

LA-SUB--95-199

TEST AND EVALUATION OF COMPUTERIZED NUCLEAR MATERIAL ACCOUNTING METHODS

(Final report in frame of Task Order 001, Subcontract No. 625UU0005-35)

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1. INTRODUCTION. Specific Features of the BFS Material Balance Area and Requirements for the Computerized Accounting System.

In accordance with the definition of a Material Balance Area (MBA) as a well-defined geographical area involving an integral operation, the building housing the BFS-1 and BFS-2 critical facilities is considered to consist of one MBA. This MBA contains nuclear material only as individual items. The list of nuclear materials used in the BFS critical facilities includes:

- plutonium with ~95% of Pu-239 (weapon-grade),
- plutonium with ~88% of Pu-239,
- 90% enriched uranium metal,
- 90% enriched uranium dioxide,
- 36% enriched uranium metal,
- 36% enriched uranium dioxide,
- neptunium dioxide.

The BFS materials are in the form of small disks clad in stainless steel and each disk with nuclear material has its own serial number, so can be considered as a separate item. Disk diameter is about 47 mm and disk thickness is up to 10 mm. For 36% enriched uranium dioxide two thickness values are used - 1.7 mm and 5.6 mm. Bulk nuclear materials are not handled at this facility; however, an item in the accounting records may consist of multiple disk items.

Fissile material disks in the BFS MBA can be located at three key monitoring points - BFS-1 facility, BFS-2 facility and main storage of BFS fissile materials (storage-1). When used in the BFS-1 or BFS-2 critical facilities, the fissile material disks are loaded in tubes (fuel rods) forming critical assembly cores. Within the storage the disks are stored in special canisters. Except for some short time when fissile material disks are kept on a loading table during loading procedures, they are located either in tubes (fuel rods) or in canisters. The general word "container" can be used both for a tube and a canister.

The following specific features of the BFS Material Balance Area should be taken into account for the purpose of computerized accounting of nuclear material:

- very large number of nuclear material items - there are about 70000 fissile material items in the BFS MBA,
- periodical very intensive shuffling of nuclear material items: during construction of reactor core mock-ups on the BFS critical facilities, up to few thousand items can change their locations in the BFS MBA within one day; new core construction time can be as long as few months.

Functional requirements for the computerized system are determined by basic objectives of nuclear material accounting:

- providing accurate information on the identity and location of all nuclear material items in the BFS material balance area;
- providing accurate information on location and identity of tamper-indicating devices

(TIDs);

- tracking nuclear material inventories;
- issuing periodical reports;
- assisting with the detection of material gains or losses;
- providing a history of nuclear material transactions;
- preventing an unauthorized access to the system and data falsification.

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Taking into account the above information, development and implementation of the test and evaluation plan for computerized accounting methods on the BFS facility was initiated within Task 001, Subcontract No. 625UU0005-35. In August 1995, the prototype computerized accounting system was installed on the BFS facility for trial operation. By that time an information on two nuclear material types was entered into the data base. The first of these materials was weapon-grade plutonium metal and the second one was 36% enriched uranium dioxide. The total number of the weapon-grade plutonium disks is 12690 and the total number of the uranium dioxide disks is 1700.

2. DESCRIPTION OF MATERIAL BALANCE ACCOUNTS.

The MBA account consists of a storage account and critical facility area accounts. Key monitoring points of the MBA are located at the main storage vault and the BFS-1 and BFS-2 loading tables to monitor transfers. Each account is divided into specific locations so that the nuclear material items can be assigned to a position within a room or to a position in a critical assembly core.

Each account in the MBA maintains the identification of each plutonium, high-enriched uranium and neptunium fuel disk as well as storage canister within the account area. In addition, the BFS-1 and BFS-2 accounts maintain the identification of tubes used in the critical assemblies and the identification of locations within the cores of the critical assemblies. The fissile material storage account also maintains identification of locations where canisters can be stored. The following accounts are considered for the MBA of the BFS facility:

Account 1: Fissile Material Storage (Room 1).

This account contains information about the fissile material disks for the BFS-1 and BFS-2 critical assemblies. The disks are stored in stainless steel canisters and each canister is serialized. The accounting system tracks the serial number of each fuel disk in the canister, from which the total amount of fissile material in each canister can be determined. The seal identification number for each canister is also included in the data base. Sometimes canisters of fuel disks are shipped from and received into this MBA. Transfers of fuel disks from the BFS facility to other facilities at IPPE and from those facilities to BFS are made in this account. Fuel disks are received into the storage area and their accounting data are entered into the data base when the canister is opened for verification of its contents. The account data base is updated items are transferred to and from the fissile material storage room.

