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How To Maintain Effective IAEA Safegauards While Reducing Facility Impact

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EXECUTIVE SUMMARY

For almost twenty years, inspectors from the International Atomic Energy Agency have been visiting the K-Area Material Storage facility at the Savannah River Site where excess plutonium has been placed under IAEA safeguards as part of the United States Volunatary Offer Agreement. During that time, the mission of K-Area Complex has expanded from storage of nuclear matieral to glovebox operations in support of the National Nuclear Security Administration's Plutonium Disposition program. With this change in mission, it is becoming increasingly challenging to manage facility staff radiation exposure and operating activities during the IAEA's annual Physcial Inventory Verifications (PIV). This study has identified both near-term and long-term recommendations for IAEA monitoring protocols that would allow the IAEA to maintain effective safeguards of the material while decreasing the impact to the facility.

A statisitical analysis has shown that reducing the number of containers measured during an annual PIV from 12 to 4 still ensures a high level of confidence in the confidence while reducing the inspector time in the facility amd with a corresponding significant reduction in personnel radiation exposure. A modified installation pattern of Remotely Monitored Sealing Arrays (RMSAs) is also proposed utilizing only the outer rows of arrays of stored material containers in the Stack Area (SA). The modified RMSA placement will provide equivalent protection, while significantly reducing personnel radiological exposure, manpower requirements and associated costs. With advances in technology, there are additional potential options in containment/surveillance and continuity of knowledge that would allow the agency to be outside of the facility during PIV measurements and have confidence in the accuracy and authencitity of the results.

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LIST OF ABBREVIATIONS

BNL	Brookhaven National Laboratory
C2S2	Coincidence Counter Signal Splitter
DOE-EM	Department of Energy, Environmental Management
GIC	Gamma Isotopic Counter
IAEA	International Atomic Energy Agency
IIV	Interim Inventory Verification
KAC	K-Area Complex
KAMS	K-Area Material Storage
NMC	Neutron Multiplicity Counter
NNSA	National Nuclear Security Administration
PIV	Physical Inventory Verification
RMSA	Remotely Monitored Sealing Arrays
RPD	Radiological Protection Department
SA	Stack Area
SNL	Sandia National Laboratories
SRNL	Savannah River National Laboratory
U.S.	United States
VOA	Voluntary Offer Agreement
WIPP	Waste Isolation Pilot Plant

1.0 Introduction

In 2002, negotiations were initiated between the United States (U.S.) and the International Atomic Energy Agency to dedicate a portion of the K Area Material Storage (KAMS) Area for support of the US Voluntary Offering Agreement (VOA), in order to maintain the Nation's nonproliferation objectives. Since the initial placement of the first metric ton under IAEA safeguards, changes in the Department of Energy (DOE) Environmental Management's (EM) mission and reorganization of the DOE Enterprise have resulted in an additional 1.8 mteric tons of plutonium being placed under IAEA safeguards.

The DOE decision on changing the plutonium disposition strategy to downblending excess plutonium for dispoal at the Waste Isolation Pilot Plant (WIPP) has resulted in K-Area Complex (KAC) changing from a storage mission to a full time operating facility including glovebox operations. The increase in facility activities, coupled with on-going plutonium surveillance activities, has raised new challenges for integrating facility operations and IAEA activities. Opportunities to reduce radiation exposure to facility staff and reduce IAEA inspector time in KAMS while at the same time ensuring the IAEA can maintain effective safeguards of the material under the VOA need to be formulated into the new program protocol.

This study offers several alternatives to the current IAEA safeguards program at KAMS that would reduce the burden on facility staff and activities while ensuring that the IAEA maintains effective safeguards of the material under the VOA.

2.0 Review Of Alternatives

2.1 Statistical Analysis of IAEA Verification Measurements

During the annual Physical Inventory Verification (PIV), IAEA inspectors request an average of 12 drums to be assayed by Gamma Isotopic Counter (GIC) and 14 drums to be assayed by the Neutron Multiplicity Counter (NMC). In addition to limiting operational activities when the IAEA inspectors are in the facility, K-Area staff who support movement of the drums receive a significant amount of radiation exposure. As K-Area begins to increase throughput in downblending of surplus plutonium, operator dose and limitations to operations become more significant.

