RESEARCH REACTOR FRJ-1 (MERLIN)
THE CORE STRUCTURES OF THE REACTOR BLOCK ARE DISMANTLED

B. Stahn, R. Printz, K. Matela, C. Zehbe
Forschungszentrum Jülich GmbH
52425 Jülich, Germany

J. Pöppinghaus
Gesellschaft für Nuclear-Service mbH
45127 Essen, Germany

J. Cremer
Siempelkamp Nukleartechnik GmbH
69123 Heidelberg, Germany

ABSTRACT

After an operating life of 23 years, the FRJ-1 research reactor (MERLIN) was finally shut down and decommissioned in 1985. Fuel element discharge was followed by the regulatory safe confinement of the plant. Actual dismantling then began in 1996.

This report gives an overview of previous work on dismantling the FRJ-1 research reactor (MERLIN). These activities were performed within the framework of three partial licence approvals. From 1996 to 2001, the coolant loops and the experimental installations were dismantled, and the internals removed from the reactor tank. After draining off all the reactor tank water, work subsequently began on dismantling the reactor block.

In the present report, attention is focused on dismantling the core structures of the reactor block. During reactor operation, these structures were exposed to high neutron fluxes and, with the exception of the core internals, displayed the highest activities and dose rates. In this region, termed the "central section" due to its position in the reactor block, dose rates of up to 420 mSv/h and activities of up to1.0 E+07 Bq/g were measured even after a decay time of more than 17 years.

For the dismantling and disassembly of the metallic structures in this region, a remote-controlled sawing device and a device for segmenting the beam tubes from the inside were designed and constructed. The remote-controlled electrohydraulic dismantling excavator proved to be an universally applicable dismantling tool not just for the concrete structures. However, the universal application of this tool, for which it was not designed, led to high levels of wear and tear and to increasing downtimes.

A spread of contamination due to dismantling work has been reliably avoided during dismantling activities so far. This was primarily due to the fact that the condition of the dismantled material and the rigorous application of technical aids ensured that no appreciable airborne contamination was present at any time.

The dismantling of the central section was completed in November 2003. Dismantling of the bottom and final section of the reactor block was completed by the end of 2003.

In parallel to the dismantling of the reactor block, an application for the clearance measurement of the reactor hall with subsequent release from the scope of the German Atomic Energy Act was already made

in mid 2003. It is expected that the fourth partial licence for the performance of these activities will be received in spring 2004.

INTRODUCTION

The FRJ-1 research reactor (MERLIN) is a light-water-moderated and -cooled swimming pool reactor of British design, constructed from 1958 to 1962.

It was last operated with 10 MW thermal power at a mean thermal neutron flux of 3.2 E+13 n/(cm^{2}s) and a maximum thermal neutron flux of 1.1 E+14 n/(cm^{2}s).

After an operating life of about 23 years, the FRJ-1 (MERLIN) was finally shut down in 1985. The fuel elements were removed from the facility and the plant was transferred to safe confinement. Actual dismantling began in 1996 with the decisive planning activities, and the first selective dismantling activities started in 1997.

DISMANTLING ACTIVITIES TO DATE

The application for the first decommissioning step was made at the end of 1996. On the basis of this application, a licence was granted in 1997 covering the dismantling of plant components that had become dispensable. These components were essentially the coolant loops and the experimental installations.

By the end of 1998, the complete secondary cooling system and the major part of the primary cooling system had been dismantled within the scope of this first partial licence. Furthermore, the experimental installations, including a rabbit system conceived as an in-core irradiation device, were disassembled and disposed of. In total, approx. 65 Mg of contaminated and/or activated material as well as approx. 70 Mg of clearance-measured material was disposed of during these activities.

To date, two further partial licences for decommissioning have been granted. Within the framework of the second partial licence, in 2000/2001 the reactor tank internals were removed and then the water in the reactor tank drained off. The reactor tank internals were essentially the core support plate, the core box, the flow channel and the neutron flux bridges (see Fig. 1).

