

CONF-970744-15

SAND97-1798C
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US Department of Energy (DOE)/Gosatomnadzor (GAN) of Russia

Project at the Petersburg Nuclear Physics Institute (PNPI)*

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Introduction

The Russian Academy of Science B. P. Konstantinov Petersburg Nuclear Physics Institute (PNPI), located 45 kilometers from St. Petersburg, operates facilities to research basic nuclear physics. Current world conditions require particular attention to the issue of Material Protection, Control, and Accounting (MPC&A) of nuclear materials. This paper presents a summary of work accomplished within the scope of the DOE-GAN Agreement to reduce vulnerability to theft of direct-use nuclear materials in Russia. Sandia National Laboratories is the lead DOE lab for this MPC&A upgrade project with PNPI.

Site Description

The Water-Water Research Reactor WWR-M has been in operation at PNPI since 1959 and is the Russian Academy of Science's principal reactor for basic research. The reactor operates at a capacity up to 18 Mwt, with a neutron flux greater than 10^{14} n/cm²/s.

In 1983, PNPI began operating the PIK Reactor Critical Assembly test unit with an operating capacity of 100 wt. The test unit is housed in the WWR-M complex and has been used to study different aspects of PIK reactor physics and technology and to substantiate issues relating to nuclear safety. Reactor personnel were trained in special techniques and technology for working with nuclear and special non-nuclear materials.

The Institute's chief prospect for growth is the construction of a high-neutron flux research reactor PIK, operating at a capacity of 100 Mwt and a neutron flux greater than 10^{15} n/cm²/s. The reactor will be a source of hot, cold, and super-cold neutrons and will have 8 neutron transport systems and approximately 50 positions on the beams. The reactor complex is more than 70 percent complete.

All fresh fuel for the PIK facility as well as the WWR-M fresh fuel is currently stored at the WWR-M facility. This fuel is in the form of rods—5 mm in diameter, 0.6 m in length, and contain 7 g of U²³⁵—or fuel assemblies containing up to 241 fuel rods. The total amount of U²³⁵ stored at the facility exceeds 100 kg. See Figure 1 for the relationship of the facilities at the PNPI Site.

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*This is a joint project of PNPI and Sandia National Laboratories in accordance with the U. S. Department of Energy-Gosatomnadzor Agreement signed by DOE Secretary O'Leary and GAN Chairman Vishnevsky in June of 1995.

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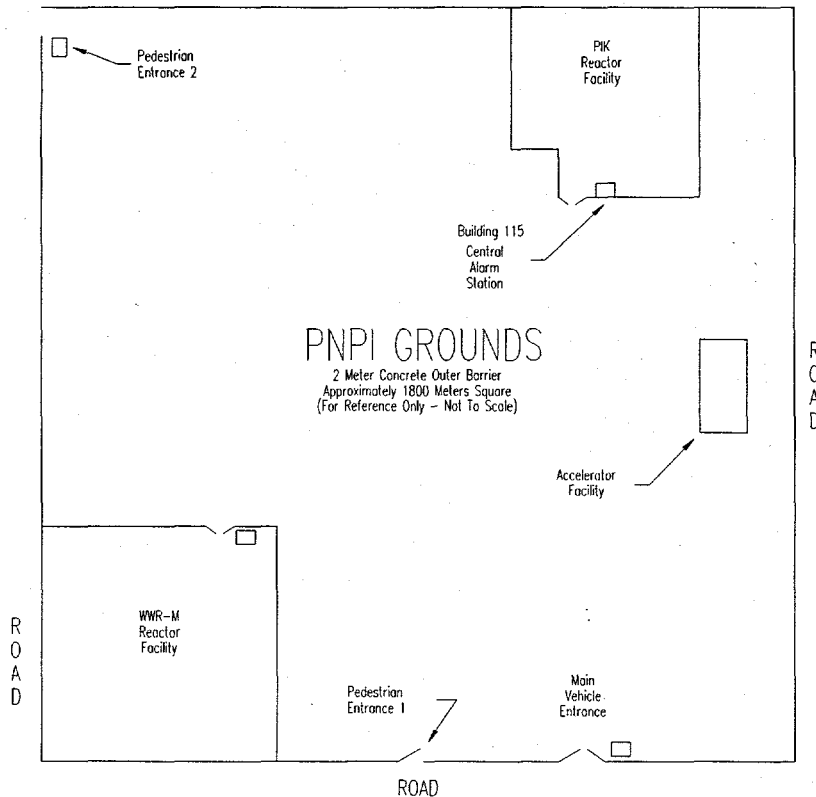


