DECOMISSIONING OF THE FORMER GERMAN REPROCESSING SITE WAK – STATUS OF VITRIFICATION PLANT AND DISMANTLING OF THE HLLW STORAGE TANKS - 9023

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ABSTRACT

The German pilot reprocessing plant WAK was shut down in 1990 after reprocessing about 200 Mg of nuclear fuels and is decided to be dismantled completely to the green field until year 2023. During the years 1994 until 2008 approximately 2.000 Mg of partly highly contaminated process equipment and 1.500 Mg of concrete structures corresponding to 99% of the radioactive inventory of 5E14 Bq of the WAK reprocessing building have already been dismantled.

A mayor prerequisite for the complete dismantling of the WAK is the management of the 60 m³ high-level liquid waste (HLLW) with a total β/γ-activity of 8.0E17 Bq resulting from reprocessing. For this purpose the Karlsruhe Vitrification Plant (VEK) was constructed in the years between 2000 and 2005 and inactively tested in 2007. The subsequent nuclear test operation and routine hot operation of the VEK plant are planned to start in 2009.

In parallel to vitrification operation, dismantling of the four HLLW tanks in the storage buildings will be prepared for remote dismantling. For this purpose, a new access building was built and set into operation. It serves as main barrier against radioactive releases and to bring in and operate the remote handling tools and allows for the contamination-safe removal of drums containing the contaminated equipment.

The paper will present the actual status of the VEK hot test operation, and outlook for the forthcoming hot vitrification operation and the ongoing remote controlled dismantling of the highly contaminated tanks of the HLLW storage building of WAK.

INTRODUCTION

The German pilot reprocessing plant WAK was shut down in 1990 after reprocessing about 200 Mg of nuclear fuels from R&D and power reactors. After national commercial reprocessing was given up in 1989, the decision was made to shut down WAK and to dismantle the site completely to the green field. To reach the technical objective "green field" the reprocessing site including the main process building of WAK and the adjacent units of HLLW treatment and media supply shall be dismantled and demolished in six different and independent steps as described below.

A major precondition for the complete dismantling of the WAK is the management of the 60 m³ high-level liquid waste (HLLW) with a total α/γ-activity of 8.0E17 Bq resulting from reprocessing and stored in two tanks. For this purpose the Karlsruhe Vitrification Plant (VEK) was constructed in the years between 2000 and 2005. Functional testing of single components and of single process systems (e. g. HLLW receipt system) as well as successful demonstration of all remote handling operation including cask loading were completed in 2006 and 2007. Cold commissioning was completed in 2007 by a long-term integral cold test carried out under representative operation conditions.

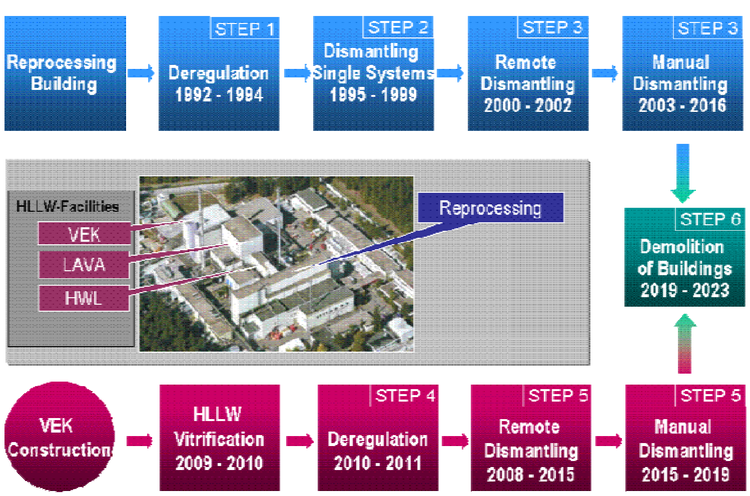
The subsequent nuclear hot test operation requires the operational license, being expected to be issued by the competent authority in late 2008. VEK is scheduled to start hot operation in 2009.

