IAEA-SM-352/7

XA9951775

SPENT FUEL DRY STORAGE IN HUNGARY

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Abstract

Paks Nuclear Power Plant is the only NPP in Hungary. It has four VVER-440 type reactor units. Since 1989, approximately 40-50% of the total annual electricity generation of the country has been supplied by this plant. The fresh fuel is imported from Russia. Most of the spent fuel assemblies have been shipped back to Russia. Difficulties with spent fuel transportation to Russia have begun in 1992. Since that time, some of the shipments were delayed, some of them were completely cancelled, thus creating a backlog of spent fuel filling all storage positions of the plant. To provide assurance of the continued operation, Paks NPP's management decided to implement an independent spent fuel storage facility and chose GEC-Althom's MVDS design. The construction of the facility started in February 1995 and the first spent fuel assembly was placed in the store in September 1997. The paper gives an overview of the situation, describing the conditions leading to the construction of the dry storage facility at Paks and its implementation. Finally, some information is given about the new Public Agency for Radioactive Waste Management established this year and responsible for managing the issues related to spent fuel management.

1. INTRODUCTION

Hungary has a population of 10.6 million and a land area of 93,000 km^2, with a population density of 114 inhabitants/km^2. Nuclear power generation in Hungary has an important role in the electricity supply. The country's only nuclear power station is located on the west bank of the Danube at Paks. The plant consists of four pressurised water reactors of the Soviet VVER-440/213 type, commissioned between 1981 and 1987. The rated electric performance of each unit is 460 MW. Since 1989, approximately 40-50 % of the total domestic electricity generation has been supplied by Paks NPP.

Concerning the fresh nuclear fuel supply and management the spent fuel assemblies arising from this activity, Hungary has so far relied on foreign services, first from the Soviet Union and later from Russia. Changes of the political and economical system in the Soviet Union and in the relations with countries operating VVERs, made inevitable some modification and diversification in fuel strategy.

2. FUEL CYCLE STRATEGY

2.1. Fresh fuel supply

The fresh fuel is being imported form Russia (previously from the Soviet Union). There was only one exception. Two years ago, 235 slightly used German fuel assemblies of Soviet origin were shipped from Greifswald NPP and then loaded into the reactors.

To diversify the fresh fuel procurement, Paks NPP together with the Finnish utility IVO signed a contract for developing alternative VVER-440 fuel, in 1995. The contract was awarded to BNFL (UK). The Lead Test Assemblies are being tested at Loviisa. If the results of the one-year test are satisfactory, the Hungarian Operator can start the domestic licensing procedure and will be in a position to choose from different suppliers.

2.2. Amounts of spent fuel unloaded from the reactor

There are 349 fuel assemblies in the reactor core. They have a hexagonal cross section, each enclosing 126 fuel rods. Yearly, 120 spent fuel assemblies are unloaded in average, which is equal to 14.4 t HM. According to this spent fuel production rate, more than 15,000 spent fuel assemblies will be discharged from the four reactors during their expected 30 years lifetime.

Since the early 1990s, Paks NNP has been working on introducing the "partly three four years" and "total four years" fuel cycles. Evaluation of the results and further extension of the programme is expected in the near future. This will result in higher burnup and a corresponding lower amount of discharged spent fuel. Taking into consideration the possible life extension of the reactors, however, the total amount of spent fuel generated could increase significantly.

2.3. Spent fuel management

2.3.1. Original ideas and their first modification

According to the original fuel strategy, the Soviet Union undertook not only the supply of new fuel but also accepted the spent fuel for reprocessing. This arrangement included some unique elements. As it was foreseen by the original design, spent fuel was to be transported back after three years cooling in the at-reactor (AR) pool. Products of the reprocessing process (all radioactive waste, plutonium, uranium) were supposed to stay in the Soviet Union. Consequently, spent fuel racks in the AR pools were designed and constructed to hold spent fuel unloaded for 3 years (i.e. 349 assemblies).

Later, the original concept was changed, when spent fuel only after a five year decay cooling was accepted for shipment. To double the AR storage capacity, spent fuel pool racks were constructed and presently, the borated stainless steel containing compact storage racks provide for roughly 6 years AR storage.

