INTERSTORAGE OF AVR-FUELS IN THE RESEARCH-CENTER JÜLICH GMBH

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ABSTRACT

Between 26.08.1966 and 31.12.1988 the experimental nuclear power plant AVR was operated in the area of the Jülich research-center by the **A**rbeitsgemeinschaft **V**ersuchs-**R**eaktor mbH, the AVR company. This plant was a Helium cooled high-temperature-reactor with an electric gross-power of 15 MW. This type of power plant was the first one being developed exclusively in Germany. The high-temperature-reactor AVR was one after the principle of the ball-pile-reactor developed by Professor Schulten. The core consists of spherical, graphite fuels with 60 mm diameter, that contain the fissile-material and breed-material in form of coated particles. The fuel is enclosed by a cylindrical graphite-construction wich serves as the neutron-reflector. The coating of the fuel-particles consist of pyro-carbon and silicon-carbide and is used for the retention of the fission-products. The reactor has continuously been refueled by feeding the fuel balls into the core at the top and discharging them at the bottom during full operation. After the shut down the reactor now is on the way to safe closure while planings for dismanthing have been started. The Jülich research-center was engaged with the storage of the spent fuels as part of the fuel management. The storage of the fuel in CASTOR® THTR/AVR casks is preceded by different actions, like the removal of the fuel from the reactorcore, the interim storage of the fuel in AVR-cans in the buffer-storage, decanting of the fuel balls from AVR-cans in the dry-storage-cans (TLK), the interim storage of the TLK, welding of the TLK wich contain wet fuel and the loading of each CASTOR® THTR/AVR cask with two TLKs, are necessary. The action is taken at different locations in the research-center. The steps of the fuel management are described in the following.

FUEL MANAGEMENT

On their way from the reactorcore to the AVR-interim storage the fuels run through different institutes in the research-center.

Core unloading in the AVR

As operator of the reactor the AVR-company has discharged the fuel into so-called AVR-cans in order to empty the reactorcore. Doing so 50 fuel balls where filled into an AVR-can. The AVR-can is made of stainless-steel and is closed by a plug. The so loaded AVR-cans were transported from the reactor to the buffer storage pool in the hot cells by a transportation-bell. The reactor core is now completely emptied from fuels.

Handling of the fuel in the hot-cells

In the hot cells the AVR-cans passed through the pool, are transported into the transfer cell where they are opened and emptied. When opening, one keeps an eye on signs indicating that water has penetrated into the can during it's stay in the pool. Such signs are hissing sound, the appearance of fog or steam while pulling the plug out as well as water running out during the subsequent emptying the AVR-cans. If such a sign is registered, the content of this AVR-can is excluded from the filling into TLKs. The AVR-can is than brought back to the buffer storage. Water can enter through leaky sealing of the AVR-can. From the transfer cell the fuel is transported with the ball-conveyor into the TLK wich is kept ready in the sluicebox. Until now all AVR-cans with 50 fuel balls have been decanted in the hot cells into TLKs, which hold 950 fuel balls. TLKs which contain wet fuel balls, are separated for a special treatment. The TLKs are transported with a special shielded vessel from the hot cells to the waste-cells in the interim storage site.

Handling of the fuel in the interim storage site

The TLKs filled with 950 fuel balls are collected in the dry storage cell. Two of them are loaded into a CASTOR® THTR/AVR cask. The loaded cask is transported to the AVR-interim storage. Standing in position it is connected with a monitoring-system for seal control.

LOADING OF THE CASTOR THTR/AVR® CASK

The loading of the CASTOR THTR/AVR® cask is performed as dry loading in the waste-cell area of the interim storage site. The CASTOR® THTR/AVR cask is brought into the loading- and unloading cell and there filled with two TLKs taken from the dry storage cell. However before the cask can be loaded, preparations at the dense-surfaces of the lids of the CASTOR® THTR/AVR cask must be made outside the cell. There the protection-plate, the secondary-lid and the primary-lid are lifted off and prepared. After the control of the dense-surfaces the primarily lid is put on the cask again. The so prepared CASTOR® THTR/AVR cask is then moved into the loading- and unloading cell. The shielded door of the cell is then closed. Afterwards the primarily-lid of the cask is fixed to a rack and taken off. All movements of the lid are controlled by a laser equipment to ensure correct replacement of the lid after loading. Afterwards, segmented cover plates are placed on top of the open cask to protect the dense-surfaces. After this the cask can been loaded with two TLKs remotely. After removal of the cover plates the laser marked lid is also put on the cask remotely. Now the shielded door of the cell can be opened a split so that radiation-protection-measurements can be executed at the cask.