The HLLW will be vitrified to about 50 tons of borosilicate glass and filled into 130 stainless steel canisters (400 kg). The vitrification technology used by VEK is based on a liquid-fed ceramic melter (LFCM) which converts the waste liquor into glass by a single-stage process. The technology has been developed during the last three decades by the Institut für Nukleare Entsorgung (INE) of FZK [1]. One of the major design features of the waste glass melter is its suitability to process highly noble metals-containing waste solutions as generated by WAK operation.

Dismantling of the four HLLW tanks (2 actually in use and 2 emptied) in the storage buildings will be a particularly challenging task in terms of remote dismantling and radiology. The handling of the HLLW tanks and also of several mean-active waste (MAW) tanks which are located in thick-walled concrete cells requires remote-controlled horizontal access. For this purpose, a new access building was built and put into operation. It serves as main barrier against radioactive releases and to bring in and operate the remote handling tools and allows for the contamination-safe removal of drums containing the contaminated equipment. The outer wall of the storage building has already been penetrated using the remote-controlled machinery. The dismantling of the tanks is foreseen to be carried out parallel to the vitrification operation starting with the demolition of MAW tanks in early 2009.

CONCEPT OF WAK DECOMMISSIONING AND DISMANTLING

WAK decommissioning, dismantling and waste management is being carried out in six different technical steps (Fig. 1) depending on the purpose of the relevant building (either chemical reprocessing or HLLW treatment). The HLLW plant areas related to storage and vitrification still in operation, and therefore require high safety standards, are technically completely separated from the former reprocessing building being in an advanced stage of dismantling. The decommissioning steps 1-3 comprise the dismantling steps of the former reprocessing building until it can be released from the deregulations of the German Atomic Energy Act. Step 4 covers all technical adaptations at the end of vitrification operation (emergency power supply, cooling water and ventilation) including those organizational measures, which allow reducing shift personnel and the total staff number.



VEK = Vitrification Plant

LAVA = HLLW storage building (two tanks in operation)

HWL = HLLW storage building (two tanks emptied and rinsed, out of operation)

Fig. 1: Steps of WAK decommissioning and dismantling (1999 – 2023)

Besides the last step (6), which is the final demolition of all buildings after the controlled area inside and outside the facilities have been eliminated, step 5 is the greatest challenge and most complicated effort, because it covers the dismantling of the highly α-contaminated equipment of the HLLW treatment facilities. For this reason it will be executed in 10 different subgroups, e.g.

- Construction and commissioning the "HWL-Annex South" (building for access of manipulator-carrier-system "MTS", locking out waste material from dismantling and barrier against the spread of contamination).
- Remote dismantling of MAW tanks in HWL building.
- Remote dismantling of four HLLW tanks.
- Remote and manual dismantling of various cell equipment and glove-boxes of the highly radioactive laboratory unit.
- Remote and manual dismantling of the VEK equipment including the melter and piping's between different HLLW buildings
- Conventional dismantling of the media supply units of the site's infrastructure.

HLLW VITRIFICATION BY THE VEK PLANT

Mission of the VEK vitrification facility is the immobilization of 60 m^3 of a HLLW solution, the composition of which is shown in Fig. 2. It is characterized by a high specific activity of $1.2 \cdot 10^{13}$ Bq/l and the presence of considerable concentrations of the Platinum metals group (Ru, Pd, Rh). These elements are practically insoluble in borosilicate glass melts require a special melter technique, which is being applied by VEK.

