DISPOSAL OF SPENT FUEL FROM GERMAN NUCLEAR POWER PLANTS – PAPER WORK OR TECHNOLOGY?

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ABSTRACT

The reference concept “direct disposal of spent fuel” was developed as an alternative to spent fuel reprocessing and vitrified HLW disposal. The technical facilities necessary for the implementation of this reference concept – the so called POLLUX-concept, e.g. interim storages for casks containing spent fuel, a pilot conditioning facility, and a special cask “POLLUX” for final disposal have been built. With view to a geological salt formation all handling procedures for the repository were tested aboveground in a test facility at a 1:1 scale. To optimise the concept all operational steps are reviewed for possible improvement. Most promising are a concept using canisters (BSK 3) instead of POLLUX casks, and the direct disposal of transport and storage casks (DIREGT-concept) which is the most recent one and has been designed for the direct disposal of large transport and storage casks. The final exploration of the pre-selected repository site is still pending, from the industries point of view due to political reasons only. The present paper describes the main concepts and their status as of today.

1. Introduction

Since the late seventies the German industry has been developing an alternative to spent fuel reprocessing and vitrified HLW disposal. It is called "direct disposal of spent fuel". The feasibility was examined and safety aspects were evaluated. The Federal Government concluded that the technology of direct disposal had to be developed. A reference concept based on the triple purpose cask POLLUX for transport, storage and final disposal as well as a conditioning technique that separates fuel rods from the structural parts of the fuel assemblies were developed.

In 1994 the Atomic Energy Act was amended allowing the direct disposal of spent fuel without prior reprocessing. The assumed cost advantages of direct disposal of spent nuclear fuel compared to reprocessing gave reason to follow the path more and more. Moreover, the concept of phasing out nuclear energy was pursued by a red-green government and on June 30th, 2005, the delivery of spent fuel to the reprocessing facilities was abandoned. So, as of today, direct disposal is the only route of spent fuel out of nuclear power plants.

Competition among various techniques of electricity generation forced utilities and the nuclear industry to strictly control their costs and to finish unsettled issues as far as possible. All cost saving potentials at all steps along the route towards direct disposal have to be explored. At the same time the highest levels of safety standards as well as flexibility for future improvements, decisions and regulatory needs have to be maintained. So, the reference concept is still under investigation and potentials for optimisation have been identified.

The main and today most promising option is called BSK 3-concept. The most recent option under investigation is called DIREGT-concept, and aims at the direct disposal of large transport and storage casks. The main steps of these three options are shown in figure 1.

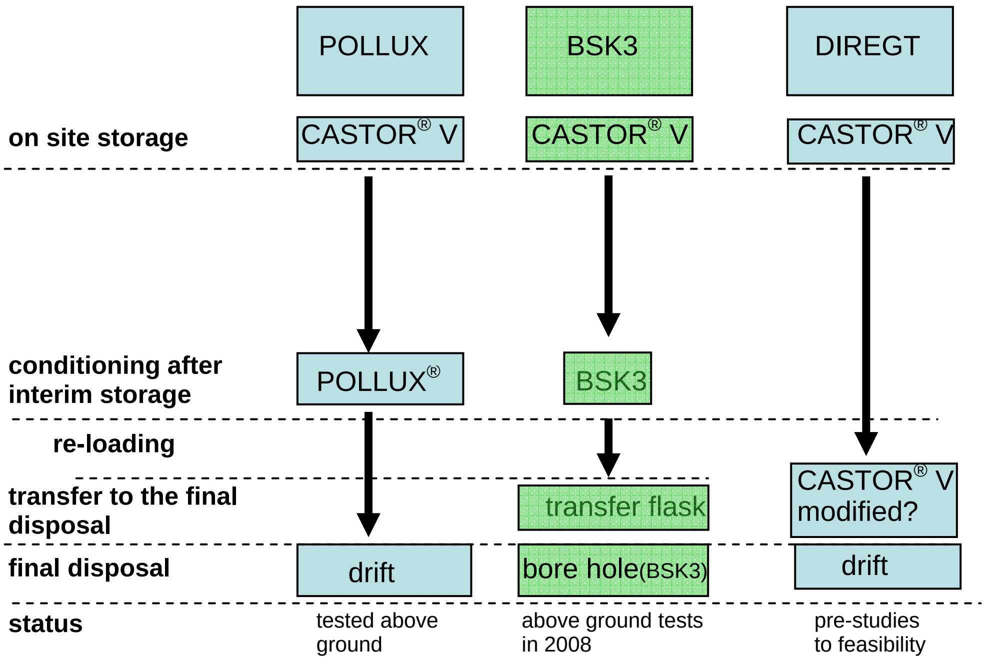

Fig. 1 Direct disposal of spent fuel: Reference concept and two alternatives under investigation

