Remote-Controlled Removal of Bricks from a Reactor Shaft: An Unconventional Approach - 16406

Anja Graf , Oliver Fath
WAK Rückbau- und Entsorgungs-GmbH,
P.O.Box 12 63, 76339 Eggenstein-Leopoldshafen, Germany

INTRODUCTION

The first German prototype Fast Breeder Nuclear Reactor (KNK) is currently being dismantled after being the only operating Fast Breeder-type reactor in Germany. The complete dismantling is based on 10 decommissioning permits. Package 3 of the 9th decommissioning permit, which is currently under preparation, comprises the dismantling of the biological shield. Package 2 comprised the dismantling of the Primary Shield. (Figure 1 and 2)
In preparation to lift the 14 primary shield segments on height of the reactor core, these were milled at 16 positions (establishing a plan surface) and equipped with a total of 26 holes (Ø100 mm, 400 mm deep; Ø 4 inches, 16 inches deep) [1].

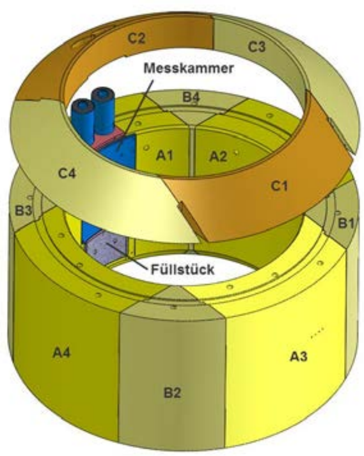

Figure 1: Primary Shield (total)

Figure 2: Milling and drilling positions

As a result of the milling and drilling process, an estimated amount of 500-600 kg (1100 – 1350 pounds) cast iron swarfs accumulated at the bottom of the 12 m (36 feet) deep reactor shaft. The cobalt in the cast iron was activated to cobalt-60 during operation. This results in a measureable dose-rate of 30-35 mSv/h (3 – 3,5 Rem).

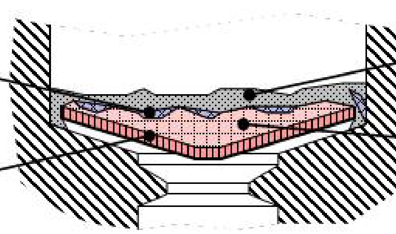

Figure 3: Schematic representation of the bottom of the reactor shaft

At the conical bottom of the reactor shaft were still the remaining parts of the thermal insulation [2] consisting of a lining with brick stones (in original position), covered with loose remnants of the thermal insulation (cutted stud bolts, sheet metal liner and broken brick stones), loose metallic residues and cut-off wheels of the angel grinder (Figure 3, 4, 5 and 9).

