SPENT NUCLEAR FUEL IN BULGARIA

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Abstract

The development of the nuclear energy sector in Bulgaria is characterized by two major stages. The first stage consisted of providing a scientific basis for the programme for development of the nuclear energy sector in the country and was completed with the construction of an experimental water-water reactor. At present, spent nuclear fuel from this reactor is placed in a water filled storage facility and will be transported back to Russia. The second stage consisted of the construction of the 6 NPP units at the Kozloduy site. The spent nuclear fuel from the six units is stored in at reactor pools and in an additional on-site storage facility which is nearly full. In order to engage the government of the country with the on-site storage problems, the new management of the National Electric Company elaborated a policy on nuclear fuel cycle and radioactive waste management". The underlying policy is de facto the selection of the "deferred decision" option for its spent fuel management.

1. STATUS AND NEW REALITIES

The development of the nuclear energy sector in Bulgaria is characterised by two major stages that are inextricably bound up with the prospects for use of atomic energy for peaceful purposes in the former socialist system and is based on the technical and economic support provided by the former Soviet Union.

The first stage consisted of providing a scientific basis for the ambitious programme for development of the nuclear energy sector, elaborated by the former communist Government in the country and was completed with the construction of an experimental heterogeneous, water-water reactor (IRT-type reactor with a heat output of 2 MW) at the Institute of Physics of the Bulgarian Academy of Sciences (BAS). The reactor core consists of forty-eight aluminium-coated assemblies which contain 10% or 36% enriched uranium oxide fuel. The reactor was commissioned in September 1961 and operated for 24,600 hours. In July 1989, the reactor was shut down for the implementation of a modernisation and refurbishment programme.

The spent nuclear fuel (SNF) stored during that period of operation amounts to 73 assemblies (totalling to 184 kg heavy metal) of which 57 assemblies are of the type EK-10 with an enrichment of 10% and 16 assemblies of the type C-36 with an enrichment of 36%. At present, this spent fuel is placed in a water filled storage facility, built within the reactor biological shield. The facility can store 112 assemblies of the EK-10 and C-36 type. According to information received from the governing body of the Institute for Nuclear Research and Nuclear Energy to the BAS, the spent fuel from this reactor will be transported back to Russia, within the scope of the contract for transportation of Kozloduy NPP spent nuclear fuel.

The second stage of that programme started with the commissioning of the first unit of the NPP at Kozloduy in 1974 and is continuing up to now. At present, six VVER-type reactors are being operated on the site. The first four units have each a capacity of 440 MW(e) and the other two units each 1000 MW(e). In addition, the construction of another 1000 MW(e) reactor is being planned.

According to their design, the reactor core of the VVER-440 units consists of 312 fuel elements and 37 control rods. Measures for reactor vessel protection against neutron embrittlement were taken and the fuel assemblies along the core periphery of the first three units were replaced by dummy assemblies. That resulted in a reduction of the number of the reactor assemblies by 36. On the average, 400 spent fuel assemblies are annually discharged from the four reactors and are stored according to their design in at-reactor pools for three years. Pursuant to an intergovernmental

agreement, they are subject to return to the country of origin, i.e. the former Soviet Union. 3,086 VVER-440 spent nuclear fuel assemblies were sent back under this agreement on a zero value basis during the period 1979-1988.

Already in 1979 through the COMECON, we were notified of a change in the storage period of the spent fuel from 3 to 5 years and, due to that reason, an additional pool-type storage facility of Soviet design was built (Figs. 1 to 3). Some of the operational safety features are shown in Fig. 4. In 1989, the first assemblies were placed in that. storage facility, but yet it has not been licensed by the Bulgarian Nuclear Regulatory Agency owing to a number of discrepancies with the new safety requirements. Spent nuclear fuel storage is authorised through temporary permits which are renewed annually. For the current year, a temporary permit was granted provided the amount of spent fuel stored will not increase. This means that the same quantity of spent fuel to be taken out of the at-reactor pool and transported to the spent fuel storage facility must be pulled out of the spent fuel storage facility and sent back to Russia for reprocessing. The second condition is to start the implementation of its modernisation and refurbishment programme envisaging seismic stabilisation, installation of additional equipment needed for handling spent nuclear fuel generated by the VVER-1000 units and possibly maximize the packing of the basins. Both conditions are met and a Framework Agreement was concluded for the return of 480 VVER-440 assemblies to Russia by the end of this year and the implementation of the programme for modernisation and refurbishment of the spent fuel storage facility has started.

