LESSONS LEARNED WITH THE DISMANTLING OF THE KARLSRUHE REPROCESSING PLANT WAK

Klaus Heger, Karl Josef Birringer, Horst Wiese
Wiederaufarbeitungsanlage Karlruhe Betriebsgesellschaft mbH,
Postfach 1263, D-76339 Eggenstein-Leopoldshafen, Germany

ABSTRACT

The WAK plant was closed down on June 30, 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, remote techniques, or a mixture of both, depending on radiological conditions. 5,500 tons of contaminated solid waste, 3,200 m^3 of liquid waste, 130 canisters of HLW glass, and 75,000 tons of rubble will arise from dismantling the plant (Jungmann 1999).

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. 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 30, 1991, the plant was finally closed down after a half-year rinsing campaign with nitric acid.

RADIOACTIVE INVENTORY

70 m^3 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 9 years after shutdown.

CONTRACT SITUATION

On December 10, 1991, a contract was signed between "Forschungszentrum Karlsruhe" 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 "Forschungszentrum Karlsruhe" 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 objective 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.

Step 1:

Decommissioning of obsolete systems in order to reduce maintenance and operation crew.

This step was 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 was completed in 1997.

Step 3:

Dismantling of all process and auxiliary installations in the main process building, decontamination of all rooms and cells, and suspension of the controlled area.

This step will be completed in 2005.

In parallel, separation of HAWC storage from the main process building. Therefore, the laboratories for low and middle active analytic have been dislocated to the central waste treatment division at "Forschungszentrum Karlsruhe." For HAWC analytics, new manipulator boxes with 90 t shieldings have been installed in the cell hall of the HAWC-storage building LAVA.

As a prerequisite for realization of the following steps, the 70 m³ of HAWC stored on site have to be solidified. For the solidification of the HAWC, a small vitrification plant called VEK is under construction on site, which is based on the ceramic melter developed by "Forschungszentrum Karlsruhe." Hot operation of the vitrification plant is scheduled for 2004.

Step 4:

Deregulation and decommissioning of the waste storage buildings and the vitrification facility VEK after solidification of the HAWC has been completed.

Step 5:

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

This step will be completed in 2008.

Step 6:

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

This step will be completed in 2009.

RADIATION PROTECTION

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 agreed on by the supervisory board:

- Maximum individual doses limited to 20 mSv in one year; anticipated individual doses for planning purposes 10 mSv in one year.
- Individual external exposure for activities with permanent installations reduced to 4 mSv/y in analogy to § 54 of the German Radiation Protection Ordinance.
- Hands-on activities only in radiation fields lower than 0,5 mSv/h.
- Yearly uptake of radionuclides was restricted to 5% of the limit of the German Radiation Protection Ordinance (§52), that means 5 Bq Pu-239 per year uptake by inhalation.

Extremely strict protective measures are necessary to cope with this limit for uptake of radioactive nuclides. Air masks have to be worn in areas with surface contamination 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 personnel each year.

DISMANTLING ACTIVITIES IN THE MAIN PROCESS BUILDING

Dismantling activities in the main process building are carried out depending on local conditions by hands-on techniques, manually with shielding and distance, or 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 in the pond and water purification system
- Uranium and plutonium final purification and storage of end products
- Intermediate low level liquid waste storage
- Steam and hot water supply
- Sampling gallery
- Valve gallery
- Chemical supply and chemical makeup.

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.

Dismantling of individual systems was always carried out in a standard procedure:

- Survey of radiological conditions in the beginning
- Electrical and operational shutdown procedures

- Decoupling measures to other units
- Erection of locks for personnel and materials
- Use of local containments (greenhouses) to prevent undue spread of contamination
- Dismantling procedures with minimum spread of contamination
- Size reduction of scrap compatible to transport packages
- Packing procedure and transport to the central waste treatment division at “Forschungszentrum Karlsruhe”
- Housekeeping and decontamination after dismantling and
- Survey of the radiological conditions after cleanup.

The systems have been dismantled by individual working groups, composed of 1 engineer, 1 technician, 2 to 6 craftsmen, and 1 health physics worker. The engineer was responsible for the detailed planning of the interventions, one of the craftsmen was responsible for the workplace, and the technician was responsible for the work. Coordination and supervision was due to the section leader of dismantling. In support of this working group, the operation crew of WAK carried out shutdown operations, commissioning of new installations and equipment, waste management, and health physics service.