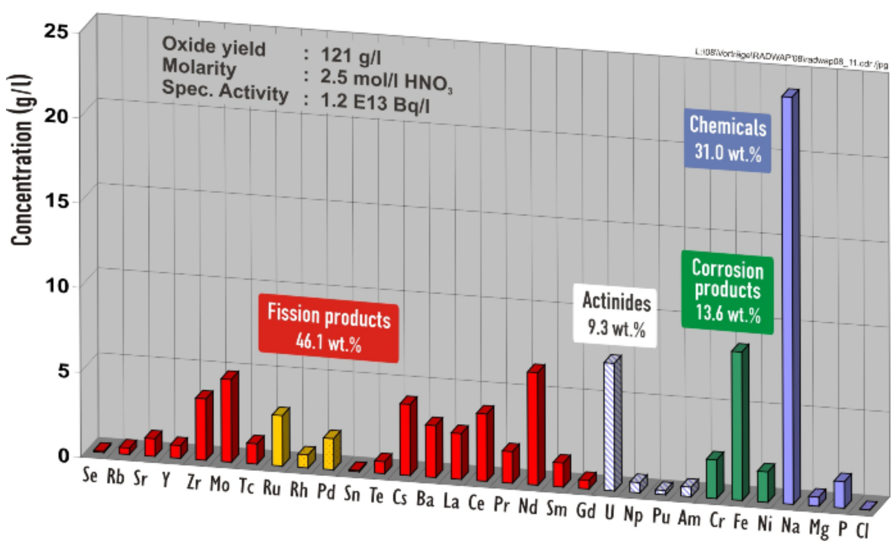


Fig. 2: Chemical composition of the HLLW to be vitrified by the VEK plant

Commissioning and hot test

The commissioning phase of VEK has been finalized in 2007 by performance of a 77 days long-term integral plant operation (cold test). The cold test has been required to accomplish the goals laid down in the first partial operation license.

Precondition of the start of the cold test operation was the completion of all function tests for single components (e.g. glass melter) and systems (e.g. wet off-gas cleaning). This requirement did not only comprehend process-related installations but also other areas like process control system or remote handling equipment.

In the focus of the cold test were:

- Long-term demonstration of the vitrification operation in accordance with the established regulations
- Verification of the operational manuals
- Proving of the procedure of sampling and chemical analysis
- Production of glass canisters within specified ranges of relevant parameters
- Demonstration of canister transfer, treatment and handling procedure
- Education and training of operational staff

Overall purpose of the cold test was the demonstration of the vitrification operation under conditions close to that of the hot operation. Control of the whole plant operation had to be carried out by means of the central process control system, consisting of a conventional and a safety system. The requirements included the conduction and control of the process according to the operational manuals approved by the regulatory body. All routine remote operations as well as possibly occurring maintenance or intervention actions had to be exclusively carried out by the installed remote handling equipment. Manual operations are routinely necessary to carry out all steps of glass canister handling and treatment. Another main goal was the verification of the control strategy to produce a specified glass product according to the quality assurance program. The simulated waste solution used for the test had been composed according to the available reference composition data of the genuine HLLW as given in Fig. 2.

Cold test operation was carried out between April 3 and July 12, 2007. During the cold test totally 17 m^3 of HLLW simulate were processed to 12.7 t of glass product. The glass melt was filled into 32 canisters. The complete duration of the processing period was 77 d. One of the main results of the cold test operation was the accurate control of the waste glass loading with a target oxide loading of 16. wt.%. Fig. 3 shows the calculated values for the first part of the test period.

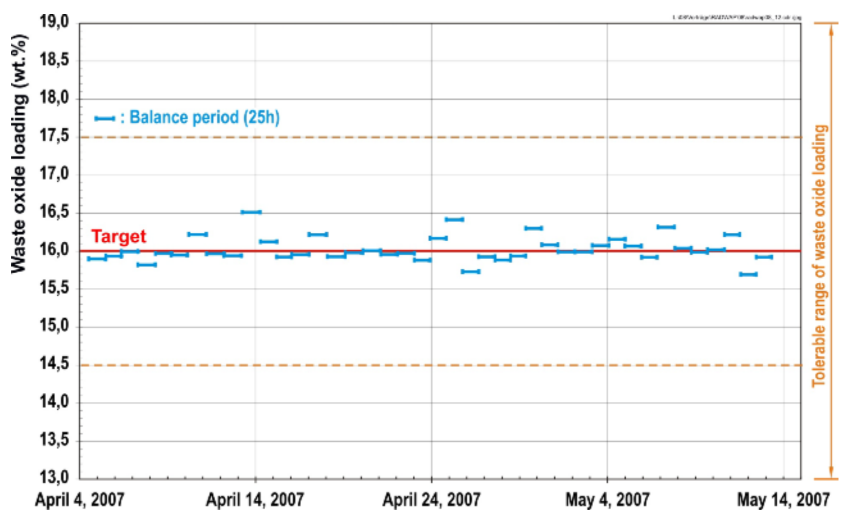


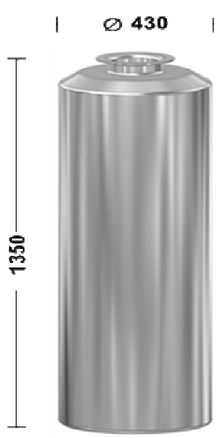
Fig. 3: Waste oxide loading in the glass produced in the cold test

After release of the hot operational license expected in late 2008, the plant will be prepared for radioactive application. Steps like establishing radiation-protected control areas and connection of the transfer pipes to the HLLW storage facilities will be made.

