Wir setzen Maßstäbe.
Mit Sicherheit.

KTE
Kerntechnische
Entsorgung Karlsruhe

NUCLEAR ENGINEERING EXPERTISE IN KARLSRUHE

DECOMMISSIONING AND WASTE MANAGEMENT POOLED

A Company of the EWN Group

View into the biggest low-level waste storage facility in Germany.

CONTENTS

ABOUT US

Kerntechnische Entsorgung Karlsruhe GmbH – KTE – presently has about 650 employees and is funded mainly by the Federal Ministry of Education and Research and the Baden-Württemberg Ministry of Economic Affairs, Labor, and Housing.

KTE's sole shareholder is EWN, Entsorgungswerk für Nuklearanlagen GmbH.

KTE is responsible for the decommissioning of shut-down nuclear facilities in Karlsruhe/KIT Campus North.

All associated activities for the disposal of radioactive wastes, including later transfer to the federal repository "Schacht Konrad", are also accomplished by KTE.

Sociopolitical development in Germany has made large-scale nuclear research history. At its location, about ten kilometers north of Karlsruhe, KTE decommissions nuclear facilities built in the 1960s, 1970s, and 1980s for fundamental and applied nuclear research. These facilities mostly represent research and prototype reactors of various types as well as a plant for development of nuclear fuel reprocessing. In addition, other old installations are dismantled, such as the Hot Cells originally used for examining irradiated nuclear fuel.

Upon complete decommissioning of all nuclear facilities transferred to KTE for this purpose, the radioactive residues arising have to be processed to waste packages suited for final disposal and to be subjected to interim storage until transfer to the federal repository. KTE currently operates the biggest – in terms of waste volume – interim storage facility for low- and intermediate-level wastes in Germany. As soon as the "Schacht Konrad" federal repository will start operation, the waste packages stored at KTE will be transported there.Final disposal work of KTE will be completed in the late 2060s. Finally, all residual buildings will be demolished.

Stored waste packages are controlled constantly.

COMPANY POLICY

Apart from its main mission, decommissioning of nuclear facilities and waste disposal, KTE works on further improving its high standards in safety and environmental protection, industrial safety and health protection, quality and energy efficiency. To prove this to the staff and all interested parties, KTE's policy follows these basic values:

- Safety of the people and facilities and protection of the environment shall be of highest priority.
- Company's management provides for maximum industrial safety and health protection of all staff members by defining technical and organizational workflows and making available the protective equipment required. Potential risks are identified and eliminated.
- Valid legislation, regulations, standards, and other binding obligations are complied with by the company.
- With its company policy and its company goals, KTE has defined precise actions and implements them.
- The integrated management system of KTE is checked constantly for appropriateness and effectiveness, evaluated and improved, if required.
- Comprehensive documentation is of high importance in all areas of KTE. The company is constantly working on proper documentation to ensure that future members of staff will always have access to structured information.
- KTE saves resources by increasing its staff's awareness, encouraging adequate conduct, and using efficient processes.
- KTE remains in dialog with all parties involved and interested third persons in order to adequately consider their interests.

DECOMMISSIONING

In the Decommissioning of Nuclear Facilities, Protection of Men and Environment is of Highest Priority

Shut-down nuclear facilities must not be left on their own. They continue to be subject to the Atomic Energy Act and to supervision by federal and state authorities. Hence, special licenses are required for decommissioning and dismantling all facilities. The biggest challenges are the dismantling of highly contaminated and/or activated components of high dose rate as well as the safe management of the radioactive wastes produced.

Direct dismantling of the Multi-Purpose Research Reactor.

Worldwide, two approaches to decommissioning nuclear facilities are being pursued:

DIRECT DISMANTLING

As a rule, nuclear facilities in Germany are dismantled directly. This results in several advantages:

- The personnel familiar with the facility is still available.
- Dismantling tasks are not postponed to the next generations.
- Social consequences for the operations staff are reduced by their continued employment.
- The premises can be used again after dismantling at an earlier point of time.
- Safety and waste disposal can be managed within a foreseeable period of time.

DISMANTLING AFTER SAFE ENCLOSURE

Although safety and waste management aspects favor direct dismantling, a facility may also be dismantled after several decades of safe enclosure. This approach is to reduce radioactivity in the facility by natural decay over the years. In this way, dismantling will be facilitated. However, safe enclosure has to meet special requirements:

- All fuel elements have to be removed and the facility must have been characterized radiologically.
- By taking appropriate technical and construction measures, the radioactive inventory of the facility must be enclosed safely for the planned period of time, even in case of reduced monitoring expenditure.
- Important installations have to be subjected to an adequate aging management and every ten years, a new safety analysis of the facility has to be made.
- Information on the plant's operation and safe enclosure, which is relevant to later dismantling, must be documented.