2. Disposal scheme for high-active and/or heat-generating wastes

All options for direct disposal must be seen in context with disposal of reprocessing residues (s. figure 2). About 6,000 tHM will be reprocessed and about 10,000 tHM will go to direct disposal. These quantities are calculated based on the regulations laid down in the Atomic Energy Act that allows the operation of an existing nuclear power plant for about 32 years. No new nuclear power plants will be licensed.

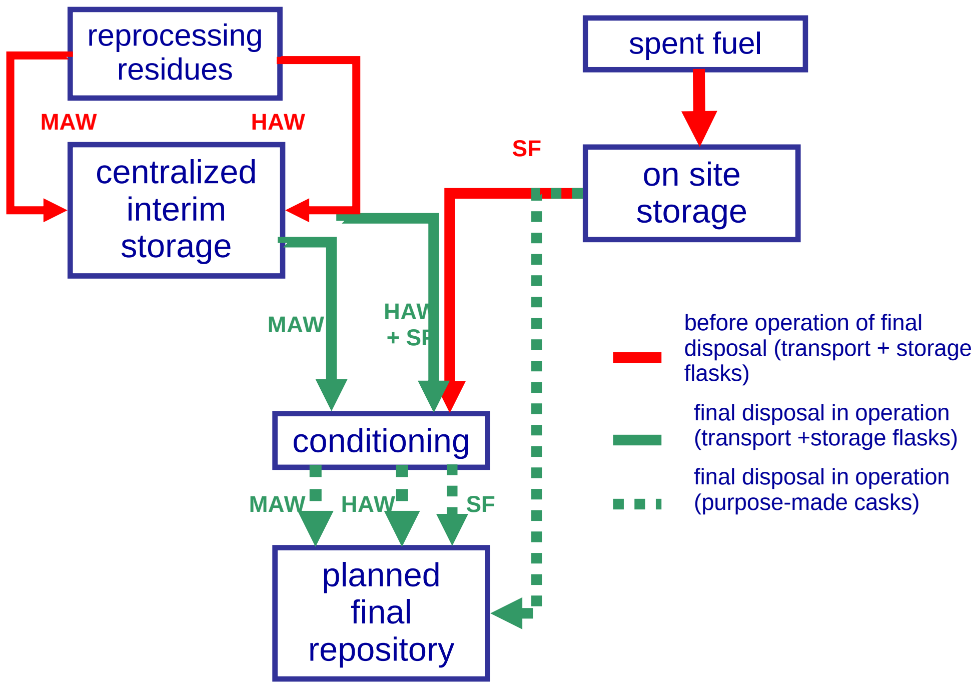

Fig. 2 Routes of waste concerning SF

In total, reprocessing will lead to about 4,000 HAW-canisters containing vitrified fission products and about 6,000 MAW-canisters containing compacted structural parts of fuel assemblies. Prior to disposal they will be stored in large transport and storage casks. A total of about 300 casks containing HAW- and MAW-residues is expected, 63 casks with HAW are already in storage at the Gorleben site. The disposal concept of today envisages to place all canisters in boreholes. So, canisters have to be transferred from the transport and storage casks into a transfer cask that serves as "shuttle" between the de/reloading station and the repository. The transfer cask is transported into the repository just onto the top of the borehole, the canisters are placed into the borehole and the transfer cask is ready for the next transfer. De/reloading of transport and storage casks was planned to be carried out in the same conditioning facility that is intended to be used for the direct disposal route.

The reference concept POLLUX for fuel assemblies also relies on large transport and storage casks and on the same type of interim storage, but differs concerning the final disposal technique.