Account 2: BFS-1.

This account tracks the fissile material disks as they are transferred from the stainless steel storage canisters to the tubes in the assembly core. When a storage canister is received at the BFS-1, the account data base is updated to reflect canister receipt. This receipt transaction includes recording the canister number, opening the canister, and verifying the fuel disks against the accounting system data. If all of the disks in the storage canister are used in an experiment, then the storage canister is tracked as an item containing no fissile material. If some of the disks remain in the storage canister or disks from a core tube are added to the canister, then the data in the accounting system for that canister is updated to reflect the new values.

Each position in the core is tracked by the accounting system. When a core tube is loaded with fuel disks, the accounting data for the tube, i.e., tube identification number, identification numbers for all disks, which can be used for calculation of the total amount of fissile material, is input in the accounting system for the location of the tube in the core. When a tube is removed from the core, the accounting data for the core location is changed to reflect the new status. When all or some of the fuel disks are removed from the tube, the data base is changed to reflect the new fissile inventory for the tube.

All changes in the BFS-1 account data base are made from the client terminal located at the loading table.

Account 3: BFS-2.

The structure for this account is identical to Account 2. However, there is some minor difference between these two accounts. Critical assembly tube locations are identified in the BFS-1 and BFS-2 facilities in different way. In the BFS-1, the tube location is determined by a set of three figures. The first of them identifies a sector in the BFS-1 core (total - six sectors in the core), the second one is a number of a tube row (starting from the core center), the third one is a number of a tube position in the row. In the BFS-2, the tube location is determined by two figures (coordinates). The first of them is a number of a tube row (in the direction from the BFS-2 control room), the second one is a number of a tube position in this row.

All the corresponding changes in the BFS-2 account data base are made from the client terminal located at the loading table .

Account 4: Fertile Material and Fuel Subassemblies (Room 3)

Fuel subassemblies are treated as individual items with total quantities of reportable nuclear materials. The fertile material disks are placed in canisters. This account will be added at a later date.

Account 5: Thorium (Room 3-1).

The way the thorium items are treated will be defined at a later date.

In addition to characteristics used for tracking an item within the MBA (identifications of specific locations such that nuclear material items can be assigned to a position within the MBA - key monitoring point, container, position of a container in a room or in a critical assembly core), some passport parameters of fissile material disks are kept in the data base of the BFS computerized accounting system. For plutonium disks these are the following parameters:

- serial number of the disk,
- total mass of the disk,
- total mass of plutonium in the disk,
- isotopic composition of plutonium.

As for the disks of uranium dioxide, the passport characteristics kept in the data base for each item include:

- a serial number of the disk;
- total mass of the disk;
- mass of uranium dioxide in the disk;
- mass fraction of uranium in uranium dioxide;
- uranium-235 enrichment.

3.HARDWARE ENVIRONMENT, OPERATIONAL AND DEVELOPMENT SOFTWARE

The BFS computerized accounting system is a network-based one. It runs in a client/server mode. The equipment used in the system includes a computer network consisting of:

- a. 1 Server computer system, including peripheral hardware.

The server is located near the control room of the BFS-2 facility outside of the "stone sack" to ensure access during operation of the critical assemblies.

Characteristics of the server computer:

CPU - i486DX4/100 Mhz

BUS - PCI

Hard Disk - 1 GB SCSI-2

RAM - 32 MB

256K Cache

CD ROM with SCSI-2 Interface

Floppy Drive - 3.5 inch, 1.44 MB

Internal Tape Backup System - Jumbo 250 MB

Monitor - 15 inch

Video Board - Diamond Stealth 64 DRAM PCI with 2 MB
Microsoft Serial Mouse
Network Board - 3COM Etherlink III (3C509-TP)
Full Tower Model.

Miscellaneous:

HP LaserJet 4P (A4 Format)
APC Back-UPS 900
3COM LinkBuilder FMS 12-Port TP (3C1627-1)

b. 3 Client computer systems, two of them being located near the assembly tables of the BFS-1 and BFS-2 facilities while the third one being in the Fissile Material Storage.

