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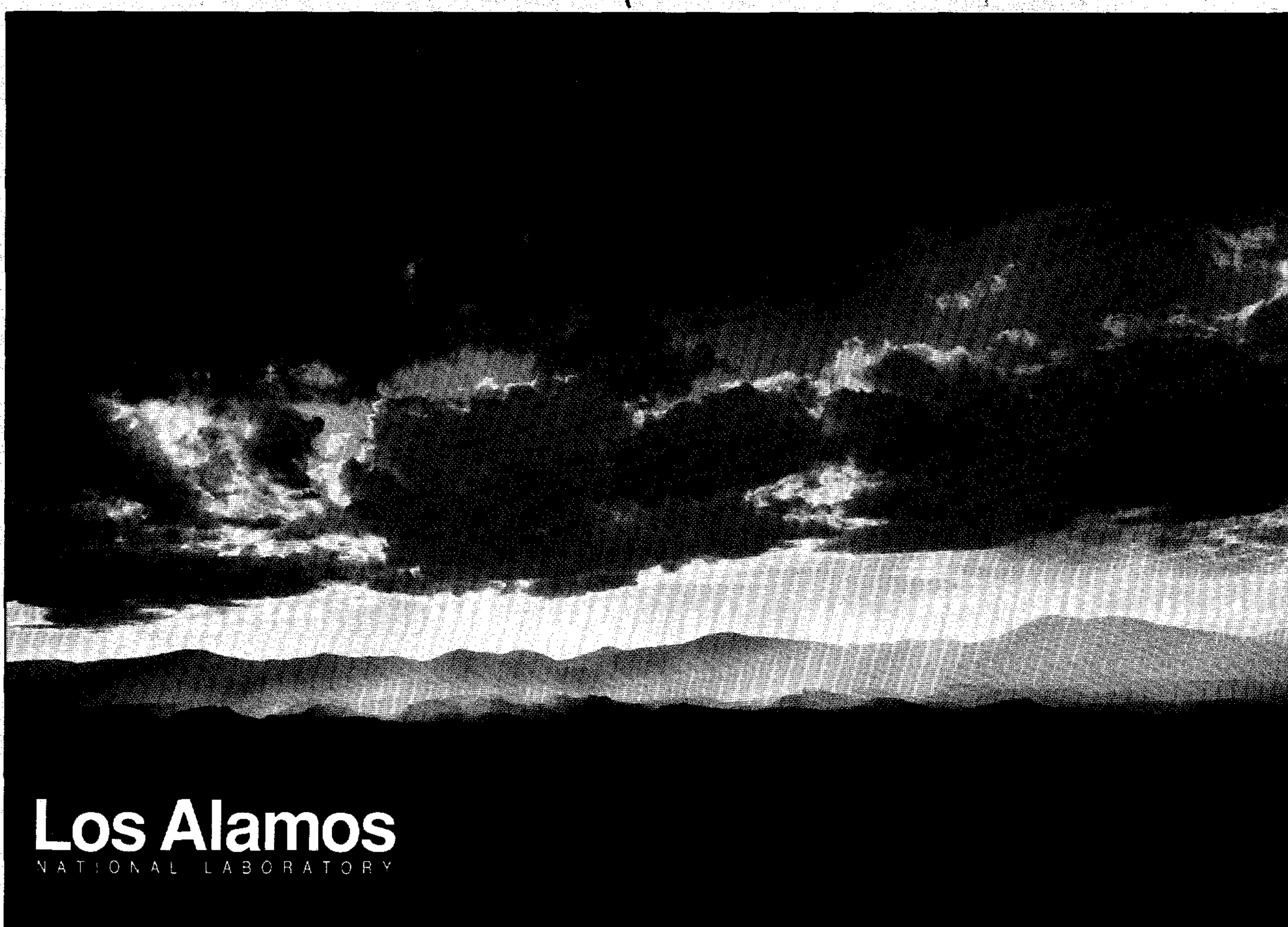

