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Department of Energy
Nuclear Material Protection, Control, and Accounting Program at the Mangyshlak Atomic Energy Complex Aktau, Republic of Kazakhstan

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Abstract

As part of the Cooperative Threat Reduction Nuclear Material Protection, Control, and Accounting (MPC&A) Program, the US Department of Energy and the Mangyshlak Atomic Energy Complex (MAEC), Aktau, Republic of Kazakstan have cooperated to enhance existing MAEC MPC&A features at the BN–350 liquid-metal fast-breeder reactor. This paper describes the methodology of the enhancement activities and provides representative examples of the MPC&A augmentation implemented at the MAEC.

US/Kazakhstan Program of Cooperation

In 1992, the Republic of Kazakhstan signed the Nuclear Nonproliferation Treaty (NPT) as a nonweapons state and joined the International Atomic Energy Agency (IAEA). As an NPT signatory, Kazakhstan is obligated to accept full-scope IAEA safeguards on nuclear material within its borders. In December 1993, the government of Kazakhstan and the United States signed an agreement of cooperation concerning MPC&A of nuclear materials. The Ulba Fuel Fabrication Facility at Ust Kamenogorsk was the first facility selected for collaborative MPC&A work. Following successful collaboration with the Ulba facility, another major effort was begun to assist personnel at the BN–350 liquid-metal-cooled fast breeder reactor located at the Mangyshlak Atomic Energy Complex (MAEC) in Aktau, Kazakhstan. US DOE cooperative activities began at the BN–350 in September 1995 when US DOE MPC&A experts visited the BN–350 and conducted an initial site survey. Following this survey, US DOE and Kazakhstani experts began active collaboration in early 1996. Their first activity was to jointly determine that MPC&A enhancements would provide significant benefits at the BN–350 reactor. Since that time, an active MPC&A enhancement program has been underway at the BN–350 reactor. This program is expected to be complete by the end of FY98.

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BN–350 Reactor

The BN–350 reactor is a sodium-cooled fast breeder reactor with a nominal output power of 350 MW, located outside Aktau, Mangyshlak Oblast, on the shore of the Caspian Sea in western Kazakhstan. The BN–350 output is used to 1) desalinate Caspian seawater for use in Aktau for drinking and industrial purposes, 2) generate process heat for use in Aktau for commercial and residential use, and 3) generate electricity to supply power to the local area. The BN–350 was the first of a series of fast breeder reactors developed in the Former Soviet Union (FSU). The BN–350 achieved first criticality in 1973 and has been operational since that time.

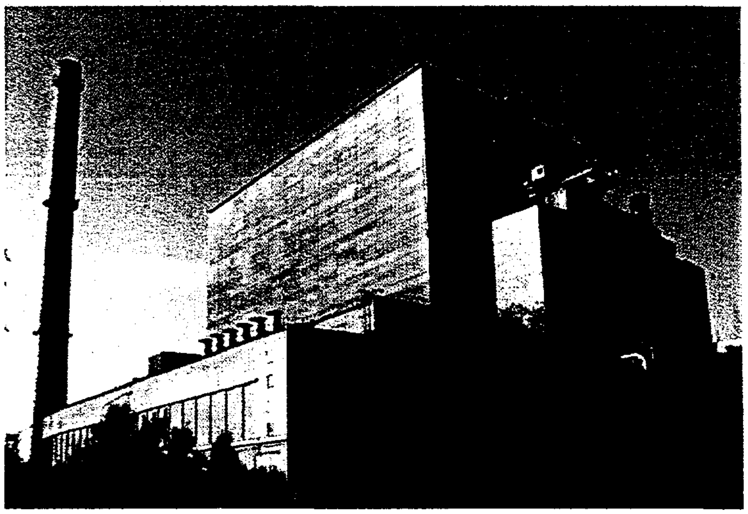

Figure 1. *BN–350 reactor exterior, Aktau, Kazakhstan*

The BN–350 reactor is housed in a single building located at the MAEC. This building contains the reactor, control room, spent fuel pond, hot cell facilities, office space, and other ancillary facilities required to operate the reactor. BN–350 fuel has been produced exclusively at the Elektrostal Plant outside Moscow, Russia, and is delivered by rail to the MAEC. Fresh fuel may be stored within the reactor building itself or in a separate secure fuel storage. The core or "driver" fuel elements contain $_{235}U$ enriched up to 26 percent; blanket elements contain depleted uranium. Until 1991, spent fuel elements were routinely returned to the Mayak Combine, north of Yekaterinburg, Russia, for reprocessing. As reported by the government of Kazakhstan in April 1998, the BN–350 is to be decommissioned in approximately 2003 and the spent fuel moved to dry storage at one of two candidate locations within the Republic of Kazakhstan [1].

