LA-UR-98-3166

Approved for public release; distribution is unlimited.

Title: US/Russian Cooperative Efforts in Nuclear Material Protection, Control, and Accounting at the Siberian Chemical Combine

CONF-980733--

Author(s): I. Goloskokov, A. Yarygin, V. Petrushev, R. E. Morgado, W. Buckley, R. Logsdon, R. Copp, L. Fishbone, M. Bonner, J. Jarrett, W. J. Toth, and R. B. Berry

Submitted to: Institute of Nuclear Materials Management Conference

Naples, Florida

July 27-31, 1998

Los Alamos
NATIONAL LABORATORY

DISCLAIMER

US/RUSSIAN COOPERATIVE EFFORTS IN NUCLEAR MATERIAL PROTECTION, CONTROL, AND ACCOUNTING AT THE SIBERIAN CHEMICAL COMBINE

I. Goloskokov, A. Yarygin, and V. Petrushev
Siberian Chemical Combine, Seversk, RUSSIA
and
R. E. Morgado, Los Alamos National Laboratory,
W. Buckley, R. Logsdon, and R. Copp, Lawrence Livermore National Laboratory,
L. Fishbone and M. Bonner, Brookhaven National Laboratory,
J. Jarrett, Pacific Northwest National Laboratory,
W. J. Toth, Oak Ridge National Laboratory, and,
R. B. Berry, Sandia National Laboratory

ABSTRACT

The Siberian Chemical Combine (SKhK) is the largest multifunction nuclear production facility in the Russian nuclear complex. Until recently, it produced and processed special nuclear material for the Russian Defense Ministry. SKhK and its US partners in the Department of Energy (DOE) US/Russian Materials Protection, Control, and Accountability (MPC&A) Program are nearing completion of the initial MPC&A upgrades at the six SKhK plant sites that were begun three years ago. Comprehensive enhancements to the physical protection and access control systems are progressing on a site-wide basis while a comprehensive MC&A system is being implemented at the Radiochemical Plant site. SKhK now produces thermal and electrical power, enriches uranium for commercial reactor fuel, reprocesses irradiated fuel, converts high-enriched uranium metal into high-enriched oxide for blending into reactor-grade, low-enriched uranium, and manufactures civilian products. We will review the progress to date and outline our plans for continuing the work in 1999.

I. BACKGROUND

The Siberian Chemical Combine (SKhK) is the largest nuclear processing facility in the world and has produced and processed approximately 70 metric tons of weapon-grade plutonium during its 45-year lifetime. Combine activities also include spent-fuel reprocessing, centrifuge enrichment, and fabrication of nuclear weapon components. It is one of the sites selected for storage of special nuclear material (SNM) from dismantled Russian weapons and the proposed site for the storage of fissile materials.

SKhK is located within the city of Seversk (formerly Tomsk-7), approximately 15 km northwest of the city of Tomsk. Seversk remains, by choice, a closed city of 107,000 people of whom approximately 18,000 are employed at SKhK. There are six major nuclear sites within the Combine: the Radiochemical Plant, the Chemical Metallurgical Plant, the Enrichment Plant, the Conversion Plant, the Reactor Plant, and the Experimental Physics Plant.

Several tens of metric tons of high-enriched uranium (HEU) and plutonium are either in process or in storage at various locations within the site boundary. More recently SKhK has converted from strictly military to civilian operations, including the production of thermal and electrical energy, low-enriched uranium (LEU) for commercial reactor fuel, the conversion of HEU metal into HEU and LEU oxides and hexafluorides, and the manufacture of high-technology civilian products.

In 1995, SKhK was selected for US-assisted upgrades in materials protection, control, and accounting (MPC&A). To that end, a program was initiated that involved experts from the US Department of Energy and from six of its national laboratories and their counterparts at SKhK. The initial efforts in this program were reported at the 1996 INMM conference[1]. Since then, a substantial increase in cooperation and MPC&A upgrades resulted in the placement of over 40 new task orders.

Significant progress has been made on these tasks, focusing initially on the physical protection area, and more recently, addressing the MC&A requirements throughout the Combine. This paper summarizes these accomplishments and planned activities and includes a brief discussion of the program implementation features that have contributed to its success.

II. TECHNICAL ACCOMPLISHMENTS

A. Physical Protection Measures

1. Site-Wide Radiation Monitoring at Access Control Portals

Twenty-seven Category-II SNM pedestrian portal monitors are now in routine operation at all the principal access control points of the six plant sites of the combine and the main entrances to the city of Seversk. Twenty-seven hand-held monitors were also supplied to assist in resolving alarms. Complementing the pedestrian portal monitors are twenty-seven Russian-made metal detectors. The installation of additional pedestrian monitors at the access control portals of interior buildings at several plant sites is scheduled for the summer of 1998.

