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# BAR-CODE BASED WEIGHT MEASUREMENT STATION FOR PHYSICAL INVENTORY TAKING OF PLUTONIUM OXIDE CONTAINERS AT THE MINING AND CHEMICAL COMBINE RADIOCHEMICAL REPROCESSING PLANT NEAR KRASNOYARSK, SIBERIA.

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## ABSTRACT

**This paper describes the technical tasks being implemented to computerize the physical inventory taking (PIT) at the Mining and Chemical Combine (Gorno-Khimichesky Kombinat, GKhK) radiochemical plant under the US/Russian cooperative nuclear material protection, control, and accounting (MPC&A) program. Under the MPC&A program, Lab-to-Lab task agreements with GKhK were negotiated that involved computerized equipment for item verification and confirmatory measurement of the Pu containers.* Tasks under Phase I cover the work for demonstrating the plan and procedures for carrying out the comparison of the Pu container identification on the container with the computerized inventory records. In addition to the records validation, the verification procedures include the application of bar codes and bar coded TIDs to the Pu containers. Phase II involves the verification of the Pu content. A plan and procedures are being written for carrying out confirmatory measurements on the Pu containers.**

## I. INTRODUCTION

**GKhK is an underground site located in the city of Zheleznogorsk on the east side of the Yenisey River about 80 kilometers north of the Krasnoyarsk in central Siberia and is shown in Figure 1. The site includes three nuclear reactors, a radiochemical reprocessing facility, a nuclear heat and electric power plant, water supply and ventilation facilities, underground high-level waste storage tanks, a plutonium oxide storage area, and a high enriched uranium (HEU) storage area. One of the reactors, the ADE-2 dual-purpose reactor, continues to operate to produce electricity and heating steam for Zheleznogorsk as well as weapons grade plutonium.**

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**Figure 1. Map of Russia**

**The radiochemical plant, (operational since 1964) continues to produce plutonium oxide from the ADE-2 spent fuel rods. A core conversion option for ADE-2 is being evaluated to develop a fuel loading that would not produce excess plutonium.**

## II. MPC&A OBJECTIVES AND STRATEGIES

**Initial focus areas for the MPC&A upgrades include the plutonium oxide ($PuO_2$) storage area and the radiochemical reprocessing plant. Because the existing $PuO_2$ storage area contains a significant quantity of attractive nuclear material, it was chosen as the highest priority area for initial MPC&A upgrades.**

**The radiochemical reprocessing plant utilizes a PUREX process, (modified specifically for application in this unique underground site) to reprocess the spent ADE-2 fuel. The $PuO_2$ produced is packaged in the plant before being transferred to the storage area. MPC&A upgrades in this area contribute to upgraded steps in control of the product $PuO_2$. To improve the accounting for input, output, and hold-up materials in this area, a new method for tank volume measurements, estimates of hold-up and chemical analysis measurement technologies are being implemented.**

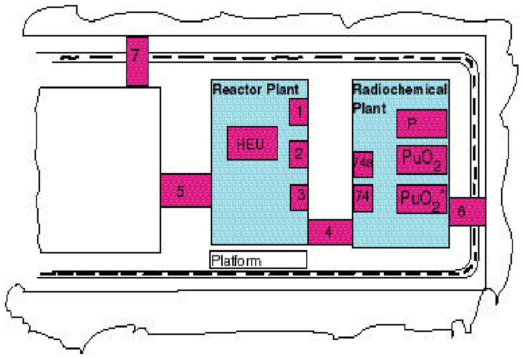


Figure 2 Schematic of the GKhK Underground Site

The plutonium oxide storage area is located within the radiochemical reprocessing plant in the underground site. The area is an interim storage area that was redesigned as a long-term storage for $PuO_2$ in 1994. Prior to 1994, all $PuO_2$ was shipped off site after production. Because of the amount and type of $PuO_2$ stored in this area, it is imperative that MPC&A be upgraded.

