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Implementation of an Expanded Material Control and Accounting Program (MPC&A) through Performance of a Gap Analysis and an Expanded MPC&A Plan at the Mining and Chemical Combine

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Abstract:

Since 1996, the Mining and Chemical Combine (MCC- formerly known as K-26), and the United States Department of Energy (DOE) have been cooperating under the cooperative Nuclear Material Protection, Control and Accounting (MPC&A) Program between the Russian Federation and the U.S. Governments. Since MCC continues to operate a reactor for steam and electricity production for the site and city of Zheleznogorsk which results in production of the weapons grade plutonium, one of the goals of the MPC&A program is to support implementation of an expanded comprehensive nuclear material control and accounting (MC&A) program. To date MCC has completed upgrades identified in the initial gap analysis and documented in the site MC&A Plan and is implementing additional upgrades identified during an update to the gap analysis. . The scope of these upgrades includes implementation of MCC organization structure relating to MC&A, establishing material balance area structure for special nuclear materials (SNM) storage and bulk processing areas, and material control functions including SNM portal monitors at target locations. Material accounting function upgrades include enhancements in the conduct of physical inventories, limit of error inventory difference procedure enhancements, implementation of basic computerized accounting system for four SNM storage areas, implementation of measurement equipment for improved accountability reporting, and both new and revised site-level MC&A procedures. This paper will discuss the implementation of MC&A upgrades at MCC based on the requirements established in the comprehensive MC&A plan developed by the Mining and Chemical Combine as part of the MPC&A Program.

I. Introduction:

The approach to the systematic development and implementation of the MC&A system at the Mining and Chemical Combine was reported in a previous paper [1]. The approach involved the gap analysis which is a structured review and evaluation of existing site practices relative to the requirements of a fully compliant program that, when implemented, meets all requirements of Federal, industrial and site level regulatory documents. The areas for development under the MPC&A upgrades were identified in the site MC&A plan developed by the MCC staff. The MC&A Plan is a comprehensive document that details; a) Plant Configuration (facility layout and MC&A equipment), b) People and Resource

Application (baseline and required personnel resources and organizations), and c) Procedural Implementation (documented instructions, operator aids, and procedures that are supported by a job task analysis based training program).

II. MBA Structure

To facilitate the implementation of an effective MC&A system, the MCC staff divided the facility into seven MBAs some of which have sub-MBAs. The structure of MBAs was based on item operations and bulk processes and to establish Key Measurement Points (KMPs) to track the flow of material through the processes and storage areas (see Figure 1). MC&A procedures were then implemented in each MBA that enables a more manageable system of material control and accounting. Considerations in MBA designations included bulk material or discrete item processing, change in nuclear material form or operation, nuclear material transfer methods and frequencies, method and ease of performing accounting measurements, the physical layout of the areas, and personnel access. A primary consideration was the establishing of MBAs when the type of nuclear material changes. For example, a reactor fuel-storage area and the reactor were considered as separate item MBAs, in consideration of reactor operations that change the concentration and isotopic composition of nuclear material in the fuel. Similarly, when nuclear material changes in attractiveness such as plutonium process solutions as a result of processing operations, MBA boundaries were defined so that the lower and higher levels of attractive material are accounted for in different MBAs.