Characteristics of the client computers:

CPU - i486DX4/100 Mhz
BUS - VLB for 486
Hard Disk - 500 MB IDE
RAM - 16 MB
256K Cache
Floppy Drive - 3.5 inch, 1.44 MB
Monitor - 15 inch
Video Board - Diamond Stealth 64 DRAM with 2 MB
Microsoft Mouse
Network Board - 3COM Etherlink III (3C509-TP).
APC Back-UPS 900

Each fissile material disk as well as each canister and each critical assembly tube is serialized and their serial numbers are used for the identification of these items. It is planned that in future bar-codes will be applied to all disks, canisters and critical assembly tubes. However, by the time of the August demonstration, the bar-code technology for fissile material disks was not available at the BFS. The bar-codes were only applied to tubes, canisters and tamper-indicating devices. To read these bar-codes each client computer of the accounting system is provided with a bar-code reader.

The Computer Network Layout of the BFS Accounting System is shown in Annex 1.

Software (Operational)

For Server:

Microsoft Windows NT Server Version 3.51 - 20 Users
Microsoft Access Version 2.0
Cyrillic True Type Fonts for Windows

For Client:

Microsoft Windows NT Workstation Version 3.51
Microsoft Access Version 2.0
Cyrillic True Type Fonts for Windows
(Development)
Microsoft Visual Basic Professional Version 4.0

The computerized accounting system core includes the database and software developed for providing major functions of the system. The database of material type and location resides on the server, while the user interface runs on the client. The user interface accesses the server via the network. The computerized accounting system core consists of those functions which provide necessary information requested by the user and which manipulate the database to record information about material transactions inside of the BFS Material Balance Area. Accordingly, the following software modules are included in the core of the computerized accounting system:

- search a location and passport parameters for any single fissile material item selected for the demonstration in the BFS, including a search of an item with some particular serial number or an item from a random sample.

- tracking an actual movement of fissile material items during all operating procedures including transactions of nuclear materials from/to the storage and to/from the BFS facilities as well as loading and unloading of fuel rods;

- determination of an amount of fissile material in any BFS tube or storage canister, or total amount of fissile material in each of the three key monitoring points in the BFS Material Balance Area;

- search a location and identification of tamper-indicating devices;

- computer generation of a random set of nuclear material items to be taken for inventory verification with indication of location and passport parameters of each item in the sample;

- based on the hypergeometric distribution, computation of a minimum sample size when input parameters are population size, total number of defects in the population (defect rate), maximum allowable number of defects in a sample and confidence level for detecting the given defect rate;

- based on the hypergeometric distribution, computation of point estimates and interval estimates for the total number of defects in the population when input parameters are population size, sample size, number of defects in the sample and confidence interval for the number of defects in the population;

- computation of inventory difference on the basis of measurement results obtained for a random sample of fissile material items and estimation of standard errors of inventory difference on the basis of measurement error variances.

The system relies on users to provide the timely entry (normally in near-real time) of material transactions. Once these transactions are entered by the user, the inventory is updated in real time.

4. TEST AND EVALUATION PROCEDURES FOR THE BFS ACCOUNTING SYSTEM.

The test and evaluation procedures for the BFS computerized accounting system were carried out to check the system capability of performing its major functions as well as to evaluate the accuracy of the data base records on nuclear material items characteristics. The test program was done in three stages. At the first stage, the accuracy of the data base records on passport characteristics of nuclear material items was evaluated. At the second stage the major operational functions of the system were checked. At the third stage the performance of the computerized accounting system was tested on the basis of statistical sampling procedure during the physical inventory taking.

The test and evaluation procedures were planned taking into account such policy dependent parameters as performance requirements for accounting records system and performance requirements for TID records system. The performance requirement for the accounting records system was chosen as an accurate reflection of identity and location for at least 99 % of the items in a given MBA, in accordance with Ref. 1.

For the TID records system, at present there is no performance requirement in Russian regulating documents, so the requirement specified in Ref. 2 (accurate reflection of location and identity of TIDs in at least 99 % of the cases) was considered as a basic one for the demonstration in August 1995.

4.1. EVALUATION OF DATA BASE RECORDS FOR ITEM PASSPORT CHARACTERISTICS.

The mentioned in part 2 passport characteristics of fissile material items were entered from a computer keyboard and some human errors were possible during the entering procedure. There are two types of the above mentioned characteristics, and consequences of the errors are different for these two different types.