Photograph: by Chris J. Lindberg

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ABSTRACT
Enhancement of the nuclear materials protection, control, and accounting of (MPC&A) at the Elektrostal Machine-Building Plant (ELEMASH) has proceeded in two phases. Initially, Elektrostal served as the model facility at which to test US/Russian collaboration and to demonstrate MPC&A technologies available for safeguards enhancements at Russian facilities. This phase addressed material control and accounting (MC&A) in the low-enriched uranium (LEU) fuel-fabrication processes and the physical protection (PP) of part of the (higher-enrichment) breeder-fuel process. The second phase, identified later in the broader US/Russian agreement for expanded MPC&A cooperation, includes implementation of appropriate MC&A and PP systems in the breeder-fuel fabrication processes. Within the past year, an automated physical protection system has been installed and demonstrated in building 274, and an automated MC&A system has been designed and is being installed and will be tested in the LEU process. Attention has now turned to assuring long-term sustainability for the first phase and beginning MPC&A upgrades for the second phase. Sustainability measures establish the infrastructure for operation, maintenance, and repair of the installed systems—with US support for the lifetime of the US/Russian Agreement, but evolving toward full Russian operation of the system over the long term. For phase 2, which will address higher enrichments, projects have been identified to characterize the facilities, design MPC&A systems, procure appropriate equipment, and install and test final systems. One goal in phase 2 will be to build on initial work to create shared, plant-wide MPC&A assets for operation, maintenance, and evaluation of all safeguards systems.

I. INTRODUCTION

A. Site Description and Brief History

The Elektrostal Machine-Building Plant (ELEMASH) is located in the town of Elektrostal, (population approximately 120,000) 34 miles (54 km) east of Moscow. Built in 1917 with the help of the French, the plant has had a vivid history as a munitions plant in World Wars I and II, producing ordinance for mortars and rockets. They have received two Order of Lenin medals for their contributions to the Soviet war effort and took on nuclear missions in 1945.

ELEMASH is operated as a Minatom facility. The primary product of the plant is LEU (2% to 4% enriched) fuel for RBMK and VVER power reactors. The plant also produces medium-enriched uranium (MEU, 17% to 26% enriched) for fast-neutron (BN) breeder reactors. There is also capacity for production of high-enriched uranium (HEU) fuel for nuclear ice-breakers & submarines.

Facility operations span the full range of fuel-production stages — from UF_6-to-UO_2 conversion to production of fuel assemblies. The plant imports both UO_2 pellets and UF_6 for fuel production. The fuel-fabrication operations are situated in widely separated buildings on a compound with a 7-km perimeter. Material exists in bulk form (UF_6, UO_2 powder, UO_2 pellets, in-plant holdup) and as items (fuel rods, fuel assemblies, sealed storage items). Storage facilities exist in several locations on the plant compound. There are also pedestrian, vehicle, and rail-car accesses to the plant facilities from the outside.

Active US-Russian Government-to-Government nuclear materials protection, control, and accounting (MPC&A) cooperation began in 1994 (after 2 years of negotiations) with the technical site visit to ELEMASH, to assess MPC&A

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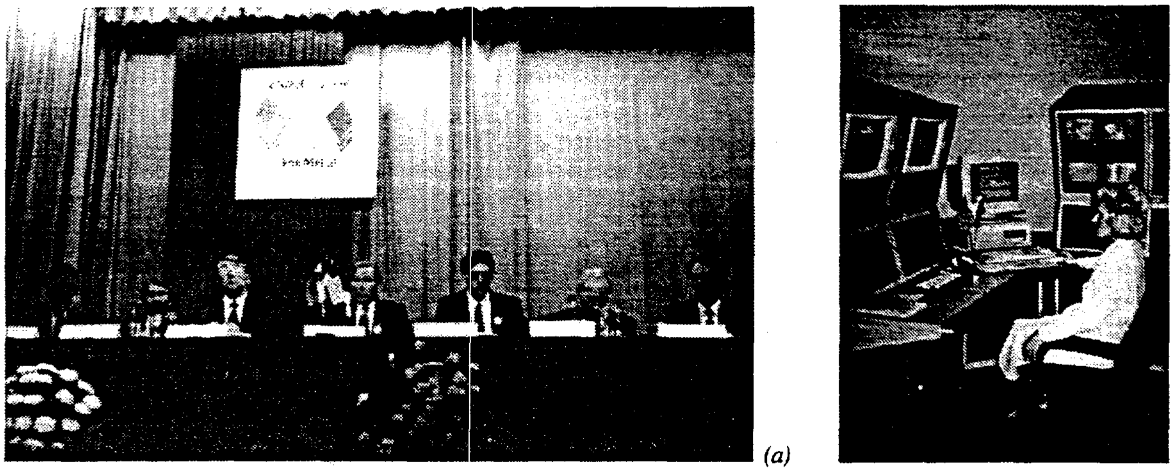
II. TECHNICAL ACHIEVEMENTS TO DATE