2.3.2. Spent fuel shipments to Russia

The first spent fuel shipment to the Soviet Union took place in 1989. The number of assemblies returned to the Soviet Union and later to Russia is listed in Table 1. All shipments were carried out using the standard Railway Transport Unit, including the TK-6 containers.

TABLE 1. SPENT FUEL ASSEMBLIES RETURNED TO RUSSIA

Year	No. of Assemblies
1989	116
1990	235
1991	210
1992	240
1993	180
1995	480
1996	240
1997	450
1998	180
Total	2,331

Until 1992, the shipments took place regularly, once or twice a year, providing the necessary at-reactor cooling pool capacity, but since that time the process had an occasional character. All transports were on an exceptional basis only and it is always possible that they will be discontinued, if Hungary does not take back the reprocessing wastes.

2.3.3. Selection of the storage technology

Taking into account the above described uncertainties and economic conditions, Paks NPP started to review the spent fuel strategy in the early 1990s, looking for new alternatives. Having reviewed other countries' solutions and in line with the "wait and see" policy, a decision was made to construct an AFR storage facility to provide interim storage at the Paks site. This solution keeps the way towards both options, once-through or reprocessing, open.

Information was collected about existing interim storage facilities and the requirements for the format and content of a Feasibility Study were drawn up. After a pre-selection process, 7 companies were invited to submit Feasibility Studies, mostly for dry storage technologies.

As a result of the wide range evaluation by Paks NPP with the contribution of the invited Hungarian organisations (designer, regulatory body), SKB of Sweden and the IAEA, the number of potential vendors was reduced from seven to three.

Having considered all aspects, the final decision by the management of the Paks Nuclear Power Plant was the selection of the GEC-ALSTHOM's (UK) Modular Vault Dry Storage (MVDS) system and a design contract was signed on 28 September 1992.

2.3.4. Long-term considerations

In case return of the spent fuel would no longer be possible to Russia, the AFR storage facility according to its modular nature, can be extended to accommodate all spent fuel assemblies discharged from the four reactors at Paks. This will provide the necessary time to select the site and technology for the disposal of high level waste and spent fuel. The final disposal facility for high level radioactive waste, or for conditioned spent fuel in case of direct disposal, is expected to be commissioned by 2040 and that defines the anticipated length of operation for the MVDS, i.e. 50 years.

Since the construction of a high level waste repository is required independently from the strategy for the back-end of the fuel cycle, as disposal of the operational and decommissioning waste originating from the nuclear power plant is necessary, a National Project was launched. In the first phase of the Project, a complex radioactive waste management strategy was developed.

To provide for the organisational framework of these activities, in the new Law on the Use of Atomic Energy, and related decrees published in 1997, a non-profit organisation was created to take care of all the relevant issues. According to this new Law, a so-called Nuclear Waste Fund was established in 1997.

3. IMPLEMENTATION OF THE DRY STORAGE FACILITY

3.1. Description of technology

The MVDS (Fig. 1) provides at least 50 years of interim storage for VVER-440 fuel assemblies in a contained and shielded system. The fuel assemblies are stored vertically in individual Fuel Storage Tubes, the matrix of Storage Tubes being housed within a concrete vault module that provides shielding. To prevent the development of eventual corrosion processes, the fuel assemblies are in an inert nitrogen environment inside the Storage Tubes. Decay heat is removed by a once-through, buoyancy driven, ambient air flow across the exterior of the Fuel Storage Tubes, through the vault and the outlet stack. There is no direct contact between the fuel assemblies and the air flow.