Figure 1. Representative layout of PNPI facilities

Project Description

Initially, to determine direction and define the project's basic phases, specialists from DOE visited PNPI to become familiar with the facility. As a result of that visit, a long-term plan was developed:

- Complete the WWR-M reactor building security perimeter to supplement an outer perimeter that already exists.
- Train PNPI specialists to assess the vulnerability of physical protection systems.
- Design and implement interior physical protection systems including personnel access controls, portal and SNM monitors, and interior intrusion sensors for the WWR-M reactor building.
- Design and implement upgraded exterior access controls, including pedestrian and vehicle portals and SNM monitors for the WWR-M reactor building.
- Design and implement an MC&A system compatible with the national system including control procedures, measurements, and computerized accounting for the WWR-M reactor building.
- Conduct a design review for MPC&A of the PIK reactor to identify areas for further cooperation.

The project was organized into three major efforts: (1) training, (2) physical protection upgrades, and (3) MC&A upgrades. The training and design phases were conducted primarily during the harsh winter months; actual field implementation occurred during the summer. MC&A activities are not directly affected by the weather.

Training

The following courses and workshops were presented to PNPI personnel:

- Basic Physical Protection July 1996
- Vulnerability Assessment Training November 1996
- Principles of MC&A February 1997
- Physical Inventory Taking (Dubna) April 1997
- Tamper-Indicating Devices and
Non-Destructive Assay June 1997

Figure 2 shows all scheduled MPC&A activities for calendar years 1996 and 1997.

ID	Task Name	3rd Quarter			4th Quarter			1st Quarter			2nd Quarter			3rd Quarter			4th Qua		
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
1	Design Phase	[Bar spanning from Jul 1996 to Mar 1997]																	
2	Training	[Bar spanning from Jul 1996 to Jun 1997]																	
3	Basic Physical Protection	[Small bar in Jul 1996]																	
4	Vulnerability Assessment	[Small bar in Nov 1996]																	
5	MC&A Fundamentals	[Small bar in Feb 1997]																	
6	PIT Workshop	[Small bar in Apr 1997]																	
7	TID & NDA Workshop	[Small bar in Jun 1997]																	
8	Interior Upgrades	[Bar spanning from Apr 1997 to Nov 1997]																	
9	Building Access	[Bar spanning from Apr 1997 to Sep 1997]																	
10	Storage Vault	[Bar spanning from Apr 1997 to Sep 1997]																	
11	Access Control	[Bar spanning from Apr 1997 to Sep 1997]																	
12	Exterior Upgrades	[Bar spanning from Jul 1996 to Nov 1997]																	
13	Perimeter	[Bar spanning from Jul 1996 to Sep 1996]																	
14	Perimeter Video Assessment	[Bar spanning from Apr 1997 to Sep 1997]																	
15	Entry Control Portal	[Bar spanning from Apr 1997 to Sep 1997]																	
16	MC&A Upgrades	[Bar spanning from Mar 1997 to Nov 1997]																	

Figure 2. MPC&A activities for calendar years 1996 and 1997

Physical Protection Upgrades

The physical protection system (Figure 3) was upgraded using an integrated approach to detection, delay, and response. This resulted in severely restricted personnel access to nuclear material while providing the most convenient environment for the experimenters. All activities aimed at enhancing the physical protection system were conducted in collaboration with the security forces and were immediately put into operation by them upon completion of the installation.

The first layer is the double-fenced perimeter with two lines of detection. Included in the perimeter was a vehicle portal with a crash barrier. The perimeter upgrades were completed and tested in September 1996. Video assessment capability is being added and is scheduled to be completed in September 1997. The assessment is currently accomplished by manning two guard towers 24-hours-a-day at opposite corners of the perimeter.

