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NUCLEAR SPENT FUEL DRY STORAGE IN THE EWA REACTOR SHAFT

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ABSTRACT

The EWA reactor was in operation from 1958 until February 1995. Then it was subjected to the decommissioning procedure. Resulting from a prolonged operation of Polish research reactors a substantial amount of nuclear spent fuel of various types, enrichment and degree of burn-up have been accumulated.

The technology of storage of spent nuclear fuel foresees two stages:

- wet storing in water pool (deferral period from tens to several dozens years);
- dry storing (deferral period from 50 to 80 years).

In our case the deferral time in the water environment is pretty significant (the oldest fuel elements has been stored in water for more than 40 years). Though the state of stored fuel elements is satisfactory, there is a real need for changing the storage conditions of spent fuel.

The paper is covering the description of philosophy and conceptual design for construction of the spent fuel dry storage in the decommissioned EWA reactor shaft.

1. Introduction

At the Institute of Atomic Energy at Świerk in Poland two research reactors EWA and MARIA have been operated for many years. The 30 MW(th) MARIA reactor which was commissioned in 1974 was modernized in the period of 1985-1992 and it is anticipated to operate this reactor until 2015. The pool type reactor EWA was in the operation from 1958 until February 1995. Then it was permanently shut down and a bit later successfully decommissioned. Resulting from a many years operation of both reactors a substantial amount of nuclear spent fuel of various types, enrichment and degree of burn-up has been accumulated.

Actually in several water pools about 610 kg uranium and fission products of activities from 300 to 25000 GBq/fuel element is being stored. These comprise nuclides (such as e.g. Kr-85, Cs-134 and Sr-90) of substantial activity and long decay half-times. Another 900 kg of uranium and fission products will be accumulated after the operation of MARIA reactor will be terminated.

Our spent fuel elements canned with aluminum alloy have been stored in wet conditions for a long time, e.g. the EK-10 type for more than 39 years and the WWR-SM type for about 28 years and though the state of their cladding is still satisfactory there is a need for changing their storage conditions into the dry ones.

- After having analyzed different options of management of the spent fuel including eventual shipment for reprocessing abroad we have chosen the most promising economical solution based on storing fuel on the site in the shaft of the decommissioned reactor EWA

The paper contains a brief characteristic of the proposed solution.

2. Justification of the project

The aim of construction of the spent fuel dry storage facility at the Institute of Atomic Energy at Świerk is to create appropriate conditions which can substantially slow down corrosion process in the fuel cladding and which will not allow to lose the integrity of spent fuel.

According to the world practice the conversion of storing conditions from wet into dry ones and providing the neutral gas atmosphere inside the hermetic fuel cans will create the acceptable conditions enabling the safe storage of spent fuel for at least 50 years. Poland doesn't plan to construct a nuclear power plant in this decade so it also doesn't intend to utilize presently any deep geological formations, e.g. as salt mine as a repository for high level activity wastes. After having considered and analyzed all technologically and economically feasible options of management of the spent fuel in Poland, the most reasonable solution seems to use the well in the reactor tank of the decommissioned reactor EWA.

The basic threat for the fuel cladding integrity is caused by the corrosion of aluminum. Though the natural process of aluminum surface corrosion in water proceeds very slowly, around 0.08 mg/dm2, but the other forms of its such as the pitting corrosion or intercrystalline corrosion are occurring rather nonuniformly. They are exhibited by local damaging of the surface, which brings about to the release of the fission products. The accelerated corrosion can be prohibited by proper chemistry of water, in which the spent fuel elements are stored.

For the time being at the Institute of Atomic Energy the research works on the release of fission products to determine the limit period for wet storage are being carried on. It is very difficult to determine the limit period for wet storage of the spent fuel elements in water. In some publications on the subject this limit has been constrained to 35 years [1]. The substantial majority of the spent fuel from Polish research reactors already meets this quantity.

Bearing this in mind it has been decided to construct dry storage facility in the former EWA reactor building.

3. Construction of the dry storage facility [2].

The dried fuel elements are closed in helium atmosphere in the leak-tight cans made of stainless steel. Lack of moisture and chemical passivity of environment confines in a significant way corrosion of aluminum. The proposed way of isolation of spent fuel from the ambient outside environment enables safe fuel storage for at least 50 years [3].

