Experience in Decommissioning of Nuclear Fuel Cycle Facilities in Germany – 17195

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ABSTRACT
Several nuclear fuel cycle facilities have been decommissioned in Germany and the sites released from regulatory control. There is an overview of past and current decommissioning projects of fuel cycle facilities, either past fuel element fabrication facilities or past and current (experimental) reprocessing facilities. Several examples of technological advances are given, being developed due to obstacles, which occurred during conduct of these decommissioning projects.

INTRODUCTION

Several nuclear fuel cycle facilities have been decommissioned in Germany and the sites released from regulatory control. One site was released after ground water remediation. Two challenging decommissioning projects are still ongoing. This paper provides an overview over the major decommissioning projects of fuel cycle facilities in Germany, focuses on special aspects of the decommissioning of these facilities, and highlights some of the transferable knowledge gained.

OVERVIEW OF PAST AND CURRENT DECOMMISSIONING PROJECTS OF FUEL CYCLE FACILITIES IN GERMANY

Past Decommissioning Projects of Fuel Element Fabrication Facilities

Several nuclear facilities in Germany were built for the fabrication of nuclear fuel elements for light water reactors and high temperature research reactors.
The major part of these commercial facilities was built in Hanau near Frankfurt/Main. They were mostly situated in the same industrial zone as Degussa (German precious metals separating works), because Degussa was founding shareholder of subsequent NUKEM A (see fig. 1).

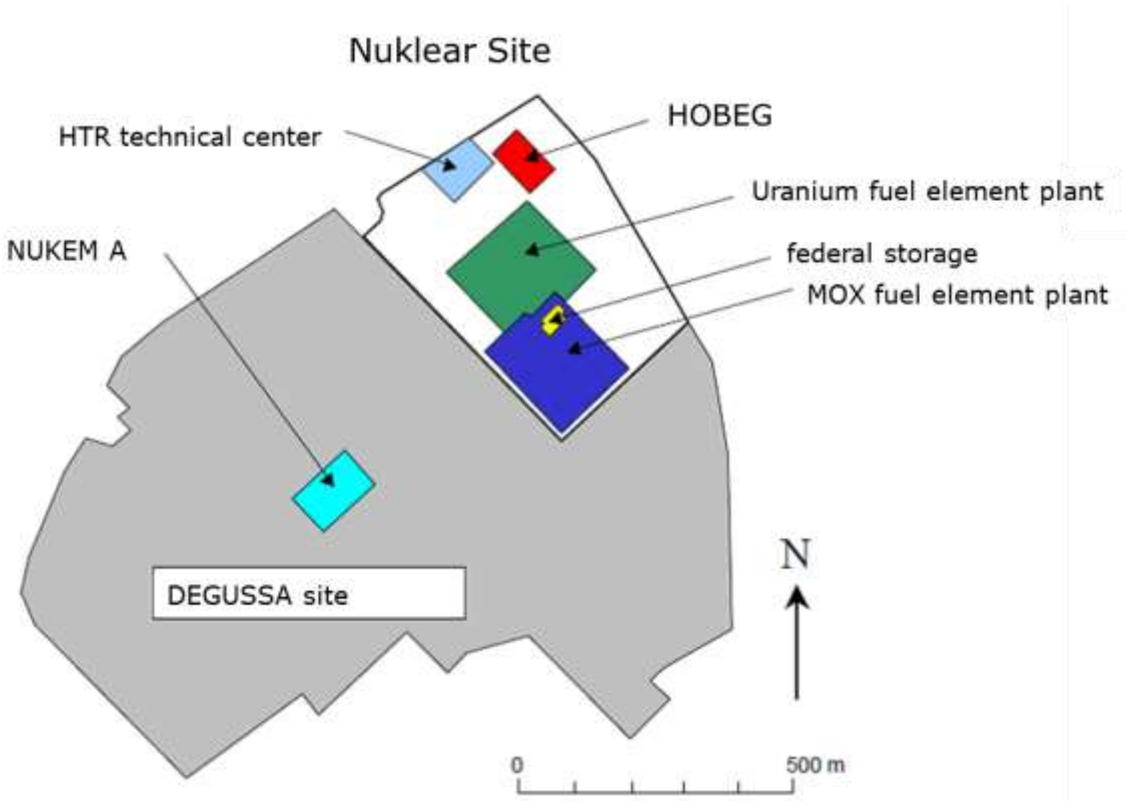

Fig.1 Location of Fuel Element Fabrication Facilities at Hanau.