The entry control station on the perimeter is also being upgraded. This includes video monitoring of personnel before entering the portal, a badging system, metal detection, and special nuclear material (SNM) monitoring of personnel and packages. The entry control station is scheduled for completion in November 1997.

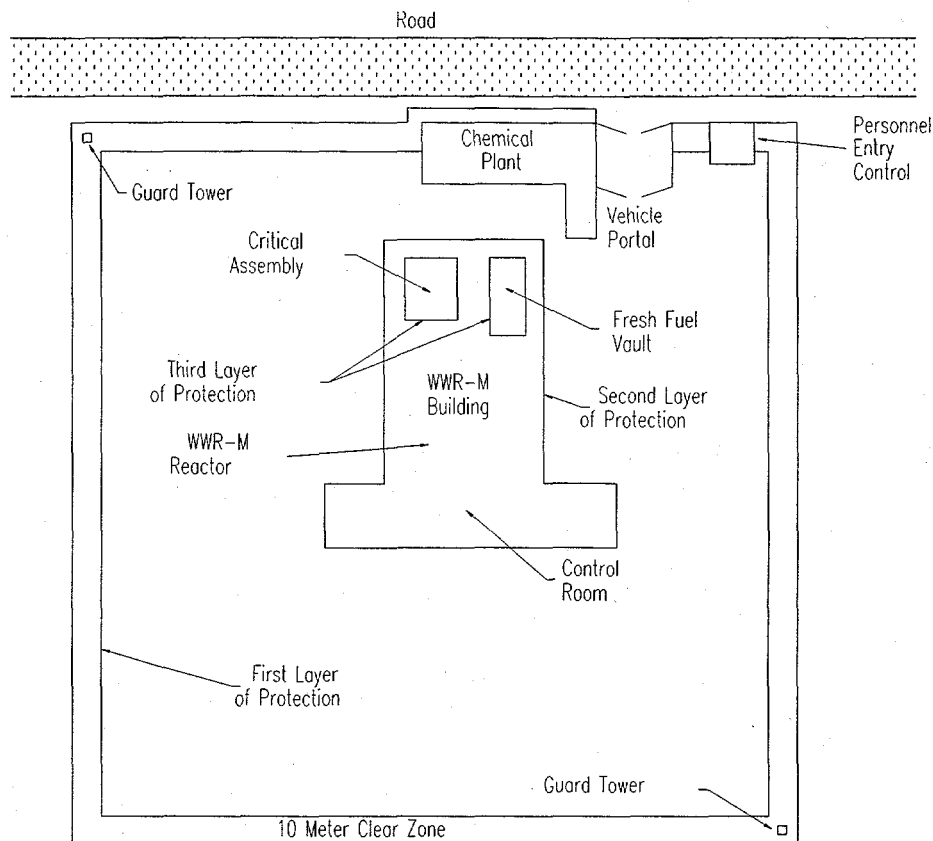


Figure 3. Three-layer approach to physical protection at the WWR-M facility

The second layer of protection is the building exterior. This second layer is scheduled for completion in September 1997 and consists of sensing and hardening doors, bricking up windows to the reactor hall, installing bars and sensors on all remaining windows, and closing roof entrances. Procedurally, all doors will remain locked and barred—entry will be restricted to one manned entry point where badging verification is conducted.

The third layer of protection is the materials storage vault and the critical assembly. These upgrades are to be completed by November 1997 and consist of replacing the doors with two layers of sensed steel doors; bricking up the windows, microwave sensors, video monitoring; and a separate entry control consisting of badging and personal identification numbers (PINs) coordinated with the guards at the Central Alarm Station (CAS). In

addition, chemical smoke generators are planned for the vault to increase delay times. The storage vault has been given the highest priority for the third-level protective measures.

By incorporating this three-layer approach to physical protection, the delay associated with the barriers and the detection at each stage far exceeds the response time for the response force housed less than half a mile away at the CAS.

In addition to lessening the possibility of theft of nuclear materials, an additional benefit of these security upgrades is the protection from sabotage and other external and internal actions that could affect vital safety systems.

