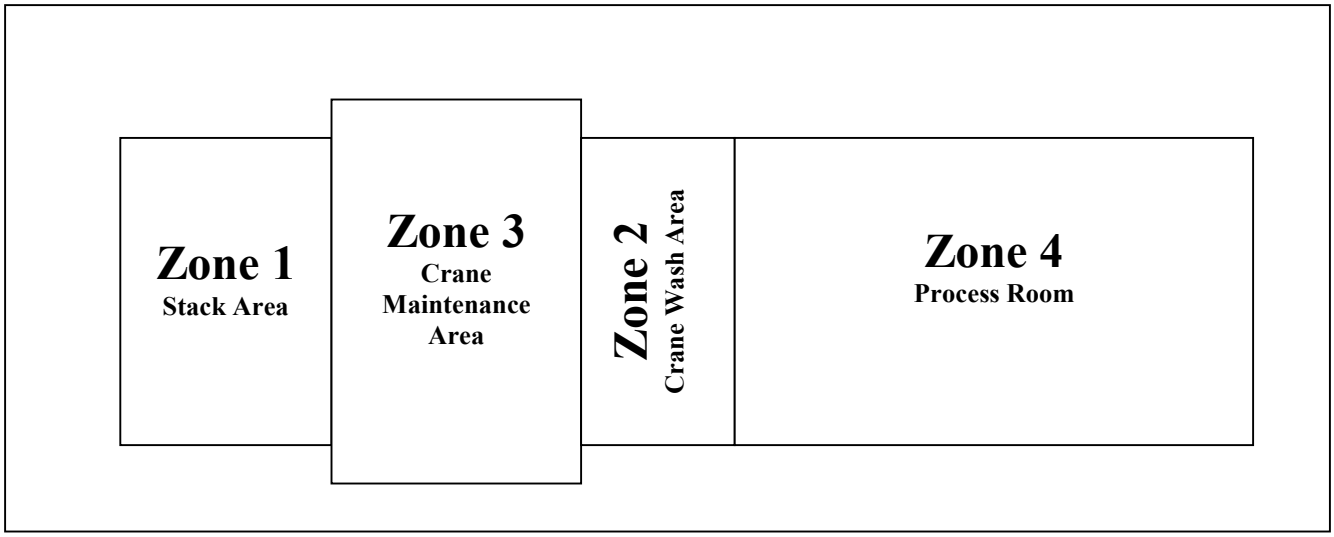


Figure 3

The reactor building is being modified to accommodate safe interim storage for approximately 3000 model 9975 type Shipping Packages similar to 35-gallon drums. See Figure 1. Each shipping package will contain approximately 4.4 kg of plutonium packed in a containment vessel compliant with DOE Standard 3013. The form of plutonium will be either metal or oxide. Five drums will be banded together on a metallic pallet for storage in rows. Current plans are to limit stacking of the pallets to two high.

Storage will be accomplished in two phases. Phase I, starting in January 2000, includes storage of about 1000 drums of plutonium in the Process Area of the 105-K building. Phase II, starting in January 2001, includes storage of about 2000 drums of plutonium in the Stack and Crane Maintenance Areas. See Figure 2.

(Fig 2: K Area Material Access Area Zones)



The Process Area is approximately 740 square meters. It will be used solely for storage of shipping containers.

The Stack Area is approximately 430 square meters and has a large, secure roll door that will be used as the entry point for trucks delivering the shipping containers. This area will be used for receipt inspection of all incoming containers and, eventually, storage of some containers after the Process Area and Crane Maintenance Area are filled.

The Crane Wash Area is approximately 200 square meters located between two large shield doors. It will contain a staging area where plutonium in the containers will be measured and then placed on pallets for storage after the measurements are completed. This area will contain the instrumentation used for non-destructive assay and inspection of the shipping containers. The Crane Wash Area will not be used for container storage.

The Crane Maintenance Area is approximately 1050 square meters. It will be used for storage of shipping containers. Support facilities such as entry control points, offices, and rest rooms are located adjacent to this area.

These areas are physically separated by walls and security doors, but may be treated as one Material Access Area (MAA) for material control and accounting (MC&A) purposes. The areas are within the 105-K building and entry points will be hardened and controlled in accordance with MC&A regulations. The entire 105-K building is within the K Area Perimeter Intrusion Detection and Alarm System.

