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BELOYARSK NUCLEAR POWER PLANT

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Overview

The Beloyarsk Nuclear Power Plant (BNPP) is located in Zarechny, approximately 60 km east of Ekaterinberg along the Trans-Siberian Highway. Zarechny, a small city of approximately 30,000 residents, was built to support BNPP operations. It is a closed city to unescorted visitors. Residents must show identification for entry.

BNPP is one of the first and oldest commercial nuclear power plants in Russia and began operations in 1964. As for most nuclear power plants in the Russian Federation, BNPP is operated by Rosenergoatom, which is subordinated to the Minsitry of Atomic Energy of the Russian Federation (Minatom). BNPP is the site of three nuclear reactors, Units 1, 2, and 3. Units 1 and 2, which have been shut-down and defueled, were graphite moderated reactors. The units were shut-down in 1981 and 1989. Unit 3, a BN-600 reactor, is a 600 MW(electric) sodium-cooled fast breeder reactor. Unit 3 went on-line in April 1980 and produces electric power which is fed into a distribution grid and thermal power which provides heat to Zarechny.

Unit 3 cooling is accomplished with three coolant loops: the liquid sodium loop provides primary cooling; a secondary sodium loop provides isolation; and the water-steam loop drives the three serial 250 megawatt turbines.

The entire plant is enclosed with an irregularly-shaped three kilometer long perimeter (Attachment 1). The main entrance to the plant is through one of two personnel entrances located along the west perimeter. The plant has approximately 1900 full-time employees and uses an additional 1600 contract and other support personnel who also have routine access through the BNPP perimeter.

The BN-600 core is fueled with uranium dioxide enriched to 17%, 21%, and 26%. The hexagonal-shaped fuel assemblies, consisting of individual fuel pins loaded with UO_2 fuel pellets, each contain 27 kgs of enriched uranium in the central core region and an additional 20 kgs of depleted uranium in the axial blanket regions. Fresh fuel assemblies arrive via rail transport from the fuel fabricator (probably Electrostal outside of Moscow). There are 369 fuel assemblies within the reactor core. Fuel assemblies weigh 100 kg. The nominal fuel burn-up is 10%. The reactor consumes 400 kg of uranium annually and produces an approximately equal amount of Pu^{239}.

In addition to the core fuel assemblies, 378 radial blanket assemblies surround the core. These hexagonal-shaped assemblies contain depleted uranium and plutonium. Radial blanket assemblies weigh 110 kg. Plant personnel had indicated that 100 breeder blankets are discharged annually, each containing 1 kg of Pu^{239}. Additional plutonium is also produced and discharged within fuel assemblies.

Spent fuel is stored within the spent fuel pool for a minimum of three years, while breeder blankets are stored in the same spent fuel pool, but ina different location, for a minimum of one year. After the appropriate holding period, spent fuel and breeder assemblies are

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shipped off-site via a special rail transport car for reprocessing at Mayak (Chelyabinsk-65).

In the reactor building, all refueling and defueling operations are perfomed remotely (Attachment 2). Assemblies received from the fresh fuel storage building are loaded into a fresh fuel drum via an elevator. The fresh fuel drum rotates fresh fuel and blanket assemblies into position over the reactor core. A lifting mechanism lowers the fresh assemblies into the reactor core. Spent fuel and blanket assemblies are removed in a similar manner, using a spent fuel drum. The fresh and spent fuel drums can each handle 69 assemblies. Spent fuel and blankets are remotely moved to the spent fuel storage pool. Approximately 180 assemblies are needed for a refueling operation.

