

DISMANTLING AND SEGMENTATION OF THE RPV AND INTERNALS OF THE RESEARCH REACTOR MZFR KARLSRUHE, GERMANY

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ABSTRACT

The Research Reactor MZFR is located on the site of the Research Center Karlsruhe (FZK) and was set in operation in 1965. MZFR is a heavy-water pressurized reactor ($200 \text{ MW}_{\text{th}}$ $50 \text{ MW}_{\text{el}}$). The reactor was operated first with natural uranium later with highly enriched uranium fuel. The successful operational life of the plant ended in May 1984.

The decision to decommission MZFR by means of eight individual, one after the other steps was made in 1984. After removing the nuclear fuel the work started in 1989 with the shutdown of the process systems and auxiliary systems, emptying and drying of the RPV and the D_2O carrying systems (piping, vessels, pumps), followed by the removal and dismantling of the machinery installation and the water treatment plant, as well as the chemical decontamination and dismantling of the primary systems, and removal of all reactor support systems inside the reactor building.

Under work is now the seventh step "Dismantling and Segmentation of the RPV and Internals" described in this paper. The last step to be performed is the demolition of the biological shielding and the remaining buildings.

The identifying of the technology/technique for the dismantling and segmentation of the RPV and internals, and their application to the required tasks, the decommissioning plan and the decommissioning logic plan with identification and sequency of operations have to meet the following objectives.

- * Best technical implementation and safety
- * Best radiation protection concept
- * Economic efficiency and cost beneficial implementation
- * Legislative and regulatory requirements and other applicable guidance

THE PROJECT (7th STEP) – STARTING SITUATION, TASKS AND SCHEDULE AT THE BEGINNING OF THE 7th STEP

Based on a conceptual study the RFP came out in November 1996, and in July 1997 a consortium under leadership of DETEC awarded the order for engineering, delivery of equipment and carry out the dismantling and segmenting tasks. The client is the Research Center Karlsruhe, Germany.

State of process, mechanical and auxiliary systems

The following systems and equipment are in operation resp. can be taken in operation

- * heating, ventilating and air conditioning (HVAC)
- * waste water collecting system
- * reactor building crane
- * air-locks for personnel and material
- * radiation protection instrumentation
- * fire protection equipment and system
- * illumination equipment
- * energy supply
- * water supply
- * respiration supply
- * compressed air supply
- * fault indicator system

Any connection of former operational systems to RPV are cut, the RPV is emptied and dried, the sixth step is finished and all hoist to be applied are checked and ready to take in operation.

Radiological state

The radioactivity inventory of the RPV with internals consists of activation, contamination, and some remains of coolant (D₂O). For the center of the RPV with internals a max. dose rate of 7El Sv/h is calculated, measured are 3 El Sv/h. Without internals the dose rate is about 65 m Sv/h in the RPV.

The dose rate is generated mainly by the Co60 activity.

Concerning the dose rate generated by max. contamination (surface about 10 m²) the following data are calculated.

- * dose rate in 10 cm distance ca. 250μ Sv/h
- * dose rate in 100 cm distance ca. 50μ Sv/h

With regard to the design/construction of the RPV internals it is possible, that there will be an amount of max. 100 l D₂O water remaining in the gaps. In all a calculated Tritium amount of ca. 7 El 2 Bq is to be taken in consideration.

Tasks

The major scope of work (SOW) to be performed is as follows:

- * Engineering Phase
 - Confirmation of the identified technologies/techniques
 - Set up of the decommissioning logic plan
 - Engineering, procurement, manufacturing and delivery of equipment
- * Operation Phase
 - Site preparation
 - Dismantling of equipment above RPV
 - Dismantling of RPV internals
 - Dismantling and segmenting of the RPV, moderator vessel, and thermal shielding
- * Closeout Phase
 - Decontamination and site clean-up

Schedule

The scheduled project subjects/milestones are the following:

- | | |
|--|-----------------|
| * Project start date | August 1, 1997 |
| * End of the phases engineering, procurement, manufacturing and delivery of equipment incl. cold tests | April, 2000 |
| * Site preparation | January, 1999 |
| * Start date dismantling of the RPV internals | November, 1999 |
| * Start date dismantling and segmenting of the RPV | September, 2000 |
| * Closeout | December, 2001 |

THE PROJECT (7th STEP) – SCOPE OF WORK

Engineering, manufacturing and delivery

Based on the conceptual study the detailed engineering, manufacturing and delivery of the equipment, graded on dependence of the dismantling and segmenting steps has to be performed, while doing so a previous optimization phase was accompanied with a revision of the application documents.