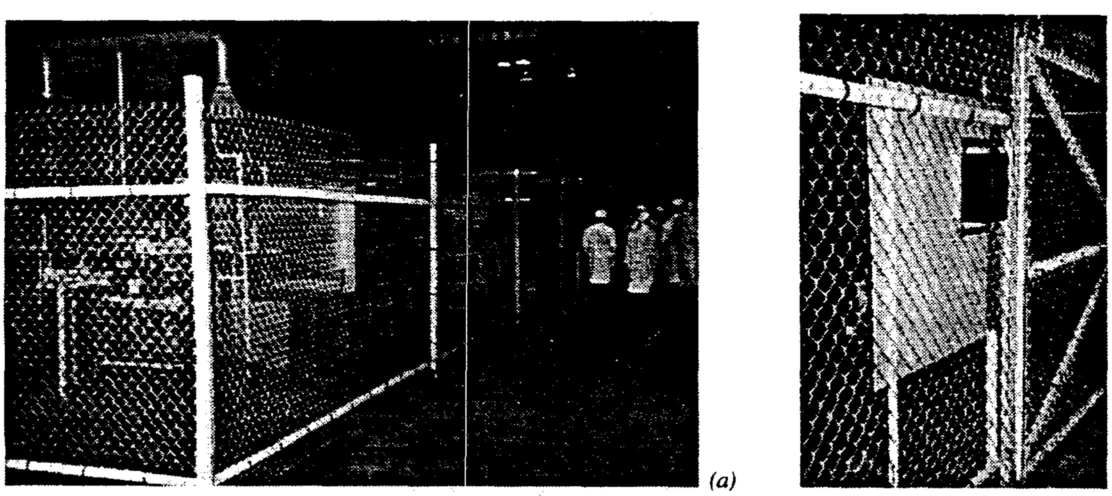
A. Dedication, Acceptance Testing, and Implementation of PP System

On November 5, 1996, the installation of the PPS in building 274 was completed and was dedicated in a formal ceremony involving top plant management, Minatom, US DOE, the US Project Team, and invited guests from Gosatomnadzor (GAN), Eleron, and other Russian facilities (see Fig. 1–3). The system provides personnel access monitoring and control for the full building, where mostly LEU fuel pellet and rod production occur. However, it focuses extra control on the BN fuel-pellet production line that is internal to the building (see Fig. 4). Installed employee access control, door alarms, portal monitors, and video surveillance were demonstrated, as well as operations in the central control room for monitoring and alarm assessment. Since that time, employees have been registered on the system; operational staff have been trained by the equipment manufacturers; and a variety of operational, response, maintenance, and testing procedures have been developed. Formal acceptance testing of the fully-operating system will occur in July 1997. After that, the system will be in routine operation.



(a) (b)

Fig. 1. (a) Ceremonial dais at the November 5, 1996, dedication ceremony for the building 274 PP system. Pictured left to right are Valery Golodyuk (ELEMASH, Deputy General Director), Nikolai Redin (Minatom), Valery Mezhuyev (ELEMASH General Director), Anatoly Suchkov (ELEMASH MPC&A Project Chief), Steve Mladineo (DOE/PNNL), Scott Touseley (CTR, American Embassy Moscow), Hastings Smith (Elektrostal Project Team Leader). (b) Central control room for the PP system, where video readouts are displayed, operations are monitored, and alarms and responses are assessed.



