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THE USE OF MATERIAL PROTECTION, CONTROL AND ACCOUNTING (MPC&A) TECHNOLOGIES FOR CONTROL OF EXCESS NUCLEAR MATERIAL: ANALYSIS, SYNTHESIS, AND DEMONSTRATION

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Abstract

During the past two years, the All-Russian Research Institute of Automatics (VNIIA) has carried out analysis of the following:

- possible control scenarios for excess nuclear weapons material after nuclear warhead (NW) dismantlement;
- possible applications of MPC&A technologies currently used; and
- effectiveness criteria of MPC&A technologies for monitoring and control of excess nuclear material (NM).

Russian, United States, and European MPC&A systems have been included in the analysis, key control procedures based on MPC&A technologies have been identified, and recommendations for the use of those technologies at each stage of excess nuclear weapons material control have been developed. In addition, criteria for use in evaluating the effectiveness of various control technologies have been developed. Based upon the results of the above analysis, a demonstration plan has been developed for key monitoring and control technologies at the VNIIA demonstration center in Moscow.

Introduction

At different stages of nuclear weapons dismantlement, different components that contain nuclear materials are placed in a container (hereinafter referred as an item). These items are sent to temporary or long-term storage either for retention in storage or possible conversion into fuel for nuclear power plants (NPP).

The storage of the excess nuclear weapons material, with adherence to adequate control, safety, and security measures has been reviewed. To support our analysis, we have developed the following tools:

- a hypothetical materials flow diagram;
- different versions of NM handling to cover the range of potential pathways that could be included in the future (these could have an impact on the choice of control technologies);
- possible control technologies at each stage of NM handling from the receipt of nuclear weapons components through disposition;
- criteria for use in evaluating effectiveness of various monitoring and control technologies; and
- a detailed plan of a small-scale demonstration of key transparency technologies at the VNIIA demonstration center in Moscow.

Use of MPC&A Technologies for the Excessive NM Handling Regime

Currently there is not an accepted standard that has been identified for excess nuclear weapons material handling and disposition. Therefore, for this analysis, a total of five possible different versions have been used. Figure 1 shows the five possible versions of NM handling to be discussed. They have the following common stages:

- transportation—all five versions;
- long-term (temporary) storage—all five versions; and
- processing (disassembly and conversion)—II–IV versions only.

The VNIIA study of the potential technologies useful for the control regime of NM handling has shown that some MPC&A control technologies for physical protection, security, and surveillance cover all those stages. Figure 2 shows a hypothetical process flow diagram for version III that includes the following stages: temporary storage, disassembly into nuclear components (NCs), NM shape conversion and long-term storage, and NM disposition.

