SCHEME OF HIGHER-DENSITY STORAGE OF SPENT NUCLEAR FUEL IN CHERNOBYL NPP INTERIM STORAGE FACILITY NO. 1

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INTRODUCTION

On 29th March 2000 the Cabinet of Ministers of Ukraine issued a decree prescribing that the last operating unit of Chernobyl NPP be shut down before its design lifetime expiry.

In accordance with the Contract concluded on 14 June 1999 between the National Energy-generating Company "Energoatom" and the Consortium of Framatome, Campenon Bernard-SGE and Bouygues, in order to store the spent ChNPP fuel a new interim dry storage facility (ISF-2) for spent ChNPP fuel would be built.

Currently the spent nuclear fuel (spent fuel assemblies - SFAs) is stored in reactor cooling pools and in the reactors on Units 1, 2, 3, as well as in the wet Interim Storage Facility (ISF-1).

Taking into account the expected delay with the commissioning of ISF-2, and in connection with the scheduled activities to build the New Safe Confinement (including the taking-down of the existing ventilation stack of ChNPP Units 3 and 4) and the expiry of the design operation life of Units 1 and 2, it is expedient to remove the nuclear fuel from Units 1, 2 and 3. This is essential to improve nuclear safety and ensure that the schedule of construction of the New Safe Confinement is met.

The design capacity of ISF-1 (17 800 SFAs) is insufficient to store all SFAs (21 284) currently on ChNPP.

A technically feasible option that has been applied on other RBMK plants is denser storage of spent nuclear fuel in the cooling ponds of the existing ISF-1.

The purpose of the proposed modifications is to introduce changes to the ISF-1 design supported by necessary justifications required by the Ukrainian codes with the objective of enabling the storage of additional SFAs in the existing storage space (cooling pools).

The need for the modification is caused by the requirement to remove nuclear fuel from the ChNPP units as soon as possible, before the work begins to decommission these units, as well as to create safe conditions for the construction of the New Safe Confinement over the existing Shelter Unit.

1 HIGH-DENSITY STORAGE SCHEME

The wet fuel storage facility (ISF-1) includes four main and one back-up cooling pool. For storage of SFAs in ISF-1, four operating storage compartments of cooling pools 1÷4 (room 134/1÷4) are used along with one emergency area (room 134/5) for maintenance periods of one of the operating storage areas.

The pool storage areas are reinforced concrete vessels whose walls and bottom are lined with corrosion-resistant steel. The areas have gap slabs which act as console-type holders on which the thimbles containing SFAs hang. The gap slabs are closed from the top with lids. The SFAs are stored in water-filled thimbles with the interval 230 mm × 110 mm.

In order to place all ChNPP spent fuel in the storage compartments in room 134, it is suggested that the fuel be stored in four re-racked storage compartments with the fifth remaining back-up.

In order to ensure higher density of storage it is suggested that the hanged SFA thimbles be displaced toward the edges of the girders where they are embedded into concrete. Denser storage would be achieved through placing two 102x2 mm diameter thimbles on the hangers. The hangers would be placed on the existing girders, with the compartment space under the girders used for storage of thimbles (please see attachment A).

In order to justify denser storage of SFAs in ChNPP ISF-1, nuclear safety justifications as well as calculations of residual heat release and radiation impact on personnel and the environment have been performed whose results are given below.

1.1 Nuclear safety

The existing normal scheme of SFA storage in 102x2 mm thimbles in cooling pools water in ISF-1 with the rectangular lattice pitch of 230x110 mm ensures K_{eff} of 0.872.

In order to ensure denser storage of spent fuel in ISF-1 with the lattice pitch of 130x110 mm and increased density coefficient of 1.41, subcriticality calculations have been performed for the storage system. The calculations were performed for the most conservative case, which is the storage of fresh fuel with the maximum U^{235} enrichment (2.4%).The calculations have shown the K_{eff} result of 0.77.

The proposed scheme of denser storage with the lattice pitch of at least 130x110 mm and the increased density coefficient of not more than 1.25, under normal operating conditions meets the nuclear safety requirements (K_{eff} ≤ 0.95) ("Nuclear safety regulation for storage and transport of nuclear fuel at nuclear facilities" PNAEG-14-029-91) (please see table 1).