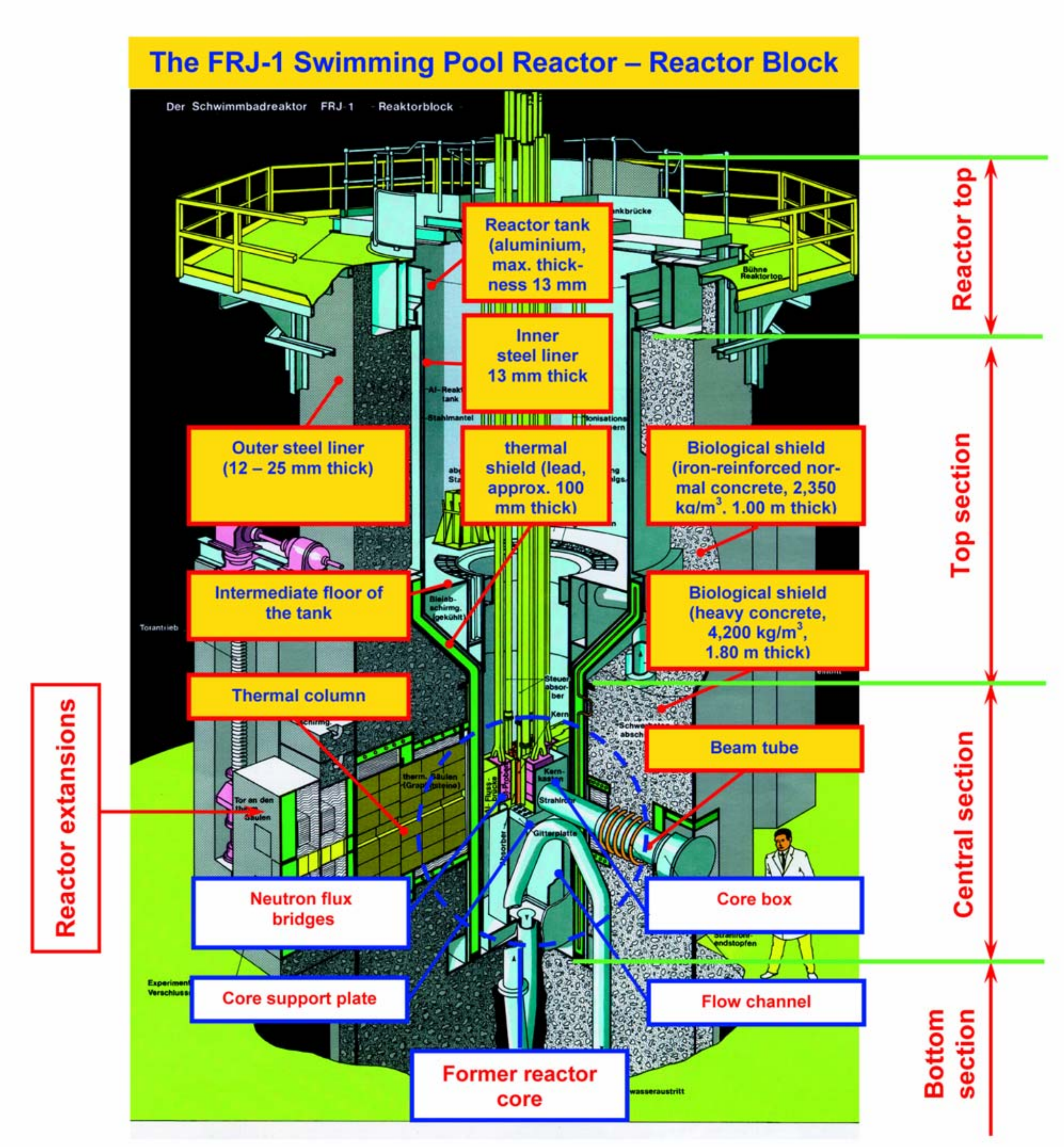

Fig. 1 Reactor block of the FRJ-1 (MERLIN)

Most components were made of aluminium. The connecting elements such as bolts and nuts were, however, made of stainless steel. Due to the high activation of the core internals, disassembly had to be remotely controlled under water. All removal work was carried out from a tank intermediate floor (see Fig. 1). Work was completed by mid 2001.

These activities represented the necessary preconditions for dismantling the reactor block. The dismantled parts were transferred to the Decontamination Department of the Nuclear Infrastructure Division of

Research Centre Jülich. This involved approx. 2.5 Mg of dismantled parts with a total activity of approx. 8 E + 11 Bq.

In order to determine the radiological condition of the reactor block, test drilling was performed in spring 1999 on the biological shield and the inner steel liner of the reactor block. The data thus obtained formed an integral part of the application for the third partial licence for dismantling the reactor block. Approval was finally granted at the end of July 2001.