The first type characteristics are mass values, mass fraction values and enrichment values. The entry errors for these quantities can result in distortions for the fissile material inventory in the Material Balance Area. For each particular kind of fissile material disks (for each stratum) these quantities are distributed near some mean values, and standard statistical

approach can be used to characterize such distributions by their calculated means and dispersions. In case of the error occurring during the entering procedure, the resulting wrong value for the respective characteristic of the item is often an outlier, so the error can be detected through the comparison of the distribution's standard deviation with the difference between the item characteristic quantity and mean value of this characteristic for the stratum. This simple statistical procedure was carried out for all the data base records of item passport characteristics.

The characteristics of the second type are serial numbers of the disks. The entry error for the serial number results in a loss of the fissile material item identity in the computerized accounting system. There is no definite distribution of the item serial numbers, so the above mentioned statistical procedure can not be used for checking the serial number entries. For this reason the entered serial numbers in the passport characteristics file were directly compared with those in the passports. In order to do it in a timely and cost-effective manner, a random sample of records in the file of the passport characteristics was verified. The sample size was optimized in such a way to minimize the required efforts while still meeting prescribed criteria.

As it was already mentioned, one of the prescribed criteria for the accounting records system is an accurate reflection of identity and location for at least 99 % of the items in a given MBA (less than 1% of defects in the accounting records system total are allowed). Taking into account that the passport data entering procedure was just one of several other possible sources of errors, it was required that number of defects introduced during the passport data entering procedure should be at least ten times less than the total number of defects in the accounting records system, that means less than 0.1 % of defective records. For a total 14390 records in the data base file of passport characteristics for two fissile materials, not more than 14 records may be defective ones.

The random sample size for verification of the data base records was determined on the basis of the hypergeometric probability density function. For the calculation it was accepted that there should be 95 % confidence level in 99.9 % accuracy of 14390 records. The calculation indicated that such a confidence level requirement could be met if no defective records were found in a random sample of 2773 records. In this sample not only the serial number entries were verified for each record of the sample, but also all other fields of the record. This was justified by the fact, that during the verification of the first type characteristics through the above mentioned statistical procedure some errors may not be detected if they do not change the characteristic quantity significantly and so do not result in an appearance of outliers.

So, the following steps were done for verification of the data base records in the fields with passport characteristics of the first type:

- for each passport characteristic of the first type, the mean value of this characteristic in the fissile material stratum was calculated;
- the standard deviation in the stratum was calculated for each passport characteristic whose mean value was determined;
- for each record the corresponding field values were compared with the field mean value in the stratum and it was checked if the difference between the record value in the field and the field mean value in the stratum was less than three standard deviations;
- in case this difference was more than three standard deviations, comparison with an original of the passport was done to detect a possible mistake;
- mistake corrections were done in the records where defects were detected.

For verification of passport characteristics of the data base records on the basis of random statistical sampling approach, the following procedures were used:

- a random sample of 2773 records was generated by a computer from the total 14390 records and a list of the records to be verified was prepared;
- for each record included in the random sample the comparison with the originals of passports was carried out both in the fields with the passport characteristics of the first type (mass quantities, etc.) and in the fields with the passport characteristics of the second type (serial numbers of fissile material disks).

- point estimates and interval estimates were calculated for the total number of defects in the passport characteristics on the basis of the number of defects detected in the sample.

Possible defects in reading serial numbers of plutonium disks were also detected by comparison of the disk list in the file of passport data with the disk list in the file of locations.

OF THE SYSTEM.

The tests of the major operational functions of the computerized accounting system were carried out after the system was installed in the BFS Material Access Area and all preparations for the system start-up were completed. These preparations included:

- installation of the local computer network consisting of the server (in the server room) and three client computers (at key monitoring points);
- development and installation of software for accounting nuclear material on the BFS facilities;
- completion of the data base file with passport characteristics for each item of the selected two nuclear materials, verification of the passport characteristic records in accordance with procedures presented in part 4.1;
- completion of the data base file with initial locations for all items of the selected two nuclear materials and combining it with the file of passport characteristics;
- completion of the data base file with initial locations of containers (storage canisters or fuel rods) with items of the selected two nuclear materials;
- completion of the data base file with locations of tamper-indicating devices and combining it with the file of container locations;
- development and installation of software for assisting in the physical inventory verification procedures;
- installation of necessary security features preventing unauthorized access to the system and data falsification.

