DISMANTLING OF THE COMPONENTS ABOVE AND INSIDE THE RPV OF THE KARLSRUHE MULTI-PURPOSE RESEARCH REACTOR (MZFR), GERMANY

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ABSTRACT

The Multi-purpose Research Reactor was a pressurized-water reactor cooled and moderated with heavy water. It was built from 1961 to 1966 and went critical for the first time on 29 September 1965. After nineteen years of successful operation, the reactor was de-activated on 3 May 1984. The reactor had a thermal output of 200 MW and an electrical output of 50 MW.

At first, safe containment and enclosure of the plant was planned, but then it was decided to dismantle the plant completely, step by step, in view of the clear advantages of this approach. The decommissioning concept for the complete elimination of the plant down to a green-field site provides for eight steps. A separate decommissioning license is required for each stage. The decommissioning work is done according to pre-approved work schedules.

As part of the dismantling, about 72,000 Mg [metric tons] of concrete and 7,200 Mg of metal must be removed. About 1,000 Mg of concrete (400 Mg biological shield) and 1680 Mg of metal must be classified as radioactive waste.

EIGHT INDIVIDUAL STEPS (LICENSES) DOWN TO THE GREEN FIELD

Each dismantling step is accomplished according to pre-approved work schedules. Adherence to the approved dismantling steps is controlled by the supervisory agency on behalf of the licensing authority. Nearly twice per month, a member of the supervisory staff visits the MZFR for controlling the dismantling progress. Furthermore, the supervisory authority charges an expert with the verification of the documentation, assessment of the dismantling techniques planned to be used, and control of the major dismantling steps directly on site, on the average once per week. At the end of each partial decommissioning license, the MZFR has to prove that the dismantling objective has been reached.Under the first and second partial decommissioning licenses, individual installations were shut down, work was done to prepare for dismantling, the systems were modified, the D_2O was disposed of, and the plant areas were dried.

The decommissioning work under the third partial license, such as tearing down the cooling towers, emptying the turbine hall, and dismantling the water treatment plant, was carried out according to schedule.

As soon as the fourth partial decommissioning license had been granted in April 1994, the work scheduled under this license began. This included the dismantling of reactor auxiliary systems in the auxiliary building, in the fuel storage pools, and, to a certain degree, the simplification of the electricity supply and the chemical decontamination of the primary systems in the reactor building. The work provided for in the fourth partial decommissioning license was completed in March 1997.

The fifth partial decommissioning license, which was granted in May 1994 covered the dismantling of security facilities on the MZFR site and the elimination of the fence around the site of the MZFR and KNK with its surveillance equipment.

The sixth stage in the decommissioning (sixth partial decommissioning license) mainly involved the dismantling of the primary systems and all reactor auxiliaries in the reactor building. After completion of the work under this license, the reactor building was empty, except for the reactor pressure vessel and its internals. The application documents for this sixth stage were submitted to the licensing authority in June 1996. The license was granted on 3 April 1997. The work in the sixth stage is now completed. The measurements for the decision on the release of the building sections from the controlled zone are presently being conducted.

In the seventh stage of decommissioning, the reactor pressure vessel (RPV) and its internals will be dismantled manually and by remote control. The license for the 7^{th} stage of decommissioning was granted on 7 January 1999. The residual materials were classified, the number and type of residuals' containers were determined, and their procurement initiated. The dismantling work began on 16 December 1999.

Draft versions of the Safety Report and Supplementary Documents for the application for the eighth partial decommissioning license were prepared in November 2000. The application was applied for in December 2000. Experiments on the release of tritium are currently being carried out with regard to the disposal of the tritium-contaminated concrete structures.

7^{th} DECOMMISSIONING STAGE: DISMANTLING THE RPV

The performance of the dismantling work in the seventh stage of decommissioning is in the hands of one contractor, a consortium consisting of NUKEM-Nuklear, DSD GHH, and Siemens. Checking and approving of the implementation plans and quality assurance as well as monitoring of the results of the work are done by the Karlsruhe Research Center.

The dismantling concept provides for the following main stages once the building site has been set up:

- Removal of the components above the RPV
- Removal of the rod-shaped components inside the RPV

- Dry dismantling, parts 1 (RPV head) and 2 (filler piece and filler piece ring)
- Wet dismantling (plasma cutting of the moderator tank and of the thermal shield)
- Dry dismantling, art 3 (oxy-acetylene cutting of the reactor pressure vessel)
- Clearing the building site

All the equipment installed for the removal of the reactor pressure vessel by remote handling is operated from a control console.

In order to prevent contamination from spreading during dismantling operations, the intervention area, the packing station, and the dismantling room will be ventilated with a supplementary ventilation system. The pressure stages are arranged so that the pressure difference from the room with the highest contamination is the lowest.

The supplementary ventilation system (ZLA = ***Z****usatz****l****üftungs****a****nlage*) has been installed already for the most part. The components of the mobile and stationary parts of the supplementary ventilation system are located in the former experiment rooms.

