

DISMANTLING OF THE REACTOR BLOCK OF THE FRJ-1 RESEARCH REACTOR (MERLIN)

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ABSTRACT

This report describes the past procedure in dismantling the reactor block of the FRJ-1 research reactor (MERLIN). Furthermore, it gives an outlook on future activities up to the final removal of the reactor block. MERLIN is an abbreviation for **Medium Energy Research Light Water Moderated Industrial Nuclear Reactor**.

The FRJ-1 (MERLIN) was shut down in 1985 and the fuel elements removed from the facility. After dismantling the coolant loops and removing the reactor tank internals with subsequent draining of the reactor tank water, the first activities for dismantling the reactor block were carried out in summer 2001. The relevant licence was granted in late July 2001 by the licensing authority specifying 8 incidental provisions. After dismantling the reactor extension (gates of the thermal columns and steel platforms surrounding the reactor block), a heavy-load platform including a casing around the reactor block was constructed. Two ventilation systems with a volume flow of 10,000 and 2,000 m³/h will, moreover, serve to avoid a spread of contamination.

The reactor block will be dismantled in three phases divided according to upper, central and bottom sections. Dismantling the upper section started in August 2002. This section as well as the bottom section can probably be completely measured for clearance. For this reason, the activities have so far been carried out manually using mechanical and thermal techniques.

The central section will probably have to be largely disposed of as radioactive waste. This is the region of the former reactor core in which the experimental devices are also integrated. Most of this work will probably have to be carried out by remote handling.

More than 80 % of the dismantled materials of the reactor block can probably be measured for clearance. For this purpose, a clearance measurement device was taken into operation in the FRJ-1. On this occasion, the limits of clearance measurement have become evident. For concrete, which constitutes the largest portion of the dismantled materials by volume, an additional conditioning step has become necessary to fulfil the clearance criteria, whereas waste packages with steel components largely have to be reconditioned once more at a later stage.

Material measured for clearance will be disposed of conventionally (recycling, landfill) after inspection by the official expert and clearance by the regulatory authority. Dismantled parts that

cannot be measured for clearance will be transferred to the Decontamination Department of the Research Centre.

From the present perspective, the dismantling of the reactor block will be completed within the first six months of 2003.

INTRODUCTION

The FRJ-1 research reactor (MERLIN) was finally shut down in 1985 and the fuel elements removed from the facility. After a prolonged shutdown time, the first targeted dismantling activities were started in 1997. The dismantling of the coolant loops and experimental devices was followed in 2000 by the removal of the reactor tank internals and the subsequent draining of the reactor tank water. These activities, which served for preparing the dismantling of the reactor block, were completed in summer 2001.

Following this, the dismantling of the reactor block was started. As the central component of the Merlin reactor plant, the reactor block exhibits the highest activity and contamination level. For this reason, prior to actual dismantling various protective measures had to be realized which primarily serve health physics purposes. For the structural implementation of these measures, first of all, preparatory work was carried out at the reactor block. The reactor extensions, especially the gates of the thermal columns including the associated supporting columns of heavy concrete and the steel platforms surrounding the reactor block (reactor top) were dismantled (see Fig. 1).