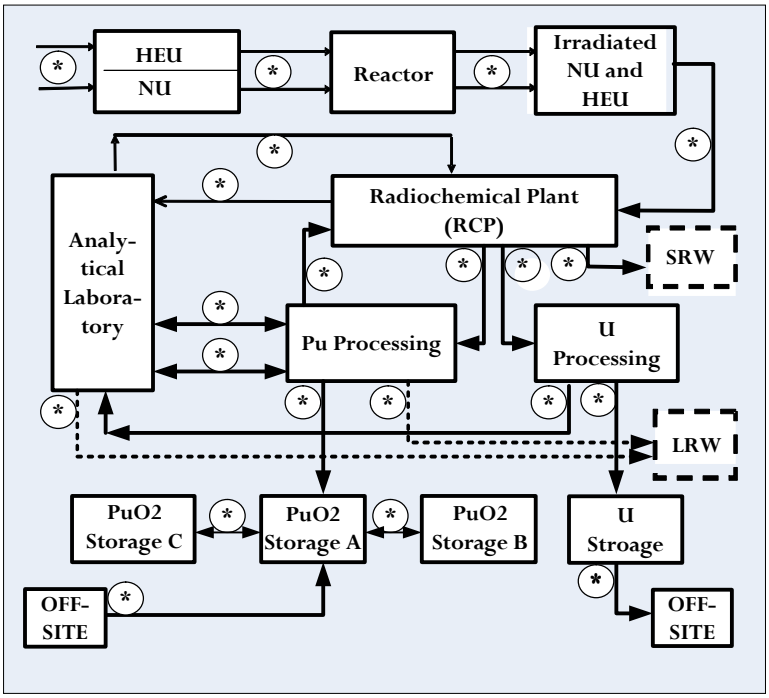

Figure 1. Schematic of MBAs and Material Flows

III. Material Accounting

Local custodians monitor nuclear material transfers between and within MBAs and prepare the inventory change reports (ICRs); collect and assure the correctness and completeness of the nuclear material measurement data. The local custodians are responsible for daily administrative checks for areas with material movements and for facilitating the taking of physical inventories (PITs). The local custodians prepare reports required to support physical inventory taking.

The individual responsible for site MC&A operations and the computerized accounting and information (CAIS) database is the site nuclear material manager. This position is responsible for developing MC&A procedures and training pertaining, but not limited to, nuclear material accounting, data access, measurement records, inventories, transfers into and out of the MBA, and data reporting. The site nuclear material manager serves as the central point for authorization of shipments to and from the site and for reporting nuclear material inventory including the monthly issuance of the Russian Federal

Information System (FIS) as well as data submissions to site management, and governmental or national organization.

Specialists in the areas of bulk measurements, and NDA and DA carry out accountability measurements and support performance of confirmatory measurements during nuclear material transfers and during inventory. Engineering/technical specialists are required to define and provide operational support to MC&A systems such as scales, access control equipment and measurement systems. Maintenance organization(s) are an integral component of ensuring reliable operations of MC&A equipment. In addition, statistical support is needed in preparation for physical inventories, analyzing measurement data, and development of quality control charts for measurement equipment.

IV. Implementation of MPC&A Upgrades

MC&A upgrades at the MCC underground facility are being implemented under the program of U.S./Russia Cooperation in Nuclear Material Protection, Control and Accounting (MPC&A). Under the program, the needs and resources required to accomplish a specified objective are discussed and the negotiated conditions for carrying out the tasks are codified in a statement of work (SOW). The task statements, over the past seven years, have included support for measurement equipment, desktop computers and systems software, training facilities and materials, and for writing of procedures. Completed and current implementation upgrades include:

Computerized Material Accounting

Installation of a Fiber Optic Site Network to support MC&A activities
Provision for equipment at MBA Custodian Workstation to support physical inventory taking and TID program

Measurement Systems and Equipment

Installation of liquid level and mass measurement systems with higher accuracy in the plutonium processing area
Installation of enhanced non-destructive assay and destructive assay equipment in the Analytical Laboratory
Installation of improved mass measurement scales and NDA equipment in the SNM Storage Areas

Material Control

Utilization of uniquely numbered, multi-lock Tamper Indicating Devices (TIDs) on HEU and plutonium oxide containers
Implementation of equipment for installation of barcodes on plutonium oxide containers
Implementation of Access Control Systems for Category 1 Nuclear Material MBA's
Installation of engineered barriers for material segregation
Implementation of radiation portal monitors for personnel, vehicles and radioactive waste
Established a system for Barcode Program
Establishment of the two-person rule
Implementation of a Daily Administrative Check program

Procedures and Training

Support for maintaining MC&A systems are included in the updated MC&A Plan
NDA and DA measurements
Conduct of Physical Inventory
Hold-up measurements
Material Accounting

To support the upgrade initiatives, the MCC staff has participated in workshops led by the USPT team members and invited experts in areas of implementation of MC&A upgrades, which include:

- Development of MC&A Plan
- Closing the Material Balance
- Computerized Accounting System
- Data Modeling for in-house Software Development
- Experts visit on Coulometer Measurements
- Demonstration of Tank-Level Measurements and Calibration
- Performance Testing
- Training Needs Assessment