The core of the VVERs-1000 consists of 163 fuel assemblies which have a 3.3% enrichment and a mass of 430 kg HM. Unit No.5 has been in operation since 1987 and Unit No. 6 - since 1991. Each year, half of the core is discharged and the spent fuel assemblies are stored in compact racks in the at-reactor basins. Last year, refuelling of the reactors has started on a three year cycle basis which will reduce the quantity of spent fuel to be stored by 30%.

Table I shows the quantity of spent nuclear fuel stored to date at the plant site and the forecasted quantities until the end of the units' design life assuming an optimum use of the fuel and conversion to high burnup fuel.

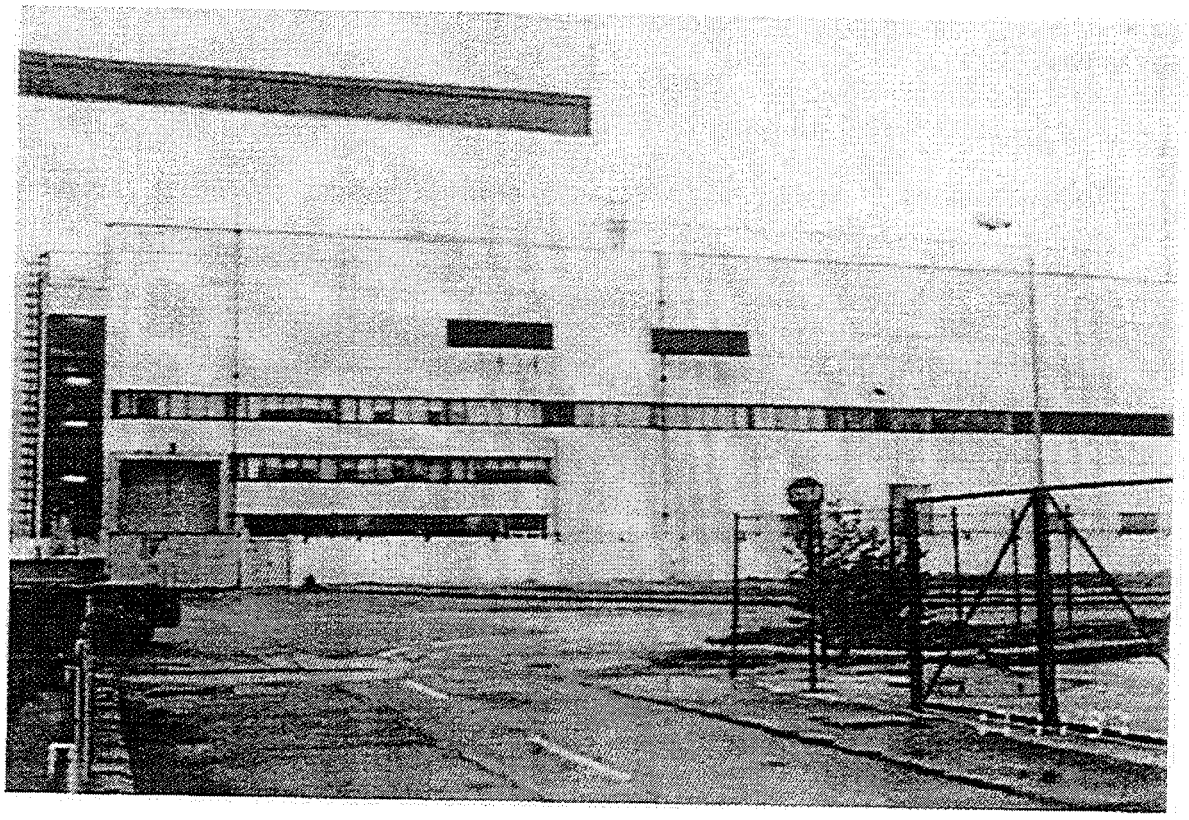

FIG.1. On-site pool-type storage facility

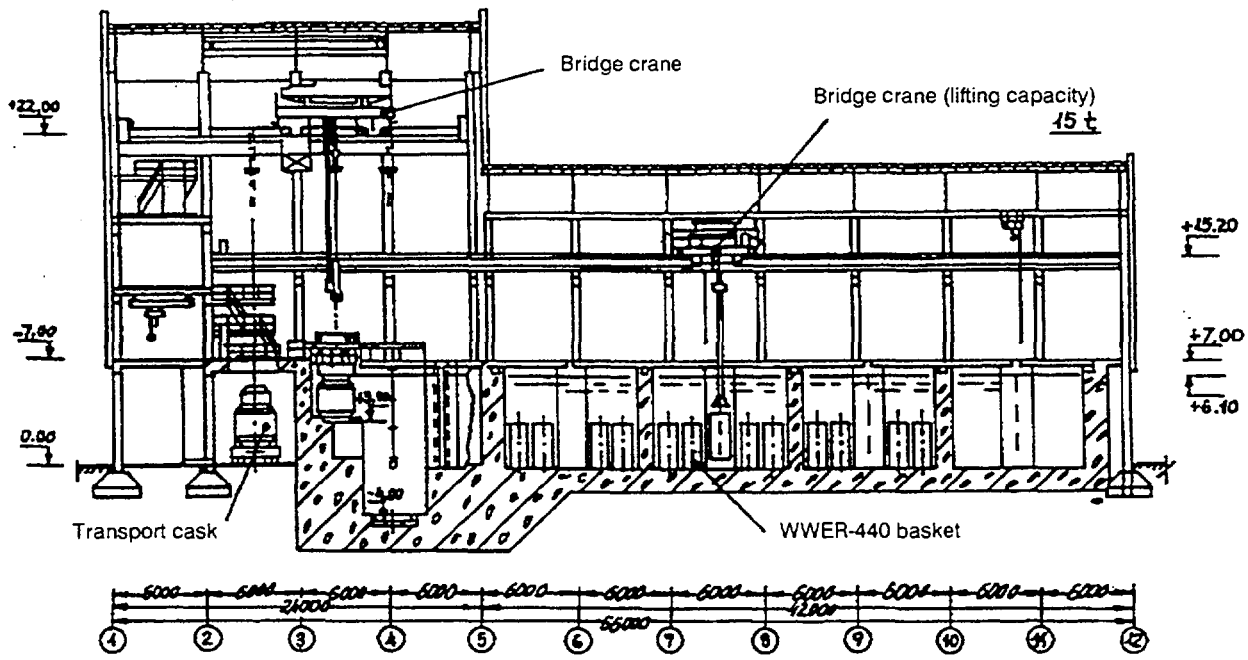

FIG.2. Vertical cross section of the pool-type storage facility

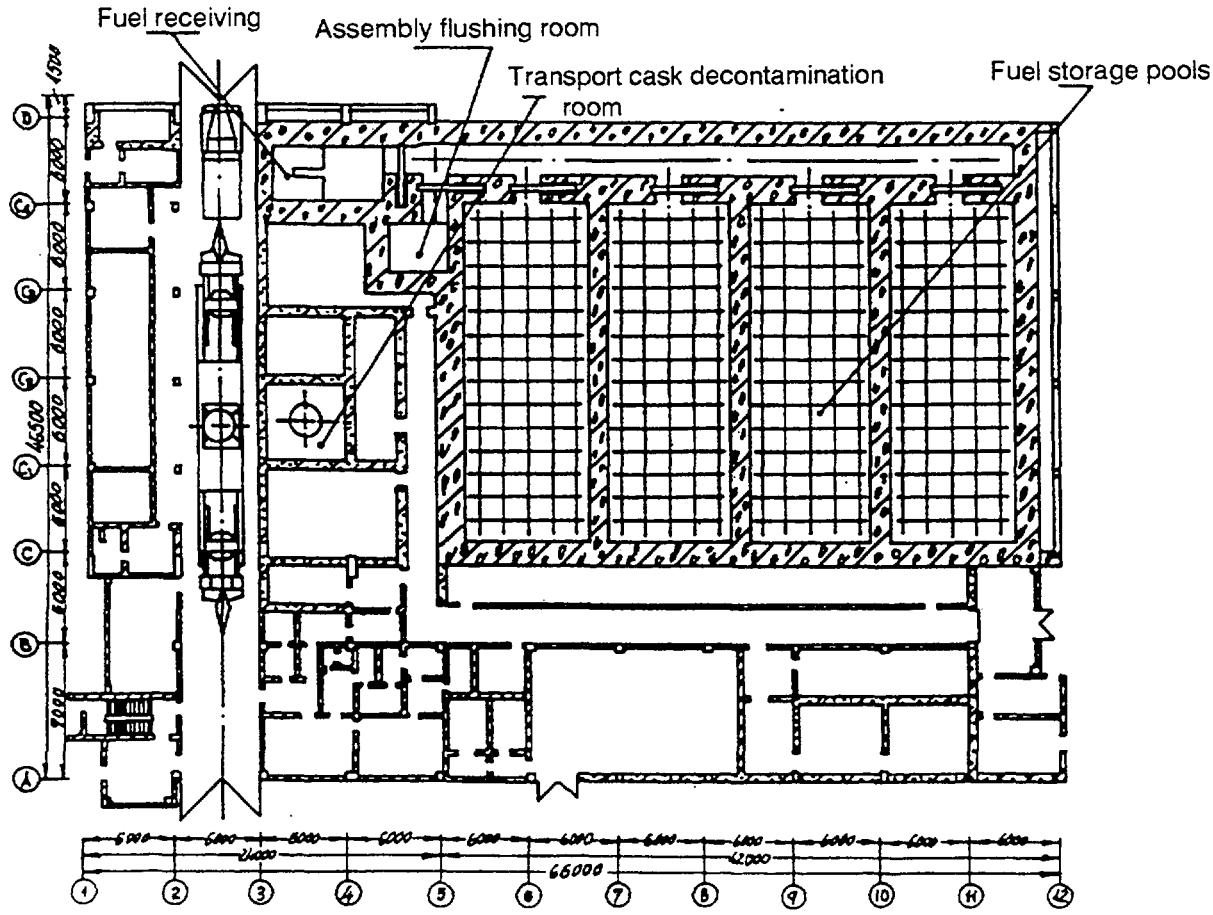

