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Abstract

In order to improve the control and accounting of nuclear materials at the Joint Stock Company (JSC) "Afrikantov OKBM", a project to automate the control and accounting system of nuclear materials was established as part of the joint Russian-American cooperation. The activities performed at JSC "Afrikantov OKBM" to create an automatized control and accounting system of nuclear materials with use of bar code technology are presented in this paper. Prior to automation the level of effort to conduct confirmatory measurements and monthly physical inventories was labor intensive. This resulted in reduced productivity and unnecessary radiation exposure for the personnel. Obscure identification numbers on many items also contributed to the problem. Over time some identification numbers had become difficult to read. This contributed to transcription errors that had to be resolved, which further increased inventory and reconciliation time. Using laser barcode technology, items with obscured identification numbers were re-marked. Workstations running computerized accounting software that automated daily operations and monthly inventories were distributed throughout the processing area. The project was successful in achieving its goals. The automation of the control and accounting system of nuclear materials using laser marking, bar coding, and appropriate software has increased the reliability of Nuclear Material Control and Accounting (NMC&A), decreased manpower requirements, and reduced radiation exposure.

Introduction

Prior to the automation of the system for the control and accounting of nuclear materials (NMC&A) at OKBM, the task of conducting confimatory measurements and monthly physical inventories was labor intensive. Consequently, the employees' time was not being used effectively or efficiently. The lack of automation took workers away from their core activity of scientific research and resulted in unnecessary time spent in radiation areas resulting in increased level of radiation dose to the OKBM staff.

Physical inventory was further complicated by the fact that the serial numbers of accounting units (AU) (e.g., inventory items) had faded or become obscured over time becoming difficult to read. This also added to the time required to complete the inventory because the possibility for and the numbers of transcription errors was high.

In order to improve the NMC&A system under the framework of joint Russian-American cooperation (General Agreement No. 42000000204), collaborators developed the concept of an automated NMC&A system. The project was aimed at not only the automation of

everyday operations of NMC&A at the facility, but also the automation of procedures to conduct physical inventory along with all the required confirmatory measurements.

Equipment

The following equipment was purchased for the implementation of the project:

- The server hardware (rack) to accommodate the core system software, and server software, as well as the cooling system of the server hardware;
- Equipment and software for work stations to perform NM activities, namely the racks with industrial PCs and printers;
- *Zenith* 20 FQ laser marking system;
- Barcode Scanners *Metrologic* MS 3870 USB;
- Data collection terminals, *Casio* DT-930M51E ;
- *Intermec* PX4B FP/DP TT 203dpi EasyLan printer (INT-810000300020)
- *Kolibri* spectrometers;
- Weighing equipment (5 types of weights) with a capacity of 0.01 grams to up to 5 tons;
- Laptops.

The system core's server equipment was mounted in the server room at the physical lab and put into operation. The local computer network was put into operation, and all of the NMC&A work stations were integrated with the server room.

NMC&A Computerized System

Software and all documentation (e.g., Technical documentation and user manuals) for the automated NMC&A system was also developed within the framework of the cooperative agreement. The software was engineered to cover all NMC&A operations for the process area.

The NMC&A system was developed using various computer technologies. The Microsoft Windows platform (Windows Server for servers and Windows XP for work stations) was used as the main operating system. The Microsoft SQL-Server was chosen as the database management system for storing information. The facility developed the application software using its own design based on a Windows platform.

Data from the user interface, peripheral hardware, and the barcode readers are input into the database. The system can operate simultaneously on multiple workstations connected to the server, which means that work involving NM can be carried out simultaneously in several key measurement points.

Quantitative information is entered by operators, double-checked to avoid mistakes, and confirmed by reading the barcode of the items containing NM. The barcode information includes the plant number of the item. Item accountancy is conducted at the levels of the material balance area (MBAs), key measurement points (KMPs), separate storage units,

and in concrete storage cells. The software monitors the correct opening and closing of storage areas, compliance with acceptable standards of storage, and provides the basis for storage cartograms and reports.