<u>Facility Personnel</u>

Oleg SAREV	Plant Director
Valery BURKIN	Deputy Director and Head of Physical Protection
Nikolai OSHKANOV	Chief Engineer
Vladimir MALTSEV	Deputy Chief Engineer and Head of MCA
Mikhail BAKANOV	Reactor Workshop, Deputy Head
Valery ROSLYAKOV	Head, Department of Nuclear Safety
Arkady CHERNIKOV	Head, Laboratory of Nuclear Fuel (fresh fuel storage)
Alexander OGORODOV	Head, Laboratory of Fuel Assemblies)
Pavel MOKEENKO	Engineer, Laboratory of Nuclear Fuel
Konstantin DYACHKOV	Engineer, Technical Department

<u>Rosenergoatom Personnel</u>

Vladimir PLOTNIKOV	Head, Department for Nuclear Material Physical Protection
Donat PETRUNIN	Head, Department for International Activity
Viktor PITEL	Senior Expert, Department of Technical Supervision

<u>Fresh Fuel Storage</u>

Fresh fuel arrives from the fuel fabricator in specially designed railcars. Fuel assemblies are shipped in cylindrical shipping containers. Each shipping container holds only one fuel assembly and each railcar can carry 64 such shipping containers. Off-loading of the fuel assemblies occurs within the fresh fuel storage building. This building is a high-bay building and is long enough to accommodate an entire railcar. An electric crane is used within the high-bay to move fuel assemblies. The crane's main electrical power switch is kept locked in the off position until the chief engineer authorizes a movement of fresh fuel for a refueling operation. With appropriate authorization, electricians unlock the power switch and permit crane operation.

There is one personnel entrance into the building, while the railcar entrance consists of large wooden doors. Both entrances are secured with magnetic switches. The railcar entrance doors are also alarmed with surface penetration sensors. These doors are locked in place with a tie-down turnbuckle. The material custodian places the sensors in secure mode when the building is not occupied.

Upon arrival at the fresh fuel storage building, shipping container numbers are checked against the shipping documentation. Containers are sealed with a lead seal by the fuel fabricator. The containers themselves are not opened at this time. No measurements are performed. The containers are stored in racks in a 6-tier configuration; each row can hold 4 assemblies. There are 21 such racks in the building. However, not all racks were filled with shipping containers.

Logs are filled in for each assembly and their locations are indicated on maps. During the physical inventory, the containers are checked against the map. A random spot check is also performed: some containers are opened and the assemblies are compared to their passports. The facility minimizes the number of containers that are opened because as long as the container is under seal, the assembly is under manufacturer's warranty. Assemblies accumulate in the storage facility until they are needed for a refueling operation. When the assemblies are placed in intra-site transport containers the serial numbers are checked against the documentation. Each transport container holds 19 assemblies. A cover is put on and a seal is applied. The assemblies are mapped. The transport containers are loaded on a flat-bed railcar, which can hold up to three transport containers. All associated documentation is administratively controlled and there is limited access to the building. The facility indicated that they would like more advanced seals (NiCu or electronic). They would also like to have NDA instrumentation to measure enrichment and to determine if containers are empty or full.

Reactor Building Operations
The reactor building is a multi-story building and is identifable by a single exhaust stack. The BN-600 is located in the tallest portion of the building which also include the spent fuel pool and hot cell. The turbine hall and reactor control room are located in the long, narrow portion of the building. The building is located within 100 meters of the fresh fuel storage building.

There is a minimum number of ground-level, outside windows around the builidng. These windows are protected with what appear to be active infrared sensors located on the outside of the building.

Main entrance to the reactor building is through the south side, where an MVD guard controls access. There are also four doors for railcars on the north side of the building. One of these doors is located at the turbine hall poriton of the building and is used for transporting heavy equipment into and out of the turbine hall. The three other doors are located at the reactor portion of the building. In addition to providing maintenance access, theses doors are used for bringing fresh fuel in from the fresh fuel storage building and for moving spent fuel out.

During a refueling operation spent fuel and blanket assemblies are remotely off loaded using a lifting mechanism and the refueling elevator. Assemblies are lifted upward to a receptacle (part of the transfer cell) to the spent fuel drum. Assemblies are checked for leakage. Non-leaking fuel assemblies are transferred to a cleaning cell where any remaining sodium is removed. Leaking assemblies are dipped in liquid lead and sealed in special containers. All assemblies are then transferred to the spent fuel storage pool. The same fuel transfer mechanisms are also used to transfer spent fuel assemblies to the hot cell for examination.

