# REDUCING OF THE DOES RATE OF HAWC CONTAMINATED CONCRETE BLOCKS

A. Graf, U. Stutz
Forschungszentrum Karlsruhe GmbH
Central Operations Decontamination Department (HDB)
P. O. Box 3640
76021 Karlsruhe
Germany

## ABSTRACT

The Karlsruhe Reprocessing Facility (WAK) is in the status of dismantling. The main part of the operating facility was a hot cell complex, which was used for the reprocessing of spent fuel. The walls of the hot cells were made out of heavy concrete and passed by a variety of pipes and ducts. Some of the pipes provided the transportation of high active waste concentrates (HAWC) between the different cells. Since there was a pipe leakage during operation, HAWC was absorbed by the concrete walls.

The dismantling concept of the hot cell complex provides the cutting of the walls by rope saw technique. The resulting concrete blocks are packed into containers and transported to the Central Decontamination Operations Department (HDB) for further treatment. There, the blocks are cut into smaller pieces and packed into special containers for final disposal. The decontamination facility, there the treatment takes place, is designed for handling material with a maximum dose rate of 10 mSv/h.

During the dismantling of the wall with the absorbed HAWC two concrete blocks with a high dose rate (up to 110 mSv/h) were generated. Due to the high dose rate the standard treatment of the blocks could not be performed and a special concept had to be developed.

This paper will explain the construction and adaptation of remote controlled tools as well as the operation of the remote controlled decontamination procedure to remove the hotspots and will also show how even higher contaminated material can be handled safely with a minimum of radiation exposition.

# INTRODUCTION

The Wiederaufarbeitsanlage Karlsruhe (WAK) was a pilot reprocessing facility located on the grounds of the Research Centre of Karlsruhe (FZK). It was shut down in 1990, for political reasons.

The plant had a design throughput of 35 t of spent fuel/year at a maximum burn-up of 20 000 MWd/tU. The plant was put in hot operation in 1971. During its operation, it processed 200 t of heavy metal, including 1.8 t of plutonium. Because of test operation with fuel at a burn up to 40 000 MWd/tU, the average-burn-up was as high as 26 000 MWd/tU.

The owner of the plant is the Federal Government of Germany. The operator is the WAK BGmbH, until 1980 a subsidiary of the chemistry industry and from 1980, a subsidiary of the nuclear power station operating utilities.

Dismantling the WAK started in 1993. It is being performed in a series of six steps, the first three that have been completed. These were the decommissioning of the process building and the early dismantling in the process building. Currently, step 3 is being executed, the aim of which is to "free" all controlled areas in the process building.

Step 3 is being carried out under a series of licences, the first two of which have been completed, includes:

- Vertical and horizontal dismantling in the process cells
- Dismantling of the dissolver
- Semi-remote dismantling of the pipe duct with the mixer settlers
- Manual dismantling of laboratories and auxiliary systems.

The third licence rules the decontamination as well as the release procedures for the remaining concrete structures of the process building. In the course of this dismantling step, the walls of the already emptied cells were cut into pieces using a wire saw. However, the walls were passed by a variety of ducts and pipelines. These ducts and pipelines had served to transport supply media and high active liquids (HAW) to the individual cells. The ducts in the wall were inclined slightly and equipped with radiation traps. Prior to the disassembly of the walls, the ducts had been rinsed to remove the liquids contained.

The ducts were running from the outer side of the cell to the inner side and had been cut off prior to dismantling and closed on the outer side of the cell. On the inner side, the ducts had been closed by squeezing only. On both sides, the ducts protruded from the concrete by about 10 cm. On the inner side of the cell, the concrete was coated with epoxy resin.

It was planned to cut portion of the concrete walls into individual blocks on the WAK site. These blocks were to be put directly into KONRAD (German Repository) disposal containers for subsequent grouting at FZK's Central Waste Treatment Department (HDB). The waste packages suitable for the Konrad Repository are stored at the Interim Storage Halls of HDB. Two blocks generated by the dismantling of a wall of WAK-Cell 3, however, could not be treated as planned, as HAW had been released from the pipelines during operation and, hence, the inner side of the cell had been highly contaminated. The contamination level could not be measured, but a maximum surface dose rate of 110 mSv/h had been estimated by WAK.

Decontamination and further cutting of the blocks on the WAK site turned out to be impossible due to lacking technical equipment at this decommissioning stage. For this reason, further treatment took place at HDB. To transport the blocks to HDB, they were put into specially constructed shielding boxes that were additionally lined with lead plates in the area of the high dose rate (hot spots). These shielding boxes were put into 20' containers.