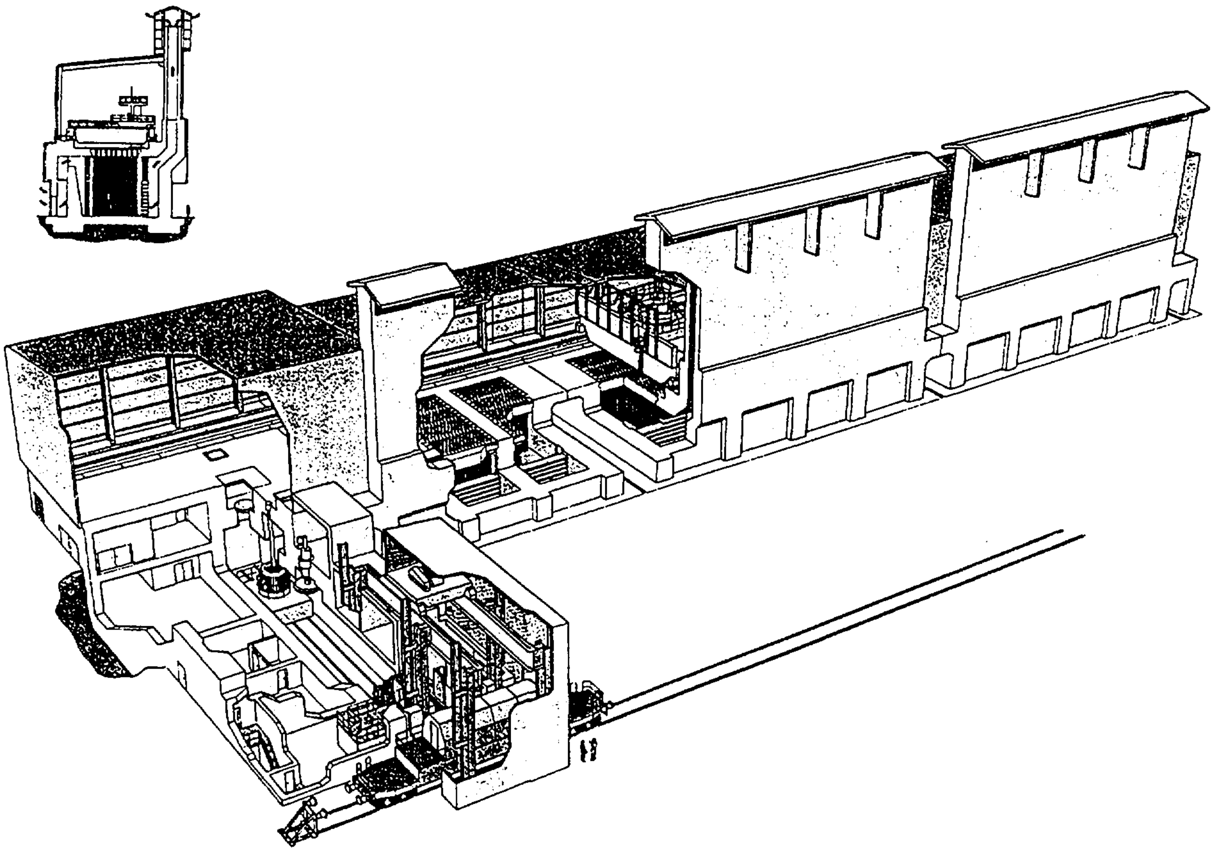

FIG. 1. Paks modular vault dry storage facility

The storage facility functionally can be divided into three major structural units. The first one is the vault module where the spent fuel assemblies are stored in vertical tubes. These vault modules include at least three or maximum five vaults, depending on the geometrical arrangement. Each vault is capable of accommodate 450 spent fuel assemblies (see Fig. 2).

The second major structural unit is known as the Charge Hall (Fig. 3) where the Fuel Handling Machine (Fig. 4) is located for the fuel handling operations. The hall is bordered by the reinforced concrete wall of the ventilation stack on one side and by a steel structure with steel plate sheeting on the other side. The basic function of the sheeting is to protect the Fuel Handling Machine against climatic stresses.

The third major unit is the so-called Transfer Cask Reception Building (Fig. 5) in which the reception, preparation, unloading and loading of the transfer cask takes place. The fuel handling system and other auxiliary systems are installed in this building.

The fuel assemblies are transported to the MVDS from the AR pool using the C-30 transfer cask and its railway wagon. The transfer cask is received in the transfer cask reception building where it is removed from the railway wagon and prepared for fuel assembly unloading. The fuel is raised into a drying tube directly above the cask where it is dried prior to being lifted into the Fuel Handling Machine. The fuel assemblies are transferred, within the Fuel Handling Machine, to the vertical Fuel Storage Tubes located in the vaults.

Once the Fuel Handling Machine has moved away from the Storage Tube the air is evacuated from the tube and replaced with nitrogen. After that operation the tube is connected to the built-in nitrogen system which monitors the storage environment of the spent fuel assemblies.