The spent fuel storage pool is located at the northwest section of the reactor building. Personnel entrance to the storage area is at the 8.1 meter level. There is also a secondary personnel entrance to the storage area, but at a higher level. The pool extends from the 8.1 meter level down to about ground level. Spent fuel assemblies and blanket assemblies are transferred in from another entrance via an unloading mechanism from the core of the reactor. Assemblies ready to be transported off-site are loaded through the top a special rail transport car. This railcar is at ground level, below the spent fuel pool.

The storage area is a large high bay, with removable metal plates covering the pool itself. Both spent fuel assemblies and blanket assemblies are stored in the pool. The assemblies are stored in "baskets" which can hold 28 or 35 assmblies, depending upon whether the assemblies are blankets or spent fuel. Spent fuel assemblies are held in the pool for about three years, until they have cooled off enough for transport. Blanket assemblies are held for at least one year before they can be transported off-site. Current inventories in the spent fuel pool are estimated to be 650 blanket assemblies and 650 spent fuel assemblies.

Movements of material within the spent fuel pool all occur underwater and are performed with an overhead crane within the storage area. The crane is locked and requires approval from the chief engineer before it can be unlocked and used. Mechanical safety stops prevent the crane operator from inadvertantly lifting assemblies out of the water.

For transport off-site, specially shielded railcars are used. The railcars are top-loaded. For loading, the top of a railcar is positioned below an opening in the loading room. Each railcar can hold one basket of 28 or 35 assemblies. Documentation for each assembly accompany the shipment which are transferred to the receiver. No NDA is performed and the accountability values and isotopic data are based on calculations.

The hot cell, also located in the reactor building is used for examining spent fuel and blanket assemblies. The hot cell, located in room #14, is at the 7.5 meter level and extends to the 5.8 meter level. The room is relatively small, allowing only enough space for an operator and several incidental personnel.

Assemblies to be examined are loaded through the top of the hot cell. To allow examination, the ends of the assmblies are cut-off, exposing the ends of the fuel or blanket pins. The pins are kept in the same configuration and the nuclear material itself is not cut. Assemblies may be disassembled and the pins could go into two containers, even though the accountability unit is one assembly. The cladding of the pins are studied for dimensional changes. Gamma spec using a germanium detector is used to determine the distribution of fissile material. A neutron scanning device using a Cf^{252} source is used to look at the fuel column from the central opening. The criteria for which assemblies are sent to the hot cell are: (1) a leak or breach in the assembly, (2) any fuel assembly with maximum burnup or that has radiation damage, or (3) new experimental assemblies. The hot cell facility may handle assemblies that have been in the spent fuel storage pool for only one year. Only one assembly is handled at a time.

Assessment

MC&A

The plant relies upon procedures and administrative controls in many cases rather than technical means for control of nuclear material. Movements are recorded in paperwork and locations of assemblies are indicated on maps. The unit of accounting is one fuel assembly. Physical inventories of fresh fuel are done twice a year. In the spent fuel pond, they rely upon inventory control and identify assemblies by a periscope in a selective manner. In the hot cell area, a visual check is done. At each key measurement point a specific individual is responsible for MC&A. All movements are signed off by the chief engineer.

The facility needs a computerized accountability system where data are input at the Fresh Fuel Storage Facility, the Reactor Building (including spent fuel storage), and the Hot Cell. The centralized computer should be under the jurisdiction of Mr. Chernikov's organization, which oversees the entire MC&A for the plant. The plant also needs tamper indicating devices. NDA instrumentation is needed for both fresh and spent fuel. The accountability values would still be based on shipper's values for fresh fuel and calculated values for spent fuel, but they need some capability of confirming/verifying these values. There needs to be upgrades in their physical inventory taking procedures and general MC&A training.