The intervention area has been set up in Evaporator Room I, Room R 402, for performing repair work. A separate caisson is provided for the band saw. Decontamination work can be done in the decontamination box.

For transporting items within the reactor compartment, the refuelling machine crane will be used. It has been placed on the crane rails of the former refuelling machine in the reactor compartment. The refuelling machine crane consists of the bridge and the trolley with two 40-Mg hoists as the main hoist. In addition, there is a boom with three 6-Mg hoists, by means of which the bell-type shield is positioned and oriented on the RPV nozzle. All work with the refuelling machine crane is done by remote control. Accordingly, there are cameras and lighting units on the refuelling machine crane.

For underwater dismantling, flame-cutting gases that are mixtures of N_2, H_2, and Ar are used for the plasma torch. For dry dismantling of the reactor pressure vessel an oxy-acetylene flame cutter is applied.

All dismantled parts are packed in repository casks in a packing station. The packing station provided for this purpose, along with its refuelling machine crane, the loading container, the cask closing container, and the transportation system have already undergone trials and are currently being installed in Evaporator Room II, Room R403.

7th DECOMMISSIONING STAGE: PLANNING/FABRICATION/TRIALS

All the equipment required for the first stage of dismantling was put into operation in accordance with the commissioning programmes. This included:

- The control console
- The refuelling machine crane in the reactor compartment
- The bell-type shield

- The transfer station with welding facility
- The tilting device
- The shielding container (transport container).

After commissioning, the trial and training programme was carried out, and after a few faults were corrected, the authorities gave the permission to perform other dismantling work.

Planning for the equipment of the second stage of dismantling, dry dismantling parts 1 and 2 (reactor closure head, upper spacer, and spacer ring) has been completed. Part of the equipment has already been fabricated and is being tested in a test bay.

The packing station with the loading and cask closing containers and the refuelling machine crane has already been set up in Room R 403, and the systems are currently being tested. A rail system with transport carriages and work platforms has already been installed.

Factory acceptance testing of the band saw and the dismantling table has taken place and the first saw cuts of workpieces with thicknesses up to 1400 mm have been performed successfully.

The equipment for the third stage of dismantling, wet dismantling (moderator tank and thermal shield) has mostly been planned already. At present, the tools for plasma cutting are being tested in a test bay. The central component of this stage of dismantling, the bridge manipulator and its handling equipment, is complete, except for a few additions.

The bridge manipulator consists of a bridge that can travel along a circular track. A trolley, to which the mast is attached, traverses along the bridge. Two carriages, independent of one another, run along the length of the mast.

On one of them, a seven-axes manipulator ("slave") is mounted, whose joints are powered by hydraulic actuators. The motions of the joints determined by the master arm are transferred to the manipulator by means of a master-slave control (unilateral position control). This manipulator serves to handle cut-off parts and can also be used for other tasks.

The five-axes tool support, which directs the plasma torch is mounted on the other carriage. The kinematics of the tool support are controlled by means of a programmable controller. The plasma torch is handled in the automatic mode, with the individual vertices of the tool path being "taught" for this purpose.

The water treatment plant and the drying plant for the cut-up pieces of the dismantled components are being planned.

The equipment for the fourth stage of dismantling, dry dismantling part 3 (dismantling of the bottom of the RPV and the lower spacer) is being planned.

7th DECOMMISSIONING STAGE: IMPLEMENTATION

Implementation began with the construction work. This included making penetrations, for example from the evaporator rooms to the reactor room as well as for the supplementary ventilation system and the electrical equipment.

The first manual dismantling work on the RPV began on 16 December. Figure 1 shows the situation on the RPV before the start of dismantling. First, the shielding, insulation, and sheet-metal covers were removed enough to allow the components above the RPV to be taken down. This work was done manually. Next, the 18 position indicator tubes of the control rods, which were mounted on the drive tubes, were removed.

After the shielding had been removed from the drive and position indicator tubes, dose rates between 2 and 20 mSv, due to contamination, were measured on the lower part of the position indicator tubes. The radiating sections were sawed off (about 30 cm) and packed into shielded casks. The position indicator tubes were wrapped in foil.

After the position indicator tubes had been dismantled, the absorber rods that extended beyond the drive tube were lopped off for the further dismantling work. To do this, the upper end of the absorber rod located in the drive tube was grasped with a grab, raised about 300 mm, clamped, and then cut off with a saw. The remaining, clamped lower part of the absorber rod was then grasped again, the clamp released, and it was then lowered about 1.5 m into the guide tube.

Next, the 18 drive tubes, on which no increased dose rate was measured after the removal of the position indicator tubes, plus the holds and platforms, were removed. The situation after this stage of dismantling can be seen in Fig. 2. The total mass removed amounted to about 17 Mg, with a total activity of 2 E 11 Bq.