This revision took the items, as following into consideration

- * New specific activity data obtained by further samples
- * More detailed description in some cases of the procedures and technical approaches
- * Results of the detailed planning

The revision was elaborated in close cooperation with client, contractor and the licensing authority.

The engineering/optimization phase has to meet the KISS (keep it simple, stupid)-principle. Results are:

- * optimization of the dismantling procedures in general as well as partly selection of other methods and equipment
- * simplified dismantling operation within the RPV, material transportation and packaging of the dismantled and segmented components.

Graded manufacturing, delivery of the equipment, and cold tests for some sensitive equipment provided in a mock-up are enclosed in that SOW-phase.

The decommissioning logic plan

The decommissioning logic plan with identification and sequency of dismantling and segmenting operations, and selected technologies/techniques has to meet the following objectives:

- * Application of industrial tested and reliable dismantling equipment
- * Limited amount of various waste containers
- * Minimization of the collective dose for the workers
- * Minimization of the contamination spread
- * Optimization of
 - Investment
 - Staff cost
 - Project life-time
- * Minimization of waste volume for final storage

Pre-operation tasks

The following measures have to be carried out

- * The ventilation systems of the intervention area with the decontamination box, the intervention area for the jig saw, the packaging station, and the dismantling station will be separately operated from the ventilation systems of the other rooms in the reactor building.
- * This a.m. areas will be ventilated by means of an additional ventilation system (ZLA), consisting of a mobile and a stationary part. A directed air flow from the areas of lower contamination to those of higher contamination shall be ensured.
- * The exhaust air of the additional ventilation system will be filtered. The aerosols in the exhaust air of the additional ventilation system will be checked on radioactivity, before the exhaust air will be passed on to the standard ventilation system of the reactor building.
- * The mobile part of the additional ventilation system will be used for the removal of aerosols directly at the point of their generation.
- * Extension of the infrastructure systems in terms of illumination, electricity supply, fire alarm systems, communication systems, radiation protection systems as well as media supply and discharge systems.
- * The installation of a control station for remotely controlled operations, an audio and video system as well as an inergenous fire extinguishing system.

Dismantling and segmenting steps

The RPV with internals will be dismantled from the top to the bottom, and from inside towards outside. The internals will be removed from the RPV without any segmenting. Low activated components will be segmented by means of a dry process, however the dismantling and segmenting of high activated components is performed under water, concerning radiation protection. To minimize radiation exposure, support by remotely controlled or remotely handled processes is provided.

The dismantling and segmenting of the RPV and internals is divided into four major steps.