Table 1 **Subcriticality evaluation for spent fuel storage in ISF-1 cooling pools**

	Existing scheme of SFA storage	Denser scheme of SFA storage with increased density coefficient 1.41	Denser scheme of SFA storage with increased density coefficient not more than 1.25
Lattice pitch, mm	230×110	130×110	Не менее 130×110
Effective breeding coefficient, K_{eff}	0,872	0,77	Не более 0,872

1.2 Residual heat release from SFAs

The existing scheme of SFA storage is based upon storing spent fuel with the cooling time of at least 1.5 years. Evaluation of SFA heat release depending on cooling time indicates that the heat release value for an SFA with 5 years cooling time is 2.67 less than the heat release from an SFA with 1.5 years cooling time (please see table 2 and fig.1). The minimum cooling time of the SFAs stored in the Units as of December 2006 was 6 years, i.e. the heat release value of a single SFA would be nearly three times less than the design value, whilst the number of SFAs in the compartments would be increased not more than 1.25 times.

The average SFA cooling time on ChNPP as of December 2006 was 15 years, which means that the heat release from the stored SFAs using the denser storage scheme would not exceed the design limits set for the existing SFA storage scheme for ISF-1.

Table 2 Residual heat release for SFA with initial enrichment 2.4% and heat release 18.58 and 23.55 MWt*day/kgU

Cooling time, years	**Burn-up 18,58 MWt*day/kgU**	**Burn-up 23,55 MWt*day/kgU**
	COMPLETE HEAT RELEASE, KWT	
2	2.496-01	2.718-01
3	1.524-01	1.722-01
5	8.434-02	1.019-01
10	5.681-02	7.153-02
15	5.020-02	6.338-02
20	4.563-02	5.767-02

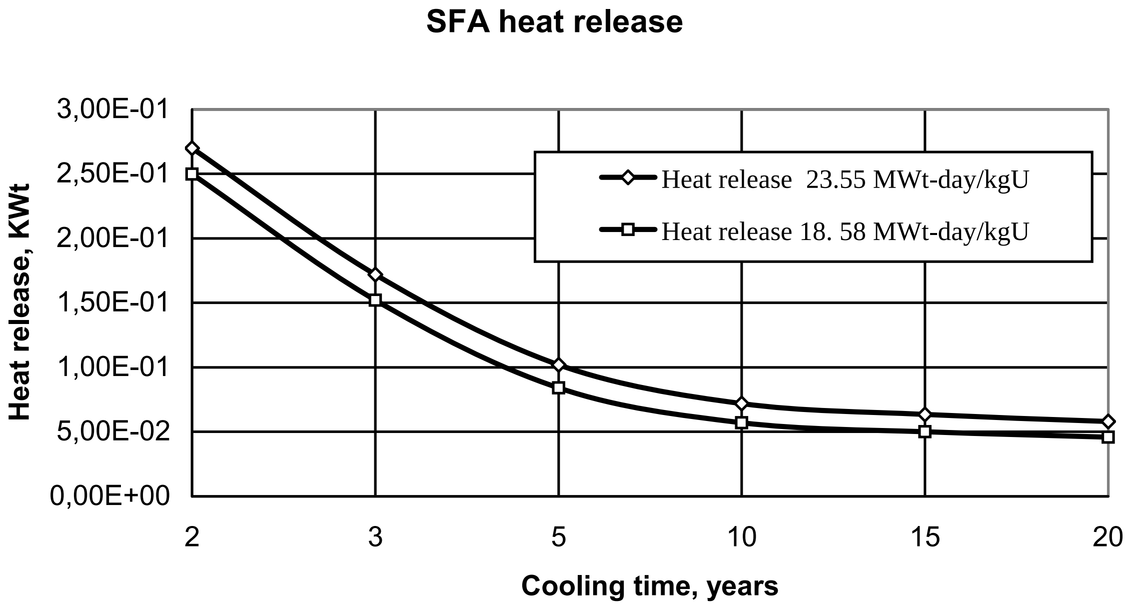

Fig. 1

1.3 Evaluation of impact of the modification on personnel and the environment

According to the normal design process of SFA storage ISF-1, the minimum SFA cooling time before shipping for ISF storage is 1.5 years. Resulting from the calculated SFA radiation properties, the contact dose from an SFA with cooling time 5 years is 1.85 times less than that for an SFA with the cooling time 2 years (please see table 3 and fig. 2, 3). In the proposed scheme of high-density storage, the minimum SFA cooling time before shipping to ISF-1 in December 2006 is 6 years, i.e. the radiation characteristics of an actual SFA would be nearly half the design values, and the number of SFAs in the storage compartments would be increased by not more than 1.25 times.

The average total cooling time for ChNPP SFAs as of December 2006 was 15 years, which indicates that the proposed scheme of denser fuel storage would comply with the requirements of radiation safety and would not exceed the design criteria.