KTE is responsible for the decommissioning of shut-down research and prototype facilities on the premises of KIT Campus North, the former Karlsruhe Nuclear Research Center. Apart from smaller nuclear research facilities, these are the following large projects:

Karlsruhe Reprocessing Plant WAK

Compact Sodium-Cooled Nuclear Reactor Facility KNK

Multi-Purpose Research Reactor MZFR

FR2 Research Reactor2

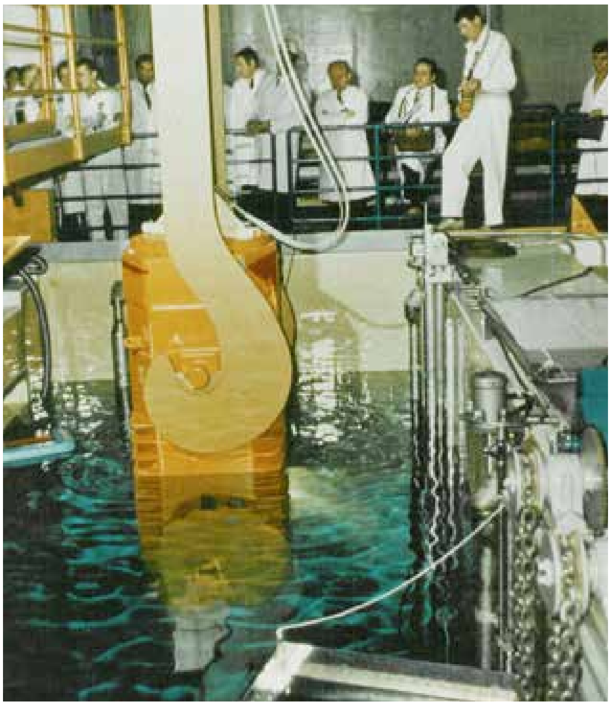
Hot Cells

KARLSRUHE REPROCESSING PLANT

WAK

The Karlsruhe Reprocessing Plant, WAK for short, was built in the 1960s as a pilot plant for later commercial reprocessing. By means of reprocessing, reusable constituents from spent nuclear fuel rods can be recovered. From 1971 to 1990, more than 200 tons of nuclear fuels from various experimental and power reactors were reprocessed at WAK. Uranium and plutonium were separated from the fission products for reuse in new fuel elements.

The high-level waste solution produced by reprocessing, called High-Active Waste Concentrate (HAWC), remained in the storage buildings of the WAK plant. In 1989, the German plan to build a commercial reprocessing plant at Wackersdorf was abandoned. As a consequence, reprocessing operation in Karlsruhe was terminated in 1991 and decommissioning of the plant was initiated.



1971 – Reprocessing can start:
Unloading of the first spent fuel elements delivered.

DISMANTLING OF THE PROCESS BUILDING

Decommissioning of WAK focused in the first years on emptying the process building that accommodated all installations needed for reprocessing. Their disassembly started in 1996. Depending on the dose rates measured, the installations were subjected to manual or remote dismantling. The process cells were dismantled remotely from the cell hall above. Pipings, tanks, and other plant components were disassembled directly and put into casks or, if possible, packed into containers undismantled and transferred to the waste management facilities of KTE.

By late 2002, all major process installations had been removed. Subsequent work on the building structure is still going on. This work covers radiological decontamination and, to an even greater extent, conventional decontamination for PCB and asbestos removal. To this end, more than 200 concrete blocks with feedthroughs have been sawed out and 4400 tons of material has been dismantled so far. In addition, many square meters of radiologically or conventionally contaminated coatings of walls and ceilings have been removed and numerous dowels have been drilled out.

Remote dismantling of process installations.

Emptied, pitted, and decontaminated:
The fuel element storage pool today.

Removing contaminated sections of the building structure.