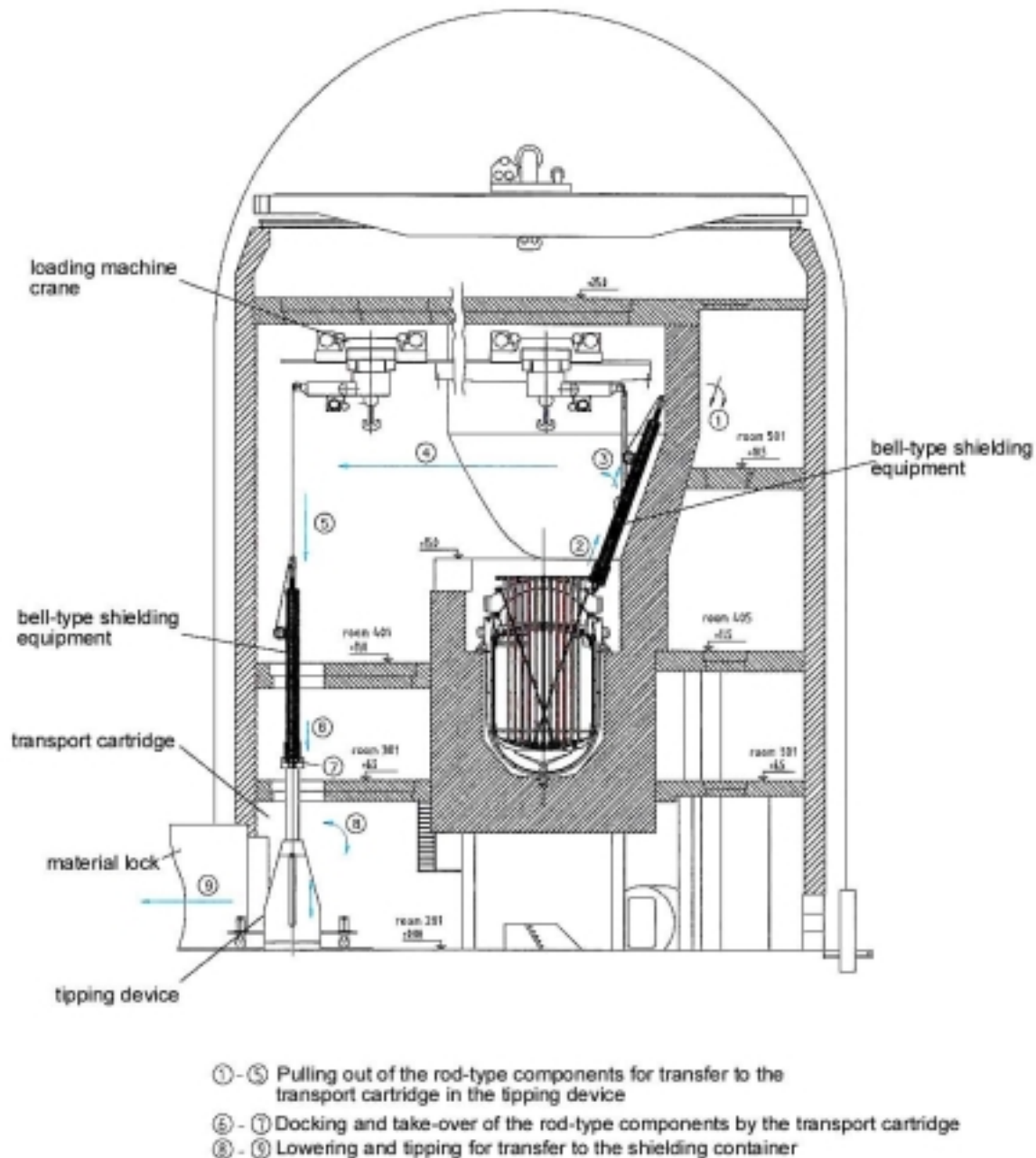


Fig. 1: Sequence of step 1

★ Step 1 (Fig. 1)

First the lead shielding, steel covery, concrete shielding bricks and insulation of the RPV cover are dismantled manually, supported by abrasive cutter. Internals above the RPV like boric acid vessel and guide tubes are manually mobilized under local shielding and packaged. Then the highly activated, rod-shaped components, such as the control rods, absorber rods, fuel element

locks with linkage, guide and separation tubes are remotely lifted into a bell-type shielding equipment which is suspended at the loading machine crane and reloaded into a transport cartridge (one-way cartridge) for the safe enclosure. The rod-type components in the transport cartridges are then transferred into thick-walled shielding container which serves for the transport to the central Decontamination Department (HDB), where the components are disassembled to drum size in cells and subjected to subsequent conditioning.