Table 3 Radiation characteristics of SFAs with initial enrichment 2.4% and heat release 23.55 MWt*day/kgU

Cooling time, years	Activity			
	Alpha, Bq	Beta, Bq	Gamma, Bq*EdR	Contact dose, Sv/hour
2	1.31E+13	3.27E+15	3.60E+14	538.6
3	9.80E+12	2.33E+15	2.86E+14	420.3
5	9.55E+12	1.56E+15	2.09E+14	291.9
10	1.09E+13	1.06E+15	1.49E+14	180.1
15	1.20E+13	8.67E+14	1.26E+14	143.8
20	1.28E+13	7.40E+14	1.10E+14	123.4

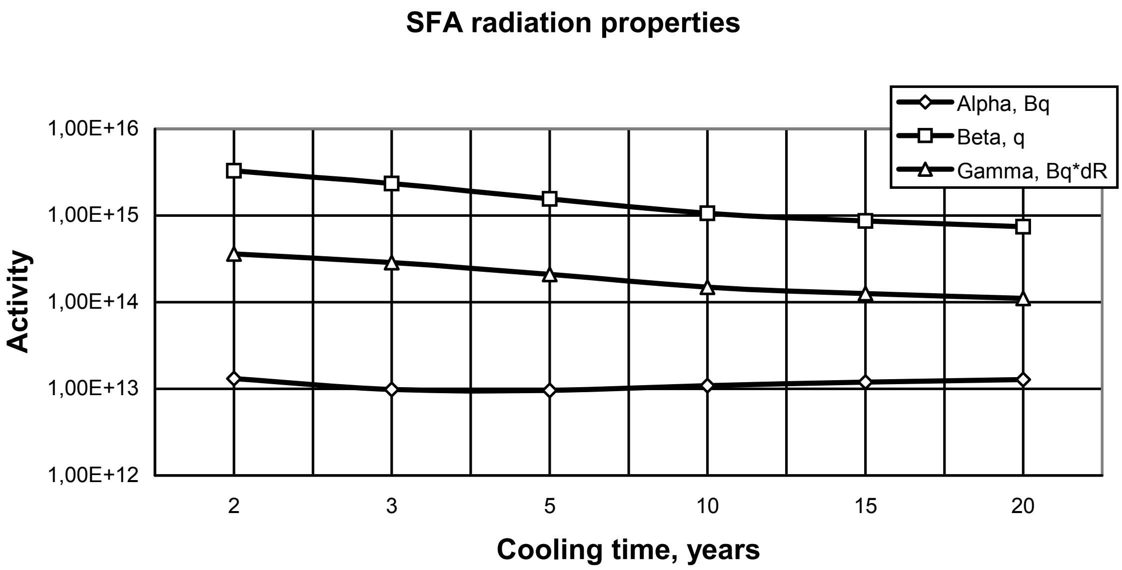

Fig. 2

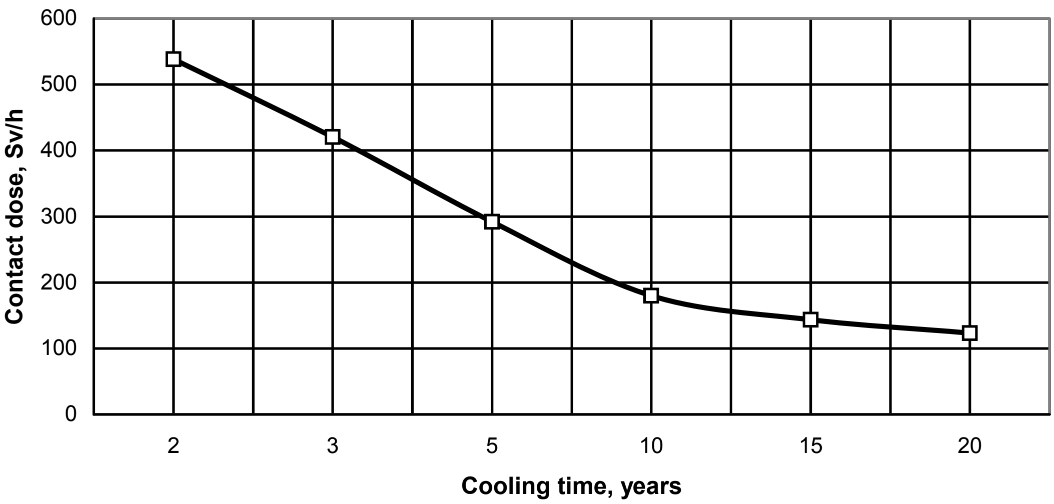

Fig. 3

1.4 Operational records of similarly modified installations internationally:

As of today, similar ISF reconstructions to achieve denser storage have been performed on Leningrad NPP and Kursk NPP. As a result of these modifications, an increase of capacity was achieved on Leningrad NPP ISF of 2 times, and on Kursk NPP of 1.67 times.

