

EXPERIENCE WITH DISMANTLING OF THE GERMAN REPROCESSING PLANT WAK

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ABSTRACT

The WAK plant was closed down in June 30th 1991 after 20 years of hot operation. The dismantling of the plant started in 1994 with the decommissioning of obsolete systems and will be finished in 2009 with a green meadow.

The dismantling activities are carried out by hands on techniques, semiremote techniques and remote techniques depending on radiological conditions.

5,500 tons of contaminated solid waste, 3,200 m³ liquid waste, 130 canisters of HLW glass and 75,000 tons of rubble will arise from dismantling the plant.

INTRODUCTION

The Karlsruhe Reprocessing Plant (WAK), operated by the WAK-Betriebsgesellschaft (WAK-BG), was built between the years 1967 to 1971 by the former Nuclear Research Center Karlsruhe, now Forschungszentrum Karlsruhe (FZK). During its 20 years of hot operation the WAK-plant has processed 208 t Heavy Metal of irradiated oxide fuel from research and power reactors. On June 30th 1991 the plant was finally closed down after a half year rinsing campaign with nitric acid.

RADIOACTIVE INVENTORY

70 m³ of high level liquid waste concentrate (HAWC) have been accumulated during processing, which is stored in 2 vessels on site in a storage building called LAVA.

Unprocessed fuel in the storage pond was shipped to La Hague.

Inner surfaces of the WAK-plant had been contaminated by insoluble matter depending on process conditions:

- Activation products in the fuel receipt
- hot resin fines from the water purification plant in the pond
- activation products, fission products and actinides in the chop-leach head-end cell
- fission products dominated by Cs-137 and actinides in the high active part of the chemical separation process
- Pu and Am-241 in the Pu-purification section

Due to decay of Ru-106 radiation levels in the middle active process cells have dropped considerably during the last 8 years after shut down.

CONTRACT SITUATION

On December 10th 1991 a contract was signed between FZK and her shareholders (the Federal State and the Land Baden-Württemberg) and the WAK-BG with her mother Deutsche Gesellschaft zur Wiederaufarbeitung von Kernbrennstoffen (DWK) to decommission and dismantle the WAK-plant. According to this contract the project will be financed by special funds of the Federal State and the Land Baden-Württemberg with a substantial contribution of the German utilities operating nuclear power reactors.

The FZK takes the overall responsibility of the project. The WAK BG conducts the remaining operation and the dismantling of the plant within its own responsibility. The target of the project is the green meadow, which will be accomplished in the year 2009.

The project to decommission and dismantle the WAK-plant is divided in 3 subprojects:

Restbetrieb:	Remaining plant operation and HAWC storage
STIWAK:	Dismantling of the WAK-plant
HAWC-Entsorgung:	Solidification of HAWC on site in the vitrification plant „Verglasungseinrichtung Karlsruhe“ (VEK).

DESCRIPTION OF THE STIWAK PROJECT

The dismantling of all facilities on the entire WAK site was planned in 6 steps, which will be applied for and licensed according to § 7 (3) on the German Atomic Act (1).

- Step 1: Decommissioning of obsolete systems in order to reduce maintenance and operation crew.
This step has been accomplished in 1994.
- Step 2: Dismantling of obsolete systems in the head and tail end section of the main process building either by hands on or by remote equipment used during reprocessing.
This step has been completed in 1997.
- Step 3: Separation of HAWC storage from the main process building, stepwise dismantling of the remaining equipment in the process building in order to suspend the controlled area.
First the equipment in chemical process cells is dismantled remotely, semiremotely or by hands on, depending on the radiological situation.
A test rig for testing the equipment for remote and semiremote dismantling was constructed and operated. The equipment for remote handling will be installed 1998-1999.
The laboratories, except for HAWC-analytics, will be dislocated to the waste treatment station Hauptabteilung Dekontaminations-

betriebe (HDB) in FZK. For HAWC samples new manipulator boxes with 90 tons shieldings have been installed in the cell hall of the HAWC-storage building LAVA.

Finally all remaining installations in the main process building will be dismantled, the rooms decontaminated and the controlled area suspended.