Each PIV measurement selection involves the movement and return of at least one (1) triple stack of containers, and up to as many as seven (7) triple stacks. There is a minimum of three (3) pallet selections made during a PIV inspection. These activities result in large dose experienced by Operations and Radiological Protection Department (RPD) personnel (up to 50 mrem per person per evolution). K-Area personnel routinely approach the Site Administrative Dose Limit of 500 mrem months prior to the end of the annual cycle. Table 1 displays the available summary data for total dose received supporting PIV's from 2017, 2018, and 2019 covered under the applicable Radiological Work Permit. During each of the 2017 and 2018 visits, 4 pallets of drums were mined from the facility storage area for assay, requiring 149 and 120 entries. During the 2019 visit, 3 pallets of drums were mined and assayed, resulting in a significant savings in personnel exposure. Conservatively, 300 mrem of exposure will be avoided by eliminating one pallet of drums that must be mined from storage, assayed, re-palletized, and transferred into storage.

Table 2-1. Summary of KAMS Personnel Radiation Exposure During PIV

Year	Radiological Work Permit	Actual Exposure (rem)	Total Entries by RWP	Average Exposure Per Entry (mrem)
2017	17NMM103	1.763	149	11.832
2018	18NMM004	1.501	120	12.508
2019	19NMM004	0.896	82	10.927
Total for '17, '18, & '19		4.16	351	11.756

When fully implemented, this strategy maintains effective safeguards, while saving up to 300 mrem in worker dose in 2020 and up to 600 mrem/year thereafter. This strategy will also be less impactful to facility operations, especially as expedited plutonium removal operations expand.

A statistical analysis was performed [1], commonly used in the manufacturing industry to determine the number of products necessary to sample in order to ensure quality specifications are met with confidence. The IAEA does not publicize the criteria utilized to determine sample size, but the most conservative values in the IAEA's field guide [2] were assumed in this study. These values are slightly more conservative than the values published in the DOE Technical Standard 1194-2019. [3]

Table 2-2. Conservative IAEA Minimum Sampling Parameters For Physical Inventories [2]

SNM Category	Confidence Level	Minimum Detectable
I	99%	3%

Table 2-3. Minimum DOE Sampling Parameters For Physical Inventories

SNM Category	Confidence Level	Minimum Detectable
I	95%	3%
II	95%	5%
III & IV	95%	10%

It is recommended that 8 items be measured in the October 2020 Inventory, then 4 items each year through 2024 to achieve a statistically adequate sample size. At that time, complimentary to the other programmatic elements, there is at least 99% confidence that if at most 3% defective drums are present then at least one would have been observed by the PIV team. Measurement of 4 containers beyond 2024 would be planned. If a defective container is observed, this analysis shall be reperformed to calculate the number of drums required to restore 99% confidence in accordance with IAEA technical guidance.

2.2 Redeployment of Remotely Monitored Sealing Arrays Seals

There are currently over 250 Remotely Monitored Sealing Arrays (RMSA) utilized in the Stack Area (SA). For the one-year period between March 2019 and February 2020, 73 units were replaced due to failure or low battery voltage. Failed RMSAs are replaced promptly per facility procedures, and most replacements involve the movement of at least 1 triple stack of material containers, and up to as many as 7 triple stacks. This labor-intensive activity results in large radiological dose to personnel.

We are recommending that RMSAs are installed and tracked only on outer rows of triple stack palletized containers located in the SA. The proposed strategy will prevent access to inner triple stacked containers protected by alarmed outer rows or blocked by facility walls. The proposed layout of alarmed and non-alarmed arrays is shown on Figure 2-1.

Benefits of Redeployment:

- Dose – annual dose is expected to drop based on the smaller population of units to be replaced
- Failed RMSAs will be replaced in a more safe and timely manner since all replacements will be "walk-ups" (no movement of triple stacks).
- Manpower – Using current failure rate for RMSAs, the elimination of approximately 66 RMSAs would reduce the manpower required to replace units accordingly.
- Cost - The modified monitoring strategy would remove 22 alarmed grid spaces, which eliminates 66 RMSAs. The costs for shipping, inspection, etc. would be reduced as well.