Nuclear material accounting is being enhanced by computerizing the inventory records, introducing bar code technology, implementing upgraded tamper indicating devices, and developing inventory plans and procedures in the storage area. Nuclear material measurement capabilities are being improved by incorporation of high-resolution gamma spectroscopy, neutron counting and electronic balances for weighing. The information generated by the nuclear material measurements will be input for a computerized material control and accounting system being installed. Installation of special nuclear material portal monitors, hand-held nuclear material detectors, and metal detectors at the portals of the plant will also improve control of nuclear material in this area.

## III. Physical Inventory Taking Goals and Requirements

A major goal of material protection, control, and accounting is to perform a physical inventory taking (PIT) of the nuclear material at nuclear facilities. A PIT involves two aspects of accounting of nuclear materials. The first is ensuring that all nuclear material on inventory is included in the facility records and the second, that the measured content of items or containers (or at least a suitable random sample thereof) corresponds to the recorded values. Accordingly, a two-phase approach to carrying out the PIT was adapted. Phase I addressed the activities involved in computerizing the inventory record system, providing bar code and TID equipment and training and writing PIT procedures for carrying out item verification. Phase II consists of providing equipment and of training personnel to write procedures for carrying out confirmatory measurement on the Pu containers.

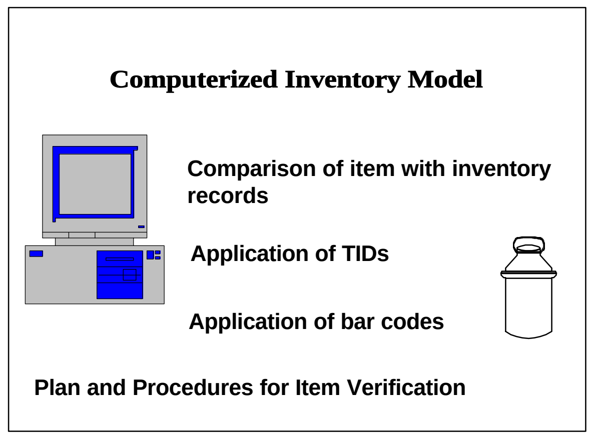


Figure 3. Phase I, Verification of Items

Phase I of the inventory task started in 1997. It was designed to provide the equipment and long-term planning that would create the right conditions for carrying out item identification of the containers. The requirements for carrying out a computerized (rapid) PIT are:

Bar code equipment and training

TID supplies and training in their application

Computers and the entry of manual based inventory records into a database.

Plan and procedures for item verification and application of bar codes and TIDs.

Activities under Phase I provided for demonstrating the plan and procedures for carrying out the comparison of the Pu container identification with the computerized inventory records. In addition to validation of the passport records, the identification verification procedures included the application of bar codes and bar coded TIDs to the Pu containers. The activities for verification of items are shown in Figure 3

Phase II of the inventory requires equipment for carrying out confirmatory measurements of the Pu containers and the writing of a plan and procedures for their use as part of the draft inventory procedure. Confirmatory measurements test whether some attribute or characteristic of nuclear material is consistent with the expected attribute or characteristic for that material. A confirmatory measurement may involve direct determination of the nuclear material, but with methods of a lower accuracy than that of the original accountability measurement. Equipment provided under the MPC&A program for use in making confirmatory measurements at GKhK are