Step 4: Deregulation and decommissioning of the waste storage LAVA and the vitrification facility VEK after solidification of the HAWC has been completed.

Step 5: Stepwise dismantling of all equipment of the waste storage LAVA and vitrification facility VEK by remote, semiremote or by hands on techniques, depending on the radiological situation. Decontamination of all rooms in order to suspend the controlled area.

Step 6: Demolition of all installations and buildings prior to recultivation of the site.

As a prerequisite for realisation of step 4, 5 and 6 the 70 m³ of HAWC stored on site have to be solidified. For the solidification of the HAWC a small vitrification plant called VEK will be erected on site, which is based on the ceramic melter developed by FZK. The storage operation of the HAWC in the LAVA-building has to be continued until the end of vitrification operation.

RADIATION PROTECTION

Concept

Based on ICRP-60, which limits maximum individual exposure to 100 mSv in a period of 5 consecutive years, a very conservative radiation protection concept for the dismantling of the WAK-plant was derived in coordination with the supervisory board:

- Maximum individual doses were limited to 20 mSv in one year, anticipated individual doses for planning purposes 10 mSv in one year.
- For activities with „permanent installations“ individual external exposure was reduced to 4 mSv/y in analogy to § 54 of the German Radiation Protection Ordinance (2).
- Hands on activities were limited to working areas with radiation fields lower than 0,5 mSv/h, except when remote techniques were not applicable.
- Yearly uptake of radionuclides was restricted to 5% of the limit of the German Radiation Protection Ordinance (§ 52), that means 5 Bq Pu-239 inhalation per year.

Extremely strict protective measures are necessary to cope with the limit for uptake of radioactive nuclides. Air masks have to be worn in areas with surface contaminations slightly above the limit for free release of the German Radiation Protection Ordinance. Dismantling work in process cells is always carried out in airline plastic suits. Besides the clean air supply air masks with P3 particle filters are used inside the plastic suits. Efficiency of the protection measures against uptake of radioactivity is controlled by analysis of feces of 10% of working personal each year.

Dose Uptake

The following doses were taken up during the activities of the dismantling step 2 and 3 up to September 98.

Table 1: Dose uptake

Activities	Step 2		Step 3	
	Dose [man·mSv]	Time [man·d]	Dose [man·mSv]	Time [man·d]
Shut down operations	0.8	77	0.4	54
Decontamination and dismantling	51.8	1,518	27.9	997
New installations	4.9	604	3.5	871
Radiation protection	8.8	820	5.1	523
Transports	1.9	122	0.3	_*-
Others	9.3	740	1.5	_*-
Sum	77.5	4,743	38.7	2,445

*no dates available

There was no uptake of radionuclides higher than 5 % of the limit of the German Radiation Protection Ordinance.

DISMANTLING ACTIVITIES IN THE MAIN PROCESS BUILDING

Dismantling activities in the main process building are carried out depending on local conditions by

- hands on
- semiremote techniques
- remote techniques.

Experience with Hands on Dismantling

Up to now 17 systems were dismantled by „direct hands on“ operation:

- Reception of fuel-elements
- Storage of fuel elements with the pond water purification system
- Uranium and plutonium final purification and storage of endproducts
- Intermediate low level liquid waste storage
- Steam and hot water supply

- Sampling gallery
- Valve gallery
- Chemical supply and chemical make up

Systems had been marked off by the criterion of equal isotopic vectors to facilitate determination of radioactive inventory in the waste packages. As a consequence waste of the different systems had to be collected in separate drums.

The dismantling operation of the individual systems was always carried out in a standard procedure.

- Survey of radiological conditions in the beginning
- Electrical and operational shut down procedures
- Decoupling measures to other units
- Erection of locks for personal and materials
- Use of containments to prevent undue spread of contamination
- Dismantling procedures with minimum spread of contamination
- Size reduction of scrap compatible to transport packages
- Packing procedure
- Assessment of the packages and transport to HDB
- After dismantling: housekeeping and decontamination
- Survey of the radiological conditions after clean up

The following personnel was assigned to a single system

- 1 engineer, responsible for the system
- 1 technician, responsible for the work
- 2 to 6 craftsmen
- 1 health physics worker

The man responsible for the system was responsible for the detailed planning of the interventions, one of the craftsmen was responsible for the workplace and the foreman was responsible for the work. Coordination and supervision was due to the section leader of dismantling.