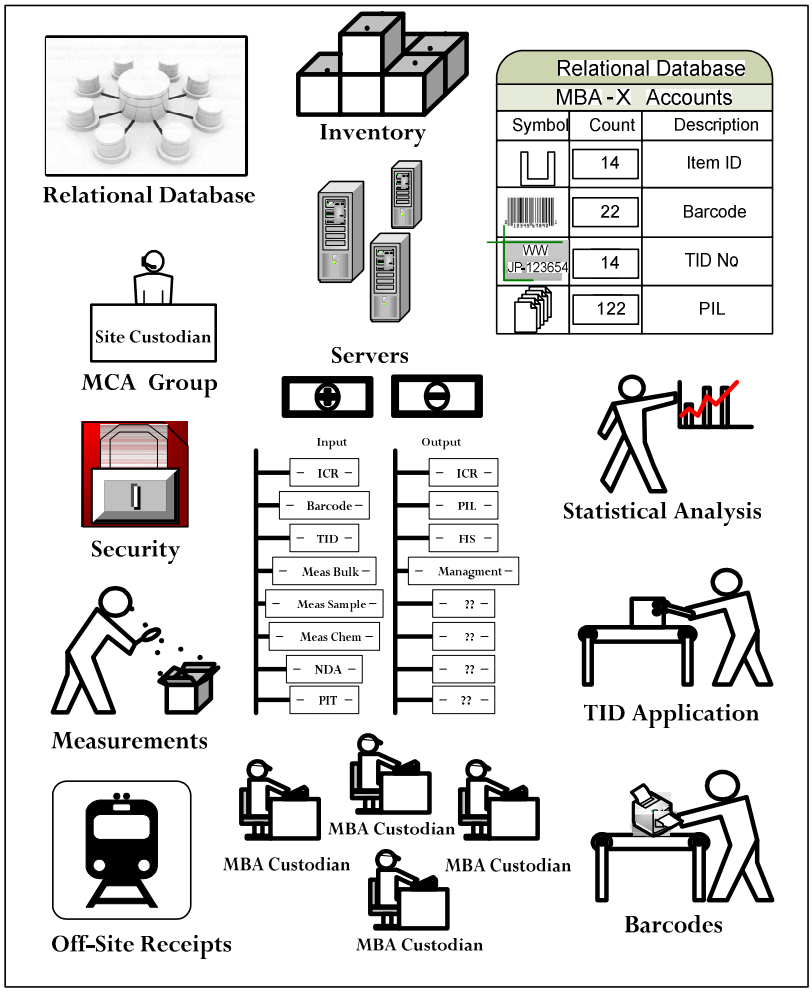

Figure 2. Components of the Computerized Accounting System

V. Computerized Accounting System

Essential components of an effective MC&A program are the material accounting functions necessary to ensure the inventory of nuclear material is timely, documented and validated to ensure no material has been diverted or removed without authorization. MCC has developed a design requirements document for the MC&A computerized system that provides a detailed description of how the site MC&A system's elements, such as types of nuclear materials, material balance areas, containers, tamper indicating devices, storage facilities and user reports are processed. This is a work in progress. The report lists functions that have to be implemented in the structure of MC&A computerized system and requirements for the system's database. In support of the computerized system, MBA custodians continue to generate transfer records and participate in the development of source documents of accounting data unique to the MBA and type of material. These could include completed operating procedures, log books and measurement data. The components of the computerized accounting system are shown in Figure 2.

The installation of a fiber optic network to all the MBA area is central to the functioning and timeliness of the computerized accounting system. The layout of the network is shown in Figure 3.

The MC&A fiber optic network is one element of the facility wide system of computer networks needed at MCC to support MC&A upgrades, Physical Protection System (PPS) upgrades and open network applications such as training and logistical support.

As part of the task, MCC provided developed a list of procedures and training required to implement and maintain the completed MC&A computerized accounting network, as well as a list of personnel to be trained and their associated MC&A organizations.

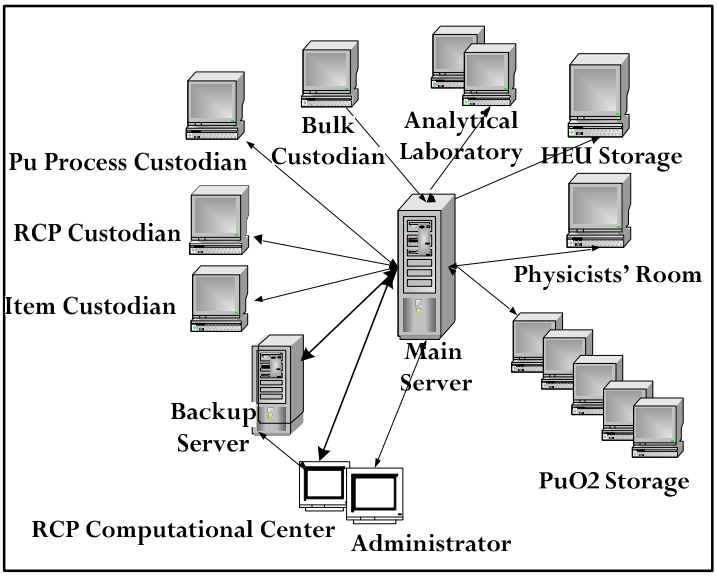

Figure 3. Computerized MC&A System Workstations

VI. Material Control

The TID seal custodian and the barcode administrator share space and secure TID and barcode stock storage at the calcination-area custodian workstation. Uniquely identifiable, multi-lock TIDs are applied to all product containers that are also identified by a barcode. Barcodes automate the PIT and reduce the inventory effort. TIDs preserve the integrity of the accountancy data and provide for detection of possible diversion. Uniquely identifiable, multi-loc TIDs are also used on the storage containers for the reactor HEU fuel elements. The primary activities of the TID program are maintaining the TID database, and procedures for control and application/destruction of the TIDs. MCC staff provides for response action in the event anomalies are encountered.