After these jobs had been completed, the bell-type shield, the tilting device, and the shielding container were put into service. These devices are used to withdraw the rod-shaped components in the RPV. Next, the withdrawing of the rod-shaped components was tried out with the corresponding equipment and tools in a test bay, and the operating personnel was trained. During this phase, some slight modifications were made with regard to the grasping tools. The trials were concluded with a demonstration of the processes to the independent expert and the supervisory agency, after which remote-controlled removal of the rod-shaped components could begin.

Dismantling Step 1: Rod-shaped Components

The rod-shaped components are subdivided into those located above the RPV and those located within the RPV (see Fig. 3a and Table 1). The rod-shaped components **above** the RPV consist of the position indicator tubes, the drive tubes with drives, and the boric acid containers. All other components are located **within** the RPV.

The rod-shaped components include the 17 absorber rods and the 18 drive tubes. Both types of components are arranged in a circle, at an angle of 20° to the vertical axis in the RPV. The 121 upper parts of fuel assemblies and the 121 guide tubes (coolant channels) are installed in the vertical position. These components must be removed by remote control, since the dose rates of the components range up to hundreds of mSv.

The position indicator tubes are flange-mounted on the drive tubes which in turn are mounted on nozzles of the RPV closure head. In the nozzles are the guide tubes which penetrate into the RPV and are fixed at the bottom of the moderator tank. The control and absorber rods are accommodated in these tubes and can be moved up and down by means of the drives mounted on the drive tubes. These elements as well as the boric acid containers with their injection tubes are arranged on the periphery of the RPV closure head, at an angle of about 20° from the vertical axis.

The cooling channels of the fuel elements, which stretch into the bottom of the moderator tank are located in the RPV nozzles that are screwed perpendicularly into the RPV closure head. The cooling channels of the fuel elements contain the fuel element linkages with the fuel element closures.

The rod-shaped components were removed using a shielded flask (called the "shielding tube") into which the rod-shaped components were withdrawn. The removal work is done by remote control from the control console. The refuelling machine crane, from which the bell-type shield is suspended (see Fig. 4), and the bell-type shield itself can be operated from here. These devices are used to remove the rod-shaped components from the RPV.

First, the upper parts of the fuel assemblies were withdrawn. For the removal of the upper parts, the bell-type shield suspended from the refuelling machine crane is shifted over the RPV closure head. An adapter is mounted onto the upper part of a fuel assembly, and over this a target device is centered onto the fuel assembly nozzle.

Then the bell-type shield is placed onto the fuel assembly nozzle. If the bell-type shield is positioned properly on the fuel assembly nozzle, this is indicated by a signal of two buttons at the control console, and the refuelling-machine crane can no longer be shifted. The bell-type shield's slide can then be opened and the grab, with the drive for locking and unlocking the grab in the adapter, can be lowered. This engages in the adapter and is locked.

There is a corresponding grab and an associated adapter for each rod-shaped component. Next, the grab with the upper part of the fuel assembly is drawn up to the highest position of the bell-type shield. Only when the limiting position (limit switch) has been reached can the slide be closed, and the refuelling machine crane then be moved.

Now the bell-type shield is moved to the transfer site on the 6.5-m level (third floor). There, a target device for positioning the bell-type shield is mounted on the vertical shielding tube of the tilting device. Once the bell-type shield is aligned, the target device is removed and then the bell-type shield is placed onto the shielding tube. Only when the bell-type shield is seated correctly on the shielding tube, which is indicated by limit switches, can the bell-type shield's slide be opened.

A transport cartridge is installed in the shielding tube and now raised and pressed against a circular groove in the bell-type shield. This ensures that any spread of contamination is precluded to a large extent. Next, the bell-type shield's slide can be opened and the upper part of the fuel assembly fastened to the grab is introduced into the transport cartridge from above. Once the upper part of the fuel-assembly has been lowered into the transport tube and the grab has been disengaged from the upper part of the fuel assembly, the grab is withdrawn into the highest position in the bell-type shield; the bell-type shield's slide can be closed, the transport cartridge can be lowered, and the shielding tube's slide can be closed. Next, the bell-type shield is transported back to the RPV. Two upper parts of fuel assemblies are loaded into one transport cartridge.

The shielding tube's slide is opened and the transport cartridge is raised until it protrudes about 300 mm above the shielding tube. The transport cartridge is then closed with a lid, a TIG orbital welding head is placed on it, and the lid is welded to the transport cartridge. This prevents any spread of contamination.

Next, the shielding tube is shifted from the vertical to the horizontal position. The control console needed for this is located on the 0.0-m level (second floor) in front of the big materials lock.

The shielding container with its lid open is connected to the horizontally positioned shielding tube (see Fig. 5) and the slide of the shielding tube is opened. A transportation device moves the transport cartridge from the shielding tube to the shielding container. The dose rate is measured during the transfer.

Next, wipe samples are taken at defined spots and assessed, and dose rates are measured. The results are entered into the waste materials shipping documents. The shielding container is passed out through the lock and transported to the Hauptabteilung Dekontaminationsbetriebe HDB (Central Decontamination Department).