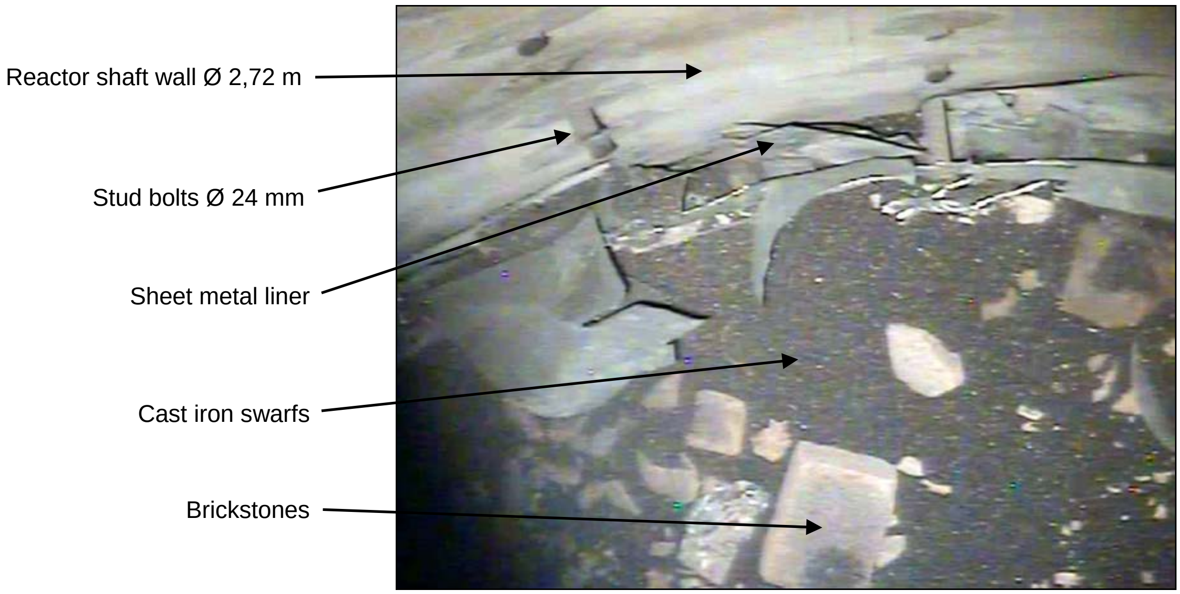

Figure 4: Shaft bottom: (09.12.2013; after milling process)

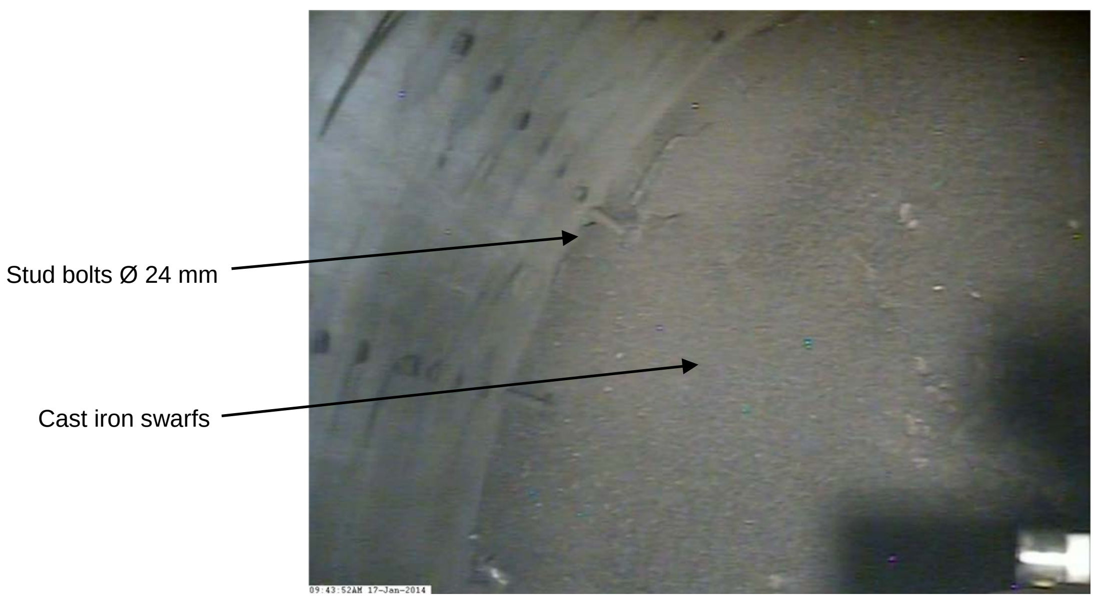

Figure 5: Shaft bottom: (07.01.2014; after drilling process)

PURPOSE AND REALIZATION

For the next dismantling step, the removal of the activated part of the biological shield, it is necessary that the cast iron swarfs must be removed as well as the remains of the thermal insulation. Firstly, this is necessary to reduce the dose rate inside the shaft for subsequent breakthrough operations and, secondly to have a statically resilient surface for the installation of a necessary working platform for next dismantling tools. There was no access for personnel. A manual removal was also not possible due to the existing dose rate (max. 33.5 mSv/h)

The cast iron swarfs supposed to be removed by a remote controlled suction unit, (consisting of an industrial vacuum cleaner), which was installed on top of a drum and mounted in a special rack. The complete system was lowered into the reactor shaft by using a crane. After removing the major amount of swarfs, the remaining swarfs as well as the sheet metal liner should be collected with a magnetic grabber. The solution for the metal removal was easy to realize, but there was no idea how to remove the remaining bricks remote controlled out of the reactor shaft.

Figure 6: Combined suction and collecting unit

Another boundary was that only existing facilities were supposed to be used in addition to the new suction system, i.e. the existing cranes, gripper, as well as the double lid lock of the encasing for the handling of the vacuum cleaner, the transport of the drum and the lock procedure. The resulting construction is shown in Figure 6. The design essentially consists of a suction unit and a collecting unit.