Prior to start-up of hot production a short pre-test of about one week will be made using diluted HLLW solution by mixing a small amount of genuine waste solution with HLLW simulant as used during the cold test. The specific activity of this solution will have about $1.5 \cdot 10^{11}$ Bq/l. Purpose of the hot test is to check the functionality of installations which can be only performed in presence of radioactivity. These installations comprehend emission control of the melter exhaust, the cleaning efficiency of the total off-gas treatment system and installations of the radiation protection system. Moreover the radiologic status of the plant will be examined.

Vitrification operation

Subsequently to the hot test, vitrification operation will be started. It is scheduled to last 1.5 years with a net production time of approximately 300 days. The approximately 130 produced glass canisters with a capacity of 400 kg of glass each have to meet the guaranteed values of the relevant set of parameters as listed in Fig.4.



PARAMETER	GUARANTEED VALUE
Waste oxide loading	≤ 19 wt.%
Canister weight	< 550 kg
Activity Sr-90/Y-90	< 4.5 E15 Bq
Activity Cs-137/Ba-137	< 5.1 E15 Bq
α activity	< 8.6 E13 Bq
β/γ activity	< 9.6 E15 Bq
Mass of U	< 7200 g
Mass of Pu	< 210 g
Dose rate:	
β/γ (on surface)	< 440 Gy/h
β/γ (1m distance)	< 35 Gy/h
Decay heat	< 734 W

Fig. 4: Set of specified parameters for acceptance of the VEK glass canisters

After termination of the vitrification operation the process equipment will be cleaned by appropriate measures to reduce the radioactive inventory as far as possible. As for the melter, it will be flushed several times with glass frit. According to experiences gained by application of this procedure (PAMELA plant at Mol, Belgium) the melt tank refractory then can be categorized as mean-level radioactive material. Step by step the process installations in the hot cells will then be dismantled, the cells decontaminated in order to be able to put the plant into a deregulation status for further dismantling.

Fig. 5: Loading of the CASTOR cask on the train (test)

The waste glass canisters will be loaded into CASTOR casks for transport and intermediate storage. The capacity of the casks is 28 canisters each. The transportation of the 5 casks to site of the interim storage facility in Northern Germany will be performed by railway. Fig. 5 shows the loading of a CASTOR cask during the testing phase.

DISMANTLING OF HLLW STORAGE AND TREATMENT FACILITIES

Technical and Radiological Data of the HLLW Tanks

The four HLLW-tanks to be dismantled have a volume of 75 m³ (two tanks in the HWL) and of 80 m³ (two tanks in the LAVA). They have a mass of 16 Mg resp. 18 Mg and a wall consisting of 10 mm resp. 12 mm stainless steel (cf. Fig. 6).