IAEA SAFEGUARDS REQUIREMENTS

Authority for application of IAEA safeguards is provided in the Statute (1957) and the Treaty on the Non-Proliferation of Nuclear Weapons (NPT, 1970). Although the U.S. is a signatory of the NPT, it is not bound by it because the U.S. was a weapons state before the NPT went into force. To show its support of non-proliferation principles and the role of the IAEA in promoting those principles, President Johnson in 1967 made a "Voluntary Offer" to submit certain nuclear facilities in the U.S. to IAEA safeguards inspections. In 1980, the U.S. entered into force the "Agreement Between the United States of America and the International Atomic Energy Agency for the Application of Safeguards in the United States of America" hereinafter referred to as the "Voluntary Offer Agreement" (VOA).

IAEA safeguards requirements are delineated in a document titled "Safeguards Criteria, 1991-1995". Section 9 of this document covers material in storage.

The "traditional" IAEA approach to safeguards is based on a system of technical measures to verify systematically that a State has not used nuclear materials or equipment in a manner that violates international obligations, and to deter such future use. This is accomplished by establishing continuity of knowledge. That is, the IAEA must prove to its satisfaction that the State has not diverted nuclear material from peaceful uses to nuclear weapons or other nuclear explosive devices since the IAEA's previous inspection. Implicit in this goal is that the detection of diversion of significant quantities of nuclear material must be timely, measurement equipment must be capable of determining the amount of nuclear material on inventory, and an accounting system must be in place to track the material. A model Agreement for a given State is Informational Circular 153 (INCIRC/153) which clearly states that any agreement between the IAEA and a State "should provide for the use of material accountancy as a safeguards measure of fundamental importance, with containment and surveillance as important complementary measures". Specifically, components of the IAEA's "traditional" safeguards are

- A measurement system for the determination of the quantities of nuclear material received, produced, shipped, lost or otherwise removed from inventory, and the quantities on inventory;
- The evaluation of precision and accuracy of measurements and the estimation of measurement uncertainty;
- Procedures for identifying, reviewing and evaluating differences in shipper/receiver measurements;
- Procedures for taking a physical inventory;
- Procedures for the evaluation of accumulations of unmeasured inventory and unmeasured losses;

- A system of records and reports showing, for each material balance area (MBA), the inventory of nuclear material and the changes in that inventory including receipts into and out of the material balance area;
- Provisions to ensure that the accounting procedures and arrangements are being operated correctly; and
- Procedures for the submission of reports to the Agency in accordance with INFCIRC/153.

In addition to the Savannah River Site, three other U.S. former nuclear weapons facilities are under IAEA safeguards, *viz.*, Rocky Flats Environmental Technology Site, Hanford, and Oak Ridge. Worldwide, all five nuclear weapons countries have made similar voluntary offers for implementing IAEA safeguards. These examples of IAEA inspections and monitoring activities demonstrate the importance and visibility of the IAEA. They also demonstrate the external and internal pressures on the U.S. to develop an inspection regime which is economically feasible and which serves as an example of international cooperation and involvement. To do this, the U.S. entered into negotiations with the Agency to apply an inspection regime in KAMS to begin with the accelerated shipments from RFETS. Although both sides worked very hard to accomplish this, legally the U.S. and the Agency have only one legal instrument by which the IAEA can conduct inspections in the U.S., viz., the Voluntary Offer Agreement. Both parties agree that elements of verification are certainly applicable to a safeguards regime, and that safeguards can be replaced by verification under the Trilateral Agreement when that agreement enters into force. Both parties also agree that the primary difference between verification and safeguards under the VOA is the need for annual re-verification of the inventory under VOA Safeguards unless dual containment and surveillance (c/s) can be achieved. Re-verification of the inventory in KAMS is a major issue in that the shipping/storage containers may not be opened in the KAMS building because of safety considerations. This restriction prohibits IAEA sampling for the destructive analysis traditionally required for IAEA safeguards. Additionally, this facility has no accommodations available for required safety inspections of the storage container. The shipping/storage containers will have to be shipped to another location for inspections and this location might not be an eligible facility.

The good news emanating from this situation is the DOE Order and Manual governing domestic safeguards for this material allow the site to take "credit" for work performed in accordance with IAEA inventory verification. Therefore, item identification, Tamper Indicating Seal (TID) verification, gross weight verification and continuity of knowledge through containment and surveillance devices all apply to and greatly reduce the effort required for domestic safeguards.