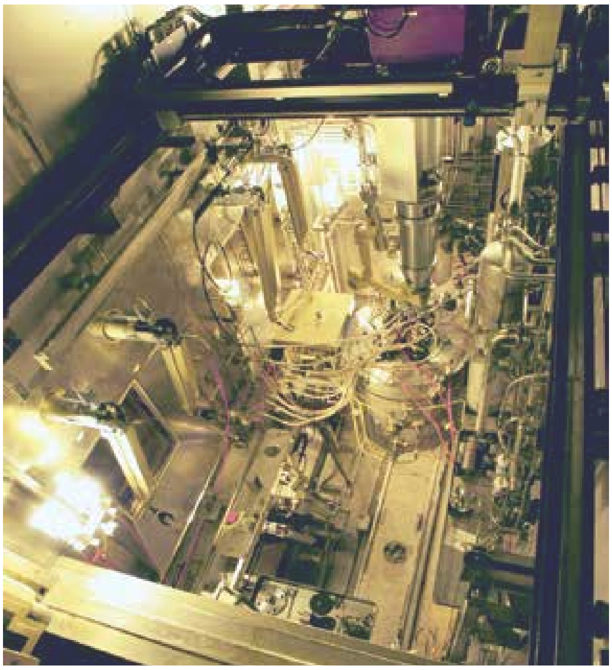
THE CHALLENGE: VITRIFICATION OF THE WASTE SOLUTION FROM WAK OPERATION

The decision to condition onsite the high-active waste solution to a waste product suited for final disposal was followed by the construction and operation of the Karlsruhe Vitrification Facility (Verglasungseinrichtung Karlsruhe, VEK). At VEK, all high-level wastes from operation of the WAK plant were solidified for final disposal. The waste packages produced, so-called glass canisters, were put into Castor casks and transported to the interim storage facility of EWN in Greifswald in 2011. As a result, activity inventory of the WAK plant was reduced by about 99%. Meanwhile, dismantling of the HAWC storage buildings has started.

Filling glass from the melter into the canister.

Transportation of glass canisters in Castor casks is history. Now, complete dismantling of the VEK has to be managed.

The VEK was built for vitrification of the waste solutions produced by reprocessing operation of WAK exclusively. From the very beginning, it was clear that the vitrification facility was to be dismantled after operation. Remote dismantling of this highly contaminated facility is a challenging task.



Due to contamination, it can be dismantled remotely only: The melter cell of VEK.

VERY DEMANDING: DISMANTLING OF STORAGE TANKS

The four tanks formerly used for storing the high-active waste concentrate are located in thick-walled concrete cells of two neighboring storage buildings that are part of the WAK plant. These storage tanks of about 60 m³ volume each were emptied and rinsed at the end of vitrification operation. Now, they are being disassembled.

Due to the high dose rates in the cells and on the tanks, remote-controlled tools and devices are applied exclusively. As the cells with the large storage tanks can only be accessed from the same level, dismantling takes place horizontally. For residue logistics and remote operation of the dismantling systems, a new building was constructed for access to the storage buildings.

The basic device used for remotely controlled horizontal dismantling is a commercially available, small electrohydraulically driven excavator adapted to the special conditions of dismantling. A single-armed manipulator system can be coupled remotely to the excavator to operate various tools, such as a grinder, sword saw, and hydraulic cutter. For concrete demolition, a concrete mill and chisel can be attached to the excavator.

In 2015, preparations started for dismantling the first of the four storage tanks. For this purpose, a wall of 1.50 m in thickness had to be cut remotely. The sawed-out block was pulled out by a special device and had a weight of approximately 30 tons. For transportation it was cut into pieces in a neighboring room. Then, it was possible to access the first tank. Since spring of 2018, the first storage tank is demolished. The remaining three tanks will follow step by step.

COMPACT SODIUM-COOLED NUCLEAR REACTOR FACILITY - KNK

The Compact Sodium-Cooled Nuclear Reactor Facility (KNK) was an experimental power plant of 20 MW electric power. From 1971 to 1974, the plant was first operated with a thermal core as KNK-I. From 1977 to 1991, it was run with a fast core as prototype fast breeder reactor KNK-II. This type of reactor uses sodium instead of water for cooling. After fast breeder technology had been given up in Germany, KNK was finally shut down in 1991. Decommissioning started in 1993. According to the decommissioning concept, the plant shall be dismantled completely. First decommissioning licenses covered the reactor periphery. Since 2003, decommissioning has been performed in the reactor building.

DISMANTLING OF THE REACTOR TANK

Dismantling work was carried out from 2005 to 2008. An enclosure with thick shielding walls and remotely controlled systems was set up above the reactor tank. All dismantling activities in the reactor area were accomplished from this enclosure, with the tool applied being lowered into the reactor tank by the cell crane. The reactor tank and its internals were cut into pieces fitting into a waste drum. Disassembled parts were loaded remotely into shielded transport containers. Due to the partly still existing sodium, work had to be performed under a nitrogen atmosphere.