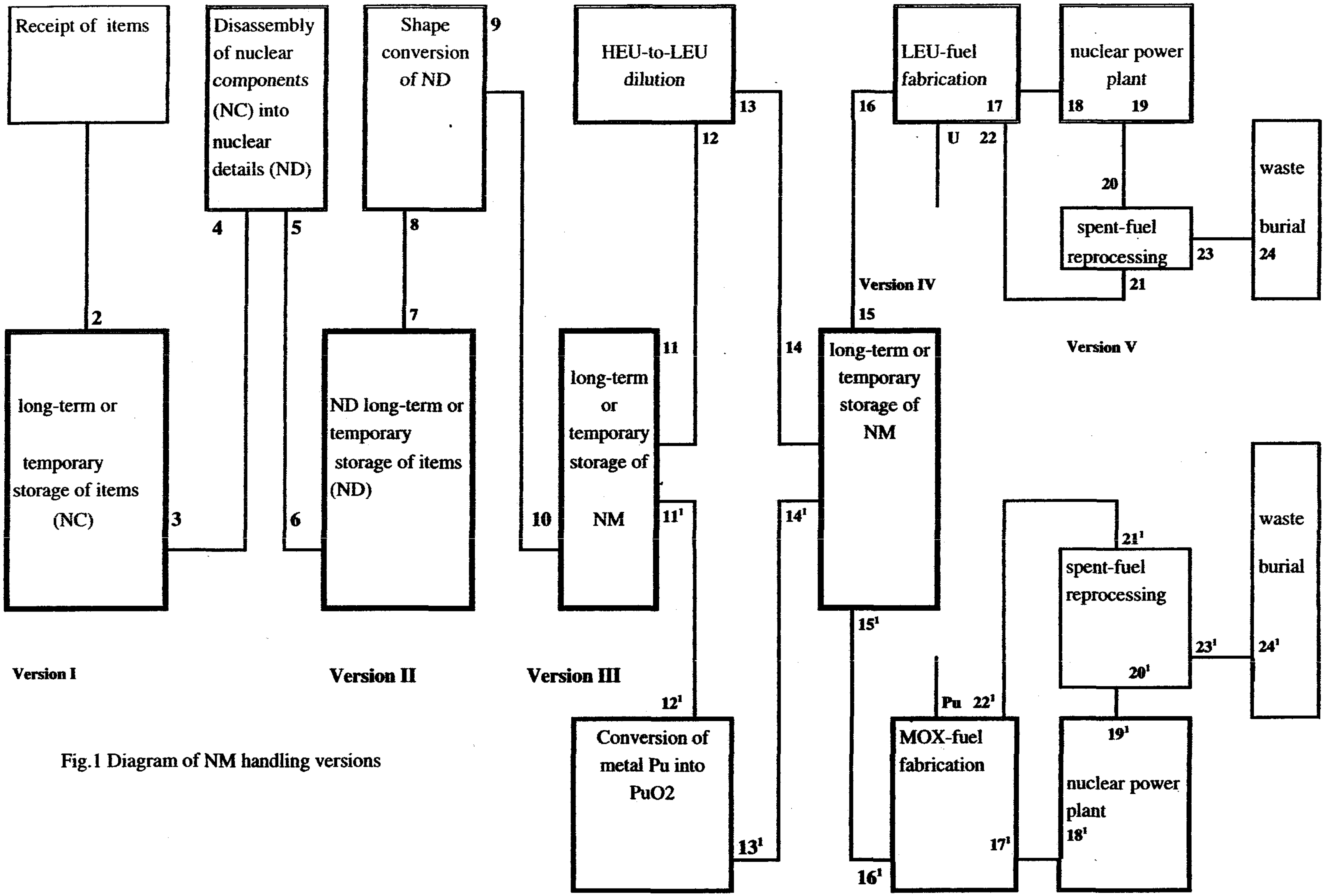

Fig.1 Diagram of NM handling versions

KEY TRANSPARENCY TECHNOLOGIES AT THE MAIN STAGES OF DISMANTLEMENT REGIIME (VERSION III)

Transportation

- check vehicle before items are placed in it;
- examination of the accompanying documents;
- check IDs and the integrity of a seal, TID, tag and other IDs applied to items;
- transfer of the accountability for items
- check of the vehicle after the items are unloaded

Temporary Storage

- receipt check (RC):
  - check IDs and the integrity of TIDs, seals another IDs. applied to an item,
  - weighing of an item,
  - measurement of radiation characteristics of an item,
- remote inventory;
- shipment check (SC): those procedures as for RC;
- issue the accompanying documents (logs, coupon, etc.)
- transfer the accountability for an item.

Disassembly

- RC:
  - check IDs and the integrity of TIDs, seals and other IDs. applied to an item,
  - weighing of an item,
  - measurement of radiation characteristics of an item;
- SC: those procedures as for RC
- issue the accompanying documents (new documents with new item attributes)
- transfer the accountability for an item.

Shape Conversion

- RC:
  - check IDs and the integrity of TIDs, seals and etc. applied to an item,
  - weighing of an item,
  - measurement of radiation characteristics of an item;
- SC: these procedures same as for RC;
- issue new accompanying documents (logs, coupons, etc.) with new item characteristics
- transfer of the accountability for an item

Long-Term Storage

- RC:
  - check IDs and the integrity of TIDs, seals and etc. applied to an item,
  - weighing of an item,
  - measurement of radiation characteristics of an item;
- remote monitoring and inventory;
- random inspections;
- SC: those procedures same as for RC (as necessary)
- transfer of the accountability foe an item (as necessary).

