STORAGE EXPERIENCE IN HUNGARY WITH FUEL FROM RESEARCH REACTORS

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Abstract

In Hungary several critical assemblies, a training reactor and a research reactor have been in operation. The fuel used in the research and training reactors are of Soviet origin. Though spent fuel storage experience is fairly good, medium and long term storage solutions are needed.

REACTORS

In the KFKI (the former Central Research Institute for Physics), six zero power critical assemblies were in operation subsequently between 1959 and 1990.

ZR-1 was a critical experiment using EK-10 fuel elements in the late 50's. The same type of fuel was used in the first period in the research reactor and is still being used in the training reactor. The fuel elements used in ZR-1 were later irradiated in the research reactor and they are stored in the Spent Fuel Storage Facility No. 1 of the KFKI.

ZR-2 was a critical facility used for reactor physics experiments in the 60's. The U_3O_8 fuel pellets were Soviet origin but the rods were fabricated in Budapest. The dismantled fuel is stored in the Central Isotope Storage Facility of the KFKI. Its storage does not require any special treatment or precaution.

ZR-3 was a critical experiment using VVR-SM fuel elements in 1967. The same type of fuel has been used afterwards in the research reactor. The fuel elements used in ZR-3 were later were irradiated in the research reactor and they are stored in the Spent Fuel Storage Facility No. 1 of the KFKI.

ZR-4 was a small critical facility used for reactor kinetics experiments and also as a thermal column in the 70's. The homogeneous uranium-polyethylene fuel blocks were fabricated in Budapest. The fuel is stored in the Central Isotope Storage Facility of the KFKI. Its storage does not require any special treatment or precaution.

ZR-5 was a critical facility using EK-10 fuel elements in the late 60's. It was a mock-up of the training reactor. The fuel elements used in ZR-5 were later irradiated in the training reactor and they are still in the reactor vessel.

ZR-6 was a critical facility used for reactor physics experiments in the 70's and 80's. The experiments were performed by an international team of VVER user countries. The fuel rods were fabricated in the Soviet Union using UO_2 fuel, similar to the VVER fuel. The fuel rods are stored in the KFKI Atomic Energy Research Institute. Their storage does not require any special treatment or precaution.

The training reactor belongs to the Budapest Technical University. It is in use for more than 20 years. The reactor is fuelled by EK-10 fuel elements. Due to the low power (max. 100 kW) all the fuel elements may remain in the reactor vessel for a long period. Storage racks are provided for medium term storage in the reactor vessel.

The research reactor belonged to the former KFKI, now it belongs to the KFKI Atomic Energy Research Institute. Four phases can be distinguished since the commissioning of the reactor in 1959:

- 1959-1967: 2 MW power, EK-10 fuel, 82 elements were irradiated
- 1967-1986: 5 MW power, VVR-SM fuel, 780 elements were irradiated
- 1986-1992: major reconstruction
- 1993- : 10 MW power, VVR-SM fuel.

FUEL ELEMENTS

Two types of spent fuel elements irradiated in the research reactor are stored in Hungary: EK-10 and VVR-SM.

EK-10 is a Soviet designed and fabricated fuel. The fuel material is U_3O_8 mixed with Al and Mg, the initial enrichment is 10% and the average burnup is 23%. The material composition per fuel element is 128 g U_{235}. The cladding material is aluminium, cladding thickness is 1.5 mm, the height of the fuel element is 750 mm, the horizontal cross section of the fuel element is 68 x 68 mm. The estimated activity of the element is $2{,}5 * 10^{13}$ Bq, the remanent heat emission (nowadays) is 1-1.5 W and the measured dose rate is 10 mGy/h. This type of fuel elements are stored in the Spent Fuel Storage Facility No. 1 of the KFKI from the early 60's (82 elements) and also in the reactor pool of the training reactor.

