CONDITIONING OF SPENT FUEL FOR DIRECT DISPOSAL EXPERIENCES DURING COLD COMMISSIONING OF THE PILOT CONDITIONING PLANT GORLEBEN/GERMANY (PKA)

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ABSTRACT

Since 1979 the possibilities and processes for the direct final disposal of spent fuel elements have been investigated in Germany as an alternative for reprocessing. A pilot plant for testing the selected conditioning process is under construction in Gorleben since 1990. In 1998 the mechanical equipment was tested and necessary optimizations were carried out within the cold commissioning. This report describes the hereby gained experience.

INTRODUCTION

In 1985 the government of the Federal Republic of Germany decided to develop as alternative for reprocessing the process for direct final disposal of spent fuel elements up to technical maturity. For this purpose technical large-scale tests for developing and testing of the disposal technique were to be performed in a salt mine and a pilot plant for demonstration of the conditioning process was erected. Owner and operating company of this facility with the name "Pilot-Konditionierungsanlage Gorleben" PKA (Pilot Conditioning Plant) is the "Gesellschaft für Nuclear-Service GNS (Association for Nuclear Service) and its daughter company "Brennelementlager Gorleben" BLG (Fuel Element Interim Storage Gorleben). In April 1990 the turnkey contract was awarded to the Consortium APK under the leadership of NOELL Rüterbau.

DESIGN OF THE PILOT CONDITIONING PLANT (PKA)

The concept favored in Germany for the direct final disposal provides that the irradiated fuel elements are dismantled and the fuel rods filled as tight packing units into stainless steel canisters which again are inserted into shielded Pollux final disposal casks. A basket is arranged in the center of the Pollux casks in which the compressed structural parts (skeletons) of the fuel elements or further fuel rods are placed.

The minimum throughput of the plant is fixed to 35 t of heavy metal per year. The design of the equipment enables to condition all types of PWR and BWR-fuel assemblies used in Germany.

The PKA is a multi-purpose plant in which in addition to the conditioning for the direct final disposal also the following further functions will be performed:

- Repacking of radioactive waste packing drums of all types
- Reloading of irradiated fuel elements from one into another transportation cask.

- Cleaning, maintenance and repair of transportation and storage casks of all types used in Germany.
- Waste treatment of all types of radioactive waste evolving during PKA operations.

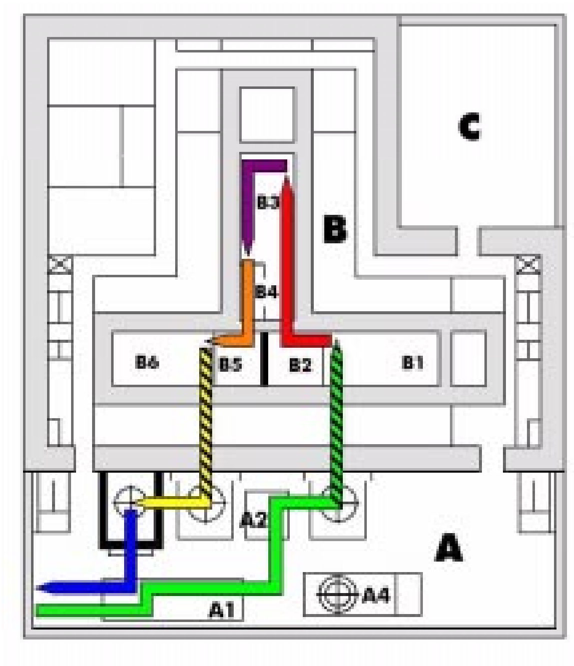
The safety related technical design of the PKA substantially corresponds to a nuclear power plant built according to the German Atomic Law, i.e. protection against impacts from outside (earthquake, airplane crash) and from inside (crash by heavy loads, criticality, fire) is to be fully assured.

CONDITION PROCESS AND ITS EQUIPMENT

The typical sequence for the conditioning process of spent fuel assemblies is shown as follows and the special properties of the respectively necessary equipment/machines are described:

Fuel Assembly Reception

Figure 1 shows schematically the routing of material through the pilot conditioning plant. The fuel assemblies are transported in the transport casks onto the truck or rail vehicle in the truck lock. The transport cask is unloaded by means of 140 t bridge crane and transported to the cask hall at work area I. After opening the secondary lid the transport cask is placed onto the suspended trolley in the transportation channel I and moved underneath the unloading cell to work area III. Here the cask is ventilated and the bolts of the primary lid removed and the docking ring is placed.
The lifting device raises the suspended trolley with the placed transportation cask and presses the transportation cask to the sealings of the docking device in the bottom of the unloading cell. The docking opening is closed from the cell by a shielding bell with lid grab. After the cask is docked - and this way the interior of the cask sealed from the outside - the primary lid is taken by the lid grab and lifted/pulled into the shielding bell.