The operation crew of the WAK was in support with

- Shut down operations
- Commissioning of new installations and equipment
- Waste management
- Health physics service

Personnel for interventions were dressed with protective clothes depending on local conditions

- Cotton overalls
- Fleece suits
- Airtight plastic suits with airline for breathing and cooling
- Protective gloves and shoes

Airmasks with P3 particle filters were used only in low contamination areas. Breathing air for ventilated plastic suits was provided by airlines from the main compressed air supply by a control unit with filters and flow meters. Maximum time of a single mission was 2 h, except 0.5 h for the unvented plastic suit. Tools for cutting pipes were hydraulic shears and handy band saws, as these instruments spread little or no contamination. Inner surfaces of vessels were sprayed with an asbestos fibre bonding fluid prior dismantling by nibblers. The waste was collected on place in drums. Gloveboxes and larger parts were packed in foils and moved into the containers for transport to HDB. Inactive parts with accessible surfaces were free released for unrestricted use.

Experience with Semiremote Dismantling Techniques

The mixer settler of the chemical separation process are located in a pipe duct along the chemical process cells. As there was only limited head space available, a special semiremote technique was developed to remove cast iron shielding, mixer settlers, piping, vessels and pumps from the up to 8 m deep pipe duct.

Work is surveyed from a small control room with several closed circuit TV cameras and intercom connections. Cutting tools were guided by handhold long tong manipulators from a shielded carriage, riding on top of the pipe duct.

Dismantling of first cycle mixer settlers has now completed. Contact dose rate at the HA-battery was up to 90 mSv/h. Mixer settlers were separated from piping and fixtures using hack saws and hydraulic shears. The separated mixer settler was lifted from the support by the existing monorail crane and lowered into a shielded coffin, which was sent to HDB in a container.

Hydraulic shears were taped to the hook of the monorail crane and guided by craftsmen with long tong manipulators. Stainless steel pipes up to 50 mm inner diameter and wall thickness of 4,5 mm were cut in short pieces. Scrap dropped down in the sump pan. The accumulated debris was later raked together, picked up with tong manipulators and collected in 170 l drums. The drums were packed into the shielded coffin and sent to the HDB in a container.

Due to an aqueous copolymer dispersion, sprayed on contaminated surfaces, no aerosol activity occurred in the adjacent intervention zone. This is remarkable, because air velocities from the intervention zone into the open part of the pipe duct were negligible.

Experience with Remote Dismantling Techniques

Two types of remote dismantling techniques were developed:

- Horizontal dismantling with a crawler type power tools for cells with horizontal access.
- Vertical dismantling with a rope suspended electromechanical 2 arm slave manipulator assisted by cranes for process cells with vertical access.

A test rig for testing the equipment for remote dismantling was constructed and operated in the turbine hall of the decommissioned research reactor MZFR in the FZK. As a result of the tests the initial system had to be simplified to speed up

operation and to provide a more flexible mode of operation. The equipment for remote handling will be installed 1998-1999 (3).

Remote Equipment for Horizontal Dismantling

For dismantling cells with horizontal access a commercial crawler digger (Brokk 150 E) was modified as a power tool carrier with 7 degrees of freedom for the arm. The tool carrier plate can accept either a hydraulic shear, a hack saw, high speed grinder with electric and hydrolic drive or a claw „EMSR 3“.

The Brokk 150 is assisted by a modified „Brokk minicut“ which carries a camera platform.

Remote Equipment for Vertical Dismantling

For dismantling cells with vertical access a manipulator carrier system with a monobridge gantry crane with 50 / 5 kN hoists was constructed, riding on new crane rails 3 m above the floor of the cell hall. The 50 kN hoist carries a platform with two Electromechanical Master Slave Manipulators (EMSM3) with 8 degrees of freedom. The tools, a hydraulic shear, a grinder with diamond disc and a hack saw are at hand on the „sombrero like“ tool carrier magazine above the EMSM3. The EMSM3 manipulators guide the tools and prevent the scrap drop down to the cell floor pan. To assist dismantling, a 50 kN gantry crane will be installed on the tracks of the old cell hall crane. This crane will be equiped with a greenhouse around the hook to avoid contamination of the cell hall during transport of contaminated parts to the lock. High dose rate components will be size reduced and packed into 150 l drums in the former chop leach head end cell.