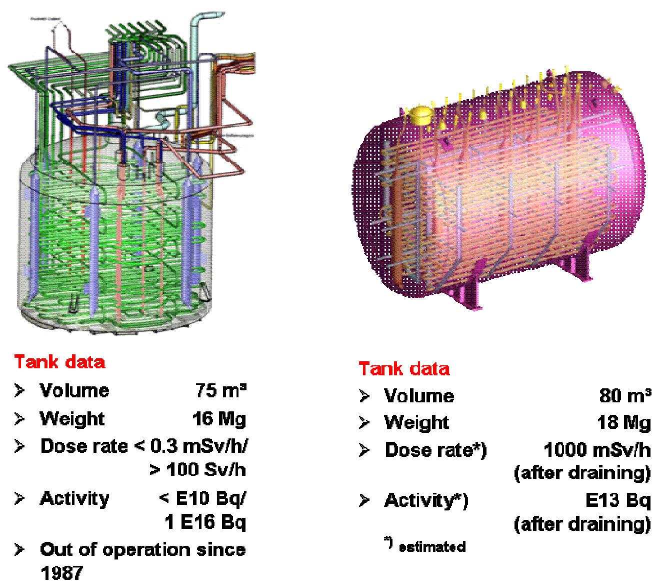


Fig. 6: 3D-view of HLLW storage tanks and technical data

According to the operation history, the tanks have a different activity inventory as well as a different quantity of deposits remaining after draining of the tanks. Thus, the total activity in the two tanks in the LAVA is estimated of about 10^{13} Bq. A significant amount of deposits will not be expected, because in the first instance the HLLW was stored in the HWL-tanks and while pumping the HLLW to the LAVA-tanks the deposits could not be transferred and have remained in the HWL. In addition, the geometry of the LAVA-tanks, the process equipment for the deposit-suspension as well as the provided procedure at the end of vitrification operation are expected to secure an effective and almost complete rinsing of the tanks.

One of the two tanks in the HWL was only partly filled with HLLW for a short time period. Subsequent to draining, the tank was rinsed with deionised water and thus decontaminated to a large extent. Deposits will not be expected in case of this single tank. The total activity is estimated to be only 10^{10} Bq, which has been verified by radiological measurements.

In the second tank the HLLW was stored over decades of years from beginning of reprocessing operation in the 70's. Hence, the residues, resulting from insufficient clarification of the fuel solu-

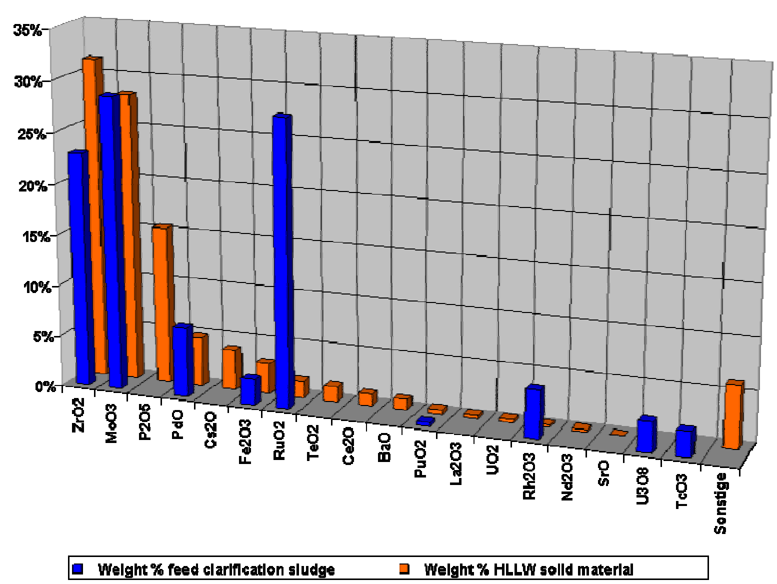


Fig. 7: Estimated chemical composition of the HLLW tank deposit

tion as well as from degradation products of reprocessing, have been deposited. Fig. 3 shows an estimation of the sludge composition. Solid material and liquid sampling is foreseen early 2008 to verify the assumed chemical composition. The collected analytical data shall be basis to define the waste product specification needed for interim storage and final repository. The mass of the deposit in the tank is estimated to be app. 100 kg with a corresponding total activity of about $6 \cdot 10^{15}$ Bq (Cs-activity $2 \cdot 10^{15}$ Bq).

In order to verify these data, the HLLW-tank was inspected, partly rinsed and the dose rates inside and outside of the tank verified. Sampling of the deposit material as well as of the rinsing liquid is foreseen beginning of 2009 and depending on the required license. Inner tank dose rates are about 100 Sv/h in 1 m distance above ground (see Fig. 8).