A	cask hall
B	cell section
C	entry and administration section
A1	transortation for arrival and departure
A2	preparing transport casks and making them ready for dispatch
A3	welding and checking of POLLUX and bolting of shielding
A4	decontamination transport casks inside
B1	unloading of fuel assemblies
B2	putting canister and basket to buffer storage (buffer store 1)
B3	disassembling of fuel elements
B4	loading of canister and basket
B5	putting canister and basket to buffer storage (buffer store 2)
B6	loading and bolting of POLLUX

Fig. 1

transport cask
fuel assemblies
fuel rods an structural parts
canister and basket
POLLUX bolted
POLLUX welded and shielding bolted
routes in ground floor

Figure 2 shows schematically the arrangement of the hot cells with the required machinery and devices. The cell crane can now raise the lid pulling device (bell) and deposit it into the unloading cell.

Prior to unloading first the cask apron is placed into the provided opening for preventing contamination and damage of the sealing surface of the transportation cask.

Access into the interior of the transportation cask is now possible from the unloading cell; the fuel assemblies can be lifted out by means of a cell crane and the special grab required according to the respective fuel element type.

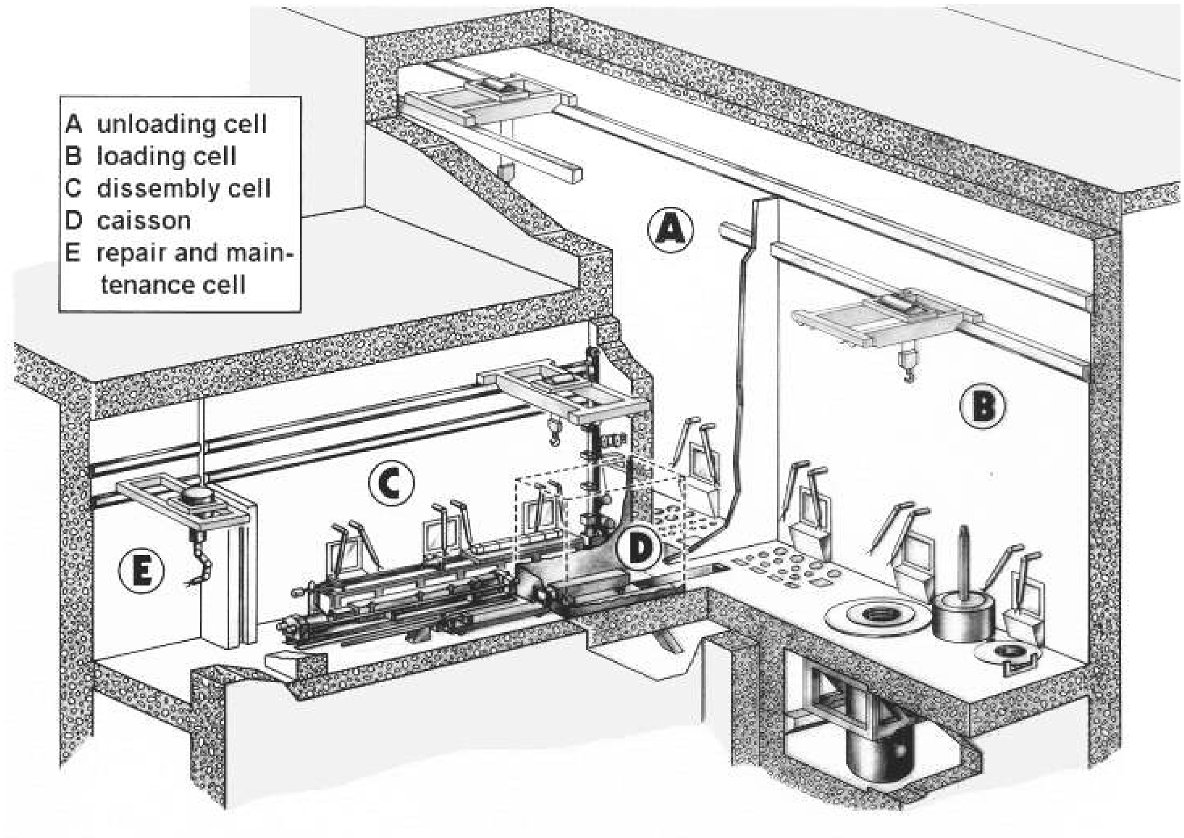


Fig. 2.

The docking station is designed in such a manner that the cask of different size is tightly docked into the area between 0,7 m and 1,8 m outside diameter. However especially adapted docking rings and aprons have to be used for each type of cask. The connection between cask and cell is gas-tight by means of the double lid principle.

The fuel assemblies are first placed into the buffer storage. The buffer store has twelve positions for PWR and 25 positions for BWR fuel assemblies. The heat of the fuel assemblies is discharged to the outside by means of an inherent safe heat removal system. The maximum heat production of a fuel element is limited to 5.5 kW to keep within the allowable fuel cladding temperature.

For transporting the fuel assemblies from the unloading cell into the disassembly cell they are placed into the transportation device which is running underneath the cells by means of the crane of the disassembly cell. The tilting device pulls the fuel element into the cell and swivels it exactly from vertical position into horizontal position on the disassembly table.

