XA9848071

EXPERIENCE WITH THE INTERIM STORAGE OF SPENT HTR FUEL ELEMENTS AND A VIEW TO NECESSARY MEASURES FOR FINAL DISPOSAL

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Abstract

In the Federal Republic of Germany the AVR pilot high-temperature reactor was operated successfully for more than 20 years and the THTR prototype high-temperature reactor for more than three years The reactors were shut down for decommissioning at the end of 1988 and the discharge of core inventories and packaging of the fuel, together with the temporarily stored fuel, for long-term interim storage in appropriate casks and facilities was started in 1992 and finished in 1995 for the THTR and began in 1994 for the AVR and will be completed at the beginning of 1998.
With a view to the long-term interim storage and final disposal of spent HTR fuel from both reactors many experiments have been carried out to characterize the spent fuel and to learn about its behaviour and during the operating period of the AVR reactor much experience has been gathered by remote handling, shipping and temporarily storing fuel packages at different appropriate facilities of the Forschungszentrum Jülich GmbH (FZJ). Furthermore, after starting the discharge of the AVR core more than 200 so-called AVR dry storage canisters (AVR-TLK), each containing 950 spent fuel elements have been reloaded from an AVR single shipping cask into CASTOR THTR / AVR shipping and storage casks in the hot cell facility, which is one part of the waste treatment and storage building of FZJ, and currently about 100 CASTOR casks, each containing in all 1900 fuel elements, have been prepared and stored in the AVR interim storage facility (AVR-BL), as another part of this building.

1. INTRODUCTION

In the Federal Republic of Germany the AVR pilot high-temperature reactor was operated successfully for more than 20 years and the THTR prototype high-temperature reactor for three years. During operation they were charged with several types of spherical graphite fuel elements, containing different U/Th mixtures such as coated HEU or LEU fuel particle dispersions. About 300,000 AVR and 620,000 THTR fuel elements were irradiated during the operating times. THTR spent fuel was temporarily stored on site and AVR spent fuel was temporarily stored at different hot cell and pool facilities of the Forschungszentrum Jülich GmbH (FZJ).

During the long operating period of the AVR reactor a lot of R&D work was carried out by FZJ to characterize the different types of spent fuel elements for developing interim storage and final disposal concepts /1, 2, 3/ and as part of this work much experience has been gathered by using spent fuel elements for experimental set-ups and by handling, shipping and temporarily storing fuel packages at different appropriate facilities of FZJ.

At the end of 1988 the reactors were shut down for decommissioning and discharge of core inventories and packaging of the fuel, together with the temporarily stored fuel for long-term interim storage in appropriate casks and facilties was started in 1992 and finished in 1995 for the THTR and began in 1994 for the AVR and will be completed at the beginning of 1998.

At the Ahaus facility, 305 casks, each loaded with canisters containing 2100 spent THTR fuel elements have been managed and stored by the Brennelement-Zwischenlager Ahaus GmbH. At the Jülich facility currently 100 CASTOR casks, each loaded with two AVR-TLK containing in all 1900 spent AVR fuel elements, have been prepared and stored by FZJ.

2. OVERVIEW OF SPENT AVR FUEL MANAGEMENT

By the end of 1988 about 190,000 spent fuel elements had been discharged during the reactor operating period and were packaged and shipped to FZJ. After granting the licences according to the Atomic Energy Act for discharging the core inventory for decommissioning by AVR GmbH and for

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handling and long-term interim storage by FZJ, work began in August 1993 on managing fuel from core discharging by means of so-called AVR cans (AVR-K), each containing 50 fuel elements, and from different FZJ facilities for fuel reloading from AVR-K into AVR-TLK as well as charging of CASTOR casks for interim storage in the AVR interim storage facility (AVR-BL).

