NUCLEAR POWER IN KAZAKHSTAN and CURRENT STATUS OF THE BN-350 FAST REACTOR

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Atomic scientific-industrial complex of Republic of Kazakhstan consist of:

_Uranium mining, production and power industry:_

- Enterprises of uranium ores geological searching and number of natural mines (using the mining and underground leaching techniques);
- Two plants of U$_3$O$_8$ production at Aktau and Stepnogorsk towns;
- Metallurgical plant producing uranium fuel pellets for fuel assemblies of RBMK and VVER reactors types;
- Energy plant at Aktau (MAEK) is used for production of heat, electricity and desalination of water and based on three energy blocks using natural gas and one nuclear unit with fast breeder reactor BN-350. The fast breeder reactor BN-350 at Aktau was commissioned in November 1972 and finally stopped in April 1999.

Three different type of the research reactors on the territory of the former Semipalatinsk Nuclear Test Site and one research reactor and sub critical assembly nearly Almaty are exploiting for the investigation in field of reactors nuclear safety and other type of investigations

_These are:_

- VVR-K - light water reactor, power - 10 MW. Reactor was run in 1969, temporarily stopped in 1988 to perform some steps to improve seismic resistance level (located near Almaty);
- EWG-1M - thermal light water heterogeneous vessel reactor with light water moderator and coolant, beryllium reflector, maximum thermal power - 35 MW, period of continuous operation at the power 35 MW is 4 hours;
- IGR - impulse homogeneous uranium-graphite thermal neutron reactor with graphite reflector. Maximum heat release is 5.2 GJ (1 GJ in a pulse), maximum thermal neutron flux $0.7 \times 10^{17} \text{ cm}^{-2}\text{s}^{-1}$;
- RA - thermal neutron high temperature gas heterogeneous reactor with air coolant, zirconium hydride moderator, and beryllium reflector. Thermal power is about 0.5 MW.
BN-350 current status:

- Decision of the Government No.456 from April 22 1999 on BN-350 final shutdown and decommissioning had been taken.
- "Plan of the high-priority nuclear safety measures on decommissioning stage" (plan duration up to July 2003) has been approved. The Plan includes measures on three main directions: overall decommissioning planning, core unloading, sodium drainage and procession, key safety issues during transition period.
- "Specific Technical Requirements on decommissioning planning" and "Organisational scheme on the design of decommissioning works" have been approved in January 2000.
- Since February 2000 the program of the core unloading has been started and full unloading and assemblies packaging have been completed at November 2000 (Pic.1).
- Preparation works for sodium cleaning, drainage, procession and waste management program are going ahead under Kaz-US, EC, Russia bilateral agreements (technologies development, documentation...).
- Works on spent fuel management going on under US-Kazakhstan agreement (packaging, stabilisation, long term storage technologies development, some transportation issues).
  Cask for transportation should be delivered by Russia.

**Brief description of the project on BN-350 spent fuel.**

A dry storage in non-deep pits has been chosen for a long-term reactor BN-350 spent fuel storage. Realizing the method the spent fuel assemblies' storage (SFAS) are placed in sealed cases. The SFASs are packed into the cases in the plant's repository on reactor BN-350 (Fig. 1, 2). In conformity with the agreed technology the assemblies, by six items, are, first, installed into the inner cases, which, in their turn, by six, are loaded in the baskets. The baskets are located in the pool of the reactor spent fuel repository. The assemblies are stored in such a way for some period up to the shipping cask arrival to reactor BN-350. After shipping cask arriving the inner cases with the assemblies are taken away from the baskets, washed, dried and installed into the outer case. The case is closed with a lid welded to the case's housing providing for sealing and eliminating an unauthorized access to the fuel. A corresponding calibration is made on the case, and then a check sealing is made. The sealing allow to control the fuel preservation and guarantees that any unauthorized try to open the case and to take the fuel away will be detected and suppressed timely.

The SFAS cases are loaded into the shipping cask and transferred to the «Baikal-1» stand complex site. Here their conditions are examined. They are unloaded from the shipping cask and installed into the pits for a long-term storage.

The pit is a vertical drifting into the earth from the ground surface. The drifting's diameter is 630...650 mm and 5500 mm in depth. The pit is cased with a carbonic steel tube. The tube diameter is 630 mm, and wall thickness - 10 mm. To prevent the casing tube corrosion every pit is equipped with a cathode protection system. After the SFAS case installation in the pit the tube is closed with a welded lid. A concrete plug providing for additional radiation protection and making difficult an unauthorized access to the pit and to the case with the fuel, is installed on the pit.

The offered technology for the spent fuel storage and the design of the case and the pit are allowed for the formation of some sequential barriers on the path of the radioactive products release and scattering of ionizing irradiation. This approach provides a high safety for the repository complex, personnel, population, and also, with the required reliability rate, eliminates environmental pollution.

The technology for packaging spent assemblies with unsealed and failed pins somewhat differs from the described above because each assembly with failed pins is placed into a separate
sealed cask. The casks with failed pins SFAS are installed into the inner case by four. In other respects the technology for packaging the assemblies with failed pins is the same as for the assemblies with un-failed pins. The individual sealed cask is an extra protection barrier instead of the failed pins' cladding. This approach provides with a presence of three protection barriers on the radioactive products release path in shipping and storage the reactor BN-350 spent fuel.

Calculations on safety validity during packaging and storage

The neutron & physical calculation (NPC) and the calculation of temperature fields (CTF) of the spent assembly cases for various loading configurations and external boundary conditions have been made. The conservative approaches and estimates were used during the statement of calculation problems and construction of the design models. To raise the reliability and results validity the NPC was made by two independent expert groups using various calculation codes. The calculations were made for packaging and interim storage in the reactor repository pool on BN-350 site, because the package configuration providing for nuclear safety in the specified conditions, will be absolutely sub critical under fuel storage conditions in non-deep repository pits. The thermal calculations have been made, on the contrary, for the conditions of the assembly cases location in the repository pit complex when the worst mode for fuel cooling is taken place.
Loading And Drying Of BN-350 Spent Nuclear Fuel Will Take Place At The Plant
BN-350 Packaging of Spent Fuel

Requirements:

- Criticality safe
- Multiple barriers to release of fission products
- Inert, dry environment for fuel
- Large physical size and mass
- Radiation level which qualifies as self-protecting
- Lifetime up to 50 years
Picture 1. Final reactor core map