The oututer row monitoring strategy has been successfully implemented in other storage locations within the KAMS

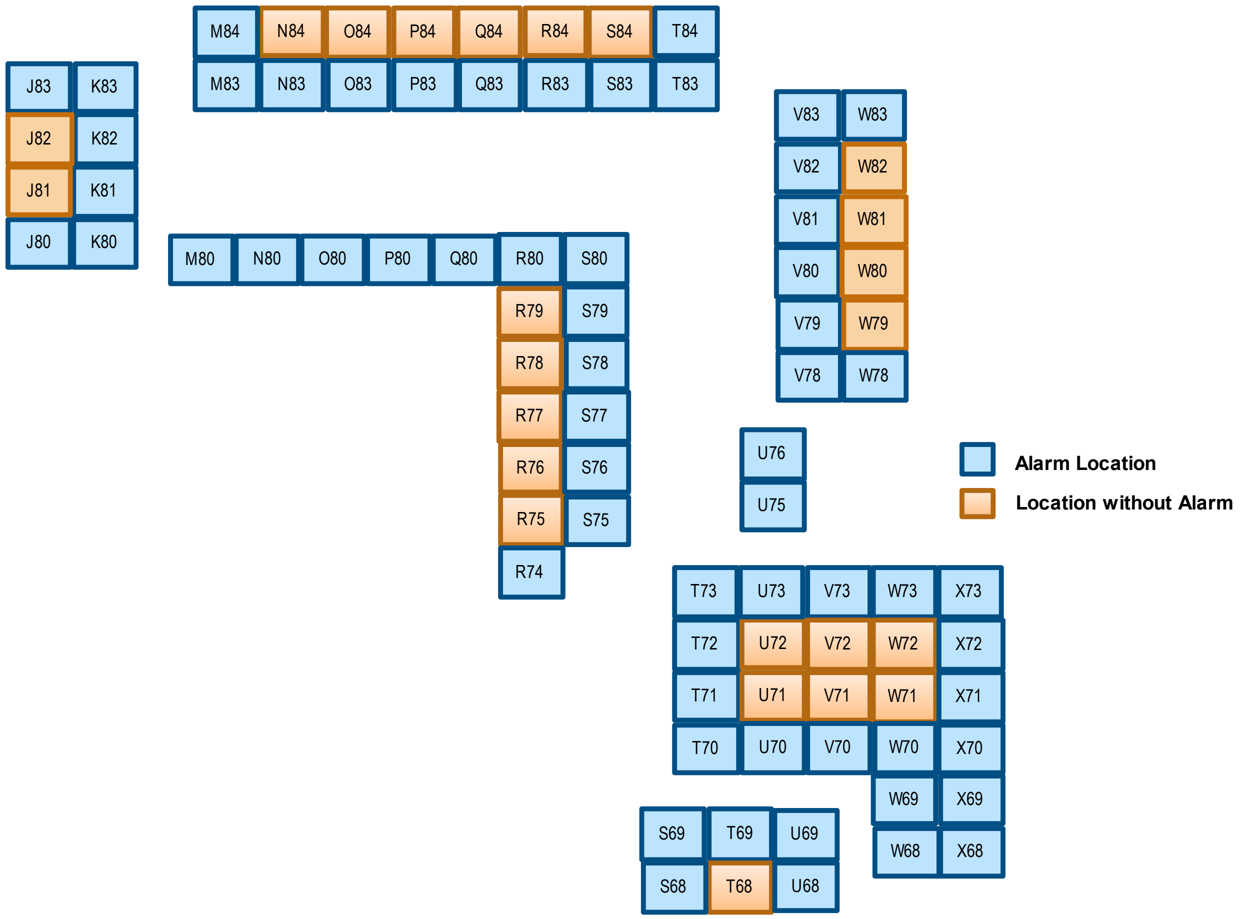

Figure 2-1. Recommended Redeployment of Remotely Monitored Sealing Arrays.

2.3 Review of New Technology

The corona virus pandemic impacted the team's ability to have detailed discussions with other national laboratories regarding application of new technologies at KAMS that, if implemented, would continue to maintain effective safeguards of material at KAMS while reducing the burden on the facility. Currently, under Voluntary Offer Agreement, the IAEA uses the Remotely Monitored Sealing Array (RMSA) system on pallets of nuclear material. The system ensures that nuclear material isn't accessed without detection. While the RMSA system has worked well for KAMS (with modifications and improvements periodically), there could be other approaches that further reduce burden on both IAEA inspectors and facility operators, especially approaches that might reduce radiation exposure further. Such approaches may align with IAEA stated interests, such as moving away from individual sealing systems to a whole-volume approach as described in SGTS-002 of the 2020-2021 Development and Implementation Support document STR-393. SRNL proposes working with Sandia National Laboratories (SNL) to examine alternate approaches for maintaining Continuity of Knowledge of materials in storage at KAMS.