3. Spent fuel disposal using disposal casks in the drifts of a repository: The reference concept POLLUX

Main steps are (s. figure 1):

- loading of spent fuel into transport und storage flasks after spent fuel has sufficiently cooled down in the pools of the nuclear power plant
- transfer of the flasks into an interim storage at the site of the nuclear power plant
- interim storage of flasks until conditioning or final disposal is possible
- transport of flasks to the conditioning facility or the final disposal site
- conditioning by separating fuel rods from structural parts of the fuel element
- final disposal of fuel rods and structural parts

3.1 Transport and Storage of Fuel Assemblies

To minimise costs of transport and interim storage, large casks, mainly of the CASTOR® V-type, are used. These contain up to 19 fuel elements from PWR and 52 fuel elements from BWR. The cask body is made of ductile cast iron, neutron shielding is achieved by polyethylene bars assembled in uniformly distributed drillings in the cask wall. So far, more than 100 casks have been loaded with fuel assemblies in Germany, they are stored on site, except for those 6 casks that are being stored at the Ahaus site and those 5 casks that are being stored at the Gorleben site.

3.2 Pilot Conditioning plant

The pilot conditioning plant at the Gorleben site was completed in 1999. License for operation was granted in 2000. According to the license the plant is operated in a stand-by modus to accept and repair casks when necessary. As of today, the throughput is limited to 35 tHM per year. --- Fig. 3 shows the hot cell where fuel assemblies are separated into fuel rods and structural parts. This, and their subsequent packing into cans is necessary to ensure sub-criticality in the repository.

Fig. 3 Hot cell of the pilot conditioning plant

3.3 Final Disposal Cask

The cans containing the fuel rods are inserted into the POLLUX cask. The POLLUX cask was developed as a triple-purpose cask for transport, storage and final disposal and is to be disposed of in drifts of a salt dome repository. The safety analysis report and the licensing documents according to the regulations of the Atomic Energy Act were submitted to the licensing authority and its independent expert for obtaining the flask approval certificate according to the transport regulations (type B(U)F) and the storage license according to the acceptance criteria of the Gorleben interim store. A drop test programme was carried out in 1994. The application was withdrawn due to the fact that precise and reliable design requirements cannot be identified until the exploration of the Gorleben salt dome is completed. Figure 4 shows the basic design of the POLLUX final disposal cask.