In line with the project in the shaft of concrete biological shield of the reactor a special separator with storage channel will be installed (Fig. 1). In the channels the cans containing spent fuel elements will be stored. The storage channels will be arranged in a fixed triangular lattice with a pitch of 130 mm (Fig.2).

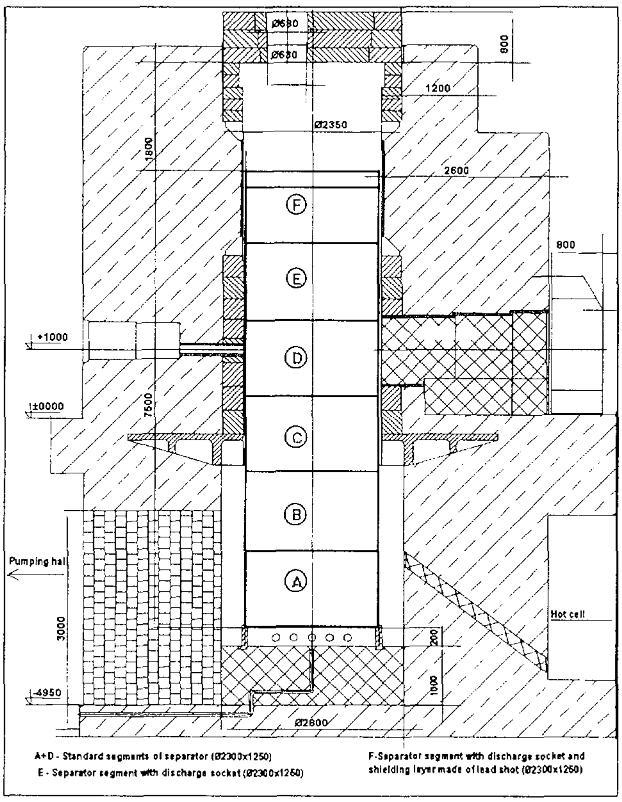

Fig. 1. Dry storage for nuclear spent fuel

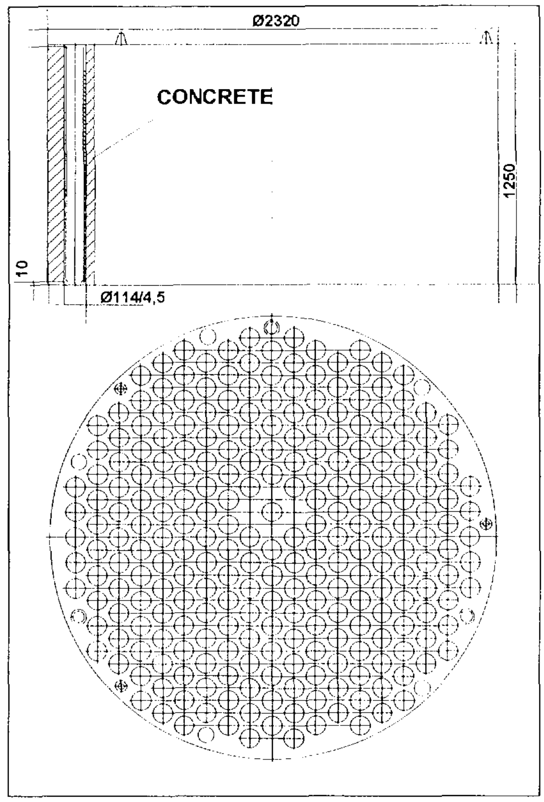

Fig. 2. Segment "A" of the separator

The separator of the storage facility consists of six independent segments comprising 250 pieces of channels constructed of the stainless steel tubes (1H18N9T). Free space between the channels in segments are filled with concrete of 2.3 g/cm^3 density and the upper and lower cover and lateral surface are made from stainless steel sheets. In that way one obtains a structure of 250 storage channels distributed within a circle of dia. 2.3 m and total height ≈ 7 m.

The separator is resting upon a supporting structure made of ductile cast iron. A special attention is put in preserving coaxial arrangement of this stratified structure. Supporting structure of the separator has a free space through which the free influx of air to the storage channel enables the removal of residual heat generated in nuclear fuel.

In the center of the separator zone the channel with a socket enabling the discharging of transport container is installed.