Physical Protection Assistance Program

Following the 1995–96 survey and meetings, US DOE and Kazakhstani experts examined the existing physical protection systems and infrastructure and identified areas needing enhancements and long-term upgrades. Immediate enhancements were identified and implemented in the spent fuel pond area. Handheld metal detectors and radiation survey instruments were provided for security force use at the facility. To address and refine the details of the proposed long-term upgrades, a contract was issued to the BN–350 to develop a comprehensive plan which would identify the needs and desires of the MAEC for enhancing the physical protection features and capabilities at the BN–350.

Early in our collaborative activities, Kazakhstani government specified their desire for US physical protection equipment for use in Kazakhstan. In keeping with this desire, the team members in the joint upgrade study comprised US DOE and Kazakhstani experts as well as representatives of the Advantor

Corporation, a US physical protection firm with experience in Russia, Ukraine, and other FSU republics. Advantor is under contract to procure physical protection equipment and assist MAEC personnel with its installation at the BN–350.

As a part of this MPC&A activities in Kazakhstan, Advantor has developed an industrial relationship with an Almaty-based Kazakhstani physical protection and fire equipment firm. This firm is now under contract to provide the long-term maintenance support for the equipment supplied at Aktau for the BN–350 (as well as other facilities in Kazakhstan which have or will have Advantor equipment).

The joint upgrade requirement study was conducted in 1996. During the study, it became clear that although the MAEC possesses a multikilometer exterior concrete fence, clear zone, and sensored perimeter, the most cost-effective security benefits would be obtained from enhancing BN–350 security at target locations within the BN–350 and working outward. Therefore, the upgrade plan began with hardening the exterior doors, windows, and entrances to the BN–350 and fresh fuel buildings and working inward toward the material to be secured. No upgrades were provided or are planned for the MAEC exterior perimeter.

The study addressed specific areas at the BN–350 and recommended the following upgrades:

- procurement and installation of a new modern Central Alarm Station (CAS)
- enhancement to the existing personnel portals of the BN–350 building [2]
- installation of exterior lighting and cameras at the BN–350 building to provide security force exterior surveillance
- installation of surveillance and intrusion sensors within the BN–350 building itself
- implementation of a modern access control system for the BN–350 facility,
- improved and expanded communication capabilities for the BN–350 and MVD security forces
- hardening of the doors and lower floor window entrances of the BN–350 building
- training for pertinent physical protection personnel in equipment operation and procedures

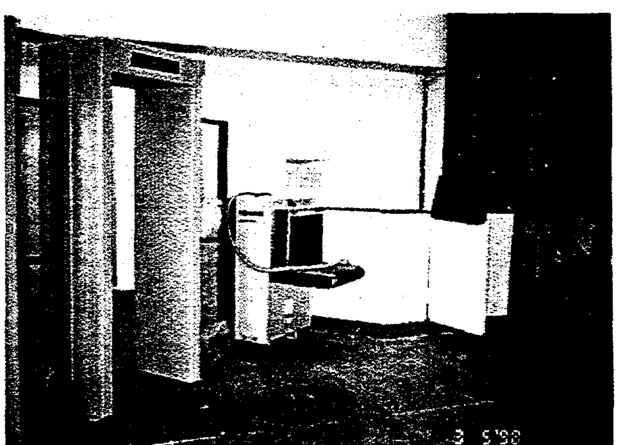

Figure 2. *BN–350 main personnel portal, showing package x-ray inspection equipment, metal detectors, and armored guard station*

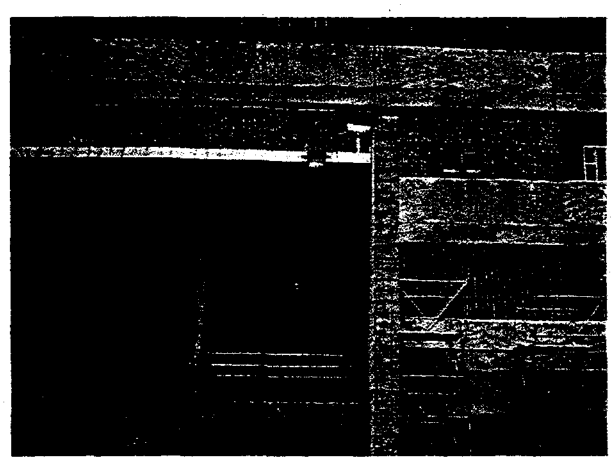

Figure 3. *Exterior of BN–350 entry portal showing window grating, exterior lighting,and exterior surveillance camera*

Concurrent with the development of these plans, BN–350 Kazakhstani personnel participated in US DOE-sponsored US physical protection courses to introduce US/Western physical protection methodologies, technologies, and philosophy. Representatives of the MAEC also visited US DOE facilities to become familiar with US policies, procedures, and installations. Kazakhstani physical protection experts also visited the United States and attended Nuclear Regulatory Commission (NRC)-sponsored courses relating to NRC physical protection philosophy and techniques. In November of 1996, a team of US DOE experts traveled to Aktau to conduct a vulnerability assessment on the proposed physical protection enhancements. Over a two-week period, MVD and BN–350 experts worked closely with their DOE counterparts to learn the vulnerability techniques being used and to apply them to the existing facility and to the proposed upgrades. The result has been useful in a number of areas. First, it validated the proposed upgrades. Second, it provided the facility another tool to conduct their own vulnerability analyses in the future. (A computer-based vulnerability assessment program, ASSESS, was provided to the facility.) Third, it demonstrated the effectiveness of the proposed plan to harden the target and then move outward.