PLANNED KAMS SAFEGUARDS/VERIFICATION PROGRAM

In January 2000 when KAMS becomes operational, the receipt, unloading and storage operations are envisioned as follows. See Figure 3 on page 8.

- Unload the Cargo Restraint Transporter (CRT) from the transport into the Stack Area. Up to three transports may be received at any given time. Each transport can accommodate up to six CRT's and each CRT has four shipping containers. ***These shipping containers will become the KAMS area storage containers.***
- Move CRT's to the staging area located in the Process Area.

- Unpack CRT's and perform receipt survey. This consists of MC&A transfer check and integrity check of RFETS TID for up to 24 shipping containers.
- Move individual shipping/storage containers to weigh station.
- Perform gross weight measurement (GWM) and read bar code. Attach radio frequency tamper indicating (RFTID) seal to individual shipping/storage container.
- Move individual shipping/storage container to MC&A room
- Determine storage container plutonium contents using the neutron multiplicity counter (NMC) and the isotopic content using the gamma isotopic counter (GIC).
- Move individual shipping/storage container to weigh station and band together up to five storage containers on a single pallet. Apply RFTID and assign storage location.
- Store pallet in Process Room Storage Area.

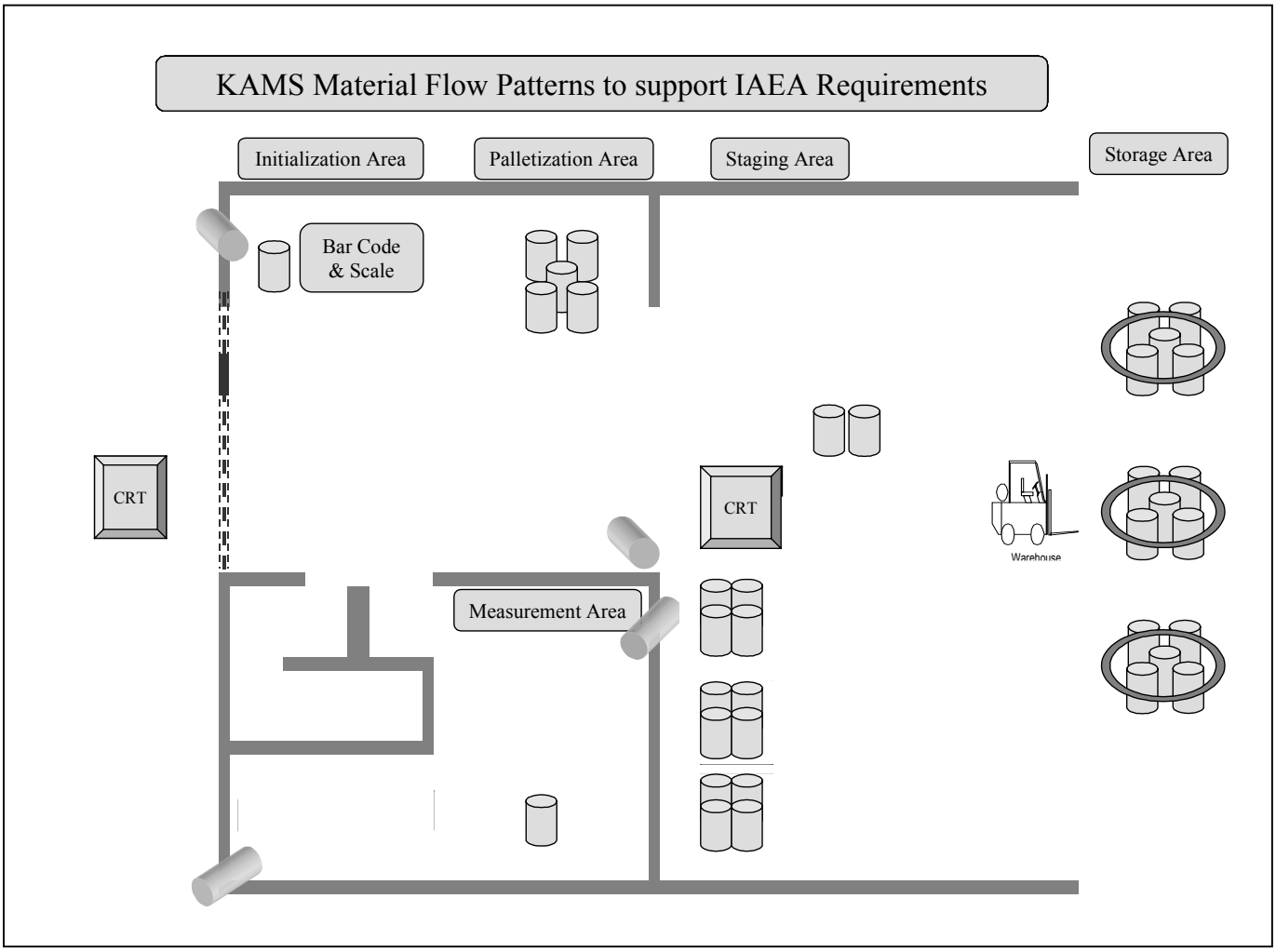
The safeguards approach to meet domestic and IAEA requirements for the above material receipt and storage procedure will consist of traditional safeguards methodology. First, the State must provide certain information to the IAEA. The basic document to be provided by the State is a Design Information Questionnaire (DIQ). It includes such information as the identification, purpose and location of the KAMS; the layout of the facility; the operational program foreseen for interim storage of weapon-origin plutonium to be submitted to IAEA verification; the types and characteristics of storage containers to be used; information on the fissile material accounting system; relevant regulations affecting fissile material control and accounting; health and safety regulations and procedures applicable to IAEA inspectors, and security control procedures applicable to IAEA inspectors.