MCC has developed procedures for Daily Administrative Checks (DAC) that provides oversight of the physical handling of SNM material in transit, exposure during measurement taking, inventory taking and SNM in temporary storage. The procedures also provide security for accountancy records and accountancy equipment.

Two-person rule procedures have been established by MCC for areas with direct access to SNM. The site level regulatory documents designate the area and activities the two-person team is to work. Controls are established to control access to a secured storage area, and that unauthorized or unaccompanied authorized personnel cannot access a storage area undetected.

The two person rule is applied to waste handling. MCC material control procedures for waste include the packaging of waste, hand-held monitors for go-no go measurements, sealing and bar-coding waste boxes, and controlled access to the waste staging areas.

VII. Measurement Systems and Equipment

Measurements of SNM product, transfers and inventory are carried out by process specialists and analytical laboratory staff. Measurement equipment upgrades include process scales, laboratory balances for samples; certified mass standards, density meters, tank level gauges, coulometer, high-resolution gamma spectrometers, passive neutron coincidence counters, and portable neutron monitors.

Systems used for measurements reported in the inventory change reports (ICRs) and inventory, receipt confirmation measurements and calibration parameters are summarized in Table 1.

Table 1. Summary of Measurement Systems and Materials

1) Counting a) HEU containers (storage) b) HEU fuel elements (reactor loading) c) Natural U containers (storage) d) Natural U containers (reactor loading) e) PuO2 containers (RCP, storage)	2) Calculated a) reactor burn-up i) Uranium / plutonium content b) RCP input i) Uranium / plutonium content c) PuO2 mass after correction for impurities d) Calibration liquid volume / mass
3) Item Weight a) HEU Containers (storage) b) PuO2 containers (RCP) c) ICR transfers (confirmatory measurements) d) Receipts (confirmatory measurements) e) Inventory (confirmatory measurements)	4) Bulk Weight : a) Pu powder fill containers b) Pu powder sample c) Calibration liquid
5) Bulk Volume: a) Tank, equipment content (RCP) b) Liquid sample c) Density d) Calibration liquid	6) Spectra-photometry a) Pu powder impurities b) Pu solutions concentration c) Moisture content 7) Coulometer a) PuO2 (concentration)
8) Gamma Spectrometer (NDA) a) ICR transfers (confirmatory measurements) b) Receipts (confirmatory measurements) c) Inventory (confirmatory measurements) d) Solid waste (Pu isotopic) e) Glove box filters (Pu mass)	9) Neutron Coincidence Counter (NDA) a) final product (Pu mass) b) Pu waste) c) Solid waste (Pu mass) d) Waste 10) Portable neutron monitor a) Solid waste scanning

VIII. Physical Inventory Taking (PIT)

Physical inventory is carried out by the inventory commission, approved by MCC's Director General, consisting of a representative of the NM accounting group, and process specialists trained and authorized to handle nuclear material. The MBA custodian is present during the work of the PIT commission. MC&A inventory procedures distinguish between bulk MBAs where nuclear material processing occur and item MBAs where nuclear material is stored in containers.