At that time about 84,000 fuel elements packaged and sealed in AVR-K were stored in the water cooling facilities of the Hot Cell (HZ) and the Research Reactor (FR) Departments, about 106,000 HEU fuel elements enclosed in AVR-TLK were stored in the LZ storage cell of the AZ hot cell facilities which is one part of the waste treatment and storage building of the Decontamination Department (DE), and about 110,000 fuel elements were still in the AVR reactor core. The paths of the AVR fuel elements from the reactor core to the AVR-BL are shown in *Figure 1.*

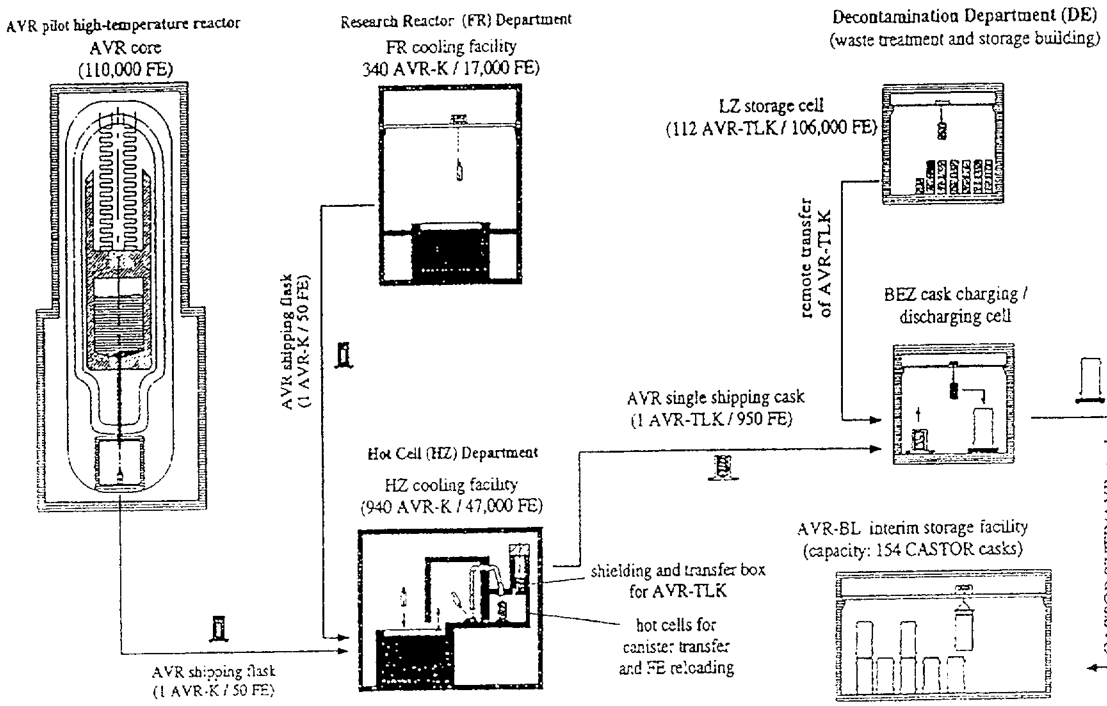

FIG. 1: Paths of the AVR fuel elements from the AVR reactor to the AVR interim store (fuel element inventories(FE) in the different facilities given by the end of 1993)

From August 1993 up to the present time about 91,600 fuel elements have been discharged from the reactor core, enclosed and shipped by means of AVR-K to HZ and reloaded there into AVR-TLK. About 65 AVR-TLK have been removed from the LZ and about 50,000 fuel elements enclosed in AVR-K have been removed from the above-mentioned water cooling facilities and reloaded into AVR-TLK so that in all 100 CASTOR THTR/AVR casks have been prepared and stored in the AVR-BL.

The delay in AVR core discharging in comparison to initial planing is caused by disturbances and failures of components from the different facilities and the equipment necessary for discharging the fuel and handling and reloading fuel packages and additionally, due to of problems, which arose at the beginning of 1995 with the liscensing procedures for LEU fuel handling and reloading in the HZ Hot Cell Department as well as handling LEU fuel packages in the DE Decontamination Department.

3. AZ HOT CELL FACILITY FOR HANDLING FUEL CANISTERS AND SHIPPING BAY FOR PREPARING AND ASSEMBLING CASTOR THTR / AVR CASKS

3.1 Preparing of CASTOR casks for charging

Preparing of CASTOR casks for charging is carried out in the shipping bay, which is part of the hot cell facility (AZ) and which covers the hot cells. Apart from a 50 Mg bridge crane for handling heavy loads, whose range of operation covers the whole shipping bay area, a 5 Mg crane is installed above the the so-called mounting area for handling CASTOR lids (*FIG. 2*).