DISMANTLING OF THE PRIMARY SHIELD

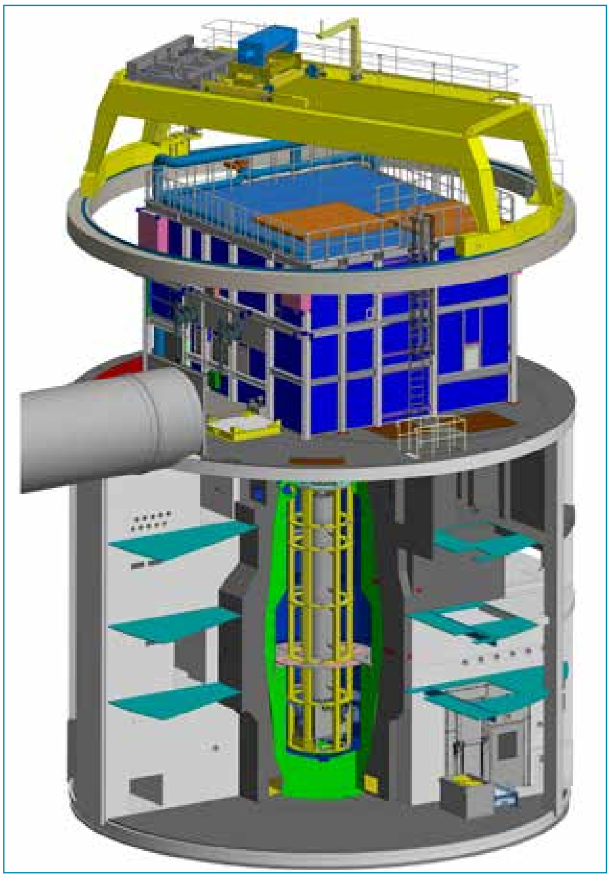
The primary shield, a ring of cast iron around the former reactor core, consisted of twelve segments, a measurement chamber, and a filler piece. Their masses varied between 0.8 and 15.5 t. For radiological reasons, they had been installed in perfect fit and interlocked in the reactor pit, so there was hardly any space left for dismantling. The gaps between the segments were only a few millimeters wide. This “cast iron puzzle” of about 90 t had to be dismantled remotely in smallest space. Access was possible from above through a small opening of only 2.10 m in diameter. The heavy segments had to be lifted into the enclosure undismantled.

For this complex task, a special machine, the so-called lifting unit, was developed. First, this lifting unit was used to drill small holes into the segments. Afterwards, pins were inserted into these holes and fixed in order to lift off the segments. In late 2013, the lifting unit was commissioned. In the enclosure above the shaft, the removed segments were cut into parts suited for transportation using a specially designed band saw. Specially trained staff operated the systems from the control room located in the reactor containment directly in front of the enclosure. The primary shield was dismantled from November 2013 to April 2015.

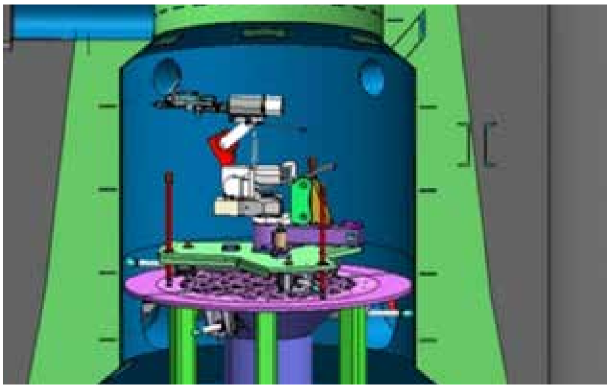
DISMANTLING OF THE BIOLOGICAL SHIELD

The biological shield of KNK encloses the reactor shaft. During operation it served to shield gamma and neutron radiation from the reactor core. It consists of highly reinforced heavy concrete that additionally contains lead spheres. During construction a tank casing was used to provide the contour of the reactor shaft.

The inner part of the biological shield was activated by reactor operation. Because the material is radioactive, it has to be dismantled remotely. This is the last remotely controlled activity in KNK dismantling and will be carried out by a special device, which is positioned on a modular modular constructed rack, from top to bottom.



Schematic diagramm of the total situation.
Green marked is the activated part of the biological shield.