FIG.3. Horizontal cross section of the pool-type storage facility

⌑ Operational Safety

- Protective layer of demineralized water - 2950 mm
- Distance between the baskets - 1600 mm
- Prevention of occasional water discharge
- $t \leq 45°C$
- Water purification system
- Leak detection system
- Remote temperature, water level, radiation measurement
- Decontamination equipment
- Transport in containers
- Two independent safety assessment reports

FIG. 4. Operational safety features

After facing the problem of licensing the additional storage facility and proceeding with transportation of fuel back to Russia at international prices, the management of the National Electric Company (NEK), which is the plant's operator, has tried to solve the problems by inviting bids for construction of a dry spent nuclear fuel storage facility. The bidding process is not finalised yet because of some organisational reasons, one of which is the absence of an agreed government strategy for the SNF management.

In order to engage the government of the country with this serious problem and meet the new requirement resulting from the conclusion of the Convention on "Safe spent nuclear fuel and radioactive waste management", the new management of NEK elaborated a "Policy on nuclear fuel cycle and radioactive waste management" which outlines the trends in this field till 2010 in prospect. This policy considers the prospects of development of the nuclear energy sector during the period when the first units of Kozloduy NPP will be decommissioned and replaced by new capacity.

Under the effective legislation in Bulgaria the spent nuclear fuel is not treated as waste as a result of which all activities related to its management in the future should provide for its re-extraction from reprocessing. This means that for the time being the country takes the so called suspended solution underlying the policy on its management.