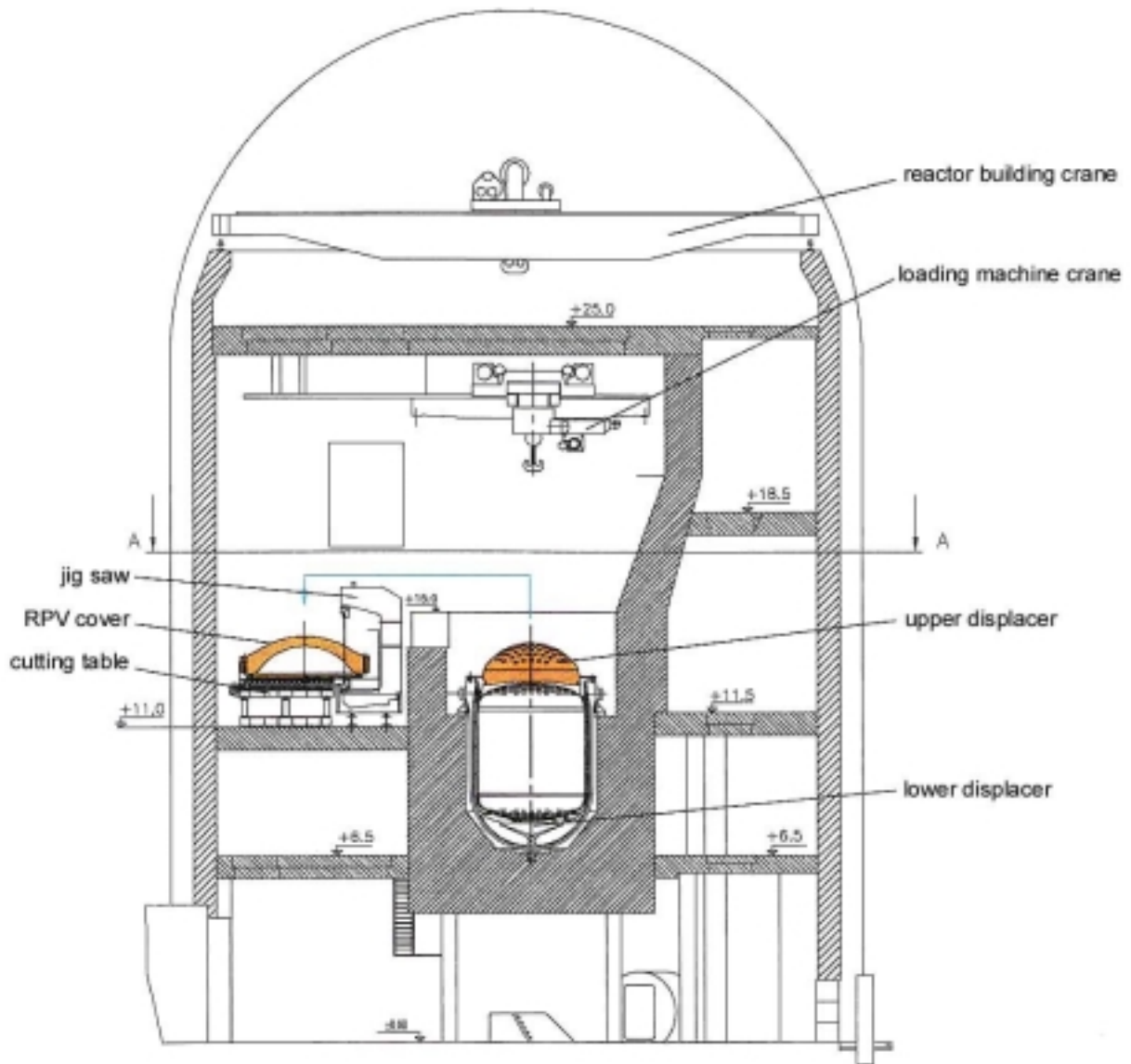


Fig. 2: Sequence of step 2

* Step 2 (Fig. 2)

Within this step the RPV bolts are manually slacked by means of a hydraulic driven screw machine, the welded lip sealing is remote handled cut open under camera control, and the RPV cover is lifted, transferred to the jig saw with cutting table and tipping device, where it is segmented. Next to this the upper displacer and the displacer ring are lifted and transported by crane to the jig saw, where the segmenting into parts suitable for packaging take place. The parts are packed into type II containers and transferred for further conditioning to HDB.