## CHARACTERISTICS OF THE CONCRETE BLOCKS

**Table I. Duct block C 3.1**

| | |
|---|---|
| Length x width x height | 1.75 x 1.28 x 1.07 m |
| Net mass | 5,661 kg |
| Maximum dose rate in contact | 25,000 µSv/h |
| Maximum dose rate at 1 m distance | 3,000 µSv/h |
| Activity inventory of the material (Bq) | α = 4.5 E+10<br>β = 9.9 E+11 |

**Table II. Duct block C 3.2**

| | |
|---|---|
| Length x width x height | 1.85 x 1.28 x 1.15 m |
| Net mass | 6,381 kg |
| Maximum dose rate in contact | 110,000 µSv/h |
| Maximum dose rate at 1 m distance | 9,000 µSv/h |
| Activity inventory of the material (Bq) | α = 7.4 E+10<br>β = 1.6 E+12 |

## RADIATION PROTECTION MEASURES

The treatment of the concrete Blocks at HDB's Decontamination Facility were planned to be executed remotely with the exception of the unloading of the concrete blocks from the shielding boxes that had to be done mainly hands on. A mobile steel shielding housing was erected to reduce the dose rate in the working area. In addition a continuous dose rate monitoring system was installed and the personnel were equipped with electronic alarm dosimeters.

Regularly the ambient dose rate is kept below 10 µSv/h, this value was never exceeded. The dose for the personnel was limited to 2 mSv/d and to 10mSv for the whole operation.

## OBJECTIVE OF THE DECONTAMINATION PROCESS

The aim of the decontamination process was to reduce the dose rate of the concrete blocks to < 5 mSv/h. This value was determined from shielding calculations performed using the waste acceptance criteria for the Konrad Repository [1].

## PREPARATIONS FOR THE DECONTAMINATION PROCESS

Prior to the remote treatment of the concrete blocks one had to establish appropriate technical conditions, especially for the surface treatment as well as for the collection of the removed material and dust produced. Some aggravating circumstances came in addition, e.g. the tubes penetrating the block jut out approx. 15 cm from the surface that had to be treated; furthermore, the distance between the tubes (see Figure 3) was rather short allowing only the use of small machines and tools.

For the operational application a remote-controlled miniature excavator, originally designed to work indoors, was selected. Equipped with a percussion jackhammer coupled to the excavator arm with a self-constructed absorber unit, which had to compensate and control the excavator contact pressure acting upon the jackhammer (See Figure 1). A loosening chisel (die-shaped chisel with mounted mandrels) was used as standard tool, allowing the removal of about 2 - 3 mm in one step.

In order to maintain the working area as clean as possible the removed material had to be collected and vacuumed continuously. For this purpose a modified industrial vacuum cleaner equipped with a cyclone separator unit for coarse dust removal upstream of the filters into a dust collection drum. The drum was placed in a shielded 200-liter cask and the suction hoses fixed to the cask with quickly opening bayonet locks. This allowed for very short exposure times during dust cask exchange.

The suction tube was installed on a separate manipulator for an optimum removal of coarse parts and dust arising during the treatment of the block surface. By means of the manipulator, the suction tube always was to be moved parallel to the loosening chisel, as a result of which a maximum suction rate was ensured. In addition the manipulator was used to clean out the floor of the working area.

All components were intensively tested on mock-ups to demonstrate the functionality and handling features of the whole equipment.

**Fig. 1a. Coupling system, percussion jackhammer and suction hose of the vacuum cleaner**

**Fig. 1b. Mock-up Tests**

# TREATMENT OF THE CONCRETE BLOCKS

## Treatment of the Block C 3.1

The treatment of the concrete blocks started with block C 3.1, as this had been identified to have the lower dose rate. The shielding box was brought into the working caisson and the lid of the box was removed. Then, a comprehensive dose rate profile was elaborated measuring all accessible surfaces of the block. The following values were measured:

| | |
|---|---|
| Front side | 180 µSv/h |
| Right side Rear side | 80 µSv/h |
| Left side | 40 µSv/h |
| Lid | 800 µSv/h |
| Bottom | 180 µSv/h |
| Gap on the side of the high dose rate | 1100 µSv/h |

The measurements were also used to estimate the intervention time for the staff as well as for the identification of the positions with the lowest dose rates to guide the workers who had to attach the lifting tackles. Then the block was lifted and placed on the workbench (See Figure 2).

**Fig. 2. Unloading of the concrete block from the shielding box**

Remote handling tools were used to measure the dose rate of the surface, the dimensions and the weight of the block before the treatment started:

**Table III. Pre-treatment Measurements of Block C 3.1**

| Block C 3.1 | |
|---|---|
| Weight in kg | 4,760 |
| Length x width x height in mm | 2020 x 1250 x 1050 |
| Maximum dose rate in mSv/h | 2.05 E+04 |

According to the information supplied by WAK, the ducts in the concrete blocks had been closed by welding on the outer side of the block (lower dose rate) and by squeezing on the inner side (high dose rate) to prevent contamination spreading. When taking the block out of the box, however, it was found that only some of the ducts were closed on the inner side. In the area of the increased dose rate, the ducts were completely open. In one case, a type of lead beaker had been put over the duct for additional shielding (See Figure 3).