Physical Protection

TBD

SF NIKIET

Overview

SF NIKIET is the Sverdlovsk Branch of NIKIET, Moscow. It is the research and development branch of the parent NIKIET and is primarily a design institute responsible for reactor design. It performs tests on reactor core elements and has hot cells for handling spent fuel assemblies. Central to its operations is a 15 megawatt IVV research reactor. The reactor is used for testing and studying design aspects of core elements and coolants. The institute also performs basic research on nuclear power plants, space propulsion, and determines characteristics of non-Russian reactors. Reactors coolants are tested from 40-60 °C and up to 3000 °C for space-based reactors. Tests performed on spent fuel elements received from Russian nuclear power plants include non-destructive and destructive assays, mechanical tests, and metallurgical tests. These tests are perfomed in the hot cell building, where test samples are also stored.

The reactor has been in operation for 30 years and is expected to have another 20 to 25 years of useful life, pending approval from GAN. The reactor is described as a modernized IRT pool-type reactor and uses similar fuel assemblies. The core consists of 36 fuel assemblies containing uranium enriched up to 96%. Each assembly has 225 grams of uranium. The institute has a cooperative RERTR (Reduced Enrichment of Research and Test Reactors) project with Argonne National Laboratory to convert the reactor to burn low enriched uranium.

The institute is located just northwest of the BNPP and shares a portion of its 800 meter long perimeter with the power plant (Attachment 1). Though not subordinate to the BNPP, it receives utilities (power and heat) from the plant and also relies upon the plant to handle its waste.

Nuclear material is at three locations within the institute: 1) fresh fuel storage vault; 2) in-core and spent fuel storage in the reactor building (Building 105); and 3) the hot cell facility in Building 102. The material control and accounting function is performed by a single department within the institute. There one material custodian at each of the three material locations.

The institute had started contruction of a new central storage facility for consolidated storage of both fresh and spent fuel. This four story building was 90% complete when consturction was stopped three years ago due to lack of funds.

The institute employs approximately 500 personnel. These personnel enter the institute through one main entrance located in Building 110, where an MVD guard controls access. There is a secondary entrance at the north perimeter, where a garage (Building 109) is located. An MVD guard is also at this location.

Facility Personnel

Victor PEREKHOZHEV	SF NIKIET Director and NIKIET, Moscow Vice-President
V. BARSANOV	Chief Engineer
Vassily TYULEYKIN	Head of Physical Protection

Sergey Morkovkin Head of Material Storage and Transport (MC&A)
V. Rychkov
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Fresh Fuel Storage

Fresh fuel is stored on the fourth floor. It is stored in a vault-like room with thick concrete walls, has interior floor dimensions of approximately 24 feet by 24 feet, and is the only room on this floor. The rest of the floor provides utility access for ventilation ducts and pipes. The interior of fresh fuel storage vault consists of two separate rooms. Fresh fuel is stored in each room. Entry to the room is through a single metal-covered wooden door. Interior sensors consist of a surface penetration sensor on the door, a magnetic switch on the door, and a volumetric sensor, possibly microwave.

The fuel is stored in one of two types of metal shipping containers. Older type containers are rectangular shaped. Newer containers are cylindrical drums. Additional fuel may be stored in metal cabinets. The newer containers can hold eleven assemblies. Drums use plastic seals for tamper indicating devices. String and wax seals are used for tamper indicating devices on the cabinets. The facility can store up to 200 fuel assemblies. The two person rule is observed for access to the fresh fuel. A physical inventory is performed once a year on October 1, by a special commission made up of representatives from various departments. The physical inventory is compared to the book records. There are only items; no bulk material is handled. The inventory is based on item counting, tags checks and gross weighing. Quarterly inventories are also done by another commission.

Upon receipt, containers are unpacked and physical and visual checks are done. The engraved numbers are compared to the paperwork. All documentation is done in duplicate; one copy is left at the storage facility, the other is sent to the central accountability section. There is an MC&A card for every accountable item. Every change (e.g., location change, transfer, shipment, splitting, irradiation) is documented. Personnel must have permission for access to material. Documentation is kept in a metal safe.