The tilting device has two hydraulical drives required for raising the fuel assemblies as well as for swiveling. The drives are connected in such a manner that they redundantly operate and in case of a failure of one drive the other one performs the function alone.

In case of a major defect the total equipment can be dismantled by remote handling and transported into the repair and maintenance cell by means of a crane.

Disassembling of Fuel Elements

The first step for disassembling a fuel assembly is separating of the head and bottom parts. At most of the BWR/PWR assemblies this is done by unscrewing; at some fuel assemblies the control rod guiding tubes have to be separated from the inside by a special cutting tool.
The row pulling tong grasps one each complete row of fuel rods and by moving the disassembly table with the clamped on fuel element the rods are pulled out of the spacers and fall in the trough arranged underneath. This process is continued row by row until only the skeleton is on the table.

The trough is designed for the rods of 2 PWR or 6 BRW fuel elements. A vibration unit initiates that the rods are aligned in parallel in the trough and an optimum filling is reached.

During the cold testing of the fuel element dummies the machines used have fulfilled their function in a satisfactory manner. 4,5 working hours were required for the total process from unloading from the transportation cask up to disassembling of a PWR fuel element. All processes were hereby controlled by remote handling in a pure simulation operation.

Loading of Fuel Canisters

The filled trough is deposited on the pushing device arranged on the opposite cell side. From here the fuel rods collected in the trough are pushed into the fuel canister. The interface for this process is a double lid system in the partition wall of the loading caisson which separates the contaminated disassembly cell from the clean loading cell and the loading caisson. The empty fuel canisters are transferred into the loading cell via the transportation channel II. The docking process for the respectively provided Pollux final disposal casks corresponds to the transportation channel I.
Each Pollux final disposal cask takes a central basket with square cross-section as well as four canisters which correspond to a quarter circle segment each. The canisters are removed from the Pollux cask by means of the loading cell crane for filling with fuel rods and are vertically placed in the docking machine. While the docking machine is approaching the double-lid system described above the inserted canister swivels automatically into the horizontal position and is pressed with its lid to the double-lid system. The automatic control of the system grabs then the lid of the canister and swivels it with the caisson lid towards the side so that the trough and the canister are standing opposite to each other. The electrically driven shifting chain can now push out the fuel rods being in the trough all at once into the canister.

The total process is automatically operated by means of a computer control and lasts approx. 1,5 hours, it takes about 2 hours together with the remote-controlled process of cask handling. During the cold testing the exact approaching of the canister to the double-lid system demonstrated to be difficult. A reason for this is the asymmetrical cross-section of the canister: the tolerances of fabrication have to be very exactly coordinated with the sealing faced to the double-lid transfer system. Otherwise long lasting readjusting work has to be performed.

The filled canister is closed via the double-lid system and moved back into the vertical position by means of the docking machine. Then it can be placed into a buffer storage position by means of the crane of the loading cell or immediately into the Pollux cask. The docking machine is then free for receiving the next canister or the basket for the structural parts of fuel assemblies.

Compaction of Structural Parts of Fuel Assemblies

A 5000 kN skeleton press has been developped for the compaction of the fuel element skeletons composed of head and bottom parts as well as spacers with water guiding tubes. This press is arranged in the center of the disassembly cell. All parts which can be subjected to heavy wear during compaction are designed in such a manner that a replacement is possible only by means of manipulators and the cell crane.
During the testing PWR and BWR skeletons as well as also Zirkaloy fuel channels of BWR were compacted by means of the press. The result was highly compacted metal block with a volume reduction of 1:8.

Up to now the press was operating in a reliable manner, the developed marks (furrows) in the press boxes had no influence on the functionability. However in the beginning the forces for pulling back the press ram after pressing were very large, because fine particles of metal oxides were clamped in the gap between head plate of press ram and the press box. This fact caused an increased formation of marks (furrows) during pulling back. It was already demonstrated after several compaction processes that the discharge force for pressed pieces considerably increased, 3-fold, with increasing roughness of wear plates.

The problem was however solved by only placing the head plate loosely in front of the press ram and hereby not following on during pulling back of press ram, but remaining at the compacted item. The limiting of discharge force was neutralized. During the next compacting process the head plate again is placed in front with the press box after pulling back the press ram.

Due to the required long distance of compacting of 5 meters the press ram is composed of five parts which are placed one after the other into the press box. This technique makes is possible to provide a relatively short length of the press, with a disadvantage that the time of compacting for a skeleton amounts to approx. five hours.

Due to an increasing routine of the operation staff it can however be expected that the required time will be reduced by approx. 50 %.

The completed pressed piece - now up to 8 pressed pieces are collected in one magazine - will finally be pushed out into the basket. The basket is docked as the canister from the loading cell to a double-lid system at the loading caisson wall and filled from the disassembly cell. Only simple resetting work at the displacement device is necessary for this purpose.

CONCLUSIONS

The testing work performed so far with fuel element dummies has demonstrated the satisfactory functioning of the installed technical machinery equipment. Minor optimization work is still being conducted for improving the process before start up of hot operation. Independent experts and approval authorities have convinced themselves about the safety related technical unobjectionability and are presently preparing the approval for the hot operation.

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