The policy on spent nuclear fuel sets as primary objectives the requirements to use new, improved fuel of higher reliability and quality, prolonged service life and fuel burnup that would provide a possibility of maximum reduction of costs for storing the spent nuclear fuel on the plant site. This will result in asking for new manufacturers of fresh nuclear fuel in Russia and in the world.

Adoption of such policy by the national Government would allow for accelerated completion of the actions taken with regard to the construction of a new dry spent nuclear fuel storage facility on the plant site and starting the project for construction of a new national storage for the radioactive wastes from the spent nuclear fuel having been returned to Russia for reprocessing.

TABLE I. PROJECTED NUMBER OF DISCHARGED SPENT NUCLEAR FUEL ASSEMBLIES OVER THE DESIGN LIFE OF THE NPPs
(3-year fuel cycle)

Year	VVER-440	VVER-1000
prior years and 1997	4,300	619
1998	415	132
1999	430	109
2000	429	108
2001	429	109
2002	430	109
2003	429	108
2004	429	109
2005	638	109
2006	533	108
2007	221	109
2008	221	109
2009	220	108
2010	221	109
2011	221	109
2012	429	108
2013	349	109
2014		109
2015		108
2016		109
2017		109
2018		108
2019		218
2020		54
2021		54
2022		55
2023		163
Total assemblies:	**10,034**	**3,468**
Total mass tHM	**1,200**	**1,400**

At present, action is being taken in three directions as follows:

- reconstruction of the additional storage facility of basin type in order to receive a licence from the National Regulatory Agency;
- maximum packing of the at-reactor basins of the first four units;
- return of limited quantities of spent nuclear fuel to Russia.

On the first direction, a project of EBRD through the Phare Programme is under way which is implemented by Bulgarian firms and its completion is planned by the end of the following year by getting a licence from the Bulgarian Regulatory Agency.

A decision on whether to pack the basins to the highest possible degree within this storage facility or to extend it with new adjacent basins is at hand.

On the second issue, a tender for a contractor who will pack the at-reactor basins of the first four units is in progress. The difficulties, we face, are only organisational since the plant management is not certain in the expedience of this work.

On the third direction, there is already a Framework Agreement for return of 480 assemblies from VVERs-440 to Russia in place and at the end of September the first shipment of 8 TK-6 canisters containing 240 assemblies will be transported. The canisters will be loaded on a barge following the existing transport route - Kozloduy NPP port, Reny port where the canisters will be reloaded on railway wagons and transported across the territories of Moldova and Ukraine to the reprocessing plants in Russia. Recently, with the establishment of Moldova and Ukraine as independent states, Bulgaria encounters serious difficulties in settling the problems with the transit of the nuclear materials via their territories. With regard to this, the policy sets as an objective to change the transport route envisaging delivery of SNF canisters to a sea port on the territory of Russia.

The economic analysis of the various options for implementing the new policy shows that the costs are within a range of 200-800 million USD. In case of maximum use of the at-reactor basin capacity of the first four units and of the additional on-site storage facility after their refurbishment and packing, the costs will be the lowest. Return of the total quantity of SNF from the first four units (10,166 assemblies) for reprocessing in Russia and construction of a new dry spent nuclear fuel storage facility for VVER-1000 will entail the greatest expense. The last option will be implemented only if the other options cannot be realised within the set time frame and temporary suspension of plant operation is enforced.

The policy does not consider an option of direct disposal of SNF, because it is regarded that there are no suitable geological formations on the Bulgarian territory where such a repository could be build. The fate of leaking SNF assemblies is not decided either and there is no decision taken for their return to Russia for reprocessing. Most probably they will have to be disposed as radioactive waste.

In conclusion one might say that it will be difficult to make up within the next year and a half before the new century for the time lost in the last 10 years when problems with the SNF were not resolved. Such speedy actions will require significant amount of financial and material resources which the plant does not have now and we hope that by approving the Policy on Nuclear Fuel Cycle and Radioactive Waste management developed by NEK, the Government will do everything in its power to settle these difficult problems.