Fuel assemblies are 750 mm long and have a gross weight of 8.5 kgs, containing 225 grams of HEU. At the time of the visit, there were 96 fresh fuel assemblies for a total of 20 kgs of HEU. The fuel fabricator in Novosibirsk supplies fuel to the institute on a yearly basis.

Reactor

The reactor is located in Building 105 (Attachment 3). One MVD guard controls access to the reactor building. The reactor is a 6.5 meter deep pool-type reactor with a core composed of six subcritical assemblies. Each subcritical assembly, in turn, is made up of six fuel assemblies and two control rods. The active zone of the core is 500 mm.

The reactor runs on a two week operating cycle, which may vary depending upon the research and testing programs. Last year, the reactor experienced 7,000 hours of operation.

The reactor's spent fuel pool, located adjacent to the reactor, can hold 142 assemblies and is 5 meters deep. Currently, there are 42 spent fuel assemblies in storage. If spent fuel is removed from the pool, radiation alarms sound at the central alarm station. In addition, there are dry storage cells located near the spent fuel pool. All material movements are done in the presence of the shift supervisor.

Hot Cell

The hot cells, located in Building 102 (Attachment 4), is accessed through an elevated pedestrian walkway connecting Building 101 with Building 102. At the entrance to this walkway, an unarmed civilian guard controls access to the hot cells.

There are two lines of hot cells with 7 cells in each line. The end cells in each line are the receiving cells. Spent fuel assemblies to be examined are loaded the tops of the receiving cells. There is a service floor on top where material is loaded. Material is transferred from the service floor by crane into the hot cell. After initial study in the receiving cell, items are transported to another cell where fuel elements are sectioned and studied. Every stage of transfer and every change in the item is recorded. Documentation must be certified by two of the material custodians. When items are not being worked on they are placed in the hot cell storage vault for intermediate storage. The storage limits are 670 grams U^{235} in each of the receiving hot cells as well as in the segmentation hot cell, and 300 grams U^{235} in the other chambers that handle the segments. If the spent fuel assembly is intact, the load limit is 2 kgs. When fuel elements are segmented, the individual samples are renamed. Material is sent back to the place of origin with the appropriate changes.

There is also a dry storage facility below the ot cell lines, which is managed and controlled by the hot cell staff. Locations of material are noted on a map and data are also recorded in logs for each item. The dry storage consists of two rows of of 150 mm diameter storage cells. There are 22 such cells. The limit per cell is 300 grams of U^{235} and Pu. There is also one row of 300 mm diameter storage cells with a per cell storage limit of 500 g U^{235} and Pu. There are 21 such cells. No two adjacent cells may contain nuclear material. The cells are sealed and require the approval of the hot cell facility supervisor and material custodian to approve material transfers.

For material transfers between cells, a transfer channel interconnects the cells within a line. A material transfer cart carries material from cell to cell. An electronic key is required to operate the cart. Keys are kept by the shift supervisor and material custodian. The keys are kept locked in a safe during non-working hours.

The hot cells have gamma spectrometry equipment and they will soon have mass spectrometer capability. There is no wet chemistry performed on the spent fuel assemblies.

A physical inventory of hot cell material occurs yearly, but more frequent inventories may also occur. There are also quarterly in-house inventories.

Assessment

MC&A

The facility needs a computerized accountability system. The facility also needs tamper indicating devices; it still needs to be determined whether these would be metal seals or some type of electronic seals. The facility also needs NDA instrumentation and possibly scales and/or balances. There needs to be upgrades in their physical inventory taking procedures and general MC&A training. The hot cell area appears to already have a good paperwork system for accountability and it may be relatively easy to transfer this to a computerized accountability system.

Physical Protection

TBD

ATTACHMENTS

1. BNPP and SF NIKIET buildings
2a. BNPP Fuel transfer (top view)
2b. BNPP Fuel transfer (side view)
3. NIKIET Buildings
4a. Hot cell floor plan (first floor)
4b. Hot cell floor plan (second floor)
4c. Hot cell floor plan (third floor)