The first dismantling activities started at the reactor block at the beginning of October 2001. Dismantling of the reactor block is divided into four stages (see Fig. 1).

1st dismantling phase:	dismantling the reactor operating floors (reactor top) and reactor extensions
2nd dismantling phase:	dismantling the top part of the reactor block (top section)
3rd dismantling phase:	dismantling the central part of the reactor block (central section)
4th dismantling phase:	dismantling the bottom part of the reactor block (bottom section)

The first dismantling phase comprised the reactor operating floors (reactor top) and the reactor extensions. The reactor operating floors gave access to the reactor block, while the reactor extensions primarily comprised the shielding doors to the thermal columns. The second to fourth phases segment the reactor block into three vertical regions, i.e. the top, central and bottom section.

The dismantling of the reactor top, the reactor extensions and the top section was completed in March 2003. In the course of these dismantling activities, approx. 60 Mg of steel, approx. 5 Mg of aluminium, approx. 170 Mg of heavy concrete and approx. 190 Mg of iron-reinforced normal concrete was dismantled. Of a total of approx. 425 Mg of material, approx. 320 Mg has been measured for clearance and transferred for conventional disposal. Clearance measurements were mainly performed with the aid of a clearance-measurement device based on the principle of total gamma measurement. Materials that cannot be granted clearance were transferred to the Decontamination Department of the Nuclear Infrastructure Division of Research Centre Jülich for further conditioning and storage.

Whereas no appreciable activity or dose rates were detected during dismantling of the reactor top and reactor extensions, activity was clearly measurable at the end of the top section. The minimum dose rate measured at the structures of the top section was <1 μSv/h, the maximum dose rate was approx. 140 μSv/h. The dismantling activities for the top section took approx. 7 months. According to the official evaluation the dismantling personnel received no collective dose during this period.

The specific activity of the dismantled material was at maximum 5 E+03 Bq/g. In order to avoid a spread of contamination the entire area to be dismantled was encased. Two separate ventilation systems with a total capacity of 12,000 m^3/h ensured that there was a directed flow from the reactor hall into the casing.

PRESENT DISMANTLING MEASURES

In April 2003 the regulatory requirements had been fulfilled to such an extent that after the top section work could begin directly on dismantling the central section.

The central section involved dismantling the structures located at the height of the reactor core. This region of the reactor block also accommodated the experimental installations such as the beam tubes and the thermal columns. Due to its position with respect to the reactor core, the central section displayed the highest activities and dose rates.

Preparatory Work

Before beginning dismantling work on the central section, various preparatory measures were required such as the installation of an additional and specially shielded personnel contamination monitor in the reactor hall in order to avoid contamination being spread when staff left the casing. Furthermore, an electronic dosimetry system was put into operation, by means of which any possible increases above the dose and dose rate limit could be detected in good time and avoided.

Dismantling and Auxiliary Equipment

The following dismantling and auxiliary equipment was used for work in the central section:

- two remote-controlled dismantling excavators
- remote-controlled sawing device
- device for segmenting the beam tubes
- moistening apparatus
- exhaust system at the dismantling site
- VIDEO monitoring system

Apart from the electrohydraulic dismantling excavator that had already proved its worth during dismantling work on the top section, in addition a remote-controlled sawing device and a device for segmenting the beam tubes were used for the dismantling work. The sawing device (see Fig. 2) was specially designed for disassembling the reactor tank (maximum wall thickness 13 mm, aluminium), the thermal shield (wall thickness approx. 100 mm, lead) and the steel inner liner approx. 13 mm in thickness.