Within the nearest time, work to increase ISF storage capacity will be performed on Smolensk NPP. In longer-term perspective, it is planned to perform modifications on the ISF buildings on Kursk, Leningrad and Smolensk NPPs in order to ensure the preparation of spent fuel for retrieving, transportation and storage in a dry storage facility.

CONCLUSION

The implementation of this proposal to modify the spent fuel storage space will lead to removal of nuclear fuel from the units eventually resulting in reduced nuclear risks on the ChNPP site as caused by:

- A significant reduction of the number of potential initiating events for design and beyond-design accidents, resulting in a reduced risk of accidents or accidental situations occurring;
- Increased control and monitoring of the nuclear installations;
- Increased system reliability due to a reduced number of elements involved with spent fuel management;
- Decommissioning of the reactor installations, systems and equipment with an expired operating life span.

Expected technical and cost benefits achieved as a result of the proposed modification:

Ensuring the conditions for start of active decommissioning of the ChNPP Units:

- Decommissioning of a significant number of systems and equipment required to support safety of the power units;
- Possibility of dismantling the systems and equipment external to the reactor installation;
- Organisation of conservation of contaminated systems and equipment.

Minimisation of all sorts of expenses (labour and financial) currently spent on ensuring the safety of ChNPP units as nuclear installations:

- Reduction of the nomenclature of the equipment procured to maintain safety of the units;
- Reduced energy consumption;
- Reassignment of staff freed as a result of the modification to decommissioning tasks;
- Location of all spent nuclear fuel (except for the heavily damaged SFAs) on a single nuclear installation.

The key problems associated with the implementation of the proposed modifications are as follow:

- The need to commission new thimbles, hangers, lifting machines, thimble modification machines, crosspieces and other additional equipment;
- The need to produce and seek approval of new documentation on SFA management, making extensive changes to the existing documentation;
- Potential modification of the transfer device, loading device;
- Construction of new civil structures;
- Potential reconstruction of a number of rooms in the ISF building;
- Increased load on both the civil structures of the whole building and certain local elements such as the girders to which the SFA thimbles are attached, the structures of each storage pool compartment, compartment lining;
- Potential knocking of the thimbles against the bottom of the storage pool during the transfer operations and installing the thimbles into the storage positions;
- Upgrading the existing SFA thimbles for a universal hanger;
- Monitoring of the level of thimble water;
- Deteriorated conditions for topping up water into the thimbles;
- Increased risk of SFA damage;
- Difficulty with seeking approval of the design package "Nuclear Installation Modification. Increased-density storage of RMBK SFAs in ISF-1" from the Regulator.