Material Control and Accounting (MC&A) Assistance Program

In parallel with physical protection activities, the 1995 site survey trip also led to a vigorous multilaboratory MC&A effort to enhance the BN–350's MC&A capabilities. The thrust of US DOE MC&A assistance was threefold:

- Enhancing the capability to both calculate and measure the nuclear loss and production characteristics of the BN–350 reactor fuel assemblies
- Improving and computerizing accounting and control capabilities at the BN–350
- Installing an unattended radiation monitoring system in the fuel handling areas of the BN–350

A primary need identified by the MC&A team in 1995—confirmed by the BN–350 MC&A specialists—was the need for modern hardware and software to permit BN–350 personnel to calculate the nuclear isotopics and elemental composition (nuclear loss and production) of the BN–350 fuel (for both irradiated driver and blanket fuel assemblies) [3].

The US DOE experts addressed this issue by initiating a program to train BN–350 specialists in the use of internationally accepted computer software which was provided to the BN–350 as part of the cooperative activities. Modern replacement software consisted of a neutron cross section and flux solver codes from the Oak Ridge National Laboratory Radiation Shielding Information Center and the US DOE Argonne National Laboratory–West. A new Sun Systems computer workstation was provided to enhance the BN–350 experts' ability to continue their assessments in this area and to allow them to develop their own computational capabilities to perform future calculations. Training for computer code operation was performed both at facilities in the United States and Aktau during workshops and weekly telephone conferences between November 1995 and August 1997.

Once the workstation and computer programs were delivered, an extensive program was initiated to compare BN–350 data with international benchmarks, results from other computer models, software calculations, and available measurements. This validation effort continues today; in most cases, the comparisons are nearly complete. However, the planned comparison of the calculated isotopic values to experimental values of plutonium buildup and uranium burn-up for BN–350 assemblies is not yet finished. Specifically, the BN–350 has experimental values of nuclear loss and production for several driver and blanket assemblies must be compared with US and BN–350 calculated values. Additional experimental measurements may be conducted in the future using a DOE-supplied nondestructive neutron coincidence counter.

The BN–350 safeguards and MC&A procedures were not extensively computerized, and thus, needed additional documenting to be acceptable in an international environment. To assist with this task, a program was established and a contract placed with BN–350 personnel to allow them to document their existing accounting system. It also helped them to develop a formal plan and related procedures for safeguarding the facility's nuclear materials. US and Kazakhstani experts developed an outline to accomplish these objectives, and Kazakhstani experts then wrote the formal plan. This method ensured the integrity of the material accounting data and the development of appropriate procedures for the facility to use in the control of nuclear materials.

Unattended monitoring equipment was provided as part of the MC&A project to enable the facility management to detect improper activities involving nuclear fuel located in the spent fuel areas of the MAEC facility. One feature of this radiation-centric monitoring system is "intelligent sensor packages" that vary the frequency with which they acquire and store data. They simultaneously communicate with complementary sensors to improve data archiving when a sensor is triggered, which facilitates the subsequent retrieval of data. One future possibility is sensor sharing with the IAEA. Subsequent data review is facilitated by software that locates events of interest in large quantities of data and allows the user to access data from individual sensors.

Figure 4. *Operator's console of the unattended monitoring system as installed in the spent fuel pond control area*

Project Status

The project completion date for MPC&A activities at the BN–350 system is September 1998. At that time, the new physical protection system will be fully installed and operating, the enhanced communication capabilities will be operational, and the new BN-350 security forces will have been trained in its use. The unattended radiation monitoring system will be fully operational, and management will have been trained in its use. MC&A procedures will be documented and in use, and the computerized accounting system upgrades will be complete. All of the new systems will have Russian language interfaces and maintenance manuals.

However, the BN–350 program itself is not complete; two follow-on activities will be necessary. The first, and most important, entails periodic visits by technical experts to assist the facility to sustain and maintain the MPC&A enhancements which have been received. US DOE has extensive experience that illustrates long-term support is vital to maintaining any upgrades in facility MPC&A until the host country develops its own vigorous national regulatory system with audits, inspections, and funding for enhancements. The second activity is already in progress: irradiated fuel from the BN–350 will be packaged and transported to a long-term in-ground storage facility.

Conclusion

The cooperative MPC&A enhancement programs which have been conducted between the US DOE and BN–350 continue; future systematic assistance to these Kazakstani sites is planned and is intended to have the BN–350 facility meet its national and international requirements. It is expected that a much lower level of US support will be desirable to assist the facility as it takes ownership of these MPC&A enhancements, assumes routine maintenance, and develops its own improvements in a new culture of continuous self-improvement.

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