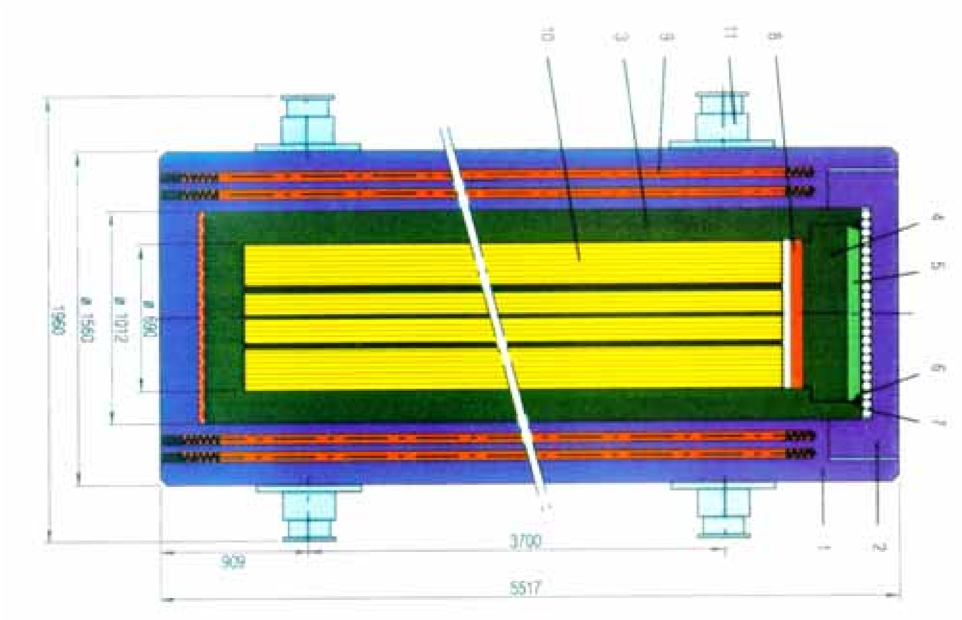

Fig. 4 POLLUX-cask for final disposal of fuel rods from spent fuel

It consists of the shielding cask with an inscrewed lid and an inner cask with bolted primary and welded secondary lid. The fuel rods are inserted into the POLLUX-cask in cans. The cylindrical wall and the bottom of the inner cask are made of fine-grained steel and extruded in one piece. The body of the shielding cask also consists of one piece and is made of ductile graphite iron. Two rows of boreholes in the shielding casks wall contain neutron moderator material. A prototype cask has undergone tests in the Pilot Conditioning plant in Gorleben. The cask will contain fuel rods from up to 10 PWR fuel assemblies or fuel rods from up to 30 BWR-fuel assemblies.

3.4 Tests for drift disposal with the POLLUX-cask in an aboveground test facility

These tests performed in 1994/1995 were aimed at demonstrating that rail-bound handling, horizontal transportation, and drift disposal of shielding-disposal casks with a weight of 65 t (POLLUX) loaded with spent fuel assemblies are technically feasible. Here, emphasis was put on the development and construction of components, such as an emplacement device, a transport cart and a mining locomotive. Their capabilities of working under normal operating conditions and under conditions of operational disturbances were demonstrated at a full scale aboveground test facility in order to guarantee the safe handling of waste packages. Figure 5 shows the mining locomotive, transport cart, emplacement device and the dummy cask.

Fig. 5 Components of the disposal system

The transport and battery-operated disposal locomotive is state-of-the-art. It is constructed in so-called open order with heading and trailing cabin and is the result of efforts to improve mining locomotives from ergonomic, operational and safety-technological points of view. The transport cart was built with a special carriage to shift the center of gravity of the POLLUX cask to a lower position. The emplacement device for drift disposal (ELVIS) was made of components that are used under comparable conditions in other technical fields and was designed for a load of 65 t. The dummy cask which was used for the tests has all the features of the POLLUX-cask.

4. Spent fuel disposal using borehole-technology: BSK3-concept

To simplify the operation of the repository and to avoid large and expensive disposal casks the BSK3-concept was developed. It is also based on the conditioning of fuel assemblies, but instead of using the POLLUX cask fuel rods are inserted into a canister that can be placed in boreholes. Thus, the same handling procedures and techniques that are used for the disposal of reprocessing residues can be used for the final disposal of spent fuel. The concept of the transfer cask has only recently been developed and is still being refined. Supported by the EU and the German Federal Ministry of Economics and Technology, DBE TECHNOLOGY GmbH is preparing an aboveground test facility to simulate all relevant handling procedures. The German utilities are involved via GNS and will provide all necessary hardware components. Figure 6 shows a sketch of the BSK 3. The BSK 3 is designed to contain fuel rods from up to 3 PWR-fuel elements or from up to 9 BWR fuel elements.

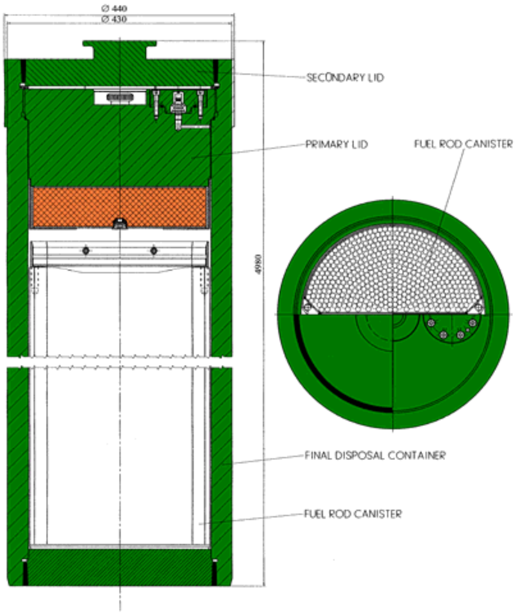

Fig. 6 Sketch of a BSK 3

Preliminary studies show that the costs for the repository operation can be reduced significantly and the total costs for casks for spent fuel can be reduced by about 50%.