(a) (b)

Fig. 2. (a) BN fuel-pellet production section of building 274, showing the instrumented fence that was added to control access to that production area. (b) The gate into the BN pellet production area is opened by keypad entry authorization, and its status is monitored by video surveillance and balanced magnetic switches.

B. MC&A System Implementation

The configuration of MBAs and KMPs for the LEU production processes have been designed since 1996. Figure 5 shows the schematic of material flows and of the MBA structure for these processes. The LEU fuel-production operation has been divided into 13 MBAs that are associated with distinct segments of the process. The MC&A system design was summarized at the first International Tripartite Conference (held at Obninsk in April 1997) on Safeguards for Uranium Fuel-Fabrication Facilities (Ref. 2).

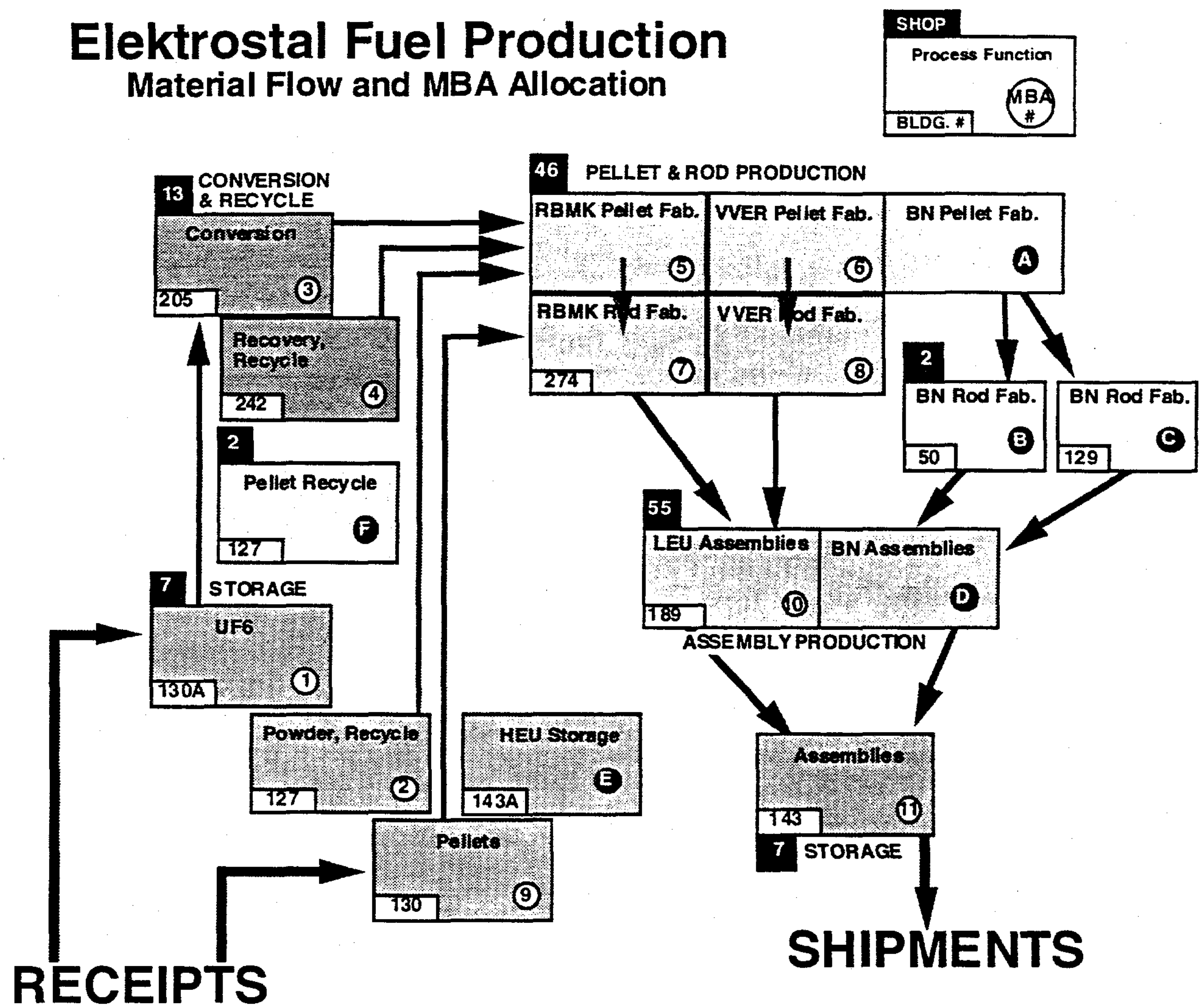


Fig. 5. MBA structure for Elektrostal's LEU processes. It should be noted that parts of the processes are housed in different (and sometimes widely separated) buildings. The allocation of activities to buildings frequently dictated the configuration of MBAs. (MBAs for the analytical laboratory and item-testing labs are not shown.) The MBAs that are indicated with white letters are new ones, planned for some of the BN processing areas.

Digital scales for measurements at some of the KMPs and Pentium™-based computers for work stations in the MC&A network arrived at the plant in mid-1996. Computer-based scale terminals arrived on site by May 1997, and equipment orders for the network and bar-coding operations is now arriving at the facility. Installation of the network and digital scales is proceeding, and every effort will be made to utilize at least a partial operating network during the scheduled annual physical inventory taking (PIT) in October 1997.

The first installation of network hardware involves the connection of the many widely separated buildings with a fiber-optic cable "backbone" that will be connected to a central server. In the process buildings, local-area networks of various

The network design supports MC&A transactions and communications among the various MBAs and will process measurement data generated at the KMPs. Initially, the primary source of measurement data will be the digital scales and manual-entry transactions. Automated recording of NDA measurements and various bar-code-based transactions will eventually be incorporated into the MC&A operations.

C. MC&A Software Implementation