Fifteen drive-through vehicle portal monitors, including both two- and three-pillar versions, will be installed in 1998. The reliability of these monitors was demonstrated in extensive operational testing throughout several Siberian winters.

Vehicle monitoring at plutonium sites is augmented with neutron detection panels for improved sensitivity. A wait-in-vehicle monitoring station, the first of this type in Russia, is under construction at the Chemical Metallurgical Plant site. Acceptance testing of the radiation detectors and the data acquisition and control systems was successfully performed in May at the manufacturer's facility. Installation and calibration in Seversk are scheduled for August 1998.

2. Reactor Plant Site

The Reactor Plant site is designated the highest priority site for physical protection upgrades by SKhK. The site-preparation work required to install physical protection upgrades to the 4.5-km perimeter of the Reactor Plant site is being completed. These include the Delfin-M vibration detection system, microwave detection system, upgraded illumination, limited closed-circuit television, hardened guard shelters and observation areas, perimeter communication system, temporary alarm station, and upgrades to the vehicle and rail access control portals. In June the US observed operational testing of the first 500-m zone of the perimeter upgrades. All perimeter upgrades are expected to be operational by November 1998.

The detailed work plan of the upgrades to interior storage areas is in progress. Most of the equipment for these upgrades, including six personnel access control booths, have been ordered for training, testing, evaluation, and installation. All upgrades at the Reactor Plant site are scheduled for completion by June 1999.

3. Radiochemical Plant and Other Sites

The conceptual design for upgrades at the Radiochemical Plant site was completed in June 1998. The Delfin-M vibration and microwave sensor systems are being procured with installation scheduled to begin in the summer of 1998. US physical protection experts visited the construction site in June and observed the site-preparation activities. Upgrading activities will continue throughout the summer of 1999, with completion expected by the end of 1999.

A contract to develop the conceptual design for physical protection upgrades at the Chemical Metallurgical Plant site was signed in April 1998. Construction is scheduled to begin in FY99. A similar contract for initiating the conceptual design at the Uranium Enrichment Plant site is being negotiated.

4. Site-Wide Access Control

Telecommunications at the Combine is presently inadequate to meet the needs of site-wide access control for physical protection and MC&A. Work was initiated in 1997 to install a 45-km fiber-optic cable for a site-wide communications network that would link all the principal plant sites. The first kilometer of this network is installed and work on the remaining 44 km has begun. The central server, the site servers, and the first six computer workstations for the network have been ordered. Contracts are in place to develop the software required to interface the site-wide access authorization central database, personnel access control booths, and badge-making equipment. Testing and implementation will continue into FY99.

5. Radio Communications

The identification of user requirements and the general planning reports covering the installation, maintenance, training, and testing of an upgraded site-wide radio communications system for the security forces has been completed. Purchase orders were placed for a trunking radio system and a number of hand-held radios for operational use. The system is scheduled to be installed in 1998. Following the installation and an initial familiarization period to identify system limitations, operational procedures will be developed and formal acceptance testing will begin.

6. Inter-Site Transportation

The requirements for safe and secure transport of SNM within the SKhK boundary have been examined and addressed. Primary concerns included theft and terrorist activities under routine and emergency situations including fire, road accidents, and other hazards. The upgrades included increasing the time delay in accessing the cargo; limited, two-person access control of cargo; and special requirements for tracking, disabling, and limiting the range of the vehicle. These requirements were met in April 1998, with the delivery of a transport truck with a specially constructed SNM vault and an armored personnel vehicle to accompany the transport truck. The modified vehicles and procedures are now undergoing operational evaluation. SKhK has requested additional hardened vehicles.

B. MC&A Measures

1. Radiochemical Plant Site

A project to develop a Russian model for MC&A of SNM at large reprocessing plants was sponsored at the Radiochemical Plant site by the International Science and Technology Center (ISTC) Project-40[2] since 1994. In addition to developing an MC&A plan for at the Radiochemical Plant site, Project ISTC-40 identified material balance areas (MBAs) within the plant site, defined key measurement points (KMPs) in each MBA, and specified the equipment and the instrument accuracies required at each KMP to meet the requirements of the Russian federal system. This work was completed in 1997, and provided the basis for the MC&A tasks now being implemented under the current program. The Radiochemical Plant site has been identified as the program model for MC&A implementation at the remaining SKhK sites .

2. Nondestructive Assay (NDA) Equipment

All of the measurement equipment identified by Project ISTC-40 has been delivered and the requisite training of SKhK technical specialists in their operations was completed in the spring of 1998.