VVR-SM is also a Soviet designed and produced fuel element. The VVR-SM fuel has two types: the single fuel element and three single with one header the so-called triple element. The initial uranium enrichment is 36%, the fuel material is UAl_4 alloyed with Al and the average burnup is 50-55%. The material composition per single fuel element is 38,9 g U_{235}. The cladding material is aluminium, cladding thickness is 0.9 mm, the height of the fuel element is 865 mm, horizontal size of the fuel element is 35 mm. The estimated activity is $2 * 10^{13}$ - $3{,}5 * 10^{13}$ Bq, the remanent heat emission (nowadays) is 5-20 W and the measured dose rate is 10-60 Gy/h. This type of fuel elements are stored in the Spent Fuel Storage Facility No. 1 of the KFKI from the late 60's (780 elements), the last shipment was sent to the facility in 1986.

STORAGE FACILITIES

In Hungary three storage facilities are being used.

The Spent Fuel Storage Facility No. 1 of the KFKI was built in the early 60's. It is an underground stainless steel vessel. The fuel elements are stored in the vessel under water in aluminium tubes. The facility is about 100 m from the reactor building. Fuel elements are transported in special small (six tons) lead container into the facility. Water is sampled and pH and conductivity are measured once in a month. The quality of the water can be improved by a movable ion exchanger filter. Water level is monitored in the control room. As the facility is situated in open air the water improvement can be done from spring to autumn.

The Spent Fuel Storage Facility No. 2 of the KFKI was built during the reconstruction period and was put into operation in 1994. The new stainless steel pool is situated in the reactor hall and is directly connected by a chute to the reactor tank. The storage facility contains B_4C rods to ensure the subcriticality of the high density (the geometry of the grid is the same as it is in the reactor core) storage arrangement. No spent fuel is loaded into the facility up till now. Water is sampled and pH and conductivity are measured once in a month. The quality of the water can be improved by a movable ion exchanger filter. Water level and temperature is monitored in the control room. For the case of emergency core unloading there is a built-in heat exchanger in the pool in order to cool the water. In this vessel there is also room for the beryllium displacers and the hermetically closed containers holding the failed fuel elements.

The storage rack of the Budapest Technical University training reactor is in the reactor vessel. Due to the low power no spent fuel assembly is stored there.

STORAGE EXPERIENCE

The storage experience with EK-10 and VVR-SM fuel elements is fairly good. No fuel failure has been detected in the storage facilities.

PROBLEMS, POSSIBLE SOLUTIONS

As far as Spent Fuel Storage Facility No. 1 of the KFKI is concerned, a great amount of empty places exist in the facility. Nevertheless, there are no intentions to load there further fuel elements. The facility should be emptied. The main reason is that the facility is not designed for a long term use and even having a good experience with the stored material another solution should be found.

At the moment two solutions are under investigation. The first one is based on transporting back the fuel elements to Russia. It is technically feasible and even designed, though the licence of the corresponding Russian containers is expired. The transport should be organized together with the transports of the spent fuel elements from the Paks NPP. As a consequence of the collapse of the Soviet Union and the new Russian regulations the future transports from the Paks NPP are uncertain. The second solution would be to store the fuel elements in the interim dry storage facility to be built (with a very high probability) at the Paks NPP. Thus in both cases the solution is tightly connected with the solution for the Paks NPP spent fuel problems.
Obviously, the solution applied for the fuel stored in the Spent Fuel Storage Facility No. 1 of the KFKI will be also applicable both for the spent fuel to be stored in the Spent Fuel Storage Facility No. 2 of the KFKI and the spent fuel stored in the Storage Rack of the Budapest Technical University.

INTERNATIONAL CO-OPERATION

Since it can be expected that spent fuel from the training and research reactors will be stored in Hungary still for a considerable time (perhaps not only in wet, but also in dry conditions), it is very valuable to learn the experience gained at other sites. Unfortunately, the special alloy used in the Soviet aluminium cladding technology does not permit to draw direct conclusions from the experience with fuel of US origin. The IAEA efforts to share the experience gained at various facilities are very much welcome.