Control technologies have been chosen in terms of the major factors that impact each specific stage. These factors are as follows:

- mutually agreed and acceptable level of confidence;
- minimal possible level of intrusiveness;
- maximal possible adaptability, i.e., minimal impact on operations unrelated to the dismantlement;
- maximal possible safety (for inspectors, operators, and the environment); and
- acceptable costs.

The priority of the above factors depends on the process stages. The process flow diagram (Figure 2) shows that key control technologies generally are the same at the different stages.

Table 1 shows possible control technologies and their inherent prioritization of the factors impacting the proposed technologies at all the stages of the item handling. It should be noted that the prioritization is preliminary and conventional, and it can be revised.

Approach to the Resolution of Data Discrepancies

The development of a conceptual approach and recommendations on the resolution of data discrepancies is a very important and complex task. In cases of data discrepancies during the dismantlement process, making adequate decisions will help both sides either to continue the dismantlement process without reducing the degree of confidence in the process or to consider such discrepancies as requiring investigation. As noted above, the major control procedures providing dismantlement transparency at the stages under question include the following:

(1) check IDs and the integrity of seals, TIDs, tags, and other IDs applied to an item;

(2) weighing (measurements of the gross weight of an item); and

(3) nonintrusive measurements of radiation characteristics of an item.

Table 1

Stage	Prioritization of the Factors Impacting the Choice of Control Technologies				
	1	2	3	4	Note
Transportation					Acceptable expense guides the choice of all control technologies at each stage.
1. Sealing 2. Documenting	safety	adaptability	intrusiveness	confidence	
Temporary (long-term) storage					
1. Weighing of an item	confidence	intrusiveness	adaptability	safety	
2. Measurements of radiation characteristics of an item	confidence	intrusiveness	adaptability	-	
3. Remote monitoring and inventory of items	intrusiveness	confidence	adaptability	-	
4. Random inspections	confidence	intrusiveness	adaptability	-	
5. Sealing system	confidence	adaptability	intrusiveness	safety	
6. Documenting (accountability transfer)	confidence	intrusiveness	adaptability	safety	
7. Administrative/technical control	confidence	intrusiveness	adaptability	safety	
Conversion (shape, contents, etc.)					
1. Weighing of an item 2. Measurements of radiation characteristics of an item	confidence	intrusiveness	adaptability	safety	
3. Sealing	confidence	adaptability	intrusiveness	safety	
4. Administrative/technical control	confidence	intrusiveness	safety	adaptability	

The approaches to evaluation and resolution of data discrepancies obtained as a result of the first three procedures can differ for the following reasons:

(1) they provide unequal degrees of confidence;

(2) they implicitly confer unequal significance upon the data about an item (through key and non-key control procedures); and

(3) differences in the order and etail of the procedural steps.

We considered possible cases of data discrepancies for each of the above control procedures.

(1) Check of Seals, TIDs, etc.

a. In case of disagreements of IDs of TIDs (seals), tags or other IDs, it is necessary to shut down the dismantlement and investigate the occurrence in accordance with instructions that should be cooperatively developed.

b. In case of doubt in the integrity of TIDs (seals), it is necessary to weight the item and complete measurements of its radiation characteristics, which are the key control procedures at all stages except transportation. If the measurement confirms the log's results within the statistical variance as measured prior to dismantlement, it is rational to continue the dismantlement process. If, on the contrary, the results go beyond the limits of the statistical variance, then the dismantlement process may be shut down, and an investigation in accordance with developed instructions may be carried out.