Preparation of the sealing systems of casks, i.e. visual inspection, cleaning and if necessary, manual refurbishing of sealing groove surfaces of lids, sealing surfaces of casks as well as of the metallic gaskets, is carried out by means of the lid tilting device and the assembly station, which are installed in the mounting area. Positioning of casks onto the flat-bed cargo trailer, which is part of the assembly station, is carried out by means of the 50 Mg bridge crane.
After inspection and refurbishing work the metallic gaskets are fixed in the sealing grooves, the cask is closed with the primary lid and shipped into the BEZ cask charging / discharging cell.

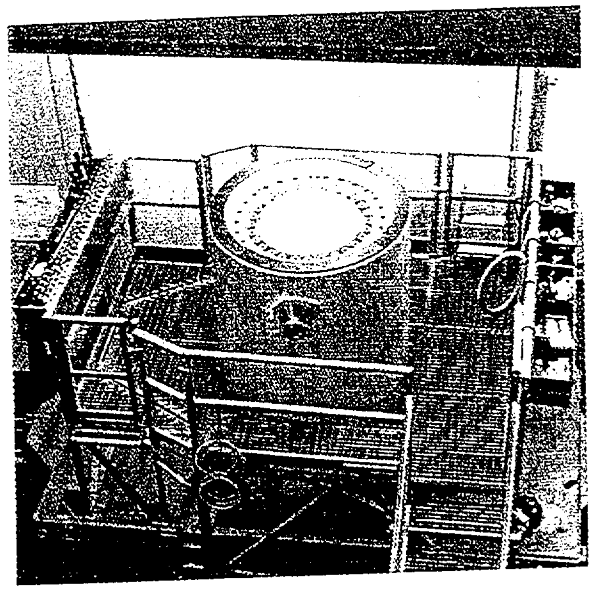

FIG. 2: View onto the assembly station with a CASTOR cask positioned on the flat-bed cargo trailer

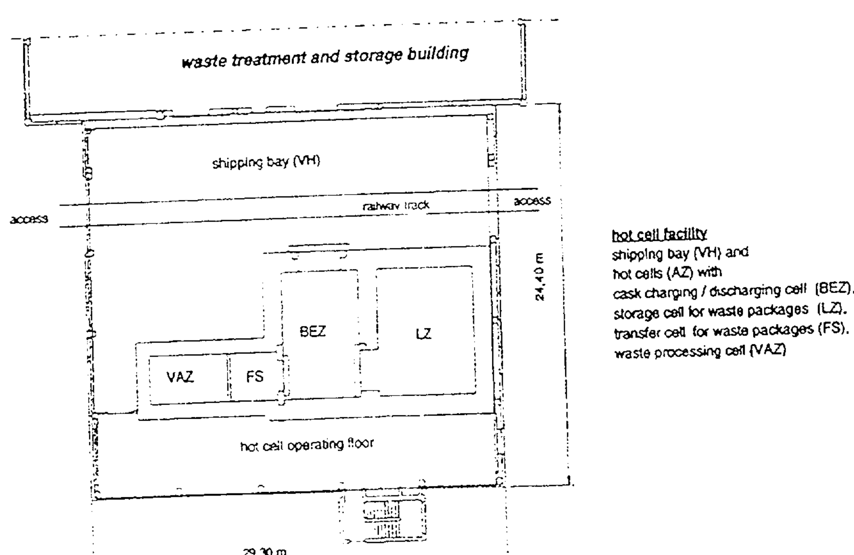

FIG. 3: Simplified ground plan of the AZ hot cell facility

3.2 Charging of CASTOR casks in the BEZ hot cell

Before remote charging of two AVR-TLK and closing of a CASTOR THTR/AVR shipping and storage cask, AVR-TLK must be shipped and discharged from the AVR single shipping cask or transferred from the LZ storage cell and lowered into lay-down positions in the BEZ cask charging / discharging cell of the AZ hot cell facility, which is accessible from the shipping hall by means of the so-called BEZ shielding gate (*FIG. 3*) . For remote handling of waste drums and heavy loads of up to 4 Mg a power manipulator with drum tongs and a hook is installed in the BEZ (*FIG. 4*).

For handling of AVR-TLK a special pintle grapple and for handling the CASTOR primary lid a coupling link can be attached to the hook. Furthermore, the manipulator is equipped with a laser positioning system for accurate lifting and lowering of the CASTOR primary lid.