3.2. Licensing

The licensing process of the Independent Spent Fuel Storage Facility was very complicated and complex. A number of new, earlier not requested permits were required. Some authorities began to work out and to publish their general requirements during the implementation process. The main authorities issuing the permits involved several other authorities in the course of their licensing process. The situation was complicated with the fact that some regulatory processes were in a way connected with each other. The licensee had to address more than 20 different authorities during the licensing of the facility.

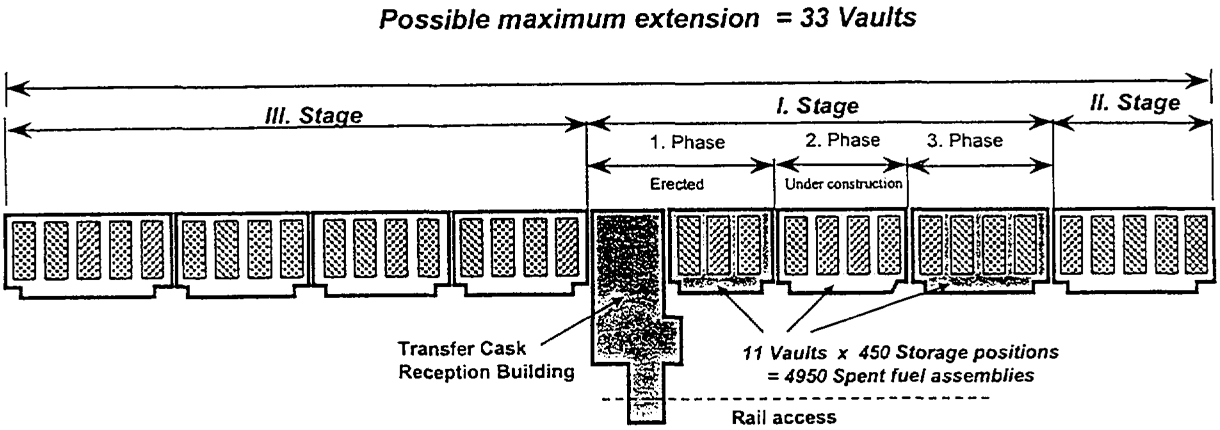

FIG. 2. Construction phases of Paks MVDS

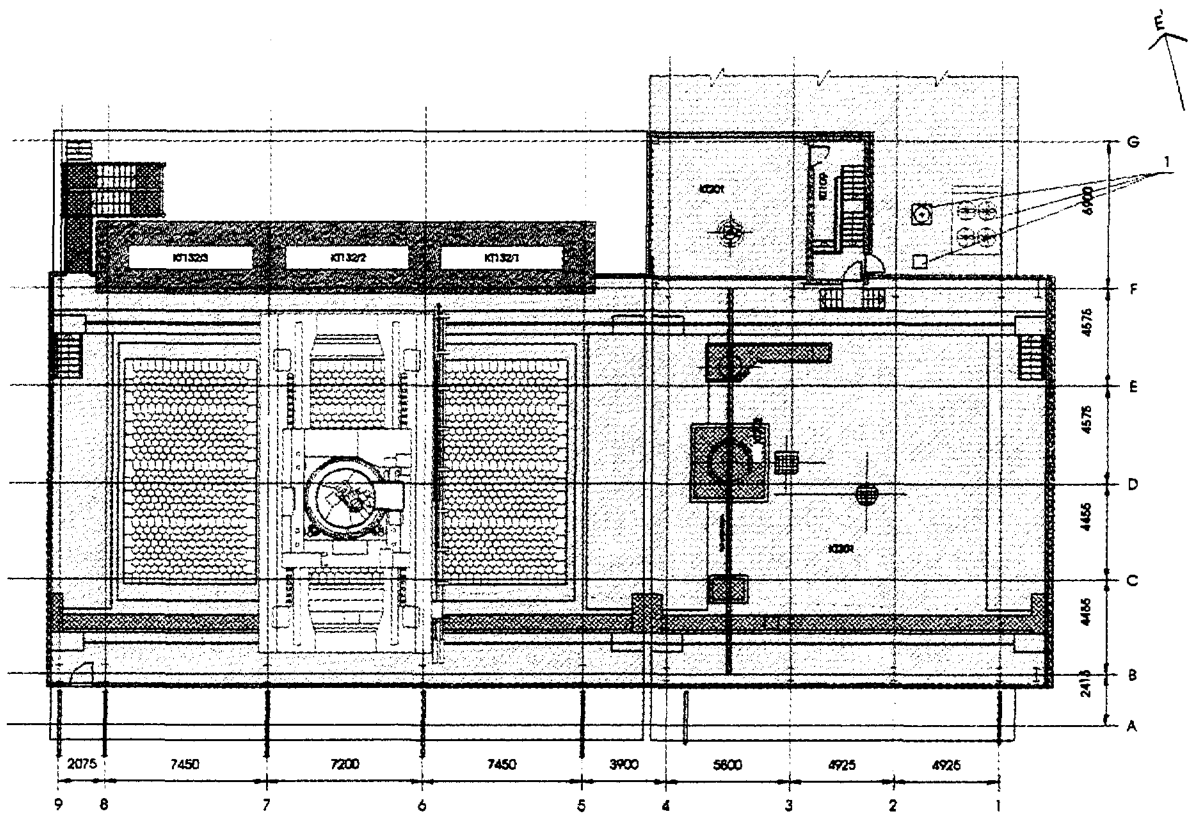

FIG. 3. Paks MVDS - Charge hall

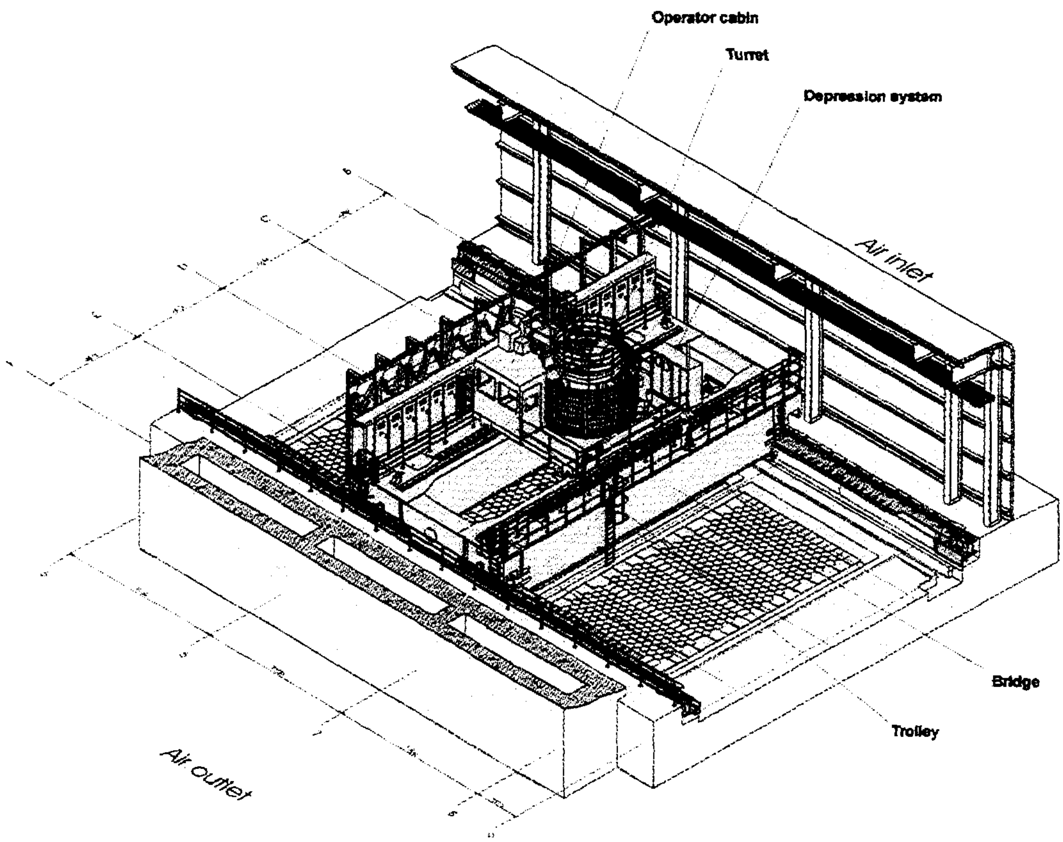

FIG. 4. Paks MVDS - Fuel handling machine

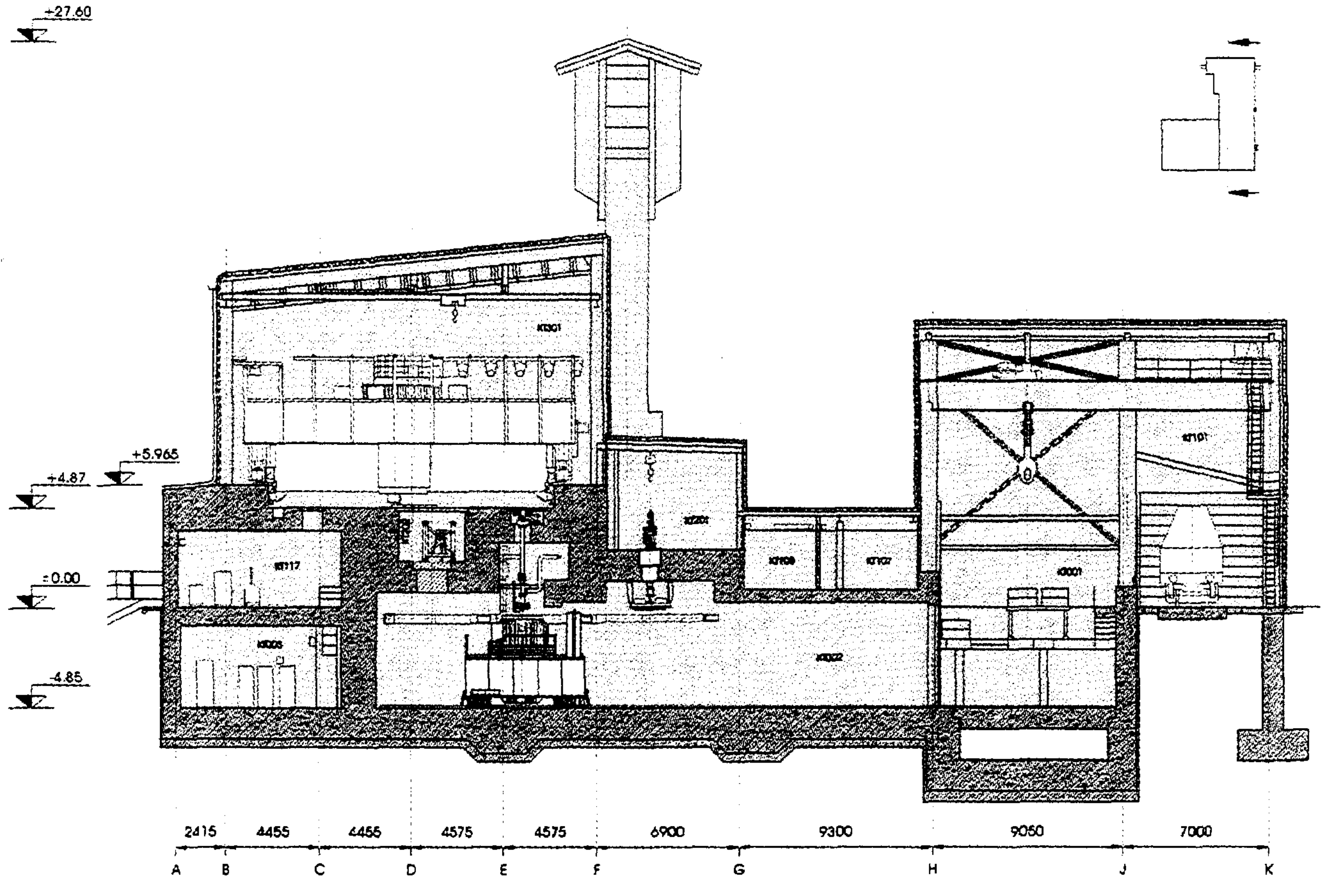

FIG. 5. Paks MVDS - Transfer cask reception building

In the beginning of the design, there were no Hungarian regulations regarding spent fuel storage facilities. Therefore, it was agreed by the competent authority (Hungarian Atomic Energy Authority, Nuclear Safety Directorate) and the operator of the NPP, to consider the relevant US regulations when compiling the PCSR. This essentially meant meeting the requirements of 10CFR72 and drawing up a Safety Assessment Report in compliance with the US NRC Regulatory Guide 3.48.

The licensing process preceding the construction lasted for 14 months. The main licensing milestones are shown in Table 2.