5. Direct disposal of large transport and storage casks: DIREGT-concept

Based on the estimated quantity of HM a total of about 900 – 1000 transport and storage casks for spent fuel and about 300 transport and storage casks for reprocessing residues (mainly CASTOR®-casks) will be stored in interim storages and scrapped later if the POLLUX-concept or concepts based on borehole-disposal technology (BSK 3- concept or borehole-technology for reprocessing residues) are used. The feasibility of the direct disposal of transport and storage casks is being investigated. The implementation of this concept - called DIREGT-concept in figure 1 – would offer the potential to avoid the separation of fuel rods from structural parts and would avoid custom made final disposal casks. Moreover, it has been estimated that the conditioning and the de/reloading process will be most probably the bottleneck in terms of time, and the conditioning time may define the operation time of the repository. It is investigated whether safe sub-criticality can be ensured with final disposal of transport and storage casks (TSC) in the drifts of the repository. Results achieved so far give rise to an optimistic answer. In addition, it is investigated whether the heat transfer from the casks meets the requirement that the temperature in the salt formation stays safely below 200° which is the critical temperature for the salt formation in Gorleben. The crucial point will be the aboveground interim storage time necessary to let heat production rates of TSC fall below acceptable rates and whether those time spans are acceptable. All investigations and studies performed so far, do not exclude the feasibility of direct disposal using large transport and storage casks. Technical equipment for the shaft transport and the transport in the drifts of the repository has been judged as feasible. Work will continue, final results of the relevant research programme financed by GNS on behalf of the German utilities are expected in 2008. This concept has a cost saving potential which is even greater than that one of the BSK 3 concept.

6. Summary and Conclusion

The technical features for the direct disposal of spent fuel from German nuclear power plants have been thoroughly investigated and a reference concept has been established. Facilities are in operation or could be operated from the technical point of view. Concepts for optimisation show a clear cost saving potential; they may simplify processes and lower operational risk without any compromise in longterm radiological safety aspects. Test programmes will be performed within the next years. So, the answer to the title's question "paperwork or technology?" must be "technology". The missing link "exploration of a final disposal repository" and "operation of a selected final disposal site" does not lie within the responsibility of the utilities, but - as laid down in the Atomic Energy Act - lies within the government's responsibility. The German utilities are ready to solve the task "disposal of spent fuel" within the next 20 years. So, they call for a restart of the exploration of the Gorleben salt dome as soon as possible. Figure 7 shows the technical facilities at the Gorleben site: In the background the Pilot Conditioning Plant, the Interim Store, and in the front the site of the exploration mine Gorleben.

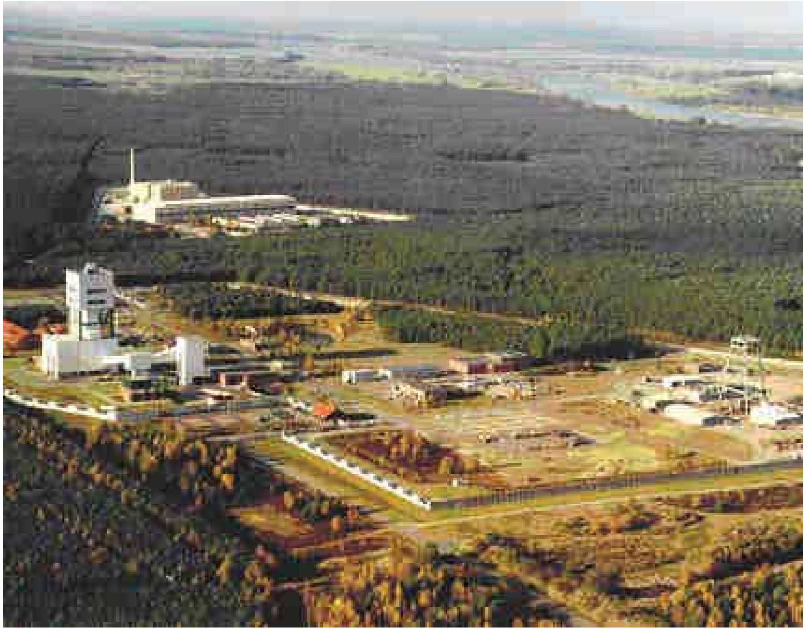

Fig. 7 Facilities for the direct disposal of spent fuel at the Gorleben site