The site must maintain up-to-date records showing the locations of all containers at all times, together with the amounts of plutonium in each container. The site must examine each shipping/storage container received and to be shipped and measure its contents by means of non-destructive assay. The site will carry out a physical inventory once per calendar year.

The U.S. shall submit Monthly Accounting Reports which will include the type of storage container and its identification number; physical form of plutonium; nominal chemical composition; identification of the shipping facility; date of receipt or shipment; plutonium mass and isotopic composition; pallet number and location; identification number of applied Agency seals; and pertinent safety information. Summary inventory information is provided as agreed between the U.S. and the IAEA. At a minimum, this consists of total number of containers stored; total number of containers received, shipped, transferred for safety examination and received following safety examination; and total amount of plutonium stored at the end of the month.

With the exception of the DIQ, the above activities are for the most part included in the domestic safeguards program. The Agency, too, has certain rights and obligations, which transcend the domestic safeguards program. It has the right to have specified staff examine and verify information in the DIQ; and it has the right to examine the facility accounting records to include the list of inventory items, the inventory change reports and the material balance reports.

(Fig. 3: Crane Wash Area)



Agency personnel will verify the physical inventory of plutonium, seals, and any changes, which have occurred to the inventory. They will review all monitoring equipment including bar code readers. They will authenticate shared assay and monitoring equipment and will lock out site personnel from using that equipment during times of Agency physical inventory verification.

To ease the burden on both the IAEA and the site operator while remaining compliant with the terms of the VOA, the NPT, and the Agency Safeguards Criteria, the IAEA will rely on "dual" c/s. This refers to redundant systems such as two camera or seal systems or two independent systems, which complement each other. KAMS will go with the latter option combining TID's with a video system. The IAEA has suggested and the site is seriously considering applying IAEA-authenticated RFTID's to all incoming drums even if inspections begin after receipt of the first material from RFETS. The video option preferred by the site is "NTvision", but this could take two years for IAEA approval. If the IAEA could permit joint use of its DCM-14 video system, Savannah River could use the signal as input to its NTvision and thus speed up IAEA approval. Whatever the decision, video monitoring will be an important part of the safeguards regime at KAMS.

The use of unattended monitoring has benefits in terms of inspection effort when these systems are implemented in conjunction with remote monitoring (RM) as this would allow reduced inspector presence at facilities. Additionally, RM has far reaching implications for the Trilateral Agreement as the U.S. and the Russian Federation are making plans for a collaborative RM effort in the near future. In order for the Agency to draw safeguards conclusions from its verification activities incorporating RM at the KAMS facility, the following is necessary.

- Equipment for RM systems must be authorized for inspection use by the Agency
- Measures must be taken to ensure the authenticity of the stored and transmitted data and appropriate encryption has been applied.
- The Agency must arrange with the State for the timely provision of information on facility operations
- The Agency must arrange with the State for the performance of inspections in conjunction with RM, especially procedures for unannounced inspections
- Safeguards review and evaluation of the transmitted data must be performed within the timeliness period.