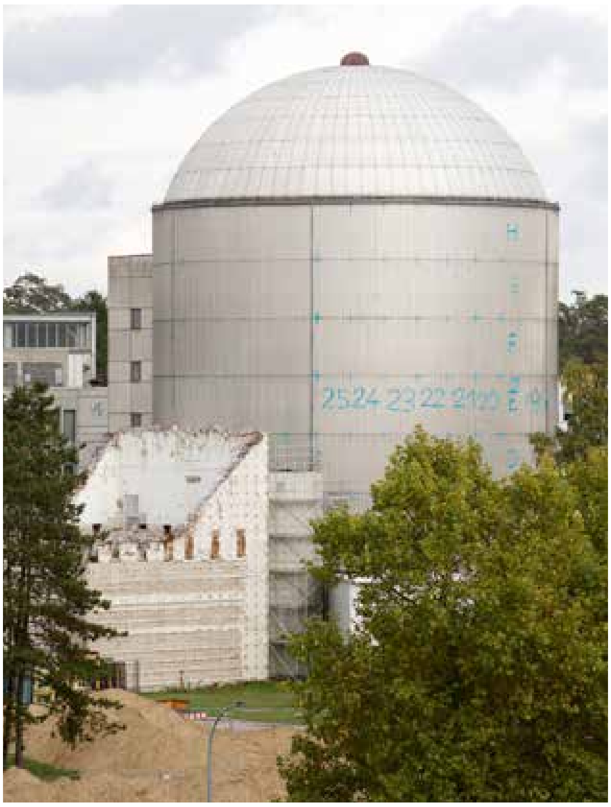


A converted digger is able to work with tools like angle grinders as well as to use the chipping hammer.

MULTI-PURPOSE RESEARCH REACTOR – MZFR

The Multi-Purpose Research Reactor, MZFR for short, was a heavy water-cooled pressurized water reactor of 57 MW electric power. In the course of nearly 19 years of operation, vast experience was gained with respect to operation of heavy water reactor systems. Apart from research and development, the reactor was used for electricity generation and for supplying the Research Center with district heat. In 1984, the MZFR was finally shut down. Since 1987, the reactor is under decommissioning.

It is the most advanced decommissioning project of KTE. No longer needed buildings of the MZFR complex were emptied, decontaminated, and demolished step by step upon measurements and release from the Atomic Energy Act. Work in the reactor building proper also is well-advanced. Soon, the reactor will be demolished.



The end of the project is near. Now, the main tasks are measuring, reworking, measuring, controlling, and confirming.

DISMANTLING OF REACTOR PRESSURE VESSEL

The MZFR reactor pressure vessel was dismantled from 1999 to 2008. More than 99% of the radioactivity inventory remaining in the plant after the end of operation was removed by this action. The reactor had a total mass of about 400 t, a height of 7.60 m, and a diameter of 4.60 m. Dismantling was only possible in installation position under remote control.

DISMANTLING OF THE BIOLOGICAL SHIELD

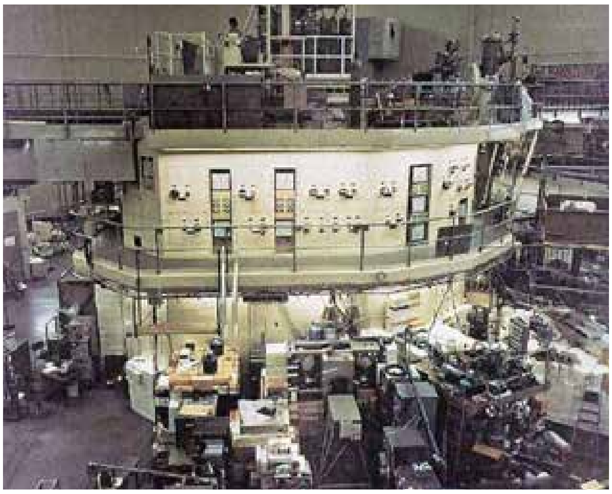
Dismantling of the biological shield started in 2010. This annular concrete encasement had been designed to shield radiation from the reactor. During operation, it was activated inside and additionally contaminated with tritium. About 370 t of activated iron-reinforced heavy concrete had to be dismantled remotely.

REMAINING WORK

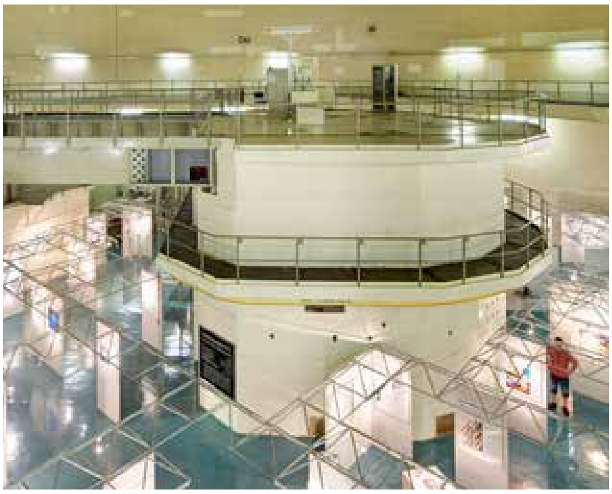
Although decommissioning of the MZFR has advanced, some work still remains: All building structures have completely to be decontaminated and the last operation systems have to be dismantled after the installation of substitute ventilation and electrical systems. Prior to demolition work, extensive radiological measurements are carried out. Only when it can be proved to the authorities that the radiological limits specified are not exceeded, will the buildings be released from the Atomic Energy Act and demolished conventionally.