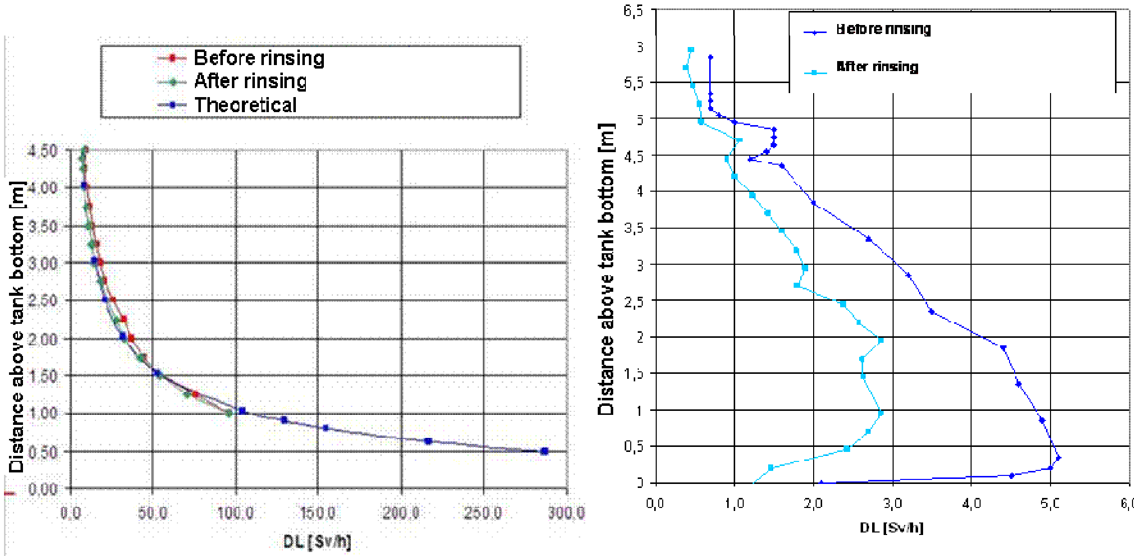


Fig. 8: Results of dose rate measurements after tank inspection (left: inside, right: outside)

Specific Techniques for Remote dismantling

All tanks will be dismantled remote-controlled /2/. The same technique will also be applied for the MLLW-tanks. During the licensing procedure it was decided to cut the tanks with mechanical tools only. No thermal cutting techniques are planned. Thus, the release of aerosols during the cutting of the tank material will be prevented.

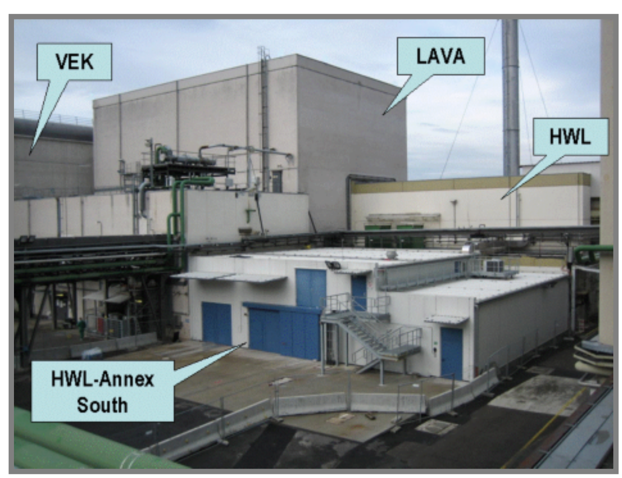


Fig. 9: Aerial view of HLLW facilities and HWL-Annex South after commissioning

The provided tools and equipment have been tested and qualified in a mock-up facility, which was specifically designed for this application. Some of the tools are not commercially available, e.g. cutting tools for steel plates with a thickness of more than 10 mm. These tools have been developed for the application at WAK. The main device is the adapted Manipulator-Carrier-System (MCS). The MCS can be equipped with a manipulator-system as well as with various other large tools (e.g. hydraulic chisel, hydraulic driven concrete mill etc.). With the manipulator system other tools for the dismantling of the tanks will be handled, e.g. hydraulic driven nibblers, jigsaws, grinders etc..

The current concept provides the cutting of the tanks within the cells to 200l-drum size. The filled drums will be locked out via the HWL-Annex South (see Fig. 9) and will be transported to the waste treatment facilities HDB of the Forschungszentrum Karlsruhe (FZK) for further treatment.