Along with the hardware installations for the MC&A network, the Elektrostal software/programming team has been working for the past 2 years on software to manage the MC&A data and orchestrate the MC&A transactions at all KMPs. The US team has provided extensive training and software development tools and also the widely used MC&A software package, Core Network Material Accountability System (CoreMAS). The Elektrostal team has chosen to develop their own software from the beginning, but they have borrowed heavily from the many features in the CoreMAS package. Their MC&A software was described in detail at the first International Tripartite Conference (held at Obninsk in April 1997) on Safeguards for Uranium Fuel-Fabrication Facilities (Ref. 3). At the same conference, Elektrostal also described software they have developed to both manage the MC&A data during physical inventories and to handle the statistical analysis of the MC&A data (Ref. 4). The statistical software came from early interactions with the US team on variance propagation and other statistical packages, as well as MC&A statistics training in 1995.

D. MPC&A Training

A key step in achieving a reliable safeguards system in a facility is to establish a pervasive safeguards "culture" through extensive training in MPC&A. Beginning in late 1994, after the first site visit, the US side offered training courses in many areas of safeguards technology and practice. Table I updates the list of courses presented to the Elektrostal specialists in both PP and MC&A. As of this date, all of the key specialists have received training in the elements of MPC&A and in operation of MPC&A systems. As the cooperation expands to different material types and involves more facility personnel, additional training needs will be identified. In addition, the US team is supporting development by the facility of its own internal training program, through which additional employees can be fully trained in their respective operations.

Much of the training listed in Table I was delivered before the establishment of the Russian Methodological Training Center (RMTC) at Obninsk, and so all of this training was delivered either at the plant or at US sites. Future satisfaction of identified training needs may well utilize the RMTC resources, at a much lower cost to all. Specialized training by equipment manufacturers may still continue to be delivered on site, but there may also be some aspects of the operational training that could be delivered periodically at the RMTC by the manufacturers' representatives. One example of this latter training is a scheduled course on maintenance and operation of portal monitors, to be presented by the firm TSA, Inc.