Continuing on the ideas of joint use and remote monitoring of sensors during measurement activities as outlined in IAEA Policy Papers 16 & 20, SRNL proposes to continue development of secure signal splitters for use in safeguards activities. Building on the success of the Coincidence Counter Signal Splitter (C2S2) [4], a device would be made which can allow simultaneous joint use from remote locations. This device, envisioned to be rack mountable and modular would accept and transmit securely coincidence counter pulse trains and analog sensor data. A remote receiving device at an external location (preferably outside of a “limited area”) would decrypt and replicate the data with high confidence at an output allowing measurements to be taken using IAEA equipment or a trusted secondary viewing method as if they were inside of the facility. The target application for the proposed hardware is use during IAEA measurement activities when their presence in KAMS shuts down operation of some areas of the facility. This would allow IAEA safeguards activities to take place while KAMS continues operation. The C2S2 device accepted signals from a coincidence counter and reproduced them at the outputs for simultaneous use by both operator and the IAEA. This was developed for use at the Pelindaba Research facility in South Africa. After the testing at the Pelindaba facility, the IAEA expressed interest in possible use in other missions worldwide and requested that SRNL provide four units for further testing.

Under a project funded by the U.S. Support Program to the IAEA, Brookhaven National Laboraty has developed machine learning algorithims for image processing. The goal of this project is to allow detctions of movement in surveillance videos be flagged by this computer processing, thus saving the IAEA singnficant man-hours of reviewing surveillance video for facilities under safeguards. These alogrithims were tested at BNL and provided to the IAEA for evaluation, which is still on-going. In the event additional testing is requested by the IAEA, there are non-security related cameras in KAMS that could provide a location, under IAEA safeguards, where surveillance video that is similar to what is provided to the IAEA can be processed by BNL system. In addition, BNL is considering the application of these machine learning algorithims to multiple camera feeds what would enable a container movement be tracked from one location to another. This advanced concept also has application in KAMS to track movement to/from the Stack Area to the NDA measurement room. This application, in conjuction with the secure data signal splitter discussed above, has the potential for the IAEA to conduct their PIV mearuements from outside the K-Area Protected Area.

3.0 Conclusions

Changes in the mission of the K-Area Complex since 2002 requires new protocols with the IAEA to ensure they can fulfill their mandate while at the same time reducing the impact of their visits on facility activities and opeating staff. Irrespective of the long-term strategy of IAEA safeguards of material in KAMS, there are near-time actions that warrant discussion with the IAEA. These could be discussed with U.S. stakeholders and, if agreed upon, discussions should be held with the IAEA during their next visit to KAMS. Constant advances in technology has resulted in new ways measurement could be taken by the IAEA without them being present in KAMS. These new technologies would be applicable only if the IAEA will continue to contine PIV’s as is presently done when operational activities increase in FY22 and again in FY23.

4.0 Recommendations and Path Forward

Prior to the next Interim Inventory Verification (IIV) inspection conducted by the IAEA, SRNL would like to discuss the potential to reduce the number of measurements conducted during the IAEA annual PIV with NA-241. As described in Section 2.1, the IAEA can perform less measruements but still maintain a high confidence level that any anomaly would be identified. In addition, we want to discuss with NA-241 the potential to redeploy the RMSA seals as described in Section 2.2. The proposed configuration would not decrease the IAEA’s confidence that material under safequards had not been accessed without alarms.

We propose to develop a device, which when connected to a measurement device, logs the measurement output for transmission through a network to a remote location, where the output is then reproduced. At this remote location, a piece of trusted measurement equipment may then be connected to this stream, where results from those measurements made would be determined.

A long-term strategy for the IAEA material at KAMS needs to be developed to account for increased 3013 container surveillance beginning in FY22 and increased plutonium disposition blendown rates beginning in FY23. Both of these activities will require increased access to the material under IAEA safeguards. If it is determined that material in the Stack Area will remain under IAEA safeguards then SRNL would like to discuss with NA-241 the development and implementation of new technologies as discussed in Section 2.3. These include

- Development and application of joint use of measurement equipment that would allow the IAEA to conduct their PIV measurements outside the K-Area Protected Area
- Explore development and application of new containment/surveillance and continuity of knowledge strategies with SNL
- Devopment and application of machine learning algorithms developed by Brookhaven National Laboratories

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