**Fig. 3. Partly open ducts with additional shielding**

Parts of the concrete surface, especially on the upper side of the block, had blistered due to the unloading of the block from the shielding box. The epoxy resin layer on the inner side of the block could be removed easily by the loosening chisel. Areas of increased dose rate were visible due to their dark discoloration.

After the removal of the first concrete layers, the dose rate on the surface of the block surprisingly increased up to 50 mSv/h instead of decreasing. This increase in dose rate was supposed to be due to a radiation source inside of a pipe. Based on the precise determination of the dose rate profile and due to the reduction of the dose rate with the further removal of the surface, this could be excluded later. No explanation was found for the increase in dose rate.

Only after about 10 cm of the concrete surface had been removed was the target value of 5 mSv/h or below reached.

The concrete dust was sucked off by the suction system and collected in shielded packaging drums. The maximum dose rate at the surface of the unshielded packaging drum amounted to 7 mSv/h. For declaration, the two concrete dust drums and one drum with rubble (the blistered parts of the upper side of the block) were subjected to gamma spectrometry and neutron measurement to determine their activity inventory and in particular their uranium and plutonium concentrations. In total 97 kg of dust and rubble with an overall activity of 4.6 E 10 Bq was removed.

When planning the treatment on the basis of the information provided by WAK, it had been assumed that the main proportion of the activity declared was located in the dust drums and could be measured technically. However, this was not confirmed by the measurements. Only 6% of the declared activity was found to be in the dust drums.

Originally, the activity of the decontaminated concrete block C 3.1 had been planned to be determined from the initial activity minus the activity in the dust drum. As the measurements on the dust drums yielded small activity values only, the activity of the remaining block sections were found to exceed the limit values given in the KONRAD repository conditions by several factors. For this reason, additional detailed studies will be required for activity determination.

## Treatment of the Concrete Block C 3.2

The shielding box with the concrete block C 3.2 was brought into the processing caisson and the lid of the box was removed. Afterwards, a comprehensive dose rate profile was determined with the following values:

| | |
|---|---|
| Front side | 60 µSv/h |
| Right side | 20 µSv/h |
| Rear side | 5 µSv/h |
| Left side | 60 µSv/h |

| | |
|---|---|
| Lid | 120 µSv/h |
| Bottom | 20 µSv/h |
| Gap on the side of the high dose rate | 3200 µSv/h |

The block could be lifted off from the shielding box easily and was positioned at the working place. Both the dimensions and the dose rate profile were determined with the following values:

**Table IV. Measurements of Block C 3.2**

| Block C 3.2 | |
|---|---|
| Weight in kg | Will be determined prior to transportation |
| Length x width x height in mm | 2200 x 1200 x 1140 |
| Maximum dose rate in mSv/h | 8.6E+04 |

Also in this case, the information supplied by WAK in advance was that the ducts had been closed by squeezing on the side of the high dose rate. This, however, did not correspond to reality, as all ducts were open and did not reveal any trace of squeezing (See Figure 4).

**Fig. 4. Open ends of the ducts in the concrete block C 3.2**

The epoxy resin layer on the inner side of the block could be removed easily by means of the loosening chisel. The areas of increased dose rate were found to be located outside of the dark discoloration. Upon the removal of the first concrete layers, the dose rate was found to be reduced to a maximum value of 15 mSv/h. By this first treatment step, the target dose rate of < 5 mSv/h was reached for about 75% of the block surface. After a second treatment of the block surface, the dose rate was found to have increased to a maximum value of 18 mSv/h, as in case of the block C 3.1 By a further removal of the surface, the dose rate was reduced to a value of < 5 mSv/h. Further treatment of the block C 3.2 by a wire saw to reduce the size was not necessary, as the dimensions of the block were smaller than declared by WAK. The block fitted well into a Konrad container without further cutting being required.

## RADIATION EXPOSURE DURING TREATMENT

When drawing up the treatment concept, an internal limit value for the maximum dose rate at the control board of 10 μSv/h had been specified. The control board represents the area, in which the operation staff stays during the entire treatment. By putting up a mobile shielding device in the processing caisson, the dose rate measured was always found to be below this internal limit value. Maximum dose rate at the control board amounted to 5 μSv/h.

The collective dose of the staff during treatment had been specified to a maximum of 2 mSv/day and 10 mSv in total. The collective dose arising from the treatment of the block C 3.1 amounted to 596 μSv. The collective dose during treatment of the concrete block C 3.2 was 776 μSv. In this case, the maximum individual dose amounted to 256 μSv.

## CONCLUSION

The remote handled decontamination of the concrete block was successfully terminated. The application of self designed simple and flexible tools were very effective and resulted in a very low collective dose of 776 μSv. The whole process has demonstrated the flexibility of the HDB and its staff to manage unusual jobs and assignments.

## REFERENCES

[1] Anforderungen an endzulagernde radioactive abfälle (Endlagrunsbedingungen für die Schachtanlage Konrad), Stand: Dezember 1995, BfS-Report ET-IB-79.