During the entire handling, charging and closing procedure the CASTOR cask remains on the flat-bed cargo trailer, which is equipped with a removable scaffold framing the cask and enabling access to the top of the cask. After the primary lid is in place, the low radiation level allows opening of the BEZ shielding gate for radiation protection measures and for preliminary tightening of primary lid's screws and for shipping the cask back to the assembly station in the shipping bay

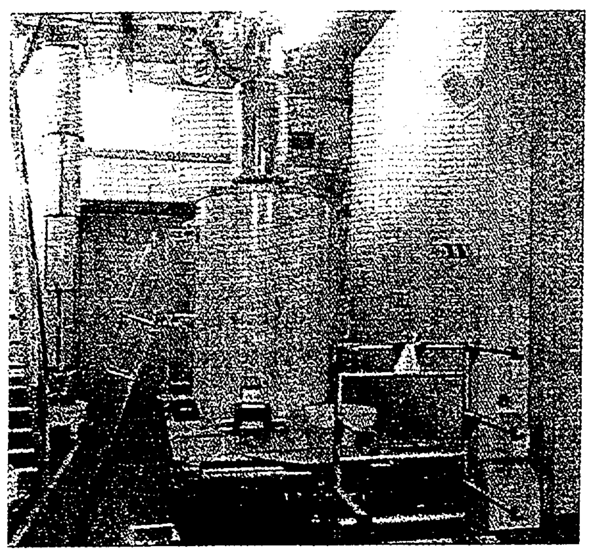

FIG. 4: Remote charging of a CASTOR cask in the BEZ cask charging / discharging cell

3.3 Assembling and leak testing procedures

After the CASTOR cask has been transferred back to the assembly station the assembling and leak testing procedures are as follows:

- tightening of the primary lid's screws
- evacuation of the cask and replacement of the withdrawn gas by an Ar /He-gas mixture
- He leak testing of the primary sealing system
- inserting the secondary lid
- tightening of the secondary lid's screws
- evacuation of the space between the lids and pressurizing the space with He gas
- He leak testing of the secondary sealing system
- mounting and He leak testing of a pressure gauge
- covering the top with the protective lid
- mounting the VACOSS seal on the protective lid
- removal of the scaffold and shipment to the AVR-BL interim storage facility

4. THE AVR-BL INTERIM STORAGE HALL

The AVR-BL interim storage facility has been built and licensed according to the Atomic Energy Act (§6 AtG) for the interim storage of spent AVR fuel elements which have been irradiated during the operating period of the AVR pilot reactor and which have to be enclosed in CASTOR THTR/AVR shipping and storage casks. Lay-out of the storage area will serve for the interim storage of 154 casks, which are stacked alternately on one and two levels (FIG. 5 and 6)

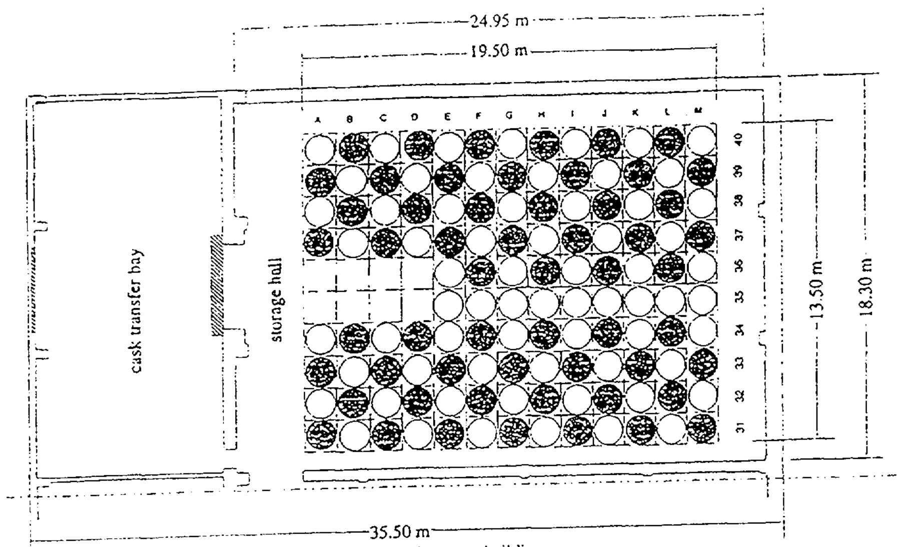

FIG .5: Scheme of the arrangement of CASTOR casks in the AVR-BL interim storage facility as another part of the waste treatment and storage building