NEGOTIATING A SUCCESSFUL IAEA INSPECTION REGIME

As with any negotiating situation, the beginning stages of applying IAEA safeguards to KAMS were more educational for each side rather than substantive. Site personnel were obliged to learn an entirely new set of safeguards goals and objectives. They had to realize that in the eyes of the IAEA, the State is the "enemy" in the sense that the Agency must assume that the State has the means and the desire to divert nuclear material from peaceful use to military use. Agency personnel, on the other hand, were obliged to familiarize themselves with facility layout, design concepts, and cost and schedule requirements. They had to realize that site personnel are responsible to many government and private entities – DOE, Nuclear Regulatory Commission, Environmental Protection Agency, the States of Georgia and South Carolina, and stakeholders, to name a few. Both sides had to learn a whole new safeguards vocabulary.

The process of implementing IAEA safeguards began with defining core requirements. Of course the IAEA and the site personnel did not always agree on what was "core". Conceptually, at least, both sides agreed that the U.S. must provide the IAEA with a complete inventory listing to include item identification and quantities; the IAEA must be able to maintain continuity of knowledge for this inventory; and the IAEA must be permitted to verify the inventory on a periodic basis. The details of how to accomplish this with minimal intrusion at KAMS; with adherence to the cost and schedule of the U.S. Environmental Management Program; and with compliance to the legal requirements of the IAEA were more difficult to agree upon. Eventually, through technical advancements, diplomatic and technical consultations, and a positive attitude on the part of all participants involved in the negotiations to make the process work, the core requirements discussed earlier in this paper have been established.

Retrofitting KAMS for storage and inspection of nuclear material could have been stymied because of physical impediments or astronomically high costs. Two such obstacles were the absence of provisions at the facility for opening shipping containers and the necessity of the IAEA to verify the inventory annually by re-measuring a portion of the inventory. The

flexibility of the VOA and the creativity of the IAEA and site personnel, however, have discovered "workarounds" to these impediments and the means to keep the costs in check. These issues, while not totally resolved, are well on the way to resolution. At a higher initial expense but reduced Agency intrusiveness and manpower, using unattended monitoring, especially unattended monitoring of receipts, has expelled the need for opening shipping packages or containers except for safety purposes as discussed previously. Dual c/s for the shipping/storage packages can avoid the need to re-verify the inventory at the Agency's annual Physical Inventory Verification (PIV). And the greatest benefit of all is that implementation of safeguards in KAMS will be for only an interim period until a legal instrument adapted to Nuclear Weapon States within the framework of the Trilateral Initiative becomes available. This is an economic benefit to the U.S., the IAEA and the other nuclear weapons states.

RESULTS

The costs of implementing IAEA safeguards in a former weapons facility need not be a limiting or interfering issue. For example, construction costs to retrofit former production and processing areas into an interim storage facility have been around $3M, with slightly over half of that attributed to costs incurred solely for implementation of IAEA activities. One might think this cost would be much higher, considering the facilities formerly processed plutonium, tritium, and uranium and contain residuals of those contaminates. Although KAMS has had no opportunity to date to determine operating costs, estimates can be derived from RFETS, Hanford and Oak Ridge, the other sites that have several years experience with IAEA inspections. Start up costs are always higher, of course, but they eventually have settled down to between $150K and $200K per year. These costs include the annual P I V which can be quite costly because it is so labor intensive.

Lessons learned from KAMS for meeting IAEA requirements in storing excess plutonium are

- Continuous, open exchange of information between the site, the DOE, the IAEA, and the Department of State throughout the project has been invaluable.
- Determination of facility modifications and funding could have and should have begun earlier.
- Informed management personnel for both the contractor and DOE can help to ward off possible problems and schedule delays.
- A tutorial on IAEA Safeguards is recommended to educate site personnel in the missions and methods of the IAEA, especially as contrasted with domestic safeguards.
- Site personnel who will interact with and have operational input to the IAEA need to be conversant with the Voluntary Offer Agreement and the IAEA Safeguards Criteria.
- IAEA safeguards can be implemented without costing millions of dollars by maintaining communications, planning ahead, and knowing the limitations of the facility and the project.

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