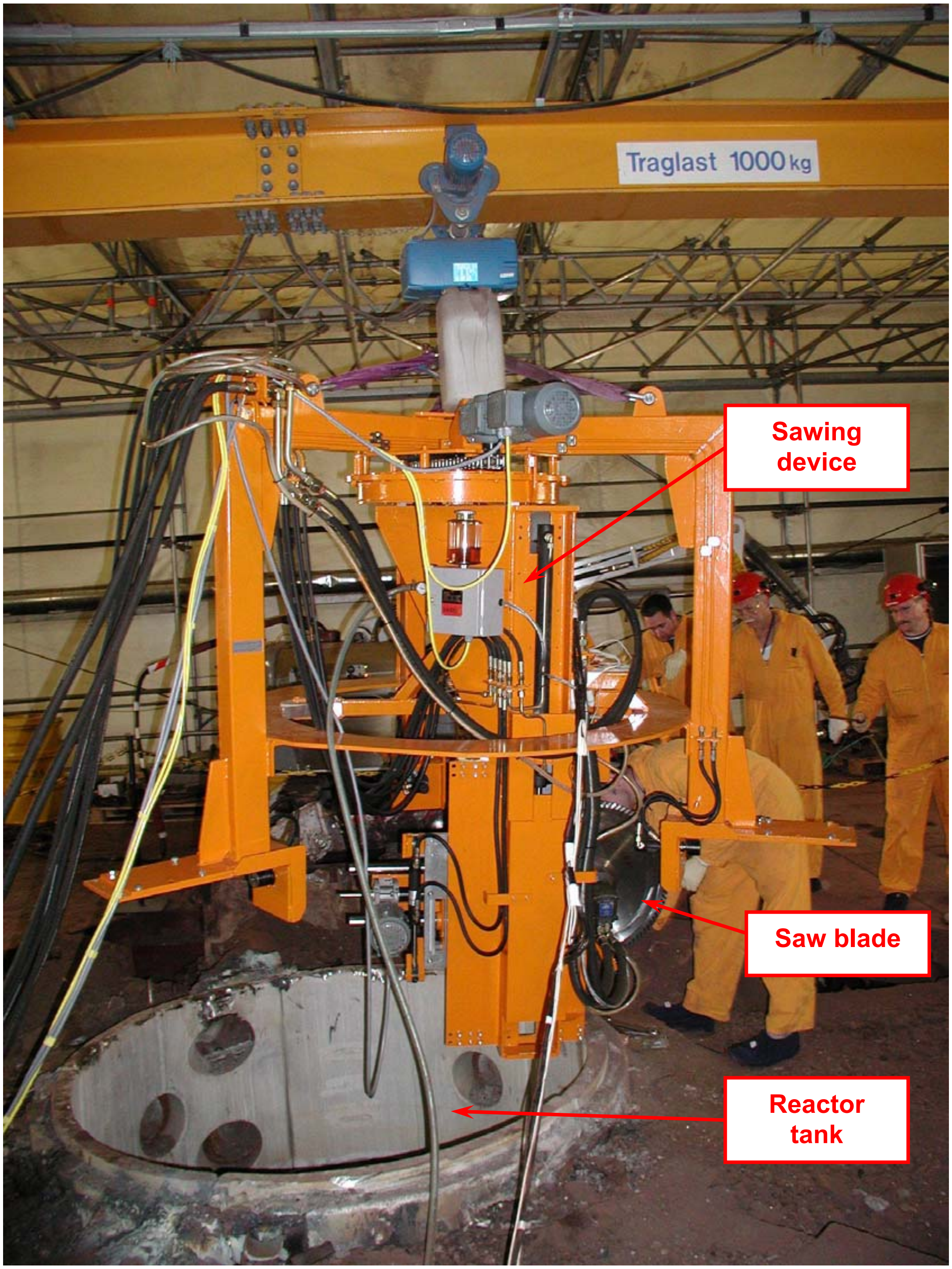

Fig. 2 Inserting the sawing device into the reactor tank

The device for segmenting the inner tubes served to presegment the beam tubes as installed so that parts were obtained that would be easy to handle during later removal from the reactor block. In dismantling the concrete structures of the reactor block, a specially designed moistening apparatus (see Fig. 3) was used, which, together with careful positioning of the exhaust air nozzle, played a major part in ensuring that contamination was not spread during dismantling. Correct positioning of the exhaust air nozzle was ensured by using a second remote-controlled dismantling excavator (see Fig. 3).