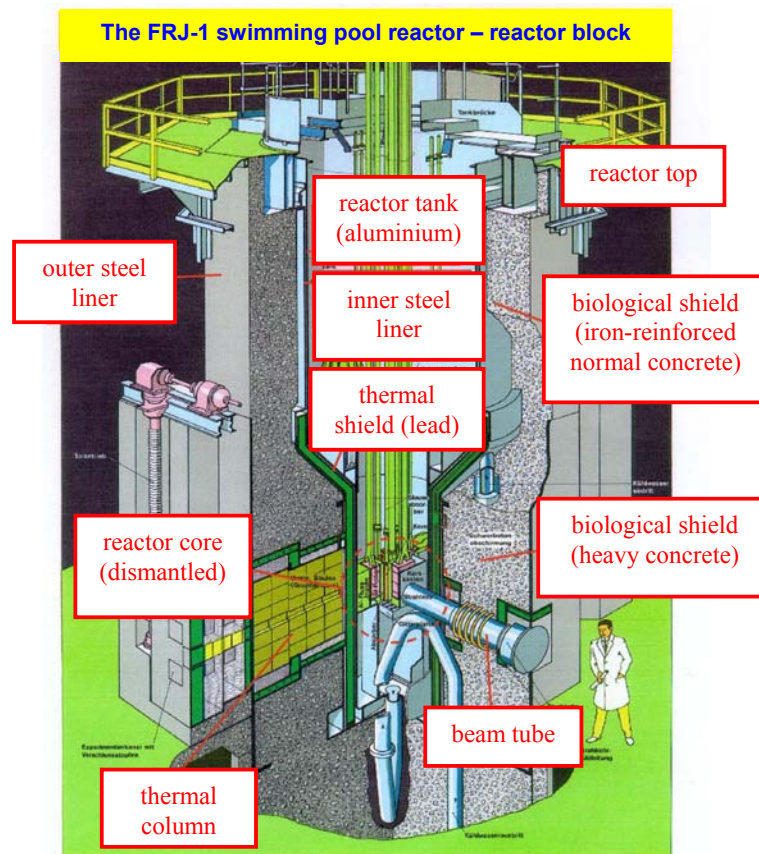


Fig. 1 Reactor block of the FRJ-1 (MERLIN) research reactor

Following this, the protective measures were structurally implemented. They serve in the first place to confine the contamination released during dismantling and to minimize the personal doses accumulated by the dismantling staff during dismantling. Due to the complexity of these measures they were only completed in July 2002 so that the dismantling the actual reactor block only started in August 2002.

LICENSING STATUS

In addition to the preceding licensing applications, which comprised the preparatory measures for dismantling the reactor block, the 3rd licensing application, which essentially contained the dismantling of the reactor block, was filed with the competent authority in November 2000.

This application was approved in late July 2001 specifying 8 incidental provisions. The essential incidental provisions which decisively influenced the start of reactor block dismantling concerned static evidence with respect to the equipment to be introduced and the integrity of the building structure as well as radiological measures with a view to the monitoring and clearance of dismantled materials.

Static evidence was above all required on account of the dynamic loads to be expected when implementing the envisaged dismantling concept (dismantling excavator and rock chisel). Particular attention was paid to the integrity of the outer shell of the reactor hall and to load application at the reactor level.

With a view to the clearance of dismantled materials, the envisaged clearance measurement device had to be qualified. This included drawing up various documents and determining the nuclide vectors. Here, the sampling programme could be used which had already been carried out in 1999.

STRUCTURE OF THE REACTOR BLOCK

The reactor block (see also Fig. 1) was the central component of the reactor plant. With an overall height of approx. 11 m the block represents an octagon with a spacing of 5.65 m between the parallel surfaces. The reactor tank of up to 13 mm thick aluminium, into which the reactor core had formerly been integrated and which was filled with light water for cooling and moderation purposes, is surrounded by a biological shield of concrete over the complete height. In the upper region, iron-reinforced normal concrete with a density of approx. $2,350 \text{ kg/m}^3$ was used with a thickness of approx. 1 m. In the bottom region, which formerly accommodated the reactor core, heavy concrete with a density of approx. $4,200 \text{ kg/m}^3$ was used. The biological shield has a thickness of approx. 1.80 m here and is internally and externally surrounded by steel liners (12 to 25 mm). In the bottom region of the reactor block a thermal shield was additionally provided. It consists of aluminium-clad lead segments with a thickness of approx. 100 mm.

At the level of the former reactor core, the experimental devices are integrated into the reactor block. These are 10 horizontal beam tubes and 2 thermal columns in total.

Due to the original design of the reactor plant, which permitted the reactor core to be moved, the beam tubes were arranged on two levels. In the past 18 years of operation, however, only the 4 lower-level beam tubes were used, so that these should represent the greatest challenge in dismantling due to the dose rates to be expected, in particular, since they exhibit a complicated structure and are composed of different materials (aluminium, steel, lead).

Furthermore, the beam tubes are surrounded by cooling pipes of stainless steel which make component disassembly additionally difficult. Due to the dose rates to be expected in this region, most of these activities will have to be carried out by remote handling.

Similar problems are expected in dismantling the thermal columns. These are also arranged at the lower experimental level and were used until the end of the FRJ-1 operational phase. The approx. 10 t of graphite bricks integrated into the two thermal columns for moderation were removed in the course of the preparatory measures for dismantling the reactor block and disposed of via the Decontamination Department. The thermal columns consist of aluminium, steel, lead and wood and are in part enclosed in waterboxes.

PROCEDURE AND STATUS OF DISMANTLING

Preparatory Measures

In late 2000 the GNS/SNT consortium was entrusted with the planning and implementation of the project. The planning, licensing and dismantling phase is divided into several steps for which meaningful and self-contained work packages have been selected. Detailed planning for the first step, which contained the preparatory measures for dismantling the reactor block, was approved by the regulatory authority in late September 2001. This involved above all the dismantling of the reactor platforms (reactor top) and the reactor extensions. In the course of these dismantling activities approx. 50 Mg of heavy concrete (density approx. 4,200 kg/m³) and approx. 25 Mg of steel were dismantled. A remote-controllable electrohydraulic working robot was used for dismantling the heavy concrete. The working area was encased and vented via a ventilation system.