In the HDB, the shielding container is taken from the transport carriage and placed on a rack by means of a bridge crane and a specially designed lifting beam. The shielding container is moved to the cell with this rack and connected to a lock. Inside the shielding container, there is a transportation device that is used to shift the transport cartridge from the shielding container to a transfer point in the processing cell.

After the dismantling of the rod-shaped components above the RPV, the fuel element linkages with the closures were dismantled. Next, the cooling channels of the fuel elements were supposed to be withdrawn. The first difficulties occurred in carrying out this work. In some cases, the upper parts of the cooling channels of the fuel elements had seized in place, so that they had to be freed with extraction tools. A cooling channel of the fuel elements comprises three pieces of tubing. The upper and lower pieces are made of austenitic material and the middle piece of Zirkaloy 2 which is additionally surrounded by two approx. 0.5 mm thick dimpled sheets of Zirkaloy 2. Where the lower and middle pieces of tubing are screwed together, there is a slightly chamfered union nut whose diameter is a few tenths of a millimeter larger than that of the middle piece of tubing. This shoulder must be pulled through an opening in the upper part of the moderator tank (cf. Fig. 3b). The clearance between the outer diameter of the union nut and the inner diameter of the opening in the moderator tank is only a few tenths of a millimeter.

Of the 121 cooling channels of the fuel elements, we succeeded in extracting 86 easily. Some of these cooling channels of the fuel elements had to be moved up and down several times in order to get past the bottleneck of the moderator tank opening. 30 cooling channels of the fuel elements could only be extracted after lengthy moving up and down and repeated alignment.

Samples were taken from one cooling channel of the fuel elements in the HDB hot cell. While being handled, it fell onto the floor and shattered into many pieces. So it was clear that breakage had to be definitely avoided during further attempts to extract the cooling channels of the fuel elements.

Five cooling channels of the fuel elements had to be left in the RPV. All attempts to extract them failed. With the help of the observation unit, it was found out without any doubt in the pulling tests with the remaining five cooling channels of the fuel elements that the union nuts on the lower end of the shroud tubes did not catch on the moderator tank opening, but could be drawn part of the way into this opening and then jammed.

The remaining five cooling channels of the fuel elements will now be parted about 1,700 mm below the nozzle by means of an internal parting device. The lower part will remain in the moderator tank and will be dismantled during the "wet dismantling". The cut-off upper parts will be divided further, packed in drums, and then disposed of.

After the cooling channels of the fuel elements had been dismantled, the absorbers, which were extracted without difficulty were removed and disposed of. During the subsequent removal of the guide tubes which have a union nut on the lower section like the cooling channels of the fuel elements, the same difficulties occurred as during the extraction of the cooling channels of the fuel elements. The space was very cramped as well. The nuts of the RPV lid screws were very close to the nozzles in which the guide tubes were located. Despite all the difficulties, all 18 guide tubes were extracted.

As part of this stage of dismantling, further components, such as a pipe with valve body (multi-port valve), inlet tubes of the boric acid injection system, experiment leads, and two thermocouple penetrations, were removed. With this the step 1 "dismantling of the rod-shaped components" was finished.

The equipment for removing the rod-shaped components, such as the tilting device with shielding tube, were then dismantled as much as necessary, decontaminated preliminarily, and transported to the HDB for further dismantling and disposal. The "shielded container" and "shielding tube" were not dismounted, but only decontaminated preliminarily and transferred to the HDB for disposal.

In order to determine the radiological situation in the RPV, the dose rate was measured at various positions and at various heights. The results are shown in Figure 6. The heights given starting from the top edge of the RPV nozzle and reach almost to the bottom of the moderator tank. The highest dose rate is 7 Sv/h in the middle of the core. Ten years ago, 30 Sv/h was measured in the middle of the core, with the rod-shaped components still installed.

For this stage of dismantling, a planning value of 189 mSv had been assumed for the collective dose. The collective dose actually received amounted to 53 mSv.

At present, the RPV is being filled with demineralized water up to the bottom edge of the upper spacer.

Dismantling Step 2:Dry Dismantling, Parts 1 and 2

During part 1 of dry dismantling, the RPV closure head will be dismantled, Then a 2-meter high reflood compensator will be mounted on the RPV flange and filled with demineralized water as a radiation shield. During part 2 of dry dismantling, the upper spacer and the spacer ring will be dismantled.

For the dry dismantling, parts 1 and 2, the dismantling area in the reactor compartment, Room R 401, the intervention area in Room R 402, and the packing station in Room 403 must be set up in the reactor building.

In this stage of dismantling, the RPV closure head, the upper spacer, and the spacer ring will be placed on the cutting table set up in Room R 401 by means of the reactor circular crane or the refuelling machine crane. A band saw that traverses on rails will also be mounted in Room R 401. It will be used to cut the components into pieces that can be handled. The cut-off pieces will be deposited on the transfer table by means of grabs hanging from the refuelling machine crane and transported with the table into the packing station. This equipment has already been fabricated and tested in the factory, except for the transfer table. The installation of this equipment in reactor compartment Room R 401 began in December.