The measurement equipment delivered to date includes the following:

- A gamma-ray spectrometer to determine plutonium and uranium isotopic compositions;
- An alpha-particle spectrometer with six vacuum chambers and two ultrasensitive detectors;
- An active-well neutron coincidence counter;
- A Flat-Squared neutron coincidence counter;
- An inductively coupled plasma atomic emission spectrometer;
- An in-line gamma-ray densitometer for determining plutonium concentration in process solutions (design, fabrication, and testing); and
- Four Pentium-based computers.

The equipment has provided the basis for implementing a computerized MC&A system to integrate the results of the NDA measurements with other measured attributes. The planned integration of the measurements into the computerized MC&A system will be based on a physical inventory around the MBA defined for the PuO_2 storage facility and is planned to begin in FY99.

3. Computerized MC&A

A task to test, evaluate, and implement computerized accounting of SNM at the Radiochemical Plant site was negotiated in August 1997. This subject was the featured topic of two workshops, one in the US in August 1997, and another in Seversk in February 1998. The US workshop provided introductory training on the tools and concepts of a computerized MC&A system based on Windows NT, SQL Server, and Visual Basic. An advanced training workshop was presented in February to computer specialists from both the Radiochemical and the Chemical Metallurgical Plant sites. Two LANL-developed MC&A software systems have been delivered to SKhK for evaluation. These are CoreMAS, a network based system that operates in a client/server mode, and E/Z MAS, which utilizes new World Wide Web technologies.

Three Pentium-based server/computers and the associated hardware and software have been delivered. In April SKhK specialists delivered documents outlining the functional requirements and the work plan for executing the task at the Radiochemical Plant site. SKhK has expressed an interest in implementing a system similar to that developed at VNIIEF. Implementation is expected to continue throughout FY99.

4. Related MC&A Tasks

Concurrently, the integration of several related MC&A tasks are being pursued. These related tasks include the following:

- Development of a site-wide plan for MPC&A,
- Test and evaluation of NDA equipment and methods,
- Implementation of the rapid inventory bar code system,
- Integration of a system of scales and weights,
- Implementation of tamper indicating devices and seals, and,
- Performance of a physical inventory at a storage facility.

5. Neutron Coincidence Measurements

A High-Level Neutron Counter and a Flat-Squared Counter are being implemented for the NDA of SNM at two key measurement points in the reprocessing stream. The measurements consist of neutron coincidence counting of bulk SNM samples, and, together with gamma-ray spectroscopy techniques, a determination of the isotopic composition and mass of the samples.

Activities supported by the task include the following:

- Evaluation of the equipment for the measurement of uranium and plutonium using site-specific NDA standards,

- Provision of calibration and measurement control support,
- Integration of neutron measurements into the existing MC&A system, and,
- Provision for training and documentation.

A workshop on neutron measurement techniques was presented in Seversk in June. This task will continue into FY99.

6. Rapid Inventory Procedures

SKhK began integrating the use of portable bar code terminals into a computerized database system in 1997, and is preparing now to introduce bar code technology for conducting rapid inventory of SNM. During a rapid inventory, bar code labels with information on container location are scanned into a hand-held terminal. Each batch of data is then transferred from the terminal to a computer for verification and report generation. SKhK is testing this new approach at a PuO_2 storage facility and plans to introduce this rapid inventory system at five other facilities in FY99.

7. Scales and Weighing Systems

An important goal of the program is to computerize the procedures and data for taking physical inventories of SNM, and material weighing is a key component of the process. Twenty-seven digital scales, ranging from precision laboratory analytical balances for gram-size samples, up to rugged industrial scales at the 6,000-kilogram level for bulk containers, were delivered and installed earlier this year. SKhK was provided with a number of Pentium-type computers and software for use in automating the weighing operations. Certified mass standards were purchased from Metron-Sib in Siberia to be used for both calibration of the large scales and by SKhK for the production of working standards needed during daily plant operations. SKhK is now utilizing this equipment to develop operating procedures and training programs. A bulk measurement workshop is planned in which US and Russian metrology experts will exchange information on weighing methodologies and the statistics of bulk measurements. Also it is expected that the second phase of the task covering the remaining weigh stations in these plants will be initiated by mid-summer 1998, and continue into FY99.