RESEARCH REACTOR FR2

The FR2 was the first reactor in the Federal Republic of Germany built according to an own German concept. It was taken into operation in March 1961. The FR2 was a tank-type reactor with natural uranium fuel (later, 2% enriched uranium oxide) and heavy water as moderator and primary coolant. The FR2 was used as a neutron source for fundamental neutron physics experiments, fuel development, and materials research. In addition, radioisotopes were produced for nuclear medicine. On December 21, 1981, the FR2 was shut down after twenty years of operation with more than 100 000 operation hours. It took until late 1996 to reach the state in which it is today. This is the state of safe enclosure, which means that the remaining radioactive components are tightly enclosed. All buildings that were no longer needed were subjected to release measurements, released from the Atomic Energy Act, and demolished. The reactor building presently accommodates an exhibition on the development of nuclear technology in Germany.



The FR2 was used for irradiation experiments, test setups were installed in several shafts.



Since 1996, the FR2 has been in the state of safe enclosure. The reactor hall accommodates a nuclear technology exhibition.

PREPARATION FOR REMAINING DISMANTLING

The fuel elements were located in an aluminum tank enclosed by a steel tank. Due to the dose rates of the reactor components, manual dismantling will be impossible within a foreseeable period of time, even when taking into account radioactive decay since shutdown.

Dismantling, disassembly, transportation, and packing of all reactor tank components will be accomplished remotely later. The activated part of the biological shield will also be dismantled remotely.

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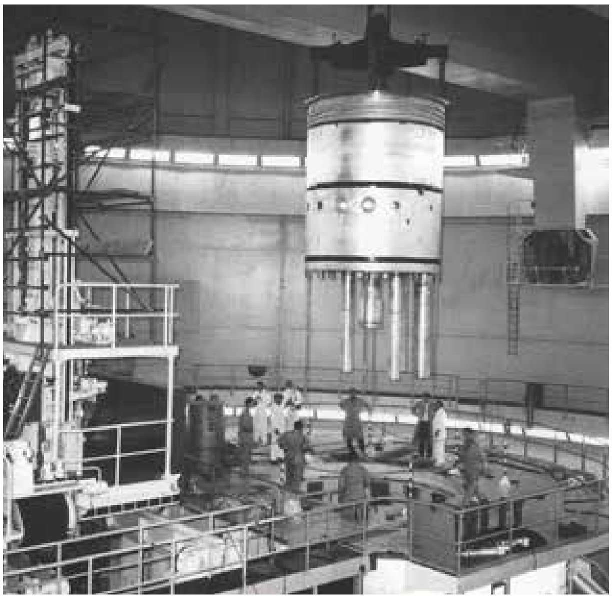
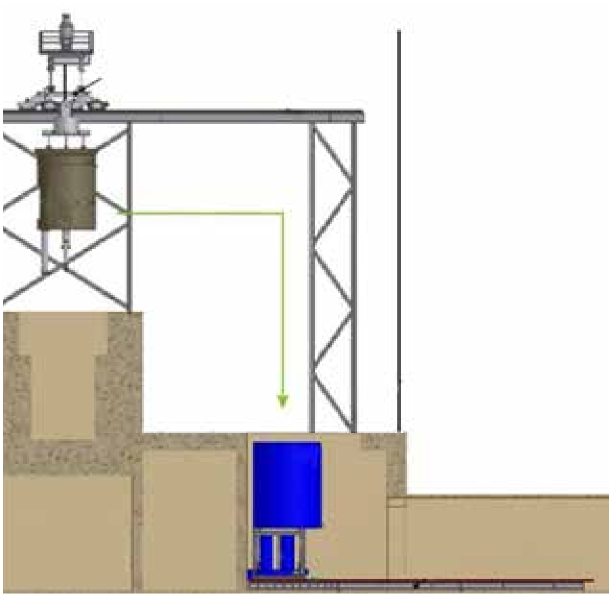
Prior to operative dismantling, the infrastructure facilities will have to be backfitted and complemented. The upper dismantling area around the biological shield will be provided with an enclosure to prevent contamination from spreading. For cutting the components, techniques successfully applied in the MZFR and other decommissioning projects will be used.

Having specified the procedure in detail, the license can be applied for. Fundamental planning is in process. The date of the start of remaining dismantling has not yet been fixed.