Protective clothes, worn for hands-on dismantling, depends on local conditions and is decided by a health physics engineer. Cotton overalls as standard clothing can be complemented with fleece suits and airtight plastic suits as soon as protective gloves and shoes. Airmasks with P3 particle filters are used only in low contamination areas. Breathing air for ventilated plastic suits was provided by airlines from the main compressed air supply via a control unit with filters, flow meters, and warning low flow. Maximum time of a single mission was 2 h, except 0,5 h for the unventilated plastic suit.

Tools for cutting pipes were hydraulic shears and handy band saws, as these instruments spread little or no contamination. Surfaces of vessels were sprayed with an asbestos fiber bonding fluid to fix contamination prior dismantling by nibblers.

Up to now, about 460 tons of process installations have been dismantled by hands-on techniques with a radioactive inventory of 1E14 Bq. An effort of about 180,000 man hours was necessary for dismantling and complementary technical work, collecting a dose rate of 113 mSv.

Experience with semi-hands-on dismantling with shielding and distance

The mixer settler of the chemical separation process is located in a pipe duct along the chemical process cells. As there was only limited head space available, remote dismantling was not practicable. By reason of radiation fields up to 90 mSv/h, hands-on dismantling with direct contact was not possible. Therefore, a special technique was developed to remove cast iron shieldings, mixer settlers, piping, vessels, and pumps from the up to 8 m deep pipe duct. Hydraulic shears were taped to the hook of a monorail crane and guided by craftsmen with long tong manipulators, standing behind a shielded movable platform on top of the pipe duct (see Fig. 1). Scrap dropped down in the sump pan. The accumulated debris was later raked together, picked up, and collected in 170 l drums. This job was also done with shielding and distance . The drums were packed into shielded coffins and sent to the central waste treatment in a container.

Work was surveyed from a small control room with several closed circuit TV cameras and intercom connections.

Except for two laboratory collecting vessels, all mixer settlers, piping, vessels, and pumps from the pipe duct are dismantled. Up to now, about 110 tons of process installations have been dismantled with a radioactive inventory of 4E13 Bq. An effort of about 34,000 man hours was necessary for dismantling and complementary technical work, collecting a dose rate of 81 mSv.

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

Horizontal Remote Dismantling

For remote dismantling in cells with horizontal access, a commercial crawler 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, or a high-speed grinder. The crawler is assisted by an additional crawler-type vehicle, which carries a camera platform. The dismantling equipment is operated by control panel, installed in front of the cell (see Fig. 2).

A first cell has been successfully dismantled, using this technique. Nevertheless, the equipment will be optimized as a result of the obtained experience.

Vertical Remote Dismantling

The equipment for remote handling was installed in 1998-1999.

For remote dismantling in cells with vertical access, special equipment (see Fig. 3) has been installed, tested, and optimized from 1994 to 1997 in the Remote Dismantling Test Facility TFD at “Forschungszentrum Karlsruhe” under supervision of WAK (Hendrich 1999). As a result of dismantling a full-scale reproduction of a process cell, the initial concept was simplified to speed up operation and to provide a more flexible mode of operation.

The main process cells are located in one block below the cranehall. The essential part of the vertical remote technique is a crane-supported Manipulator Carrier System (MCS), which is mobile along the entire cranehall. The MCS is equipped with two Electromechanical Master Slave Manipulators (EMSM), various tools, cameras, microphones, and auxiliary equipment. MCS is supported by the main crane (MC) and the auxiliary Crane (AC) for logistic maintenance and auxiliary purpose, equipped with survey and measurement systems similar to MCS. MC is equipped additionally with a ventilated greenhouse to protect the cranehall against airborne contamination while transferring dismantled equipment.

The dismantled components are either conditioned in a special installed disassembling cell (the former chop leach head end cell) or, in case of low surface radiation, transferred via an air lock.

The entire equipment is remote-controlled from a control room outside the process building (see Fig. 4).

Implementation and cold commissioning of the remote dismantling technique was implemented in 1998–1999. Hot operation is under way since March 2000 and will be finished by the end of the year. A total of 92 tons of vessels, evaporators, piping, and racks will be dismantled from four process cells with an activity inventory of about 2E13 Bq and a radiation level up to 200 mSv/h.