At Hanau, the Siemens fuel element plant MOX was operated to produce fuel elements for light water and fast breeder reactors based on uranium and plutonium mixed oxides. In total 235 glove boxes in eleven caissons in two buildings were used for fabrication. During operation between 1968 and 1991 the plant was decontaminated between campaigns. The shutdown was enforced after a contamination incident. While and after a de-loading campaign decommissioning started with decontamination and dismantling of non-essential parts. The used standard glove boxes could be deconstructed within big deconstruction glove boxes with not heat generating tools. Around the double glove boxes a double walled PVC-sheet-tent had to be built to decommission them without spread of contamination. Afterwards only both former fabrication buildings and the stack were demolished, all other buildings were cleared for unrestricted use.

The Siemens fuel element plant Uranium was built to fabricate fuel elements for light water reactors made of uranium oxide. The facility operated between 1969 and 1995 and fabricated about five million fuel rods. Decommissioning and decontamination of non-essential equipment already started during the de-loading campaign. Buildings were decontaminated to values necessary for clearance for demolishing. The site was remediated, were necessary, to values below 10 microSv per year. For that, soil removal below the former foundation of the buildings and the facility area was necessary. This was done in 0.5 m steps up to 3 m (10 feet), in some areas up to 9 m (30 feet). In 2006 the site and remaining buildings were cleared for unrestricted use. Groundwater remediation due to chemical/toxic reasons is still necessary.

NUKEM A was a facility that fabricated fuel elements for research and material testing reactors as well as U/Th fuel cores for HTR fuel elements. The facility operated from 1960 to 1988. Buildings were decontaminated to values necessary for clearance for demolishing. During decommissioning R&D was done for decontamination of metals, concrete and soil to reduce volume of the radioactive waste. All decontamination of surfaces was done with suitable procedures that generate the least secondary waste. The site was remediated, were necessary, to values below 10 microSv per year. Remediation was done on about 33,000 m². For that a soil separation line was built to sort soil for landfill and soil as radioactive waste. In 2006 most of the site and remaining buildings were cleared for unrestricted use. Due to uranium contamination, a groundwater remediation program was necessary from 2002 till 2015. In the beginning the groundwater contained about 300 µg/l Uranium, some halogenated carbohydrates and arsenic. After filtration the water was treated in an industrial sewage plant. The final value is below 20 µg/l Uranium and is consistent with the 10 microSv-concept.

Past and Current Decommissioning Projects of Reprocessing Facilities
Reprocessing of spent fuel in Germany was mainly performed on an experimental scale at the former Nuclear Research Center Karlsruhe (KFK, today KIT) (see fig. 2).