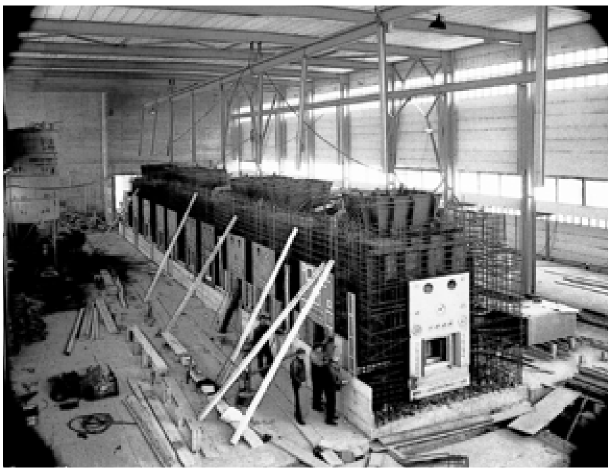
Pioneer work in the late 1950s: Installation of the aluminum tank.



A big technical challenge today: Planning of remote dismantling of the reactor tank.

HOT CELLS – HZ

The Hot Cells were used to examine materials irradiated in reactors. Here, fuel elements, fuel element test specimens, and structural materials were analyzed using physical and chemical methods. The core of the facility was made of five concrete cells, complemented by various lead cells. The cells equipped with lead glass windows, hand manipulators, heavy-load manipulators, and various lock systems contained various experimental setups. In a separate laboratory section, further investigations were carried out using e.g. scanning electron microscopy. In the same area, decontamination was accomplished and workshops were located. The facility consisted of three building sections. In early 2010, responsibility for decommissioning of sections 1 and 2 of the Hot Cells was transferred to the WAK GmbH, today's KTE, as the sole license holder according to Article 9, Atomic Energy Act. Section 3 is still operated by KIT as a fusion materials laboratory. It was separated technically and in construction from the other two sections.



The large concrete cells were built in 1964 and operated until the mid-1990s.

In late 2010, the license for the decontamination and decommissioning of contaminated components of the Hot Cells was granted by the Baden-Württemberg Ministry of the Environment. This license also covers release according to Article 29 of the Radiation Protection Ordinance and demolition of the buildings. First, the infrastructure of the buildings was adapted to dismantling needs. A whole-body monitor was installed at the exit of the controlled area and a transport lock was built for bringing in and removing containers and large components. To enter the concrete cells, person locks with breathing air supply were installed. For the removal of cell internals, a dismantling caisson was put up in the crane hall above the cells. The safely packaged material is removed through the removal locks.

The five concrete cells are dismantled using a standardized procedure: Having measured the ambient dose rate in the cells, it is decided which work has to be performed remotely with the help of a special manipulator carrier system. The cell interiors initially are decontaminated remotely to reduce the dose rates such that manual dismantling and decontamination in the cells can be permitted by the authority. Then, removal of the cell internals, removal of coatings and steel liners, and dismantling of feed-throughs take place manually. For removing the lead glass windows, additional enclosures will be set up. In accordance with the dismantling progress, these enclosures and caissons will be moved.

Access to the controlled area of the rear rooms of cells 1 to 5.

Specialized staff dismantles cell internals.

View of the hatch for bringing in and removing material (front) and of the dismantling caisson in the crane hall above the cells.

WASTE MANAGEMENT

Important to Society – Over a Long Term

At the central waste management department of KTE, all incoming materials are treated by separating non-contaminated constituents from radioactive wastes in order to minimize the radioactive waste volume. The following processes are applied:

- Decontamination, disassembly, and compaction of solid unburnable materials.
- Incineration of solid and liquid burnable wastes.
- Evaporation and solidification of liquid unburnable wastes.

Radioactive waste is subjected to treatment and packaging for later final disposal. This means that conditions for disposal at the federal Schacht Konrad repository have to be fulfilled.

The packaged waste remains in the interim storages of KTE specially built for this purpose until transfer to the federal repository. Interim storage capacities are about to reach their limits. Extensions are needed, as the federal Schacht Konrad repository is not yet ready for accepting the waste, while decommissioning projects have to be continued.

Most of the wastes to be treated results from the nuclear facilities on the site. A very small fraction of the waste consists of residues of the collection center of the state of Baden-Württemberg. These wastes are also treated and stored by KTE. Provided that capacities are available, waste treatment services are offered to external third parties, which have to store the radioactive wastes after treatment at their own facilities.

MINIMIZING THE WASTE AMOUNT

DISASSEMBLY AND DECONTAMINATION

Low-level metal and concrete parts are disassembled, cut, and decontaminated, if possible. The waste amount to be processed in this manner covers sometimes more than 1000 t per year.