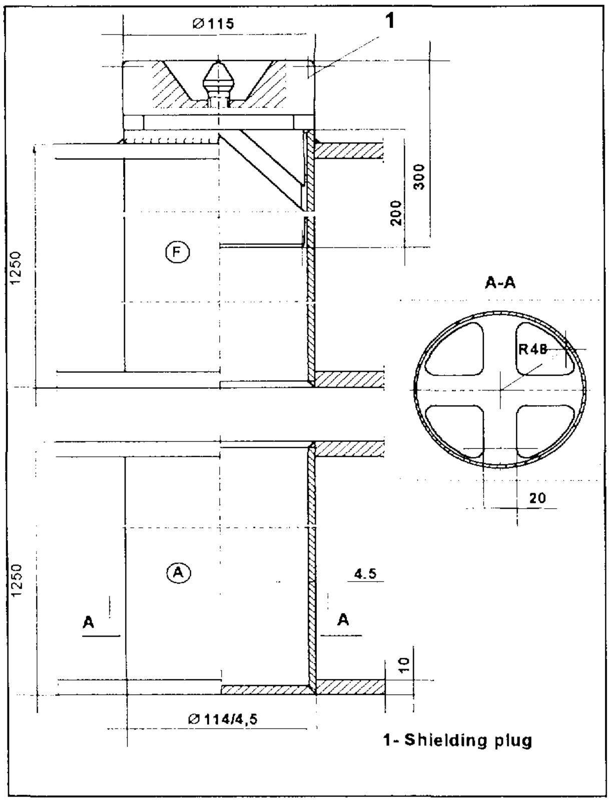

Fig. 3. Storage channel – segments A and F

The storage channels of the separator (Fig. 3) are locked from the top by the shield plugs. Each of the plugs has a labyrinth channel for airflow, which enables the ventilation and cooling of the fuel providing simultaneously a shielding against radiation.

The fuel elements are placed in the leak-tight cans filled with helium. The cans are equipped with grip heads, which allows their transportation by means of mechanical and electromechanical devices. All the cans have the same diameter, but heir height is accommodated to the length of specific fuel elements.

One can is to be loaded by:

- EK-10 fuel 40 rods
- WWR-SM, WWR-M2 3 singular (or 1 triple) fuel elements
- MR fuel: 1 fuel element.

The additional advantages of described solution are as follows:

- the structure of reactor concrete shaft and movable iron-cast covers closing the shaft from upper side are constituting a perfect biological shielding against irradiation emitted by spent fuel;
- movable rotary slabs, AR spent fuel pond and the hot cells enable to apply a safe technology for the loading operations, closing fuel in the leak-tight cans and fuel monitoring;
- existing technical infrastructure of former EWA reactor facility (such as technological ventilation, power supply system, special sewage, hot cells, hoisting devices) will enable normal and safe operation of the dry store;
- available building structure, concrete reactor structure and the technical infrastructure will allow for diminishing of expenditures of such undertaking and shortening the time of its accomplishment;
- construction of the dry storage facility is in compliance with the assumptions of the Strategic Governmental Program as regards to the nuclear spent fuel management in Poland.

The major operational equipment enabling the operation and safety of the dry storage will comprise:

- exhaust technological ventilation system expelling eventual gas products and aerosols to the ventilation stack and further to the atmosphere;
- stationary dosimetry system providing radiological monitoring of the air exhausted from the dry storage;
- water appearance detection system in space under the support slab of the storage channels;
- fuel cans leakage detection system.

Basic preliminary safety analyses and calculations for dry spent fuel store have been completed. They comprised: criticality calculation under normal and emergency conditions (using Monte Carlo methods), heat transfer conditions and radiological protection questions. The results obtained are satisfactory.

4. Conclusions

According to the opinion and recommendation done by the specialists of the BNFL (England) and FRAMATOME (France) with accounting for the limited funding to be spent for the spent fuel management in Poland, the option of using the EWA reactor well as a space for the spent fuel storage facility is very promising and economically justified.

5. Literature

[1] Acceptance Criteria for Interim Dry Storage of Aluminum-Alloy Clad Spent Nuclear Fuels, Westinghouse Savannah River Company, March 1996.

[2] T. Matysiak – Dry Storage Facility for Nuclear Spent Fuel in the Concrete Well of the EWA Reactor (conceptual design), Institute of Atomic Energy, Świerk, February 2000.

[3] A. Mołdysz, A. Hryczuk, T. Matysiak – Preliminary Information on Nuclear Spent Fuel Dry Storage in the EWA Reactor Shaft, Institute of Atomic Energy, Świerk, February 1999.