The tests of the major operational functions of the computerized accounting system included the following checks:

- a check of the system's capability to search a location and passport parameters for any single fissile material item selected for the demonstration in the BFS, including a search of an item with some particular serial number or an item from a random sample;
- a check of the system's capability to generate a random sample of nuclear material items for inventory verification with indication of location and passport parameters of each item in the sample;
- a check of the system's capability to obtain an amount of fissile material in any BFS tube or storage canister, or total amount of fissile material in each of the three key monitoring points in the BFS Material Balance Area;
- a check of the system's capability to reflect identity of storage canisters, BFS tubes and tamper-indicating devices by reading their bar codes;
- a check of the system's capability to provide accurate information on location of tamper-indicating devices;
- a check of the system's capability to calculate an item sample size required to verify that the total number of defects in the accounting record system does not exceed some predetermined value with some required probability;
- a check of the system's capability to calculate an inventory difference on the basis of measurement results obtained for a random sample of fissile material items;
- a check of system's security features.
- a check of the system's capability to generate a report on the inventory of the two selected types of nuclear materials.

All the checks indicated above were carried out at first without any handling of fissile materials. Some of these capabilities were checked with canisters and BFS tubes which did not contain any nuclear materials. However, tamper-indicating devices were installed on these canisters and tubes.

4.3. PERFORMANCE EVALUATION OF THE COMPUTERIZED ACCOUNTING SYSTEM.

The performance of the computerized accounting system was evaluated during procedures including a real handling of the two selected fissile materials. In this case a special emphasis was laid on an inventory verification of these nuclear materials. During the inventory verification it was possible to compare a real location of any inspected fissile material item with a location indicated for this item in the computerized accounting system, as well as to find out if

the item contains the expected nuclear material and a measured mass of this material in the item corresponds to that indicated in the accounting system.

Since the BFS nuclear material inventory contains too many items to locate and measure in a timely and cost-effective manner, efficiency and practicality of the physical inventory taking required that only a random sample of nuclear material items be inspected and measured. Here again, as in the case of verification of the data base records for item passport characteristics, it was necessary to determine a random sample size which could ensure that some prescribed criteria were met. The major performance requirement for the accounting records system is an accurate reflection of identity and location for at least 99 % of the items in a given MBA, so this requirement was used for determination of the sample size. However, during the physical inventory verification, a major objective was also to detect, with some specified probability, a specific minimal quantity of absent material, which presumes random sampling too. So, two random sample sizes were determined and the larger of them was chosen.

The random sample size for the performance evaluation of the computerized accounting system was also determined on the basis of the hypergeometric probability density function. For the calculation, the 90 % confidence level in 99 % accuracy of 14390 records was accepted. The calculation indicated that this confidence level requirement could be met if no defects were found for a random sample of 228 items. This is less than the total sample size determined for the August physical inventory taking from the point of view of detecting an absence of a significant quantity of fissile material (271). In reality 279 items were inspected in August. This larger sample size resulted in an increase of the confidence level in 99 % accuracy up to 93%.

The following procedures were used for the performance evaluation of the computerized accounting system:

- a random sample of fissile material items was generated by a computer with indication by the computerized accounting system of the expected location of each selected disk. After that the following procedures were used for each item:

- discharge of the tube, where the selected disk was expected to be found, from the core of a critical assembly or discharge of the canister from a storage cell;

- verification on the loading table, that the selected disk was really in the tube or the canister, which was indicated in the computerized accounting system as a location for this disk;

- checking by the device for Identification of Fissile Material (IFIM) the type of material of the selected disk and confirmation that the disks contained the expected nuclear material;

- measurement of the total mass of the selected disk, comparison of the measurement results with the data in the computerized accounting system;

- measurement of the mass of plutonium (if the item is a plutonium disk), these measurements were only carried out for 29 plutonium disks;

- returning the selected disk into the tube or into the canister, from which it was taken;

- returning the tube with the selected disk to the same position in the core of the critical assembly, from which it was taken, or returning the canister to the same position in the storage, from where it was taken.

For some kinds of defects (if such defects were detected in the sample), point estimations and interval estimations were carried out for the total number of defects in the whole population of the data base records.