After the radiation-protection-measurements the primarily-lid is fixed by four screws driven by hand. As soon as the health physicist has completed the measurements at the cask surface the CASTOR® THTR/AVR cask can be driven out of the cell for further treatment. Now, the further screws of the primarily-lid are put in place and driven with torque-keys. The denseness of the primarily-lid is controlled by Helium-leak testing and is documented. A pressure operated switch, that controls the pressure between the two lids, is fit into the secondary-lid. Afterwards the prepared secundary-lid is put on the cask and also screwed on. Now, the function of the pressure switch is checked. Also the denseness of the secondary-lid is tested with Helium. In the end, the protection-plate is installed on the cask. Afterwards, the CASTOR® THTR/AVR cask is brought into the AVR interim storage, which is located in the same building.

WELDING OF TLK's

A special treatment is required for TLK's wich contain wet fuel. This is necessary to prevent possible corrosion at the unprotected interior metal-surface of the CASTOR® THTR/AVR cask. There are two possibilities to handle such TLKs. First, the fuel balls could be dried over two days in the cell atmosphere. Second the gap between the can's neck and the plug could be sealed by welding. The first was rejected as not beeing practicable. Therefore the TLKs becomes welded in the waste cell. For this purpose a welding equipment has been instaled in the waste-cells of the interim storage site. The welding-aggregate is outside the hot cell, only the welding-head is inside.

Before the welding of the TLK, a part of it's atmosphere is replaced by Helium wich serves as an indicator for leak testing.. A special equipment was developed for changing the plug at the TLK, executing the gastaking and for leak testing, or to check the denseness at the dense-lip-welding-seams of the TLK. This so-called plug-change and leak testing machine can execute the job mentioned above in the waste-cell remotely. The gas taken from the TLK's atmosphere is filled into a flask in a glove-box. The so taken gas is analyzed in the laboratory of the hot cells. During it's handling attention must be paid to possible H2-content. The gas is examined for Tritium (H-3), Carbon-14 ($^{14}CO_2$) and Krypton-85 (Kr-85).

Before welding the TLK, the plug is pulled out of the can. The can is then evacuated to approximately 800 mbars and the Helium is filled in until the pressure reaches approximately 1000 mbars. Finally, a new plug which is provided with Elastomer-sealings is pressed into the can's neck. The can becomes welded after conclusion of this handling.

For the welded TLK a helium-standard-leakage of $Q_{max} \leq 1{,}0 \bullet 10^{-4}$ mbar • l • s^{-1} (helium-standard-leakage) is required.

Taking into account that the helium-standard-leakage of the silicone-poem (including Permeation) is approximately $2 \bullet 10^{-5}$ mbar • l • s^{-1} and the 200 mbar He supply in the can, this requirement can be regarded as full-filled, if one day after the welding the leakage rate minus underground amounts to

$$Q \leq 3{,}0 \bullet 10^{-6} \text{ mbar} \bullet l \bullet s^{-1} \text{ (measured He- leakage).}$$

The tested cans can now be loaded into a CASTOR® THTR/AVR cask. The welding-procedure at the TLK's is superiesed by an independent expert. After 11 weldings, a dummy must be produced. This is then examined by the experts. The dummy will be cut and undergo metalurgical testing. If the tests don't show failures the welding of the TLK's can be continued.

ACHIEVEMENT

From August 1993 until November 2001 124 CASTOR® THTR/AVR casks have been loaded and brought into the AVR interim storage. Altogether, 235.262 fuel balls and 114 graphite balls without fissile material were loaded in CASTOR® THTR/AVR casks.

Table I. Overview of the cask loading from 1983 to 2001 in the Jülich research-center

year	handled casks per year	cask in the AVR-interim storage
1993	17 casks	17 casks
1994	25 casks	42 casks
1995	22 casks	64 casks
1996	22 casks	86 casks
1997	20 casks	106 casks
1998	8 casks	114 casks
1999	1 casks	115 casks
2000	5 casks	120 casks
2001	4 casks	124 casks

HISTORY OF SPENT FUEL MANAGEMENT

- 26.08.1966 to 31.12.1988: AVR reactor in operation
- Till 1991: removal of fuel from the reactorcore
- 11.08.1993: loading of the first CASTOR® THTR/AVR cask

- Till November 2001: 235.262 fuel balls and 114 graphite balls stored in CASTOR® THTR/AVR cask

- Present:
  - 34 TL-cans containing 32.282 fuel balls stored in the dry storage cell.
  - From these 34 TL-cans 29 are filled with wet fuel-balls
  - 19.150 fuel balls stored in the pool of the hot cells
  - 28 CASTOR® THTR/AVR cask must be loaded.