8. Tank Volume Measurement (TVM) System

A TVM technique based on bubbler-probe manometry has been installed to reduce the errors common to conventional techniques such as capacitance probes. Technical experts from SKhK participated in a workshop at Brookhaven National Laboratory (BNL) in which various techniques were examined. SKhK provided a report assessing the applicability to their plant and identified a suitable tank where it could be installed. Following a site visit to review interface requirements, a bubbler-probe manometry system was delivered to SKhK and installed by the SKhK staff. The system was calibrated with assistance from BNL and is currently undergoing evaluation. SKhK will conduct a demonstration of the system at the conclusion of the evaluation period and will provide an assessment report. Since this tank was on the input side of the process, it is desirable to have a similar, very accurate measurement at the product end of the process. Discussions are in progress to identify a suitable point and tank to install a second system in FY99. In support of this activity, workshops will be presented on calibration procedures and bulk measurement control techniques, including measurement statistical analyses.

9. Video Monitoring of a Storage Facility

The equipment to implement video monitoring at a storage facility was procured and delivered to Seversk in April 1998. Video monitoring provides an MC&A tool for the SNM storage vaults at the

Radiochemical Plant site, reduces the need for frequent physical inventory taking, and can be used for physical protection monitoring as well. LANL technical experts have demonstrated the system in two workshops, the most recent in April. Installation of the system in an actual storage vault is planned this summer with implementations at other sites as needed in FY99.

10. Statistical Methods for Analyzing Bulk Holdup Discrepancies

The second of two workshops on the statistical analysis of material balances for material in bulk form was presented at Los Alamos in August 1997, and marked the completion of the task. The workshops provided a forum for the presentation of original SKhK work on statistical methods for analyzing material balance sequences. The focus has been on historical material balance analysis using exponential smoothing of reasonably long sequences. Recently SKhK has begun to apply the propagation-of-variance (POV) method to a limited extent, to account for correlation among measurements. The approach focuses on the correlation between beginning and ending inventory measurements when either all or some of the inventory is static, i.e., when the ending inventory is the same as the beginning inventory.

Computer hardware and software have been delivered, enabling the implementation of both the historical-based and the first attempt at POV-based analyses. The justification for follow-on work will be determined in FY99.

11. Gamma-Ray NDA Measurements

InSpector systems for U/Pu were delivered in 1997 to the Radiochemical Plant and the Enrichment Plant sites for testing and evaluation of MGA/MGAU-based gamma-ray measurements in support of physical inventory taking. Test plans for measurements were completed by both sites and evaluations of the instruments and the analysis software are in progress. Software updates to provide Russian language and Microsoft Windows support and training on the analysis methods will be performed during a visit in August 1998. Implementation of the gamma-ray measurement program is planned at both plant sites for FY99. The initiation of testing and evaluation at the Chemical Metallurgical Plant and the Uranium Enrichment Plant sites is also planned for FY99.

C. Program Management

The hallmark of the program remains the strong commitment to the cooperative implementation of rapid upgrades in nuclear material safeguards for the mutual benefit of our respective national securities. The US partners (Brookhaven, Los Alamos, Lawrence Livermore, Oak Ridge, Pacific Northwest, and Sandia National Laboratories) participate in all aspects of program development and execution through joint team meetings with the management and technical staff of SKhK. These meetings provide the forum for exchanging technical information, establishing priorities, and determining program objectives within the scope of DOE funding. Two joint team meetings are scheduled each year whose locations, when practical, rotate between US laboratories and Seversk. More frequent but smaller meetings occur as opportunities arise to review progress and to diagnose and remedy specific operational and administrative problems.

Overall responsibility for the development and oversight of specific tasks is distributed among the US partners according to expertise, allowing for broad cooperation in overlapping technical areas. Contracts are issued following negotiations with SKhK and Russian vendors to establish schedules and levels of effort to execute the task. Responsibility for monitoring contract performance resides with the US technical leads and includes the procurement and delivery of equipment, presentation of workshops, and participation and consultation in the development of deliverables.

Upon delivery of task-specific equipment to Seversk, technical teams of two or three US experts travel to Seversk to present on-site training and workshops, to assist in installations when possible, and to participate in the preparation of deliverables. This format has proven to be very effective in achieving task goals while easing access restrictions and providing the necessary end-use assurances, and will be continued in 1999.

References

1. J. Kreykes, V. Petrushev, J. Griggs, L. Runyon, R. Morgado, M. Mullen, L. Fishbone, M. O'Brien, B. Gardner, A. Runda, S. Gerasimov, M. Kuzminykh, V. Sinayevsky, Y. Ishkov, and A. Ushkov, "U. S. and Russian Cooperative Efforts to Enhance Nuclear Material Protection, Control, and Accountability at the Siberian Chemical Combine at Tomsk-7," INMM 37th Annual Meeting Proceedings, Naples, Florida, July 1996.

2. Final Report, ISTC Project No. 40, "System Design for Safeguarding Nuclear Materials Utilized at Complex Nuclear Facilities," International Science and Technology Center (ISTC), Moscow, Russia, 1997.

This work was sponsored by the United States Department of Energy.