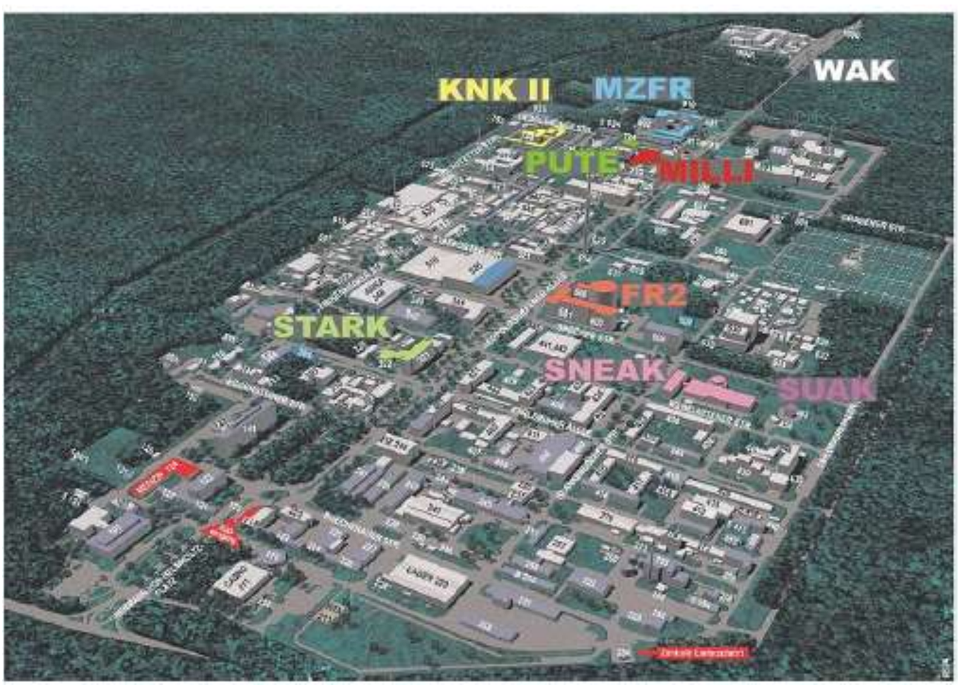

Fig. 2 Locations of different experimental nuclear installations at KIT, Karlsruhe.

MILLI was a research facility for reprocessing. It was built to improve the PUREX process to reduce (liquid) radioactive waste. MILLI operated between 1970 and 1985 and after reconfiguration from 1988 to 1989. After decontamination, the facility was dismantled between 1997 and 2000. Several new techniques were developed for the dismantling parts that cannot be decontaminated, e.g. using polyurethane foam to seal contamination in a cut pipe (see fig. 3). Further caution and a sensible choice of the corresponding decommissioning technique was necessary while cutting pipes, because in several pipes some flammable and/or explosive extractant agents/solvents were still present. The hot-cells where MILLI was installed were decontaminated to an occupational dose rate lower than 25 microSv per hour. Since 2001 a radiation monitoring has to be done every six months, although it is possible to work in the cells with basic personal protective equipment like masks without further restrictions.