Material Control and Accountability

The core of the MC&A system, still in the development stage, is a computer network. The operating software is Windows NT and SQL Server. The network accounting system will be programmed using Visual Basic and C++ languages. These software products were given tentative approval for use in the national reporting system. The staff at PNPI will program the computer network to conform to the national and site requirements.

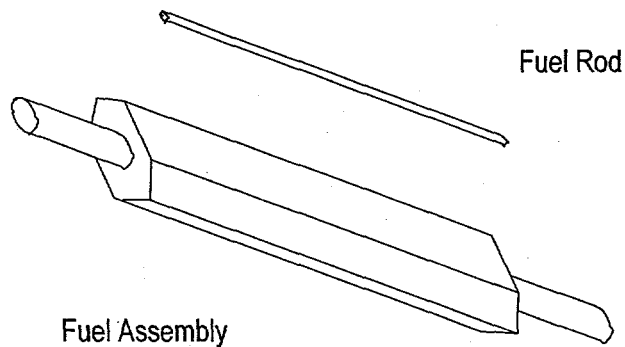


Figure 4. Examples of fuel rod and assembly
NOTE: For scale purposes, fuel rod is approximately 1 meter long

The computer network will track the inventory and movement of the fresh and spent nuclear fuel. As fuel arrives at the vault, it is characterized by gamma-ray spectroscopy and entered into the data base according to serial number and isotopic content and weight, (see Figure 4 for types of fuel elements). Part of the project is to provide scales and balances. Information from scales and balances that are directly connected to the computer network via RS-232 connection will be processed as part of the unique identification. The material will be tagged with a special proximity card and placed into the inventory for either the reactor or the critical assembly.

When fresh fuel is needed at the reactor, the computer processes requests to enter the vault from those individuals with proper authorization. The authorization will be verified by a

proximity card reader at the vault entry. The identification of the fuel that has been authorized to be removed is recorded manually and again automatically by the proximity card reader as the material passes through the vault exit portal. As the fuel assemblies pass the proximity card reader, a timer is automatically started in the computer.

When the fuel reaches the proper destination, the proximity card is read again, and the timer is stopped. If the fuel does not reach its destination within a preset time, a signal is generated and sent automatically to the CAS.

As the fuel is discharged from the reactor, it is sent to the spent-fuel storage pool. A radiation-hardened underwater camera will be placed in a location where the fuel can be viewed to verify the serial numbers. The spent fuel inventory will be verified using the underwater camera during routine inspections and special inspections for the regulatory authority.

Another aspect of the nuclear material control and accounting system will be the use of tags, seals, and tamper-indicating devices. The facility currently uses some of these devices, but the use of seals and tamper-indicating devices with unique identifiers will enhance the capability to track and control material as well as assist in the execution of inventory procedures.

Long-Term Sustainability

The systems for physical protection and MC&A will be accompanied by the appropriate procedures and training for each of the components. A contract will be put in place to provide semiannual testing and reporting of the system functionality for the first two years. Maintenance and operational costs will be minimal once the upgrades are made. The staff at the site is well qualified to maintain and upgrade the systems. Primarily, the PNPI staff is organizing the initial installation and will be able to sustain the operation. PNPI will take ownership of the system and provide for maintenance and replacement components from their operating budget or with help from the Russian Federation.

Conclusion

Once the above-listed upgrades and improvements are completed, the direct-use material at the site will have a greatly reduced vulnerability to theft. Using the three-layer approach to detection, delay, and response has enabled the guard force to respond to a threat in time to prevent theft. The MC&A system and procedures installed provide for a better control and accounting of the material and also greatly reduce the vulnerability to theft by an insider. The accounting of material will be computerized and will comply to the Russian federal standards. The MPC&A system was designed and implemented using International Atomic Energy Agency, GAN, and Minatom guidelines still under development.

The authors wish to extend special thanks to the following Russian specialists: V. Ilatovskiy, V. Kalinin, A.A. Kuz'min, M. Pak, E. Sigalev, S. Smol'skiy, and V. Khamov.