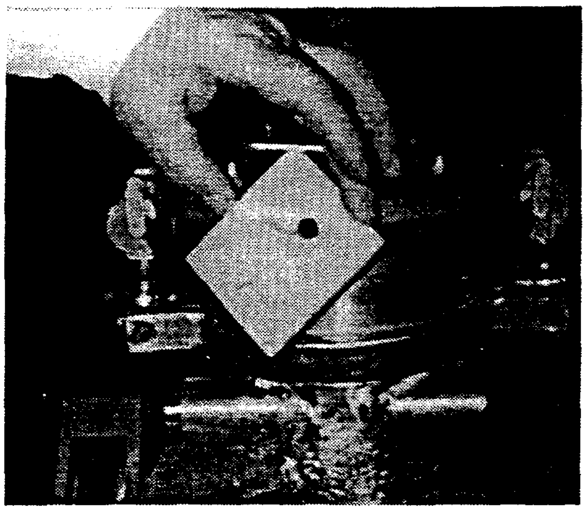
Table I: MPC&A training delivered to Elektrostal specialists (1994–1997)

Course Presented	Date	Location
Elements of MC&A Systems at a US Facility	Sept. 1994	Siemens/Richland
Elements of Physical Protection Systems	Oct. 1994	Sandia/Abq.
Elements of MC&A Systems	Feb. 1995	Elektrostal
Measurement Control and Stat. for MC&A	Apr. 1995	Elektrostal
Development of MC&A System Software	Dec. 1995	Los Alamos
Basic NDA Methods for Uranium	Mar. 1996	Los Alamos
MC&A Aspects of Vulnerability Assessment	Jun. 1996	Luch/Podolsk
Operation and Maintenance of Digital Scales	Jul. 1996	Elektrostal
Installation & Operation of PPS	Aug. 1996	Elektrostal
Operation of Advanced PPS	Apr. 1997	Los Angeles, CA
Advanced Maintenance and Diagnostics of Scales and Mass Comparators	Jul. 1997	Mettler-Toledo Switzerland
Vulnerability Assessment Training	*≈ Aug. 1997*	*Elektrostal*
Control, Accounting and Use of TIDs	*≈ Sept. 1997*	*Elektrostal*
Network Design Engineering	*≈ Oct. 1997*	*PNNL*
Portal Monitor Operations and Maintenance	*Oct. 1997*	*RMTC*

The computer network being installed contains "backbone" connections to many of the buildings that will be addressed under the expanded cooperation. The MBA and KMP structures for the BN fuel processing areas have been designed, and network and measurement hardware appropriate for that design will be procured over the next year.

Other operations being added to the MC&A support include bar-coding SNM items in the process. Manual generation of container labels will be replaced with automated bar- coded labeling, linked with the MC&A database for plant-wide materials accounting (see Fig. 8). In addition, the permanent bar-code labels on all containers will increase the accuracy and efficiency with which contained SNM is identified by the MC&A system.

The goal of the MC&A team is to complete the LEU system for demonstration and testing before the end of this calendar year. Then calendar year 1998 will focus on completion of expansions of the MC&A operations into the BN processes.



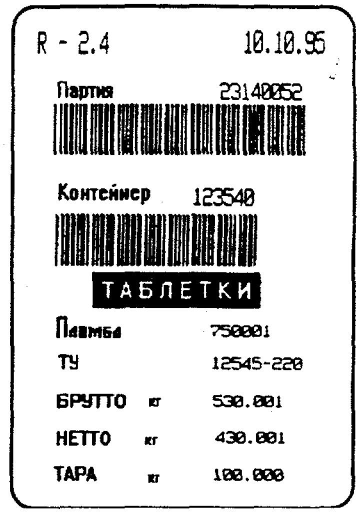


Fig. 8. Labels for SNM items will be generated by the MC&A computer system, once the item's attributes (weight, enrichment, etc.) are determined. Bar-coded labels (right) will replace the previous manually generated labels (left) for greater accuracy and speed.