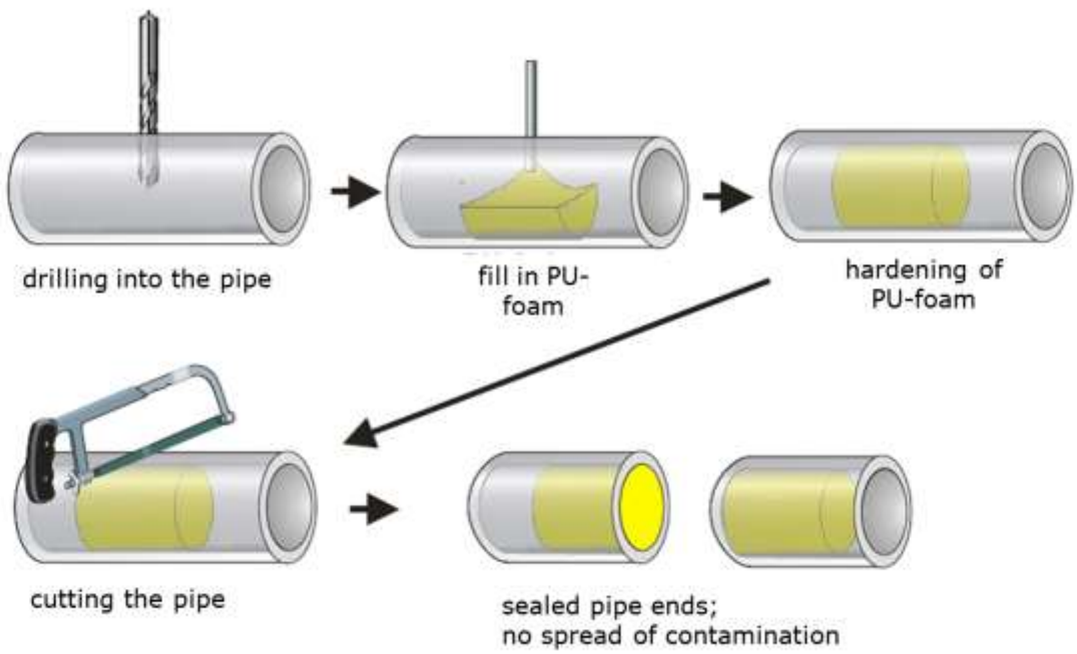

Fig. 3 Cutting a tube with sealed-in contamination.

PUTE was a research facility for testing of the improved plutonium extraction process developed at MILLI for the planned reprocessing plant in Germany. Only pure plutonium and uranium solutions were used. PUTE was in operation between 1980 and 1991. Afterwards safety related equipment had to be upgraded before decommissioning started. After decontamination and dismantling of highly contaminated equipment an occupational dose rate lower than 25 microSv per hour was achieved. Decommissioning was done in temporary multilayer plastic sheet tents with highly durable multilayer floor cover around the respective decommissioning tasks. Most of the decommissioning was done with mechanical tools, but due to spatial restrictions all parts had to be smaller than 1 m x 1 m and a mass below 100 kg. At the end of the decommissioning activities in 1996 the residual contamination within the building was about 0.5 Bq/cm² (control area level).

The WAK was a pilot plant for reprocessing of used nuclear fuel. It was in operation between 1971 and 1990 and reprocessed a variety of fuel from different light and heavy water (research) reactors. Decommissioning is ongoing and is divided into three parallel major tasks: first is to maintain a safe condition, second is the actual decommissioning work and third the vitrification of the high active liquid waste. For that a vitrification facility had to be built (fig. 4 and 5). Vitrification was done between September 2009 and November 2010 and about 65 Mg waste glass coquilles and decontamination liquid coquilles were produced. These are stored in five CASTOR-HAW 20/28 casks in the dry storage facility in Rubenow.

Fig. 4 External view of the vitrification facility (VEK).