Table 2. Item-MBA and Bulk-MBA Accounting	
Item Accounting MBA: Administrative Control	**Bulk Accounting MBA:** Process Control
Storage areas: Static Inventory	**Process Areas: Dynamic Inventory**
Inventory Change Report (ICR): • Container ID • Location • Type of transfer (between or within MBA) • Type of nuclear material • Material quantity • Barcode and TID • Measurement code	Inventory Change Report (ICR): • Batch ID • Process equipment (tank) • Type of transfer (between or within MBA) • Type of nuclear material (product/waste) • Material quantity • Measurement code
Measurements: • Item count • Item ID • Weight • NDA	Measurements: • Bulk weight / powder sample • Container / batch sampling • Mass (volume*density) • Liquid sample / chemical analysis
Physical Inventory Listing (PIL) (book inventory) • Sampling plan • Item ID (Barcode) • MBA location (Barcode) • TID (Barcode) • Material type • NM amount	Inventory Change Listing (ICL) (book inventory) • Equipment inventory list • Measurement sequence • Calibration checks • Measurement uncertainty (LE) list • Analytical assay list
Physical Inventory Taking (PIT) • Item count • Item ID (barcode) • TID verification • Weight • NDA confirmatory measurements	Physical Inventory Taking (PIT) • Steady-state operation • Sequenced inventory gauge readings • Volume measurements • Liquid samples • Chemical analysis
Closing the material balance : • Item reconciliation (IL=PIT) • Lost or missing item • Lost or missing record • Error in records • Tamper indication - TID failure • Item verification failed – material missing	Closing the material balance: • Calculate inventory difference (ID) measurement uncertainty on the ID (LEID • Analyze ID = LEID excessive ID ID trends LEID data file

The item inventory procedure establishes the timeframe prior to inventory after which there is no item movement in to or out of the MBA or sub-MBAs. The procedure identifies items accounted for by means of barcodes and serial number identification, where unique TID numbers are checked, containerized materials are verified for container integrity to the extent possible, and verification measurements are performed. For the large storage inventories, sampling plans are used to randomly select items to be inventoried by one or more measurement methods. For example, subsamples for weight and NDA measurements are weight confirmation (10%) and NDA confirmation (5%) after the

completion of Item count (100%) and barcode Item ID and TID verification (20%). Closing the material balance (MB) is based on reconciliation between the inventory listing (IL) data and the (PIT) data . The item material balance report (BMR) is ready for review in one day after inventory operations are completed.

For bulk MBA inventories, operations are suspended and the gloveboxes are prepared for inventory. MCC's bulk inventory procedure defines the protocol for a moving inventory and release of process tanks or groups of tanks for transfer and/or processing once the location and integrity of items are verified and all required bulk material measurements are validated. Apart from planned inventories, an inventory is also performed at the start of a shut down for maintenance and repair. As shown in Table 2, closing the material balance involves a list of transfers (ICRs) into and out of the MBA, the measured inventory, data on the measurement uncertainties (LEID), and the analysis of the inventory difference (ID) and the LEID. MCC has developed the calculations for closing the material balance around the Radiochemical Plant and are performing activities on identifying calculations for closing the material balance around the plutonium processing area. The bulk MBR is ready for review in two weeks following the completion of inventory operations allowing time for the reporting of the chemical analysis results and NDA data on filters and waste containers.

IX. Procedures and Training

The development and implementation of MC&A procedures represents a significant effort on the part of the MCC to meet the extensive and evolving reporting regulation. MCC has a formalized approach in the MC&A Plan that involves a detailed review of the provisions of MC&A functions and upgrades. The structure of the plan is based on a logical flow down of referenced activities to implementation procedures that can be followed by the field personnel. Depending on the area, the procedures differ in scope, and include site-level procedures, procedures that address cross cutting activities involving multiple activities or operational elements, and detailed operating procedures that directly implement MC&A requirements on an activity by activity basis.

The training of personnel is of acute importance of the implementation of the MC&A upgrades. MCC depends on in-house and specialists with expertise in subject matter and applications. Both knowledge and skill-based evaluations, with well established metrics are needed to implement MC&A upgrades, consistent with procedures and regulations. The development and maintenance of procedures and the training of MC&A staff is an on-going activity under the joint direction of the Site nuclear material manager, the facility MBA custodian and facility process operations.

X. The Path Forward

As progress on the implementation of MC&A upgrades goes forward, the factors described above need to be periodically reexamined. MCC is beginning the development of a self-assessment program to while support an internal determination of how well procedural requirements are being implemented. Based on a technical vulnerability analysis, a thorough understanding of the type, form and quantity of nuclear material is foremost in maintaining and effective program. A review of the regulatory requirements (site, industry and national) can identify addition requirements and advances in technology

in support of MC&A program implementation. Completion of these activities allows for procedure development and personnel training to occur. Documenting the program's control and accounting elements related to plant (equipment), people (staffing and training) and procedures in an MC&A plan provides an effective means of defining the structure of the program and describing upgrades and required enhancements. At MCC the MC&A Plan is the controlling document that provides a single source reference that is used to build assessment criteria for evaluating performance as part of routine internal and external assessments.

Reference:

[1] Enhancement of Material Control and Accounting Programs through the Conduct of a Gap Analysis and the Development and Implementation of a Comprehensive MC&A Program Plan, Doyle Hembree, et al, 49th Annual Meeting of the INMM, July 2008, Nashville, TN.