(2) Weighing

We consider a case, when the weighing results of the same item at the different control stages are different, for instance, $\tilde{o}_1 \pm \Delta\tilde{o}_1$ and $\tilde{o}_2 \pm \Delta\tilde{o}_2$. It is required to estimate if it is the same weight. By supporting the errors $\Delta\tilde{o}_1$ and $\Delta\tilde{o}_2$ statistically independent, we obtain the following $\Delta\acute{o}$ of y:

$$\Delta\acute{o} = \sqrt{\Delta x_1^2 + \Delta x_2^2}. \qquad (1)$$

We see if the value of *y* exceeds the double Δб in absolute magnitude, then we can conclude that Δб is significant and not random. Confidence of this affirmation (confidence probability) in case of a normal distribution (that is practically accepted in many cases) is equal to 0.95, and then it is necessary to carry out investigation on $\tilde{\text{б}}_1$ and $\tilde{\text{б}}_2$. If *y* does not exceed the double Δб, then discrepancy is considered to be random, and there is no evidence to consider that significant mass change has occurred.

(3) Radiation Characteristics Measurement

If radiation characteristic measurements are to be included, it is more difficult to evaluate data discrepancies. Currently, the number of gamma-energy lines and measurements of neutron counts are not determined. In addition, quantitative confidence intervals are not established.

We consider a simplified case wherein a result is reduced to one effective neutron channel. In this case, a radiation template is featured that includes the average neutron counts during standard time and the confidence intervals of their possible deviations. In the case of acontrol measurement, the result can be reduced to the same form. The decision on discrepancy significance is determined by the method described above for weighing.

Demonstration of Key Control Technologies at the VNIIA Demonstration Center

The major goal of a control technology and procedure demonstration is to apply, test, and evaluate the methods and instruments used in the chosen key technologies. The main condition of the demonstration is to provide key control technologies and technical means that would replicate an actual mesurement facility as completely as possible, including such features as the following:

(1) rooms properly equipped;

(2) instruments, tools, etc.;

(3) administrative measures that must be undertaken to demonstrate monitoring;

(4) technologies and procedures; and

(5) radiation simulators.

The demonstration of control technologies and procedures at VNIIA is possible for the following reasons:

(1) the storage facility for hazardous radioactive and explosive materials (HIREM) properly equipped under SNL/VNIIA contract NoBB-5084 can be used as the base for demonstrations of the various control technologies and procedures;

(2) VNIIA has developed the draft plan of a demonstration of key control technologies and procedures that meets the requirements of the current project stage;

(3) VNIIA has experts in the development and application of low- and high-resolution gamma spectrometry, a technology that provides confidence in confirmation of the pit dismantlement process;

(4) VNIIA has been engaged in activities on tests of available American and Russian TIDs and seals, and has been involved with their application for domestic MPC&A purposes; and

(5) VNIIA experts have significant experience in activities associated with the demonstration of technologies and instruments.

For the proposed demonstration, version III of the dismantlement scenario, where there is conversion in the NM shape, has been chosen. The main tasks to be performed in the demonstration are the following:

(1) identification of technologies to be used for the demonstration of control technologies and procedures on a simulated nuclear item;

(2) the demonstration for American and Russian participants of control technologies and procedures on a simulated nuclear item with a change in shape or material characteristics; and

(3) preparation of a plan for a more extensive demonstration of monitoring technologies and procedures at a Russian nuclear facility.

Therefore, to demonstrate the possible application of more extensive MPC&A technologies as control technologies and procedures, it is suggested that both low- and high-resolution gamma spectrometers being developed at one of the Russian enterprises and radiation monitors and the radiation identification "Breget" developed at VNIIA should be included in the demonstration. The demonstration may be performed after a draft plan including provisions regarding the above objectives is submitted at LANL and approved at the Department of Energy Headquarters.

Conclusions

The U.S./Russian Federation activities on developing technical means and control methods for the disposition of excess nuclear materials are still in an early stage. This work performed by VNIIA under the LANL/SNL/ PNNL/VNIIA contracts may become a prospective step for more extensive future activities.

References

1. Papers of the American/Russian Workshop on Transparency and Dismantlement of Nuclear Weapons (18–22 August, Snezhinsk 1997).
2. Report on the **Second Meeting Experts** (Russia-USA-IAEA) under the Trilateral Initiative, (IPPE, 10–13 March 1998).