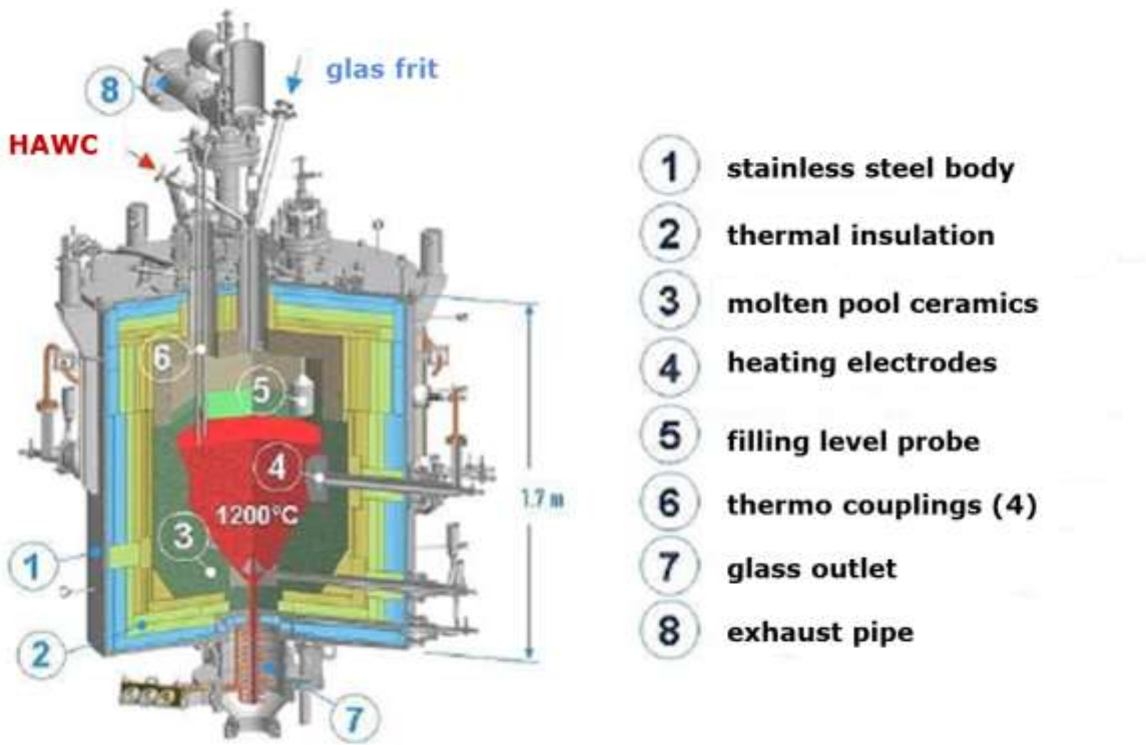

Fig. 5 Schematic of the vitrification furnace at VEK.

The decommissioning works in the former reprocessing part is ongoing. The decommissioning and decontamination of the former processing building are in an advanced state. For that about 16,500 m² contaminated walls and ceilings were decontaminated. About 1,200 concrete blocks with pipe grommets (fig 6) were removed and the ventilation system is demolished step by step.

Fig. 6 Concrete block with pipe grommets.

As part of decommissioning of the vitrification facility the storage tanks for MAW were demolished by remote handling (fig. 7). For the HAW storage and handling building the procedure for remote controlled decommissioning is currently in preparation. In some of these tanks some residual solid high active waste is still present (about 100 kg). The waste shall be removed remotely while the remote handled demolishing.

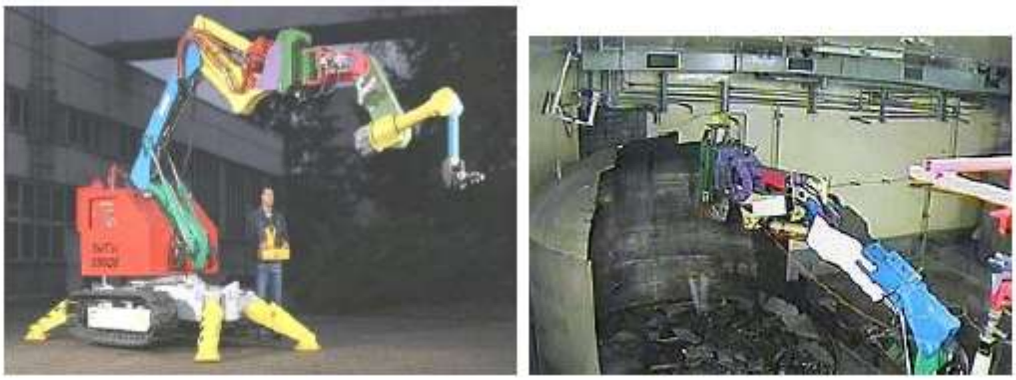

Fig. 7 (left) remote handled manipulator for various tools (right) storage tank demolishing

The former storage and evaporation facility with high activity laboratories is being decommissioned as well. The laboratories are demolished and the hot cells were the evaporation units were installed will be decommissioned remotely.

The planning for decommissioning of the vitrification facility is progressing. Some offline installations were demolished in individual rooms. So there is space for remote control installations, air locks and waste management.

CONCLUSIONS

Decommissioning of nuclear fuel cycle facilities in Germany has been done several times and where projects are finished a “green field” was achieved.
In two cases of fuel elements fabrication facilities a groundwater remediation was necessary, one for radionuclides removal is finished, the other for chemical contamination is still ongoing.
The experimental facilities for reprocessing of nuclear fuel are either decommissioned (MILLI and PUTE) or are in an active process of decommissioning (WAK and VEK).
Due to high doses and volatile contamination new and better techniques for decommissioning had to be developed (e.g. remote handling manipulators, new cutting technique for contaminated pipes, etc.).

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