Further handling of the cut pieces will be done in the packing station. This station consists of the loading freight container and refuelling machine crane, the closure container, the rails and traversing carriage, and two working platforms.

The cut pieces will be lifted from the transfer table and loaded into shielding containers with the refuelling machine crane. Before this, the covers will be lifted off the shielding containers in the closure container and the shielding containers will be positioned under the corresponding loading opening in the loading container by means of the traversing carriage.

After loading, the covers will be placed onto the shielding containers again and bolted down in the closure container. Next, the shielding containers will be set down on the 0-m level with the circular reactor crane. From there, they will be transferred to the outside and transported to the HDB:

The installation of the packing station in Room R 403 has been completed. The processes there will be carried out under remote control and will be monitored with cameras that are presently being installed. The station is currently being prepared for going into operation.

The intervention area in Room R 402, with the shielding door, intervention area band saw, and the decontamination box and intervention crane has been installed. Commissioning has already been carried out. In this area, repairs of the band saw will be carried out. For interventions, the shielding door will be closed, so as to shield the radiation from the dismantling area, Room R 401.

It is planned to test the equipment for dry dismantling, parts 1 and 2, in March-April 2001, so that dismantling of the RPV closure head can begin in May.

The shielding containers for packing and disposing of the dismantled RPV components have already been procured.

Dismantling Step 3: Wet Dismantling

In the third stage of dismantling, the wet dismantling, the moderator tank and the thermal shield will be dismantled under water.

Preliminary tests regarding wet dismantling were carried out at the Institute for Materials Testing inHanover . Various types of plasma torches were tested at different water depths and selected. The design of the main component of this stage of dismantling, the bridge manipulator with its handling devices, the tools or end effectors, and the associated water purification facility, is currently being worked out.

At present, the bridge manipulator and associated equipment is being installed in a test bed. There, experiments on plasma cutting and on handling the cut-up parts will be conducted until September 2001. The start of wet dismantling is planned for January 2002.

The reflood compensator installed during dry dismantling will be filled with demineralized water. In the reactor compartment, a circular runway, on which the bridge manipulator runs, will be mounted in the annulus between the RPV and the biological shield. The bridge manipulator consists of the undercarriage, an equipment platform, on which the water purification plant is mounted, and the mast with its attachments.

The plasma cutting device unit is mounted on the bridge manipulator. A drying unit will be set up on the cutting table used for dry dismantling, parts 1 and 2. It will serve to dry the parts that have been dismantled under water.

By means of the undercarriage, the bridge manipulator can be turned on the runway. A trolley traverses on the undercarriage, allowing the mast inserted into the RPV to be positioned. Two slides moving independently of one another are mounted on the mast. On one of them, a manipulator for handling the cut-up parts is mounted, while a manipulator for guiding the plasma torch is attached to the other. The parts cut under water are placed into a basket, which is inserted into the drying unit by means of the refuelling machine crane.

The planning for the wet dismantling of components has been completed.

The equipment has been fabricated, except for the drying unit and the water purification unit. The factory acceptance testing of the bridge manipulator and associated equipment has been performed.

Dismantling Step 4: Dry Dismantling, Part 3

In the last stage of dismantling, the insulation on the lower part of the RPV will be removed and then the lower part of the RPV will be dismantled into individualsegments. Planning of the equipment required for this is completed for the most part. Some items of equipment have already been fabricated. The equipment for part 3 of dry dismantling shall be fabricated during 2001, so that the first tests can be carried out in the first quarter of 2002. Part 3 of dry dismantling is planned to start in July 2002.

TIMETABLE FOR THE 7th DECOMMISSIONING STAGE

Due to lengthy training and trial periods, the timetable has been extended in order to increase the operating staff's confidence in handling the equipment, so that operating errors and, thus, possible malfunctions or interruptions will be prevented as much as possible.

- Application for the license — May 1997
- Start of planning — September 1997
- Granting of the license — 7 January 1999
- Start of building work in the reactor building and on the pipe bridge — 8 February 1999
- Start of dismantling of the shielding and insulation on the RPV — 9 December 1999
- Start of removal of the rod-shaped components above the RPV — 16 December 1999
- Start of removal of the rod-shaped components in the RPV — 10 April 2000
- Start of dry dismantling, part 1 and 2 (RPV closure head and upper spacer) — May 2001
- Start of wet dismantling — January 2002
- Start of dry dismantling, part 3 (lower spacer and bottom of RPV) — July 2002
- End of RPV dismantling work and start of the removal of the equipment — January 2003
- RPV dismantled and the equipment for dismantling is removed — March 2003