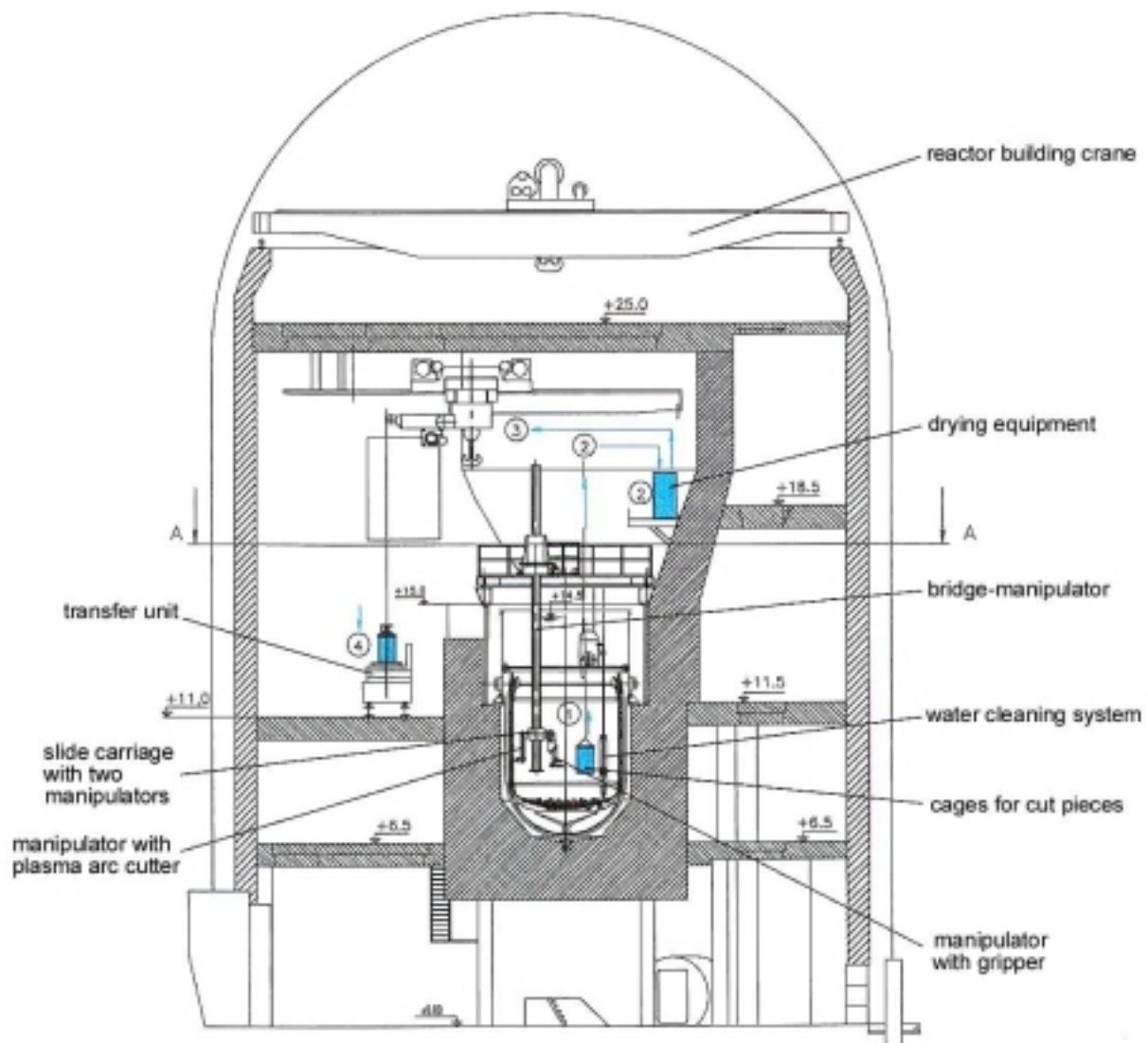
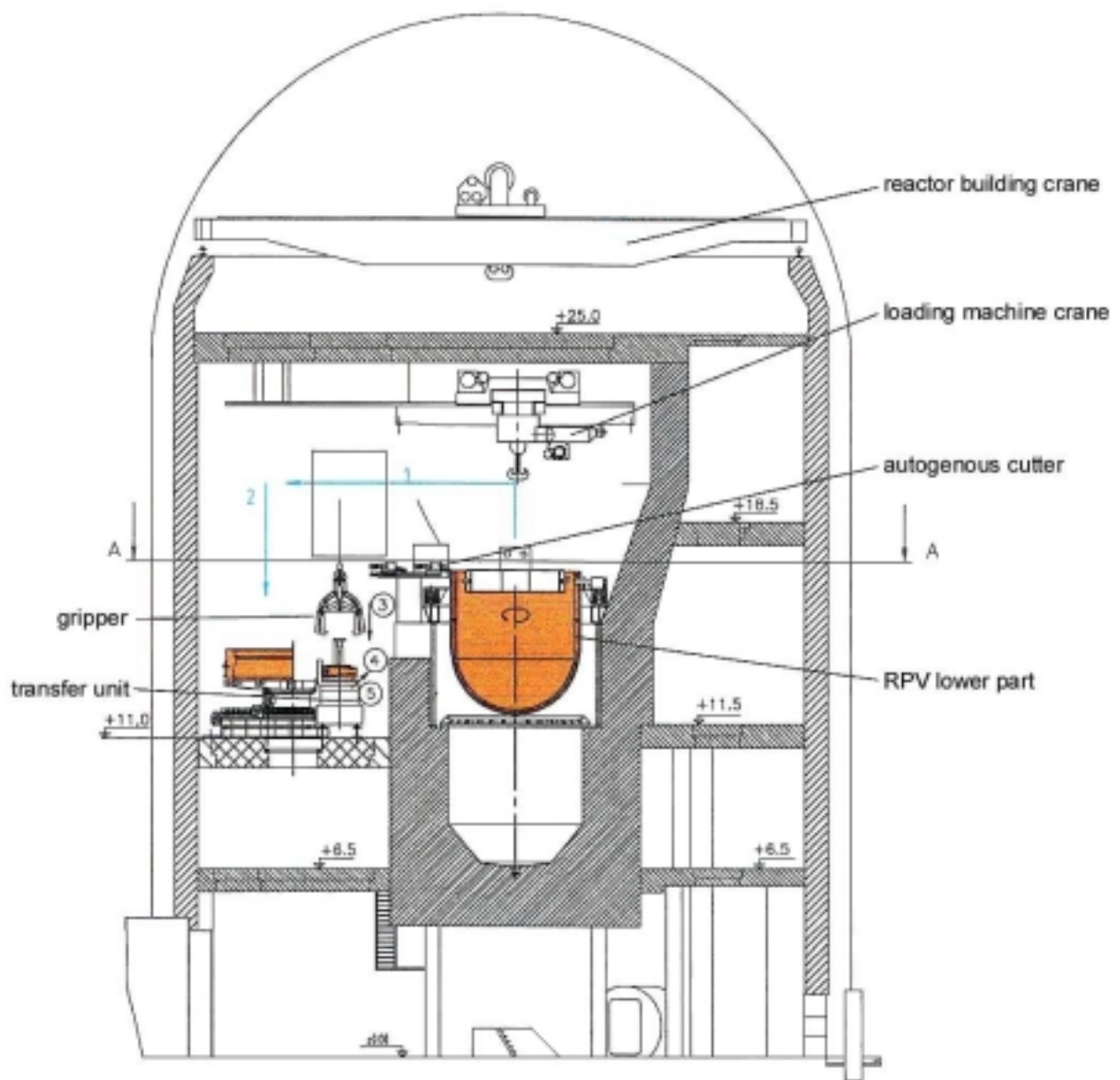