3. Integration

In a plant as large as ELEMASH, it is important to take advantage of the economies of scale as much as possible. Many of the safeguards resources being implemented, therefore, will be considered plant-wide MPC&A assets. Examples include the NDA measurement equipment, computer programming teams, security response teams, and training resources. Standardization of safeguards procedures for the different processes will also contribute to an integrated MPC&A program at the facility.

The VA process considers not only physical security vulnerabilities but also material diversion scenarios that are addressed by the MC&A systems. Material control procedures (surveillance) and personnel reliability measures will also provide a traditional common ground for these two important aspects of SNM safeguards.

B. Achievements to date

1. VA and Site Characterization

Elektrostal has already generated detailed lists of SNM inventories and locations for materials up through the BN fuel enrichments. They are also participating in formal MPC&A VAs of their existing PPS and of the buildings and process areas associated with the BN fuel production. These activities will provide the basis for decisions on technical upgrades to physical security and MC&A systems under the expanded cooperation.

4. Systems Designed

Design of the expanded PP system awaits completion of the VA activities and will address the highest-priority security needs identified by this exercise. MC&A system designs have progressed to the point where MBA and KMP structure have defined the measurement equipment needs, and procurements and associated export licenses are being formulated.

5. Facility Physical Inventory Taking (PIT)

Since 1995, Elektrostal has been performing an annual PIT in October. In each of the past inventory exercises, procedures were implemented and tested. The upcoming October 1997 PIT is expected to involve the new PP system and the operating MC&A network components, as well as procedures and bar-coding capabilities on hand. This activity will be witnessed by the US team as the final step in the fulfillment of contracted task #002 and will demonstrate the achievement of this new level of reliability and automation to the plant safeguards and security.

IV. ESTABLISHMENT OF MPC&A INFRASTRUCTURE

As the first phase of MPC&A systems are installed at the Elektrostal facility, the plant specialists are considering the impact of these new systems on plant operations and also identifying the resources necessary to support operation, maintenance, and training on these systems. In sharpest focus is the PP system in building 274, which is now being supported by operational and response procedures, and by a number of contracts for maintenance, repair, operation, and training on the system components. The US team has adopted the formula of addressing these infrastructure needs though the US cooperation for a transitional period (1–3 years, depending on the systems), and assuring that during this period the on-site resources are developed to eventually sustain operations indefinitely in the absence of US support. The US program is also contracting with equipment manufacturers and with appropriate in-country technical support companies to provide some of these support services and are training selected plant specialists to establish experience in maintenance and operational procedures. This combination should result in the installation of a significant, in-house expertise for routine technical support and the availability of experienced, manufacturer-based expertise for emergencies and special, more in-depth support.

The operation and maintenance of the MC&A equipment is being orchestrated in the same way. The vendors of the digital scales, the NDA, computer, and network equipment have been chosen so that in-country maintenance and technical support are available to the facility. The US program will establish out-year warranty support contracts for the short term, and these obligations will be fully assumed by the facility over the longer term.

V. CONCLUSION, FUTURE STEPS

The MPC&A teams at ELEMASH have progressed quite far in designing and implementing PP and MC&A systems for their LEU processes. They have also made significant beginnings to develop safeguards enhancements for their breeder-fuel production lines, and our cooperation will continue eventually to cover all nuclear materials with improved MPC&A measures. Having begun the process of safeguards upgrades first among the Government-to-Government facilities, ELEMASH has dealt with many issues that will impact cooperative MPC&A efforts at other facilities in the near future — examples include development of infrastructure for facility support of installed systems; contractual relationships with in-country technical support for the installed systems; implementation of new MPC&A procedures and associated employee training; and customs, export-control, and taxing issues connected with shipments of equipment to the facility. ELEMASH will also have operational experience on installed hardware, MC&A and PP software, and NDA measurements that will be valuable information to other facilities that bring on similar systems and capabilities in the near future.

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