In addition to the tests carried out during the PIT, some major functions of the computerized accounting system were tested during trial transactions of nuclear materials from/to the storage and to/from the BFS facilities. The following procedures were used for this purpose:

- unloading a fuel rod from the core, transportation of the fuel rod to the loading table, identification of the rod in the computer data base by reading its bar code;

- identification of the rod TID in the computer data base by reading the TID bar code, removal of a TID from the fuel rod, discharge of fissile material disks to the loading table, entering information about the discharged disks into computer;

- identification of a canister to be sent to the storage by reading its bar code, loading the disks to the canister, entering information about the loaded disks into computer;

- installation of a TID on the canister, identification of this new TID by reading its bar code;

- installation of a new TID on the fuel rod, identification of this new TID by reading its bar code, installation of the fuel rod into the core;
- installation of the sealed canister to the transport vehicle, reading its bar code, identification of the vehicle by reading its bar code, start of transportation to the storage;
- arrival of the vehicle to the storage, reading its bar code, identification of the canister in the computer data base by reading its bar code, entering in the computer information about the storage location, where the canister is installed;
- checking by computer the total time for transportation of the disks from the critical facility to the storage.

In similar way the return transaction of fissile material was carried out from the storage to the critical facility for testing the computerized accounting system performance.

4.4. PERFORMANCE EVALUATION OF THE TID RECORDS SYSTEM.

The physical inventory taking was also a good opportunity to evaluate the performance of the TID records system. The TIDs are planned to be installed in the future on each canister in the fissile material storage and on each tube in the BFS-1 and BFS-2 facilities. However, by the time of the August demonstration of the physical inventory taking, only 219 TIDs were installed. Most of them (200) were on BFS-1 tubes with weapon-grade plutonium. The performance requirement for the TID records system is an accurate reflection of location and identity of TIDs in at least 99% of the cases. Since the number of the TIDs installed was not very large, a 100% inspection was carried out instead of the random sampling procedure.

The following procedures were used for the performance evaluation of the TID records system:

- in the storage each sealed canister was taken to the storage client computer and bar codes were read both on the canister and on its TID, by means of special code these data were compared by the computer with data base records and the results of the comparison were displayed on the screen;
- in addition, information about locations of TIDs on containers (tubes of BFS-1 facility and storage canisters) was collected through reading bar codes of containers and TIDs by Intermecc Trakker; this information was entered into computer and compared with data base records.

5. TEST RESULTS

The tests carried out for data base records provided an information on probable total number of defects in the data base. Most of the detected defects were corrected during or after the tests. The following results were obtained by different methods:

- the statistical approach based on the comparison of the parameter distribution's standard deviation with the difference between the item characteristic quantity and mean value of this characteristic for the stratum resulted in detection and correction of 31 defects in the passport characteristic file;
- the approach based on checking the random sample of 2773 records resulted in the detection of one defect in entered from a keyboard serial numbers; estimates for the total population of records indicate that most probable number of such defects in 14390 records is 5 and 95% confidence interval is between 0 and 26;
- the approach based on comparison of the disk list in the file of passport data with the disk list in the file of locations indicated that at least 40 items had serial numbers which were not well readable, this could result in wrong data on location of these items;
- the verification of item locations for a random sample of 279 items during the PIT did not reveal any defects of such kind in the sample;
- 13 cases were detected in the sample of 250 Pu disks when the difference between the passport value of the total mass of the item and the measurement result was larger than three measurement error values, this situation should be investigated;
- no defects were found in TID location records.

As for major operational functions of the system, the tests indicated that all necessary functions were available in the system. However, during the transaction procedures some of the

fields in the data base were not updated properly. These were fields with operator names, procedure time and date. The necessary corrections are being introduced.

In general it could be concluded that this first step in the implementation of computerized nuclear material accounting methods on the BFS facility could be considered as successful.

6. RECOMMENDATIONS

6.1. The data base of the BFS computerized accounting system should be increased to include all fissile material items in this MBA.

6.2. The software should be improved to provide a possibility to track sealed containers (canisters and fuel rods) with nuclear materials in addition to tracking individual items.

6.3. The system should be tested for routine operational conditions, operational experience should be accumulated and evaluated, maintenance procedures should be established.

6.4. Bar codes need to be applied to fissile material items, necessary changes in the software should be introduced.

6.5. Software for tracking nuclear material movement could be implemented in other MBAs of the IPPE.

REFERENCES.

1. "Basic Rules for Nuclear Material Accounting and Control", Draft prepared by Gosatomnadzor and Minatom of Russia. 1995.
2. "Control and Accountability of Nuclear Materials." DOE Order 5633.3A, Chapter 1.

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