EXPERIENCE AND SOLUTIONS ON THE DECOMMISSIONING OF SODIUM-COOLED FAST REACTORS

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Areas of nuclear power applications and support infrastructure

- Weapons complex
- Nuclear power
- Civil freeboard ships
- Spacecrafts
- Fuel complex

Decommissioning of NRHF is a pressing problem nowadays.

Predicted scope of decommissioning by 2030:

- 30 nuclear power units
- 13 reactors for production weapon Pu
- More than 30 research reactors
- Several enterprises of nuclear fuel cycle and open storage pools for radioactive wastes

Fast power reactors have been shutdown

- ENRICO PHERMI, US, start-up – 1963, shutdown – 1973 (10 years)
- PFR, Great Britain, start-up 1974, shutdown 1994 (20 years)
- BN-350, USSR, start-up – 1973, shutdown – 1999 (26 years)
- PHENIX, France, start-up – 1973, shutdown – 2009 (36 years)
- SNR-300, Germany
- SUPER-PHENIX, France, start-up – 1986 shutdown – 1998 (12 years)

Fast research reactors have been shutdown

- EBR-1, US, 1.4 MW, Na-K, start-up - 1951
- EBR-2, US, 62 MW, Na, start-up - 1962, shutdown – 1994
- FFTF, US, 400 MW, Na, start-up – 1980, shutdown – 2003
- BR-2, USSR, 100 kW, Hg, start-up – 1956, shutdown – 1957
- BR-5 (BR-10), USSR (РФ), Na, Na-K, start-up – 1959, shutdown – 2002
- Rapsodie, France, Na, start-up – 1967, shutdown – 1983
- DFR, Great Britain, Na-K, start-up - 1959, shutdown - 1977
- KNK, Germany

The Rostechnadzor' definition:

- "Decommissioning of a NPP unit is the kind of activities carried out after removal of nuclear fuel and nuclear materials from the NPP unit aimed at the achievement pf specified end-status of the NPP unit and precluding the use of the unit as a source of energy."
- Three variants of decommissioning NRHF are envisaged
  - Liquidation of a NPP unit (RNF) with immediate dismantling;
  - Preservation under supervision, with delayed dismantling
- Burial for a long time, with delayed dismantling

Steps of decommissioning

- The first step is preparatory, including the sub-step “preliminary”: the principal Program, concept, information materials on the original project and details of operation, the order on final shutdown of the NPP (RNF). Development and implementation of the Program for complex engineering and radiation survey – reactor shutdown, unloading of the fuel and its disposition, disposition of the working media, coolants, and RW, conditioning of coolants and equipment with the development of technologies needed, project development and approval.

- At the second step, the object of inspection should be preparedness of the buildings, protection barriers, and equipment for the preservation under supervision; where necessary, they are replaced and new monitoring devices and protection barriers are installed, and the dismantling of non-radioactive and low-radioactivity equipment is carried out; the pipelines and equipment are cleaned from sodium, then dismantled (except for the reactor), conditioning of cold traps for oxides and cesium traps is fulfilled, the RW and equipment with high radioactivity levels which appear as a result of the activities listed are moved out for storage, the radiation conditions are under monitoring, physical protection of the facility is ensured, a new set of operation documentation and instructions are developed for the period storage under supervision.

- At the third, conclusive step, activities are carried out such as dismantling of all remaining equipment, including the reactor and its biological shield, sectionalizing and removing the buildings' walls, structures, etc., moving-out all RW to the sites for temporary storage or final disposal for a burial.

Problem of funding the decommissioning

- International estimates of the decommissioning duration and costs: 15 years and 350 million USD (IAEA), 200 euro/kW(el.) France, 15÷20% from the capital input (RF.)
- Administration solutions on the funding of decommissioning: governmental decrees (1997 and 2007 years)

Reactor facility	Startup year	Shutdown year	Duration of the decommissioning	Cost of the decommissioning
Rapsodie	1967	1983	2020	~50 million euro
DFR	1959	1977	2026-2042	250 million GBP.
EBR-II	1962	1994	?	?
BR-10	1959	2002	~2060 (2025)	~300 million rubles (2002-2011)
FFTF	1980	2003	?	?
Fermi	1963	1973	?	?
PFR	1974	1994	?	?
BN-350	1973	1999	?	?
Phenix	1973	2009	2029	900 million euro
Superphenix	1986	1998	2029	1.5 billion euro

- Requirements to the storage facilities of LLW, ILW, HLW
- Responsibility for storage of RW
- Possible proprietor of the storage sites (including those for spent fuel assemblies) and burial of RW
- Liabilities and organization of decommissioning-related activities
- Resolution for a certain part of these problem has been defined in the Federal law signed by the RF President «On the management of radioactive wastes»

The problem of development of advanced technological processes for conditioning of the equipment for coolants, reprocessing of SNF

- Cleaning from residues of sodium and decontamination of the pipelines, equipment, sodium circuits (pump, heat exchangers, attachments and fittings, steam generators) and reactor.
- Conditioning of the sodium coolant
- Conditioning of cold traps for oxides and cesium traps.
- Development of advanced technological processes for SNF reprocessing

- Cleaning of the equipment and circuits from residues of sodium by the vacuum method plus vapor-gas method, plus water; decontamination: KMnO4, water, oxalic acid solution with added 1% solution of hydrogen peroxide, water.
- Cleaning by wet CO2
- Cleaning by gas mixture of argon with nitrous oxide followed by removal of the products of nitrous oxide reaction with sodium (Na2O, NaNO2, NaNO3, Na2N2O2) by water

- conditioning of sodium coolant with slags of copper-smelting production
- Conditioning of sodium coolant with water (alkali water 35÷50% NOAH- process)

- Conditioning of cold traps for oxides with vapor-gas mixture followed by cleaning with water
- Conditioning of CTO with water (alkali water)
- Conditioning of CTO by nitrous oxide
- Conditioning of cesium traps

Conclusions

- Decommissioning of NRHF is a pressing, no-delay problem for nuclear power. It is apparently costly and far from safety.
- As a replacement of the most popular scenario of decommissioning with delayed dismantling, a new scenario for decommissioning is prepared, which is deeper justified in terms of moral and ethics, and a cheaper one, with immediate dismantling
- The most important problems with decommissioning of NRHF include: management and disposition of RW, handling of SNF, technologies for conditioning of coolants and equipment, designing special equipment for the dismantling, personnel and managerial structures, development of the appropriate legislative and regulatory basis, financial securities.

I thank the audience

for your kind attention