TABLE 2. MAIN MILESTONES OF THE LICENSING PROCEDURE

Type of the license, or permit	Issued on
Environmental Permit	20 July 1994
Building Permit	20 September 1994
Water Permit	28 September 1994
Site Permit	09 November 1994
Nuclear Safety Permit	23 December 1994

In possession of these permits the Hungarian Atomic Energy Commission issued the Construction Licence in February 1995, which allowed to start the construction work.

3.3. Construction and commissioning

Preceding the construction work, a number of activities relating to the preparation of the area were carried out. Parallel with these activities, contracts were concluded for the manufacturing of mechanical equipment requiring long delivery time (e.g. Fuel Handling Machine).

The actual construction work started in March 1995, and lasted for 14 months. In this phase of construction, the transfer cask reception building and a vault module including three vaults was erected.

The last task of the construction was the so-called comprehensive testing of the facility with fifteen dummy fuel assemblies, in December 1996.

The Commissioning License was issued by the Hungarian Atomic Energy Commission in February 1997. This stage was finished in December 1997 by filling the first vault with 450 spent fuel assemblies, which took almost 3 months, from 16 September 1997 to 8 December 1997.

3.4. Operational experience

Loading of the 450 fuel assemblies in the vault resulted in a collective dose of 2.4 man*mSv, which is considered to be a sufficiently low value for such operations. The highest individual dose was 0.028 mSv, while the average value was 1 μSv.

Effluents and airborne releases during the loading phase were in accordance with the design. According to the indications of the monitoring system, the environmental impact of the operation was insignificant.

During the passive storage period the operation went smoothly, there was no event to be mentioned.

Based on the evaluation of the commissioning phase and on the updated Safety Report, the Hungarian Atomic Energy Authority issued the operational licence on 26 August, 1998. Loading of the second vault to provide the necessary storage capacity in the AR pools began immediately.

3.5. Future plans

Due to the uncertainties of further spent fuel shipment to Russia, the management of the Paks NPP made a decision to continue the construction with Phase 2, to provide more storage space by 1999. Construction work began in February 1998 and was foreseen to be finished in December 1999. Decision about the construction of the Phase 3 will be made in near future, depending on the storage capacity demand. Thus, the total comes to 11 vaults accommodating 4,950 spent fuel assemblies.

Provision is made in the design to extend the storage facility to a total of 33 vaults, to 14,850 storage positions. This number would be sufficient to store all spent fuel generated during the rest of operation of the Paks NPP. The modular "in line" configuration used for the storage vaults allows the use of a single Fuel Handling Machine and a central transfer cask reception building throughout the planned extension phases.

4. THE PUBLIC AGENCY FOR RADIOACTIVE WASTE MANAGEMENT (PURAM)

4.1. Mission of PURAM

The new Atomic Energy Law prescribes: "As the solution of such matters is in the national interest, the performance of tasks related to the final disposal of radioactive waste, as well as to the interim storage and final disposal of spent fuel, and to the decommissioning of a nuclear facility shall be the responsibility of an organisation designated by the Government". According to that, the Government nominated the Public Agency for Radioactive Waste Management (PURAM) for carrying out the work defined above. The main fields of activities of PURAM can be defined as follows:

- *Low and intermediate level waste (L/ILW) management*
  - Operate the existing repository;
  - Prepare and construct a new L/ILW repository.
- *High level waste (HLW) and spent fuel management*
  - Elaboration and introduction of a new strategy for the back end of the fuel cycle;
  - Investigations to prepare for HLW disposal;
  - Operation and extension of the existing interim spent fuel storage facility.
- *Decommissioning of nuclear facilities*
  - Decommissioning of NPP Paks;
  - Decommissioning of the training and research reactors;
  - Decommissioning of the interim spent fuel storage facility.

4.2 Structure of PURAM

PURAM is a fully state owned non-profit agency established by the Director General of the Hungarian Atomic Energy Authority, acting on behalf of the Government. The managing director, to whom the following divisions report, heads the organisational structure of the Agency:

- Research and Development;
- Implementation and Ventures;
- Finance and Administration.

The operation of the existing L/ILW repository belongs to the "Implementation and Ventures" divisions. PURAM has two headquarters, one in Budaörs (suburb of Budapest) and the second in Paks, the existing L/ILW repository is located in Püspökszilágy. The staff of the Agency is about 70 persons.