Often, radioactive substances only adhere to the surfaces of the delivered parts. With the help of various surface treatment methods, contamination can be removed. Clean metal and concrete parts and a relatively small fraction of radioactive waste remain. Decontaminated material is transferred to the release measurement system. Based on the measurement results, it is decided whether the parts can be released according to the Radiation Protection Ordinance.

A big processing hall accommodates separate cabins with separate ventilation systems. In these so-called caissons, all activities associated with a risk of contamination are carried out. Apart from surface removal, such work includes disassembly by e.g. flame cutting and concrete chiseling. When carrying out this work, the staff wears air-supplied suits.

Large components are fragmented irst and thanf decontaminated.

Decontamination by pressure water jet.

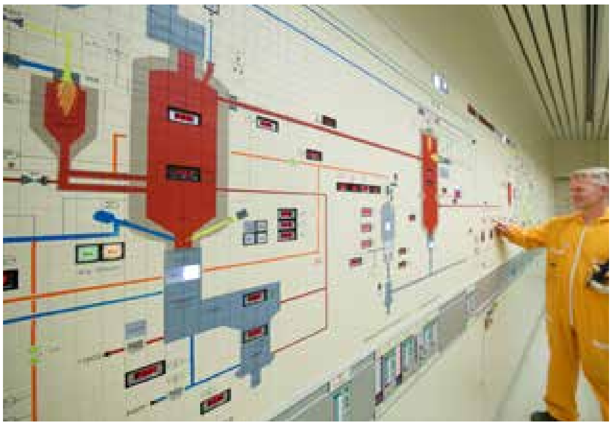
View of the treatment area for disassembling and decontamination of low level waste.

MINIMIZING THE WASTE VOLUME

COMPACTION

Volume of the radioactive wastes is reduced to the largest possible extent. Pipelines, filter elements, and other unburnable components are compacted to pellets under high pressure. These pellets are packed into drums. Concrete parts are crushed before they are put into drums. Intermediate level components can only be treated remotely in shielded cells. Using drum gripping units and manipulators, the waste is disassembled, sorted, and compacted at high pressure, with the operations staff having eye contact via lead glass windows.

Incombustible components are compacted to pellets by high pressure.



The incineration-process is centrally operated.

INCINERATION

All combustible substances and materials are processed in the incineration facility of KTE. It is the only facility in Germany that is designed for alpha-contaminated radioactive residues. Solid residues are packed in foil bags or cardboard drums and fed into the furnace via a charging box. Liquid wastes are analyzed for activity and halogenated hydrocarbons and metered into the afterburning chamber.
The ash from the furnace is filled into drums and subjected to compaction. Flue gases are passed through a multi-stage cleaning system with scrubbers, absorbers, and filters. The emission limits specified by the authorities are complied with reliably.

EVAPORATION AND SOLIDIFICATION

Chemical effluents and other unburnable liquids are subjected to evaporation. Evaporating substances are filtered several times. Radioactive substances are concentrated in the evaporator residue. This concentrate is solidified with cement in waste casks in order to generate a waste product suited for final disposal.

Chemical effluents and other unburnable liquids are sampled in large tanks and reduced in volume by evaporation.

A LONG-TERM TASK: STORAGE AND TRANSFER OF RADIOACTIVE WASTES

SITUATION

As Germany presently has no repository for radioactive wastes, the latter have to be subjected to safe interim storage. Depending on their activity, radioactive materials are classified as follows:

- Low level wastes.
- Intermediate level wastes.
- High level wastes.

For later final disposal, it is also distinguished between wastes of negligible heat production that are planned to be disposed of in the “Schacht Konrad” repository and heat-producing radioactive wastes for which a final disposal location has not yet been chosen.

THE BOTTLENECK

KTE operates storage buildings for low and intermediate level wastes. Since the late 1970s, storage capacities have been expanded repeatedly. The “Schacht Konrad” federal repository has not yet started operation, which is why no waste can be transported there.

To continue all decommissioning activities on the site, storage capacities for low and intermediate level wastes have to be further expanded. Two new buildings are under construction. In this way, storage capacity for radioactive waste from decommissioning will be increased to nearly 100,000 m³.

CONSTANT ROUTINE CHECKS

Longer storage times due to the delayed commissioning of the federal repository require the waste packages to be checked routinely for potential damage due to aging, such as corrosion. For this purpose, the containers are removed systematically from the store, controlled, and returned. The containers stacked on top of each other in up to eight layers are brought out in slices rather than layers. Hence, both older (bottom layers) and younger containers (top layers) are checked.

Wir setzen Maßstäbe.
Mit Sicherheit.

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