Weight and temperature devices

Gamma NDA

AWCC (Neutron)NDA

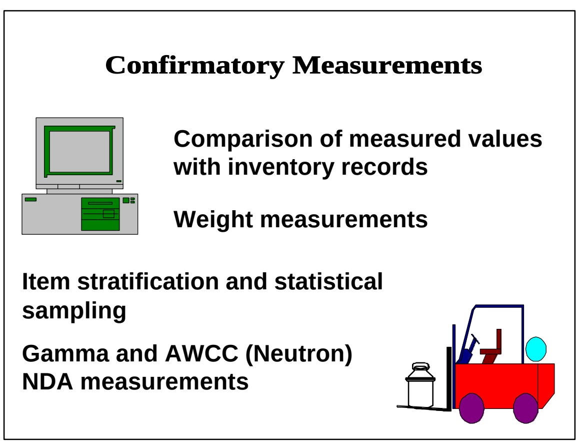


Figure 4. Phase II, Verification of Content

Confirmatory measurement devices will produce measured values for the item. However, the measured value for an item determined by means of a confirmatory method will typically not replace the book value. Gross differences with book values will be investigated and resolved. During routine inventory operations, a sampling plan may be used to select the cans to be measured by NDA. Under the sampling plan, the population will be divided into strata according to some suitable scheme that is to be defined and NDA confirmatory measurements will be made on a statistical sample of the Pu containers in each of the strata.

## IV. Physical Inventory Taking

Item verification of plutonium containers in the existing storage under the MPC&A program was carried out in March 1998. The work consisted of comparison of the container identification with the container record in the computerized inventory record database and the application of a Multi-Lok seal to each container. At this stage (Phase I of the PIT), only the physical presence of each container was verified. Bar coded TIDs content were also applied.

Bar coding is a key element for implementing a computerized nuclear material control and accounting (MC&A) system. Items to which bar codes are to be applied are: material containers, measurement instruments, sample bottles and documents, TIDs (seals), technological specialists, material locations, calibration standards, and working standards.

An effective TID program requires a TID custodian, a TID database for recording the application, checking, removal, examination, and disposal of TIDs, and a data acquisition system to capture the data. Data acquisition records comprised of measurement, measurement control, sampling, sealing, and transfer data are linked by bar codes.

Phase II of the PIT in the existing storage under the MPC&A program is scheduled for late 1999. Verification of Pu content in the storage containers will be by means of weight, temperature, and two types of NDA measurements. Equipment for four PIT working stations, provided under the MPC&A program, are being set up and tested in the GKhK Scientific Training Center in the city of Zheleznogorsk prior to installation in the underground facility. The working stations consist of a bar code and item verification station, a bar code based weighing station, a gamma NDA measurement station, and a neutron NDA measurement station. The computerized weight, temperature, and NDA data will be stored in SQL-Server database files and compared and cross-referenced to Phase I inventory records.

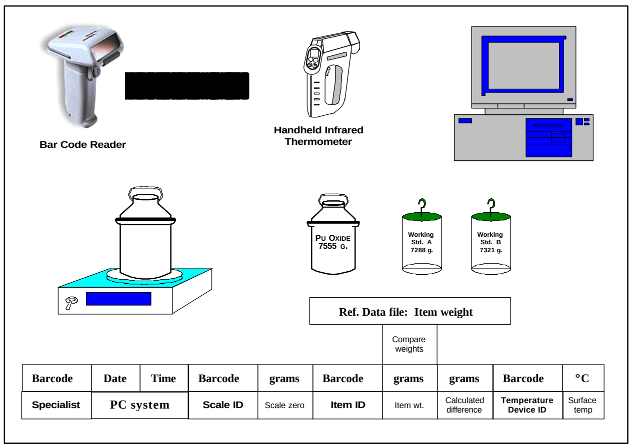


**Figure 5. Bar-Code Based Confirmatory Weight Measurement Station.**

The bar-code-based weighing station consists of a bar code reader, a 15 kilogram scale, a non-contact infrared temperature device, and two weight working standards. Bar coding and weighing will be done for all Pu containers. Weight station equipment is shown in Figure 5. NDA confirmatory measurements will be made on all Pu containers during the pilot inventory and demonstration of the equipment and procedures.

## CONTRIBUTORS

**Brookhaven National Laboratory provided equipment for the computerized weighing system and support in the development of inventory procedures.**

**The bar codes, equipment, and training were provided by Oak Ridge National Laboratory.**

**The TIDs and training were provided by Pacific Northwest National Laboratory.**

**Lawrence Livermore and Los Alamos National Laboratory provided gamma NDA and neutron measurement instruments (AWCC), respectively.**

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