CONCLUSION

The future tasks in the 7th decommissioning stage can be seen from the timetable (Sec. 4.3). The work belonging to the 8th decommissioning stage will be handled in parallel with this. The main steps are shown in the following timetable:

TIMETABLE FOR THE 8th DECOMMISSIONING STAGE

• Application for license	December 2000
• Independent expert's study	July 2001
• Expected granting of license	February 2003
• Completion of preliminary testing	March 2003
• Start of dismantling of biological shield (interior)	March 2003
• Start of decontamination/release measurement of auxiliary and service facilities	November 2003
• Start of decontamination/release measurement of reactor building	
• Demolition of auxiliary/service facilities	November 2003
• Demolition of reactor building	January 2004
• Demolition of outdoor facilities	September 2004
• Site cleared and recultivated	September 2004
	June 2005

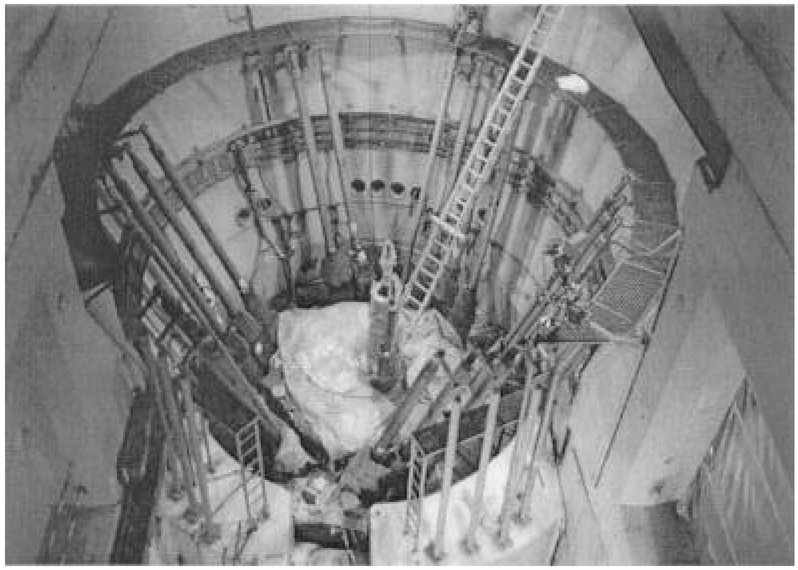

Fig. 1. View of RPV befor dismantling

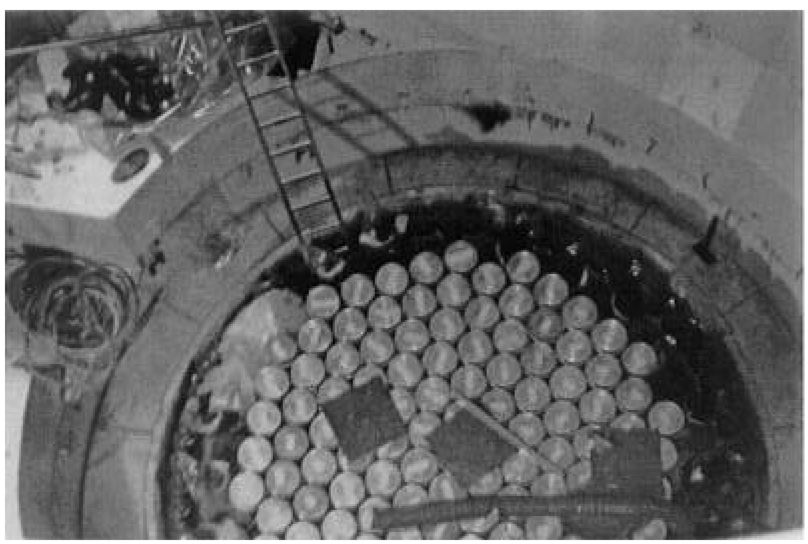

Fig. 2. View of RPV after dismantling of the rod-shaped components above the RPV

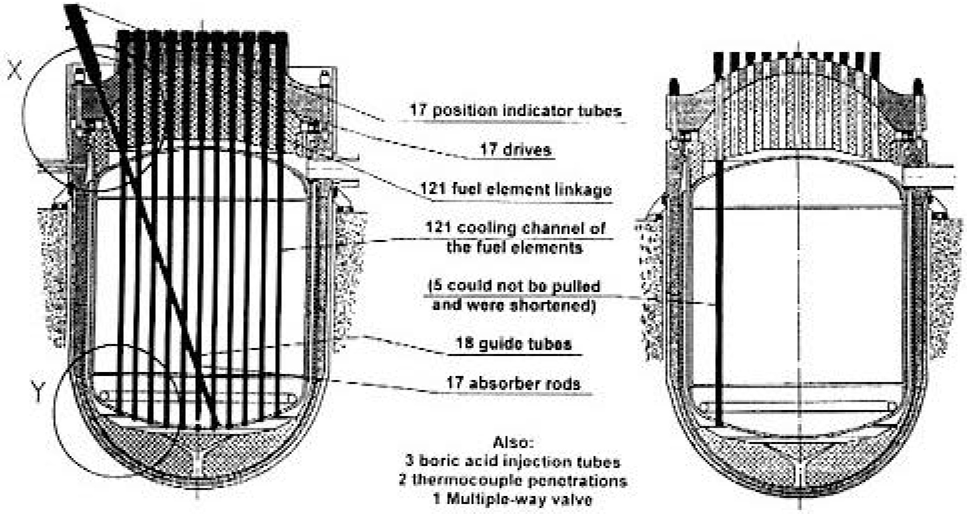

Fig. 3a. Rod-shaped components above and inside the RPV before removal of rod-shaped components (left) and after removal of them (right)