Attachment A
High-density storage scheme

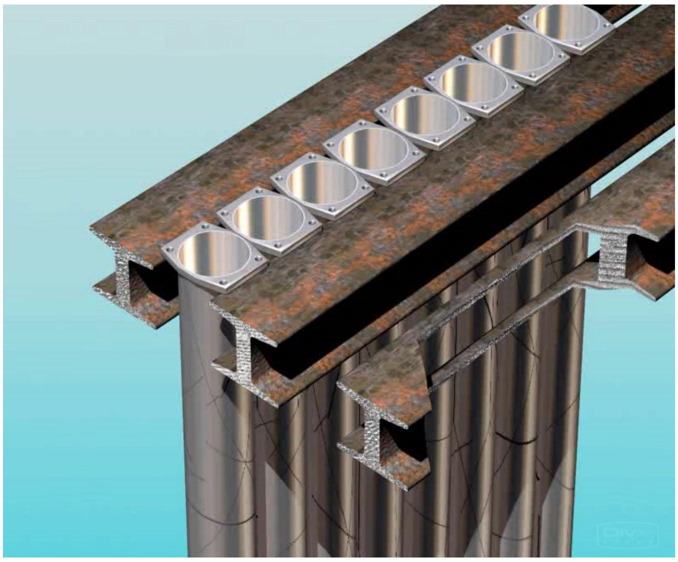

Fig.A1

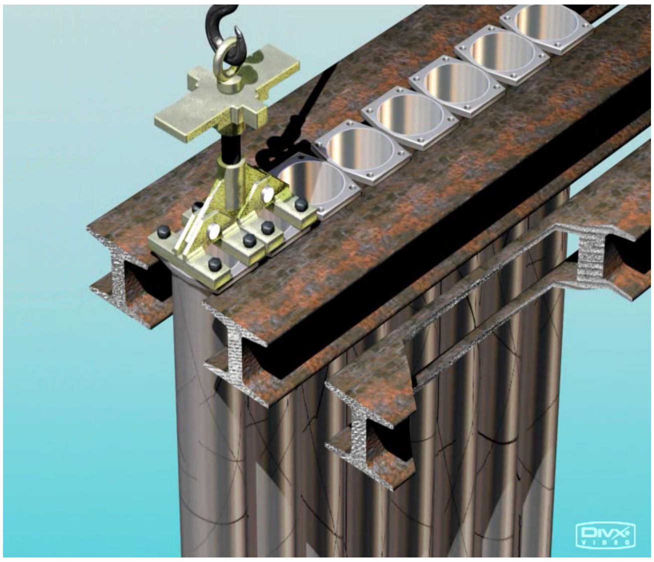

Fig.A2

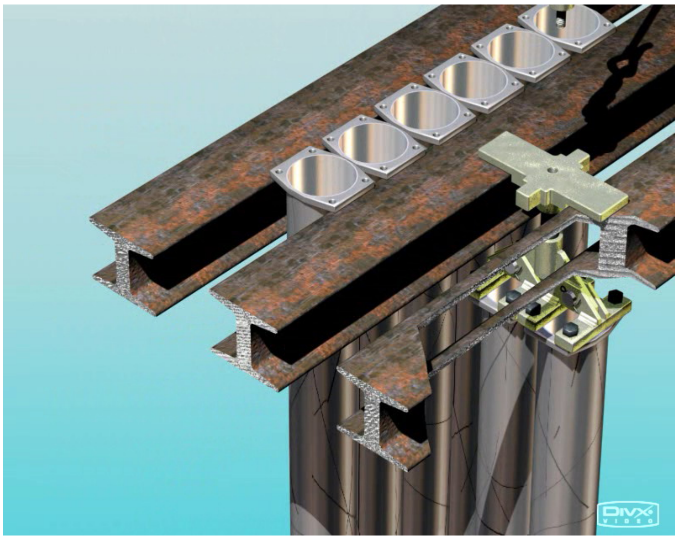

Fig.A3

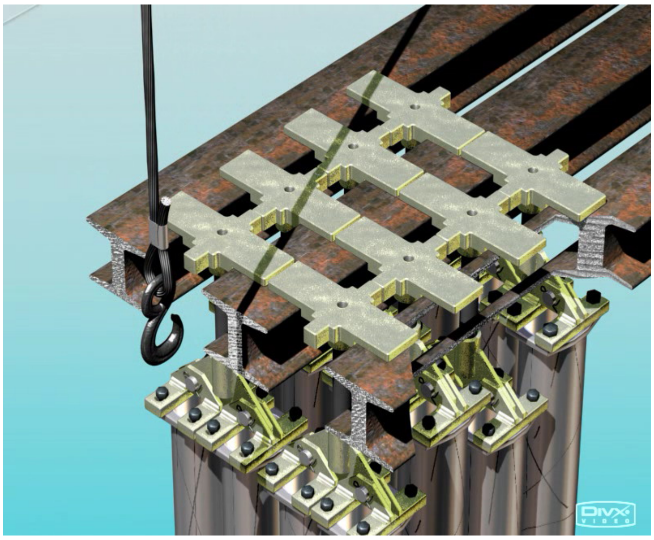

Fig.A4

Fig.A5

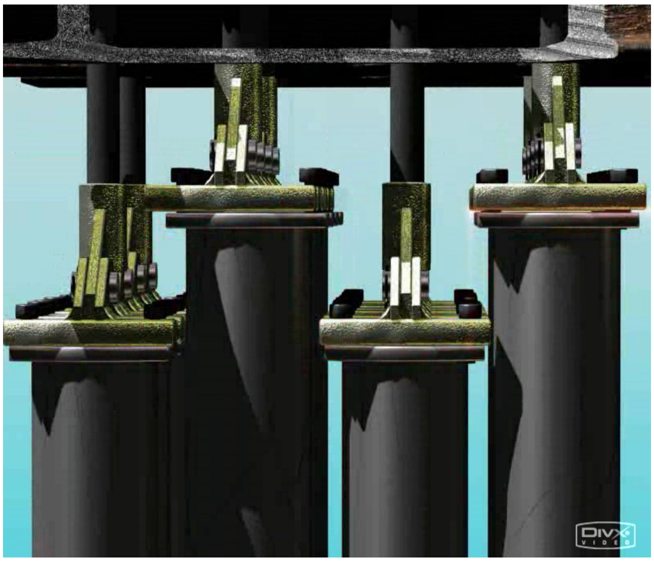

Fig.A6