Fig. 3: Sequence of step 3

★ Step 3 (Fig. 3)

The higher activated components, such as the moderator tank and the thermal shielding are subjects for underwater dismantling by plasma arc cutting. Therefore the RPV flange is

equipped with a flooding compensator and filled with deionized water for shielding purposes. An orbital railway as holding fixture for the bridge-manipulator is installed. The bridge-manipulator is equipped with the plasma arc cutter. The cut pieces are placed by means of a gripper into cages, transferred into a drying equipment before they are packaged into cast type II containers for transportation to the HDB.



- ①-② Segmenting of the RPV lower part and transfer to the cutting table
- ③-⑤ Cutting of the RPV segments (jig saw) and transfer by gripper and transfer unit

Fig. 4: Sequence of step 4

* Step 4 (Fig. 4)

The remotely controlled segmenting of the RPV lower part is carried out by means of an oxygen burner (autogenous cutter) from up to down and from outside (ferrite steel) to inside (austenite steel) bit by bit, followed by further segmenting with the jig saw. The cut parts are packaged into type II containers and transferred to HDB.

To prepare the segmenting procedure a.m. the following tasks are necessary to be done:

- Disassembling of the bridge-manipulator and the loading compensator
- Remotely controlled lifting of the lower displacer and segmenting by the jig saw
- Remotely controlled cutting-off of the RPV nozzles
- Mechanical arrangements for bit by bit lifting of the whole RPV lower part and suspending in the modified supporting ring
- Providing specific equipment to remove the insulation at the outside of the RPV lower part in the areas of the later separating cuts.

Closeout

After finishing the dismantling and segmenting activities the used equipment and tools will be roughly decontaminated, manually disassembled, partly segmented and packaged for transportation to HDB.