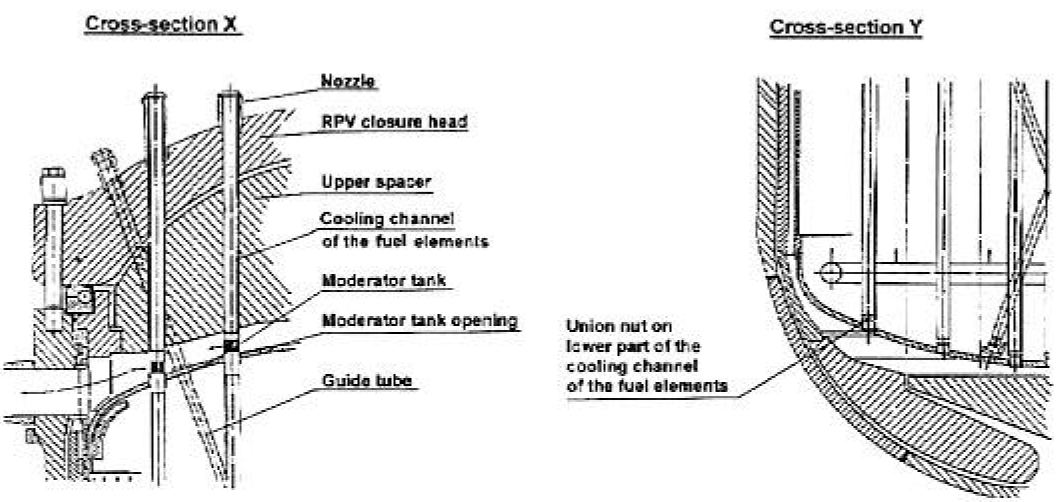

Fig. 3b. Rod-shaped components above and inside the RPV: Cross-sections X and Y

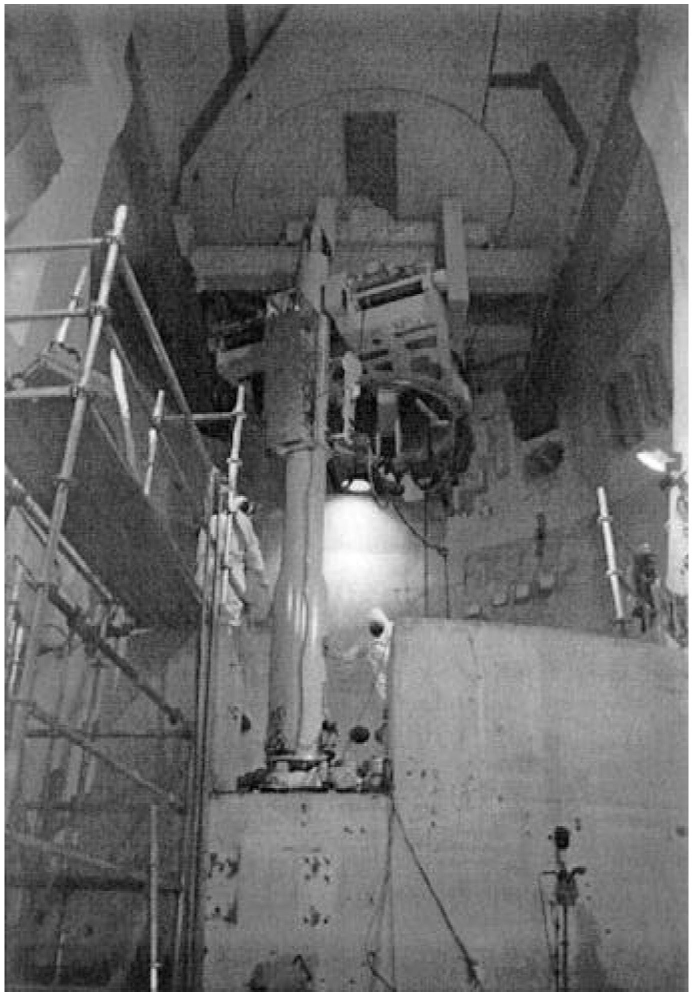

Fig. 4. The refuelling machine crane with the bell-type shield

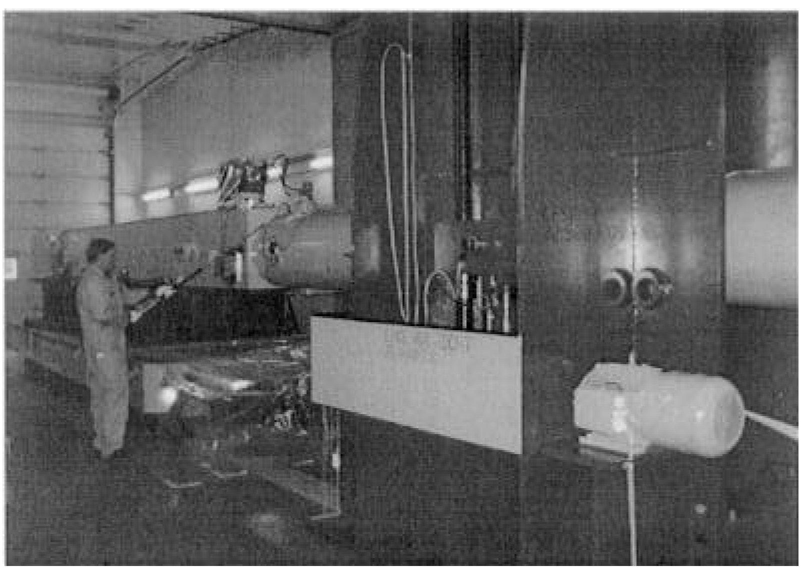

Fig. 5. Transfer of the transport cartridge from the shielding tube of the tilting device into the shielding container (level+0m)

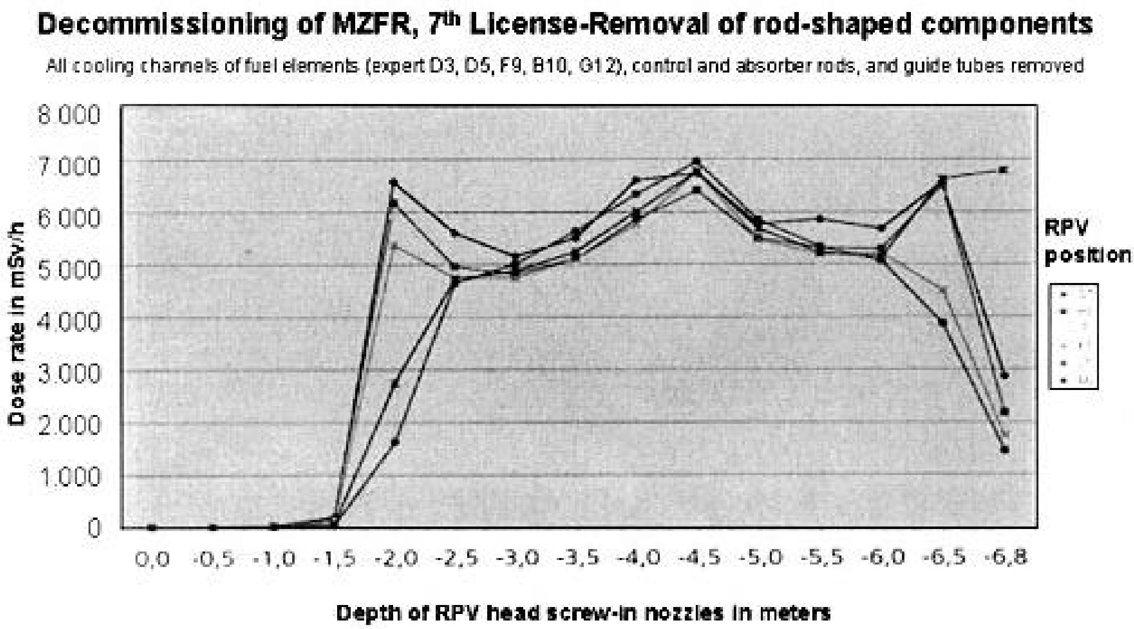

Fig. 6. Dose rate as a function of depth of measurement and position

Table I. Number of dismantled components with summary mass and activity

<u>Rod-shaped components above RPV</u>	number	mass
Position-indicator tubes	17	2,040 Mg
Drive tubes	17	4,930 Mg
Bor-acid containers	3	0,345 Mg
<u>Rod-shaped components inside RPV</u>		
Upper parts of fuel assemblies	121	11,809 Mg
Coolant channels (116 of 121 dismantled)	116 (121)	5,445 Mg (5,680 Mg)
Absorber rods	17	1,632 Mg
Drive tubes	18	0,666 Mg
Bor-injection tubes	3	0,025 Mg
Thermocouple penetrations	2	0,010 Mg
Multiport valve	1	0,020 Mg

Summery mass: ca. 27 Mg
Summary activity: α: 2,8 E 9 Bq, β: 1 E 14 Bq
Number of transports: 222
Schedule: April, 10th until September, 26th 2000