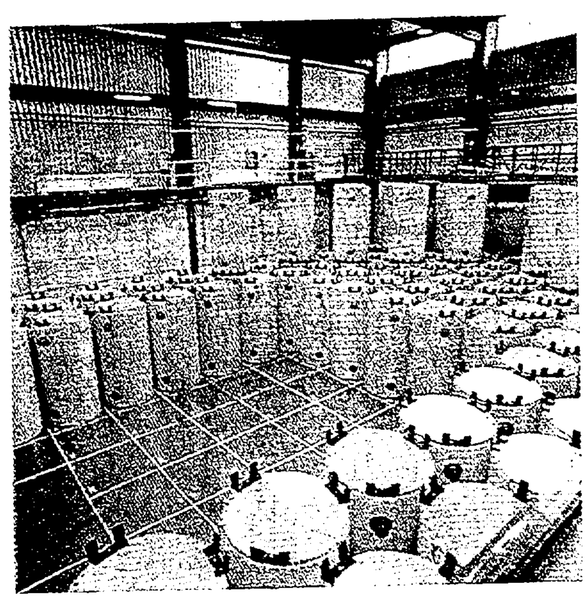

FIG. 6: View into the AVR-BL storage hall

5. SAFETY CONCEPT FOR INTERIM STORAGE

The safety concept for the interim storage of AVR spent fuel elements is based, in particular, on design requirements for CASTOR THTR/AVR shipping and storage casks as a tight enclosure so that any undue release of radionuclides is excluded both in normal operation and under conceivable accident conditions. According to design, the sealing function of both lid sealing systems is monitored during storage so that any deterioration or failure of a sealing barrier is detected and repair measures for restoring the two-barrier system can be carried out in the AZ hot cell facilities.

Within the Atomic Energy Act licensing procedures (§6 AtG) for the AVR and the BZA interim storage facility a leakage rate of $L \leq 10^{-7}$ mbar × l / s for each lid sealing sytem of the CASTOR casks is required.

Apart from the results obtained on the basis of long-term experiments with comparable lid sealing set-ups by FZJ /4, 5/ and other institutions /6, 7, 8/, which confirm the good long-term behaviour of such sealing systems with respect to the design requirements, confirmation of the required and specified tight enclosure of the spent fuel canisters has also been provided by the experience gathered from loading and preparing more than 400 CASTOR THTR/AVR transport and storage casks at the Jülich and Ahaus sites.

6. VIEW TO NECESSARY MEASURES FOR FINAL DISPOSAL

According to the plans of the Bundesamt für Strahlenschutz (BfS), solid and solidified radioactive waste forms, but in particular those with marked decay heat generation shall be disposed of in a final repository in a salt dome formation /9/. Heat-generating waste includes spent HTR fuel elements which are not to be reprocessed.

By the end of 1992 R&D work in establishing a final disposal concept for HTR fuel was focused on small 400-l fuel packages to be emplaced in 300-m deep boreholes in the final repository still to be constructed and then ultimately confined. Most of the work was discontinued at the end of 1992 /10, 11,12/.

The BfS subsequently gave preference to a final disposal concept for HTR fuel oriented along the lines of the direct disposal concept for irradiated LWR fuel elements, which is based on packaging the fuel in so-called POLLUX shipping and final disposal casks /13/.

Due to the fact that the design features, radioactive inventories and long-term behaviour of LWR fuel is completely different from those of HTR fuel further studies on the suitability of the CASTOR THTR/AVR cask to establish an adequate final disposal concept for HTR fuel have been currently initiated and will be carried out by Forschungszentrum Jülich GmbH in cooperation with Gesellschaft für Nuklear-Behälter mbH (GNB).

7. CONCLUSIONS

At the present time handling, reloading and packaging of fuel elements from AVR reactor core discharge, in addition to handling and reloading of some thousand fuel cans (AVR-K) and some hundred fuel canisters (AVR-TLK) in different facilities of FZJ as preparatory steps for charging CASTOR casks, has been conducted in a safe manner according to the requirements of the Radiation Protection Ordinance (StrlSchV).

Extensive cold testing of the equipment, training of the personnel responsible for charging and gas-tight closure of the CASTOR casks before starting hot operation and feedback of experience in addition the experience gathered by charging 100 CASTOR casks, has led to safe routine handling without the occurence of non-normal events.

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