Remarking of Inventory

In the period from September 1, 2011 to June 29, 2012, the facility conducted laser marking of all the products containing NM. To accomplish this, the following work was carried out in accordance with the "technical plan of work on laser marking and bar coding":

- The equipment was installed at the basement level in a protective cabinet and fitted in accordance with the manufacturer specifications;
- A locking device and an emergency off switch were installed to protect the cabinet;
- The parameters of the *Zenith* FQ 20 laser marking system were checked during a trial run of the program;
- Personnel were trained to carry out their work in compliance with the rules of operation and maintenance, and staff were given certificates signalling completion of a training course entitled 'Operation and maintanance of *Zenith* laser marking systems'. The training was provided at the *'Technology Identification Company'*;
- NMC&A specialists at OKBM developed an operations manual and a labor safety regulation on the basis of manufacturer specifications;
- Staff performed an analysis of material properties for the following characteristics of the material to be barcoded:
    - Light reflection and absorption (mirror-like, diffused);
    - Color;
    - Strength;
    - Operating conditions;
- The test subjects were marked;
- Staff conducted tests on the resistance of the marked items to thermal and chemical impacts.

In the course of work, 100% of the items that contain NM at the facility were remarked. Product gross weights along with the range and enrichment levels were reconfirmed and recorded. The composition of product information to include data on the type of products and serial numbers was updated. Staff established a database of the items that included identification numbers and storage locations (storage cabinet numbers and the cells within them).

Confirmatory Measurements

The *Kolibri* gamma-spectrometer (with a scintillation detector using a NaI crystal) was used for the range and mass fraction determination of the U^{235} isotope. The standard samples must have the same characteristics (geometry, thickness of the wall, and type of composition) as the marked items for comparative analysis.

Due to the fact that the items marked in the OKBM facility are rather numerous in type and content and taking into account the long fabrication time (many months) and high cost for standard samples, the decision was made to choose the standard samples from among the marked items. To select the standard samples and complete the measurements the following methodology was used:

1. Batches of items with well-known passport values (enrichment, thickness, type of composition) were selected.

2. Using a *Kolibri* gamma spectrometer, staff performed evaluation measurements. Three measurements were made for each item. The duration of the measurement taking activity was 300 seconds.

3. From among the test items, staff selected one particular item that had the most stable measurements compared to the passport data (gross mass spectrum). The item was certified at the facility level and was assigned as a facility standard sample (enterprise standard sample, ESS).

4. Staff took measurements of the mass fraction of U^{235} isotope during the marking of the other inventory items. A comparison of the ESS with the marked item was conducted.

5. The relative error in the measurement of the mass fraction of the uranium-235 isotope resulting from the confirmatory measurements was determined. Using the *Kolibri* gamma-ray spectrometer the error was 5-7% when the duration of the measurement was 300s.

The measurements were taken using the gamma-spectrometric method "of an infinite thickness" using a scintillation detector on the basis of the crystal NaI. The accuracy of this method depends on the duration of the measurement, the wall thickness of the item, and the mass fraction of uranium-235 in uranium. Similar procedures were performed for other types of items. For each type of item staff selected and certified facility reference materials. Standard samples were stored separately in storage locations. The results of the work were found in accordance with established protocols.

Barcode Data Collection

The integration of barcoding equipment to the NMC&A automated system for the purposes of data collection was accomplished. The main activities that make use of barcoding are:

- Physical inventory of NM (in the form of accountancy items (AI));
- Confirmatory measurements during the transfer of AI to the departments at the facility;
- Confirmatory measurements upon receipt of AI from the other departments at the facility.

The addition of this technology to the automated NMC&A system has decreased the required manpower[1] as well as the time required to complete confirmatory measurements and physical inventories. It also has resulted in reduced radiation doses and decreased the probability and numbers of transcription errors by personnel.

Future Efforts for the System of Automation

The facility plans to conduct an analysis of the facility level procedures and to update or develop procedures as necessary for the new automated system of NMC&A. This may include updates to the specification of functional duties and roles of employees. .It is possible that certain issues inherent to this new system will require the development of new documents at the *Rosatom* level which would require also coordination with *Rostechnadzor*. .Ideally it would be useful to develop a similar system in facilities that supply products that contain NM so material would come pre-marked.

Conclusion

This report outlines the basic steps taken by OKBM to establish an automated NMC&A system. The completion of the system, together with its further debugging and development, will significantly improve the reliability of the NMC&A accountancy system at OKBM. It will decrease the amount of time spent by personnel taking measurements in radiation areas; decrease employees' dose rates; and increase the efficiency of NM accountancy inventory-taking activities. The use of barcoded labels and readers lower the occurrence of transcription errors during NMC&A activities resulting in more efficient, accurate, and reliable inventory system.

[1] By a factor of 2-3