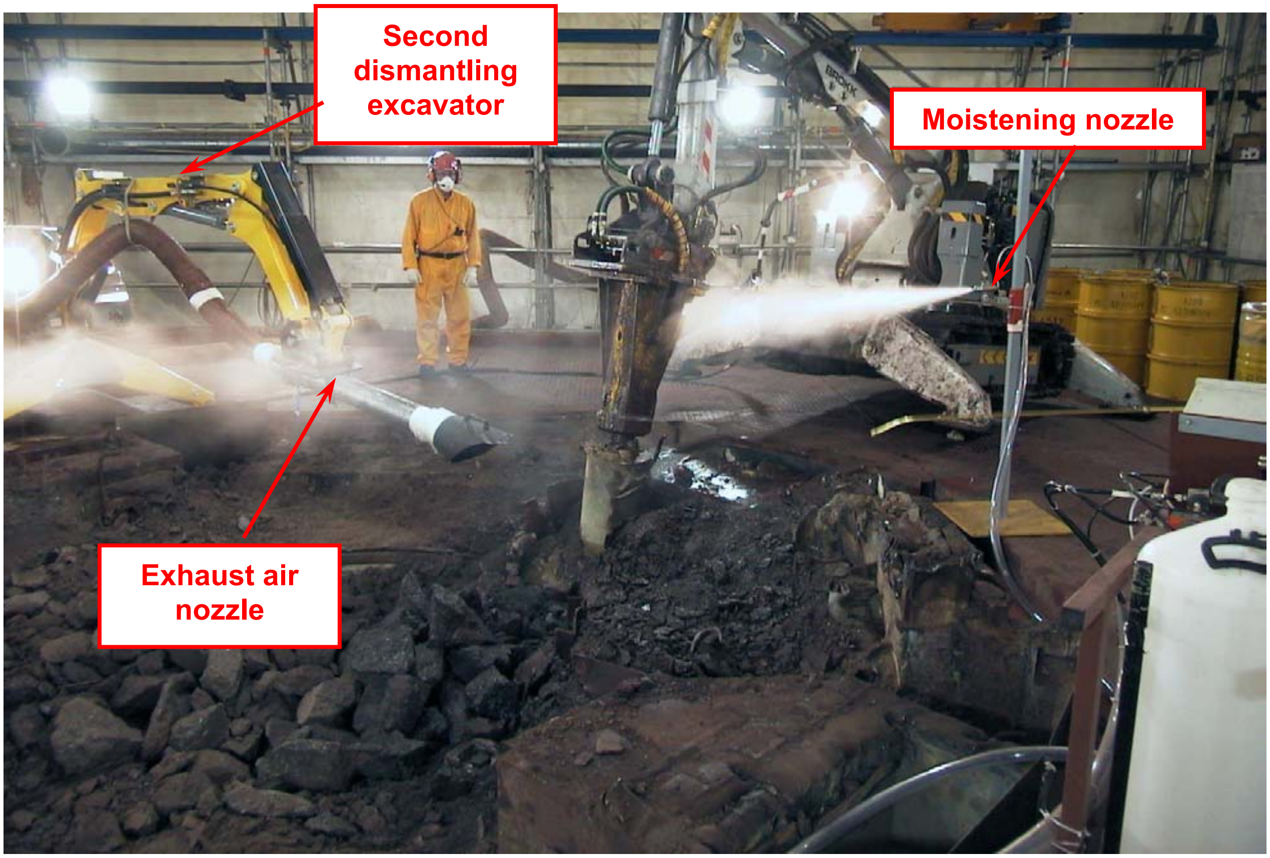

Fig. 3 Moistening and air extraction during operation of the rock chisel

Four cameras were installed in the dismantling area so that the dismantling activities could be observed from the reactor control room via monitoring systems. In this way, it was possible to intervene at any time in the work by remote operation from the reactor control room. Due to the detailed planning of the dismantling activities, which also included the shielding effect of the biological shield (dismantling from top to bottom and from inside to outside), there has been no need so far for an intervention by remote control from the reactor control room.

Implementation of the Dismantling Work

The structures of the central part of the reactor block (central section) were mainly dismantled by a dismantling excavator and a rock chisel. The dismantling excavator with rock chisel was not only used to disassemble the concrete structures but also for dismantling the lead, steel and aluminium structures. The material arising during dismantling work was packed into 200-l drums.

Radiation protection staff were constantly present during dismantling of the central section. This measure ensured that adequate monitoring and protection measures could be taken immediately, if required, to minimize the individual dose. As protection against inhalation, dust masks (class P3 particle filters according to DIN EN 143) were generally worn by dismantling staff during dismantling work. In areas of possibly higher airborne contamination, radiation protection staff ordered that helmets with external ventilation should be worn to prevent any contamination entering the respiratory air of the dismantling crew. Radiation protection staff ordered the temporary erection of shieldings to protect the personnel against the reactor block and also against the waste packages filled with highly active material.