The existing 150 kN crane will be used to support the manipulator carrier system during normal and abnormal operation.

The existing ventilation system of the chemical process cells was not adequate to provide a minimum airflow of 0.5 m/s from the cell hall through the open cell hatches. Therefore a new ventilation system is installed. 30,000 m³ of air per hour will be introduced from the ceiling of the cell hall by a laminar distributor over the open hatches. The air from the cell will be returned to a self cleaning 2-stage filter system installed in the former sample gallery. A new fire wall will be erected because the new ventilation ducts from the cells are routed through the empty pipe duct.

The complete system for vertical dismantling will be operated from a new central control room outside the controlled area on the roof of the old product storage. The shell of the building has been completed, installation of technical equipment is now under way.

WASTE MANAGEMENT

Waste Quantities

Dismantling of the WAK-site will result in 5,500 tons of contaminated solid waste.

- 2,500 tons from structural material
- 300 tons from newly installed equipment.

- 2,000 tons from contaminated concrete
 - 700 tons from materials for interventions and remaining plant operation
- 3,200 m³ liquid waste will arise from decontamination and operation of the VEK
 All waste will be treated at HDB, resulting in 6,600 m³ of conditioned radioactive waste for final disposal and 1,300 tons to be recycled for restricted or unrestricted use.

70 m³ of HAWC will be solidified in the VEK-Plant creating 130 canisters of HLW-glass.

The demolition of the decontaminated buildings on the WAK-site will result in 75,000 tons of rubble.

The table 2 shows the waste quantities of step 2 and step 3.

Table 2: Waste quantities of step 2 and step 3 up to September 1998

Activities	Step 2		Step 3	
Contaminated dismantled materials	289	tons	113	tons
Contaminated rubble	54	tons	143	tons
Dismantled materials for free release	8	tons	1	tons
Rubble for free release	64	tons	21	tons
Liquide waste	167	m ³	-	-
Liquide waste for free release from storage pond water	689	m ³	-	-
Materials for interventions, maintenance and remaining plant operation	14	tons	6	tons

Minimizing Waste

As all materials from dismantling of the WAK-site have to be delivered to the waste treatment station, HDB has the responsibility to minimize the waste according to the federal guidelines (4). Criteria for free release, restricted or unrestricted recycling are established. Very low contaminated metal is collected separately for melting at Siempelkamp, Germany. Reusable instruments, for example from the laboratory, are reused.

Characterisation of Waste

Depending on their radioactive inventory waste is separated into

- Residues for free release
- Residues for restricted release or recycle (e.g. melting)
- Low level waste
- Intermediate level waste
- High level waste

Isotopic vectors vary in different parts of the reprocessing plant. As a consequence the waste from different systems has to be collected separately. Systems are defined by the criterion of similar isotopic vectors to facilitate determination of radioactive inventory in waste packages. Representative samples from the systems have to be

taken and analysed. Nuclides below detection limit are calculated using the key nuclide concept and the KORIGEN-calculation.

Assessment of inventory for some 70 nuclides was done by

- measuring the dose rate at the packages. Taking into account the geometry of the package and the internal shielding by the waste, the contact dose rate can be related to the radioactive inventory.
- measuring the weight and specific activity of solid or liquid waste
- measuring the waste in a drum monitor using γ -spectroscopy and passive neutron counting /5/.

Packaging and Transport

Waste from dismantling is separated to facilitate waste treatment at HDB. Waste is transported to HDB according to FZK transport regulations.

Intermediate Storage and Final Disposal

The conditioned waste at HDB is stored at HDB until final disposal. Only 45 m³ of rubble could be sent to the existing Endlager Morsleben (ERAM) for final disposal due to the very restricted α -levels there. As ERAM will be definitely closed by the new government, the bulk of the waste from the WAK has to go to the future KONRAD mine.

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