The suction unit, comprising of a cyclone cleaner, differential pressure monitoring, lights and power supply, is fixed with the 3-point traverse and directly connected to the cell crane. The cyclone cleaner as well as lights is to be controlled (by switching on/off) by the remote handling staff at the operating desk. Power is supplied by a spring-loaded cable-drum which is installed at the cell crane operation system.

The collecting unit consists of a rack with the adjusted drum and the permanent mounted suction pipe.

Both units are connected hooked by the three single suspension chains on the rack on the traverse and connection of the suction tube. Due to the choice of chains an unintentional disconnection of both systems in the reactor shaft was excluded.
To create sufficient visibility a video unit, consisting of 2 dome cameras and lights, was additionally drained in into the reactor shaft. As supply cable a no longer needed audio/video cable of the multi purpose tool of the recently completed dismantling step was used (Figure 7).

Figure 7: Complete suction unit and video unit in reactor shaft

Subsequently the entire unit was drained in the 12 m deep reactor shaft. The suction of shaft bottom was carried out purely on the control of the cell crane within the encasing. The filling process has been monitored by the differential pressure indicator on the vacuum cleaner, or by microphone and speaker on the control console. The entire unit has been lifted out of the reactor shaft and placed on a defined set-down position. At this position, now both of the units could be separated by using the Master-Slave-Manipulator in the encasing (A100). To achieve this, it only was necessary to unhook the chains and the suction hose. Then, the suction unit could be lifted and moved away with the cell crane. The drum could now be lifted with the existing drum gripper to be set into containers by using the also existing double lid lock.

Figure 8: covered bottom (rim)

Figure 9: covered bottom (middle)


Figure 10: Suction unit at bottom


Figure 11: Suction of cast iron swarfs

By using different suction pipes the reactor shaft bottom could be exempted from the cast iron swarfs within a few days (Figure 8 to 11).

The suction unit worked in such a positive way that it was decided to remove the loose refractory bricks, metallic residues, cut off wheels, etc., too. For this purpose, the suction unit worked as a "vacuum lifter". A brick stone was sucked in and stuck at the suction pipe. By switching off the cleaner the brick stone could be placed and dropped at a defined position. Additionally, a separate modified drum with a solid bracket got placed at the bottom. Accordingly, the picked-up pieces were dropped in this drum. The filled drum was lifted off the reactor shaft by crane and a special S-hook and transferred in regular T150-drums (Figure 12 - 15).


Figure 12: Collecting cutting-off wheel


Figure 13: Collecting non-metallic residues

During the removal of the cast iron swarfs, dust and loose brick stones, it was recognized that the lining of brick stones, remaining in original position, were not firmly immured and that even these complete bricks stones of the thermal insulation (edge length 18 x 14 x 10 cm; 7 x 5,5 x 4 inches) could be grabbed with the suction unit (Figure 14 and 15).

Figure 14: Collecting complete brick stones

Figure 15: Collected brick stones in drum

Metal parts remaining on the ground were removed by a magnet. The interior of the inner tank fixation was purified by a smaller magnet (Figure 16). With this cleaning-action the result of the final dose rate measurement showed a reduction of the dose rate in the bottom area from 33,5 to 4,3 mSv/h (3300 to 430 mRem) (Figure 17).

Figure 16: Magnet in use

Figure 17: purified reactor shaft bottom

SUMMARY

This pragmatic approach avoided additional complex design works and the need of constructing special solutions and thus, massively saved time, cost and dose rate. The duration of planning, permission including implementation amounted to approximately 3 to 4 months. The additional work could be performed directly after the actual dismantling step.

Planning period: 3 weeks *.
Adjustment/submission/approval documents for reviewer: 8 weeks *.
Procurement and testing (including tests with reviewer): 6 weeks *.
Material costs: €7000
Implementation period: 4 weeks
Applied mass: 734 kg in 12 drums
Dose reduction: from 33,5 to 4,3 mSv/h (3300 to 430 mRem)

* Parallel to the ongoing dismantling step

The poster will explain the exact procedure, statements about time and dose rate savings. The specialty of this approach, regarding German regulations will also be shown.

REFERENCES

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