Status of HLLW tank dismantling

In June 2008 a first milestone for the further decommissioning of the HLLW facilities at the WAK reprocessing site has been reached, the commissioning of a new building adjacent south to the HWL (Main Waste Storage Facility). The so-called HWL-Annex South comprises various functional areas for locking out waste material resulting from the dismantling activities as well as personnel locks and locks for the dismantling equipment and tools.

Via the HWL-Annex South the storage tanks for MLLW and those HLLW in the HWL and the LAVA (Storage and Evaporation of high-active fission-product-solution) will be made accessible. Furthermore, the HWL-Annex South is the main barrier against the spread of contamination resulting from the dismantling operations.

Hence, the pre-conditions for the dismantling of the five MLLW-tanks and the four HLLW-tanks are fulfilled (see Fig. 10). The preparation activities for the dismantling for the MLLW-tanks have already been started in mid of year 2008. The first remote controlled break-through of the outer cell-wall was already executed. The measured dose rates of the MLLW-tanks resulted in approximately 100 mSv/h. Personnel access and manual dismantling is completely included under the conditions of the German radioactive protection regulations. Start up of tank dismantling is planned early 2009.

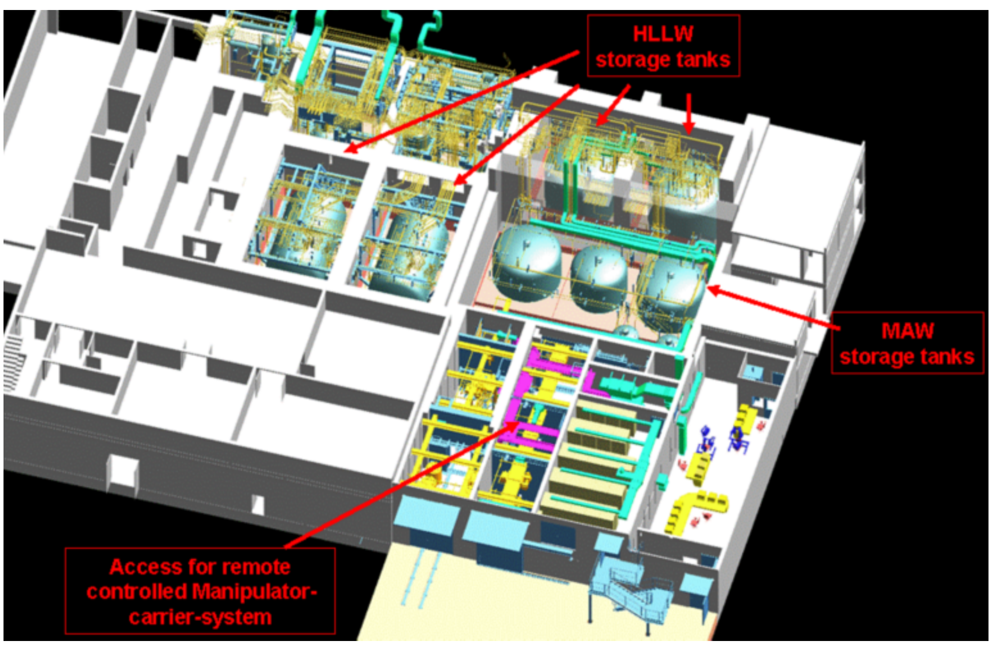


Fig. 10: Horizontal cut view of HWL Annex South and HLLW storage building

SUMMARY AND CONCLUSIONS

Decommissioning and dismantling of the HLLW facilities of WAK are a new challenge with respect to planning, licensing and execution including the handling and conditioning of the resulting wastes. The process made during the last years and the first encouraging steps in realization give evidence that

- The remote approach for HLLW tank dismantling will be successful
- The regulations according to the German Atomic Act and Radiation Protection can be fulfilled
- The inactive tests of equipment and remote techniques give evidence for the next steps of hot applications.

The results of VEK cold commissioning have proved the suitability of the vitrification process and of the control measures to meet the glass canister specification.

The production of radioactive canisters is expected to start in 2009 after the operational license has been issued by the competent authorities.

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