Dose Rates and Waste Volumes

The minimum contact dose rate measured at the structures of the central section was 1 μSv/h, the maximum contact dose rate was about 420 mSv/h. The maximum dose rate measured at a waste package was approx. 160 mSv/h. Drums with high dose rates were taken to the Decontamination Department inside special shielding casks (MOSAIK) and interim-stored there. On the working platform there were dose rates of, as a rule, less than 100 μSv/h. The dose rate in the area where the staff were employed was on average approx. 30 μSv/h, up to a maximum of 80 μSv/h.

Dismantling of the central section took about 8 months. The collective dose accumulated by the dismantling staff amounted to approx. 30 mSv, and the maximum individual dose was approx. 5 mSv. The maximum specific activity at the dismantled structures was 1.0 E+07 Bq/g. In the course of dismantling the central section, approx. 200 Mg of heavy concrete, approx. 65 Mg of steel, approx. 7 Mg of aluminium and approx. 60 Mg of lead was dismantled. More than 90 % of this material could not be measured for clearance and was transferred to the Decontamination Department.

CONCLUSIONS

The dismantling of the central section was completed in November 2003. The dismantling of this section made the greatest demands so far, particularly with respect to radiology but also concerning the demands made on the tools. Furthermore, on the basis of the experience gained and the problems encountered, modifications were made to the original plans in the course of dismantling work. Thus, for example, the sawing device specially designed for the dismantling of the central section was not used as extensively as originally planned. In the course of detailed planning activities, it became apparent that increased use of the chisel technique combined with the remote-controlled dismantling excavator was of great benefit. The advantages of using the chisel were, in particular, minimization of the intervention times spent by the personnel in the radiation field, and also the obvious increase of effectiveness in the dismantling work. Using this technique it was not only possible to effectively dismantle the heavy concrete but also the aluminium, lead and steel components (see Fig. 4).

Fig. 4 Part of the Thermal shield separated by the rock chisel

The electrohydraulic dismantling excavator thus proved to be a universal dismantling tool not just for concrete. The disadvantage of this change of plan was a great deal of wear and tear of the corresponding dismantling tools, which involved increasing downtimes for the dismantling excavator as work progressed.

In order to avoid spreading contamination, especially with respect to the central section, the entire region to be dismantled was encased at the start of dismantling work. However, it became apparent that no appreciable airborne contamination was present at any time. On the one hand, this can be attributed to the measures taken for moistening and air extraction. On the other hand, it became clear that the activity in the central section was essentially present in the form of activity in the heavy steel fraction of the concrete, which was not so mobile. Within the casing it was therefore possible to ensure that the floor surface remained free of contamination at almost all times throughout the course of dismantling. These unexpected circumstances contributed to the fact that the spread of contamination due to dismantling work into regions outside the casing was completely avoided

During dismantling work, the air in the reactor hall was monitored by an aerosol monitor and the permissible limits were not exceeded at any time. The same is also true of monitoring the total exhaust air for aerosols, tritium and noble gases. The approved emission limit for radioactive aerosols amounts to 8.0 E +08 Bq/Year. During dismantling work at the reactor block less than 0.01 % of this value was reached.

OUTLOOK

In parallel to the dismantling of the reactor block, work has been performed since early 2003 for clearance measurements of the building structures of the reactor hall. As part of the planning activities, a sampling and analysis programme was performed with the aim of extending knowledge of the radiological condition of FRJ-1. In particular, the spread of contamination in the individual regions and the possible introduction of contamination into the subsoil was investigated by means of wipe, scratch and core sampling tests. The results served as the basis for an application concerning clearance measurement of the building structures. The corresponding application was made in May 2003; the final documentation for the application being submitted at the beginning of August 2003.

In the meantime, activities have also begun on planning the concept of work for releasing the facility from the scope of the Atomic Energy Act. Within the framework of this concept, as a preparation for clearance measurements of the reactor hall all internals and installations not belonging to the building structure will be disassembled and the building decontaminated. An appropriate sequence must be observed in order to avoid cross- and recontamination. After planning activities have been completed, work will begin on implementing the planned measures. The aim is to decontaminate the surfaces of the building (wall, floor, ceilings) to such an extent that optimum conditions are created for the clearance measurements. From the present point of view, the 4th partial licence for performing these activities is expected in spring 2004.