CONCLUSION AND PROSPECTS

Up to now, dismantling work at the main process building of WAK went ahead on schedule. Careful preparation and trained personnel are prerequisites for a successfull mission. The next important step is to implement effective decontamination techniques to suspend controlled the area in the main process building.

The construction of the vitrification plant VEK is under way and detail engineering to dismantle the HAWC storage installations has begun.

SAMPLE REFERENCES

Hendrich, K., Wiese, H., Katzenmeier, G., 1999, "One Year Ahead of Remote Dismantling of the German Prototype Spent Fuel Reprocessing Plant Karlsruhe," Proceedings Eight International Topical Meeting on Robotics and Remote Systems, Pittsburgh.

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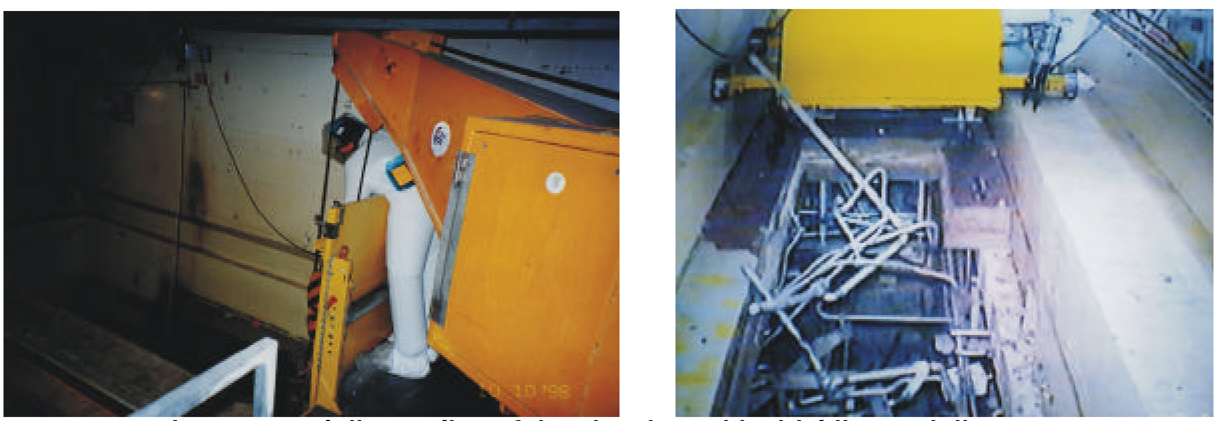

Fig. 1 Manual dismantling of the pipe duct with shielding and distance.

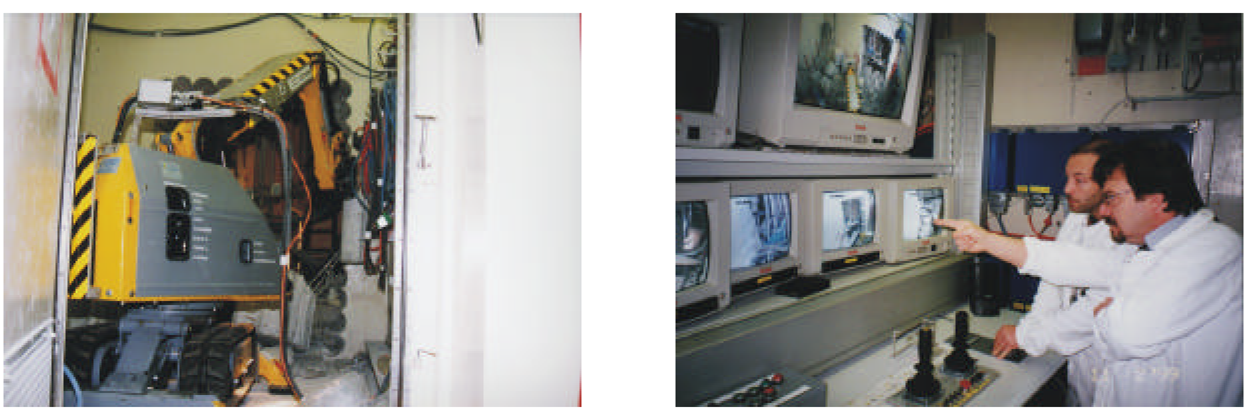

Fig. 2 Horizontal remote dismantling.

Fig. 3 Vertical Remote Dismantling Test Facility.

Fig. 4 Cranehall above the cells and central control room.