After preparing the reactor block for dismantling, construction work for the heavy-load platform and casing was begun. These measures were completed in July 2002. Tubular scaffolding was used as the supporting structure for casing, into which a bridge crane with a carrying capacity of 1 t was integrated for handling the required tools and the waste packages.

The preparatory measures also included the installation of a special ventilation system with safety afterfilter. This ventilation system constructed for 10,000 m³/h ensures a directional flow into the casing. The filtered air is blown into the reactor hall again outside the casing. The necessary air collecting channels in the casing are also integrated in the tubular scaffolding. This ventilation system is complemented by an additional system, which is specially suited for extracting aerosols from thermal cutting processes. This system for a volume flow of 2,000 m³/h is also equipped with a safety afterfilter and connected to the reactor exhaust air.

Dismantling the Reactor Block

The reactor block is being dismantled in several steps from top to bottom and from inside to outside. These steps are divided into upper, central and bottom section (see Fig. 2).

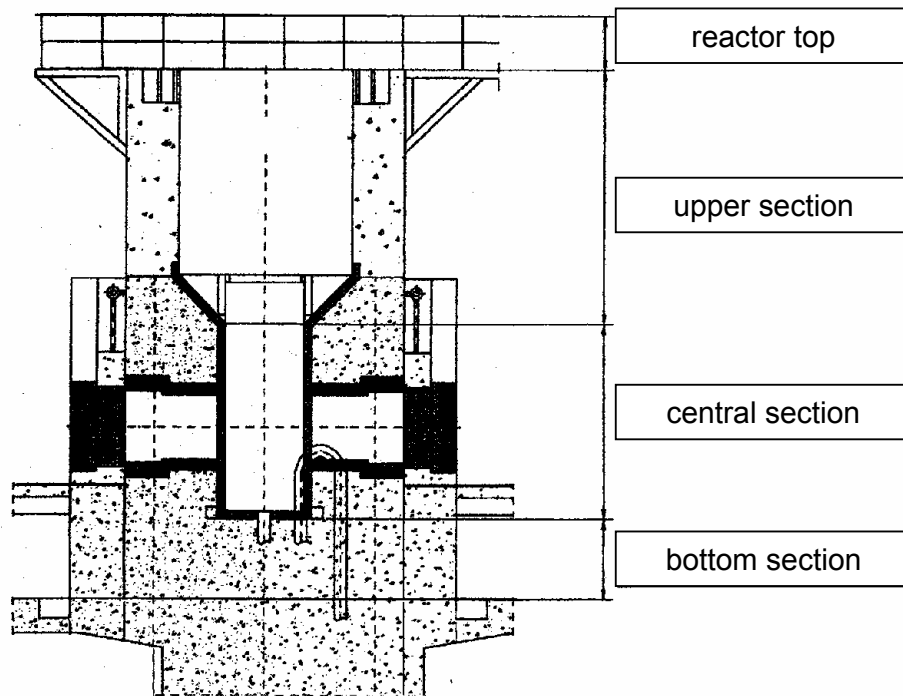


Fig. 2 Dismantling sections of the reactor block

Dismantling the upper section of the reactor block started in August 2002. This section comprises the upper cylindrical part of the reactor block with a wall thickness of approx. 1 m including the conical part of heavy concrete. It is being assumed that almost 100 % of the dismantled materials from this region can be measured for clearance. Up to the present, about half of the upper section has been dismantled and disposed of (see Fig. 3).



Fig. 3 Dismantling the upper section of the reactor block

For the approx. 100 Mg of hitherto dismantled parts, the assumption of a 100 % clearance measurability has so far been almost confirmed. In the procedure so far applied, the steel components, above all steel liners and sectional steel structures, have been preferentially thermally cut. The aluminium tank was disintegrated mechanically with the aid of a circular saw down to the intermediate tank bottom (see Fig. 1) and disposed of. The biological shield is being dismantled, as provided for in the concept, with the aid of the dismantling excavator with rock chisel. All the techniques used so far have proved efficient.

Due to the large distance from the former reactor core and the shielding components currently still in place, all the work has so far been carried out manually on site. In preparation for the future remote-controlled dismantling work in the former core region (central section), however, 25 % of the activities are already carried out by remote handling. In this way, it is possible to identify and solve problems in areas that can be entered without major effort.

WASTE LOGISTICS

More than 80 % of the dismantled materials of the reactor block can probably be measured for clearance. A clearance measurement device was taken into operation in the FRJ-1 to ensure an effective and reliable radiological assessment of the dismantled parts with the aim of clearance measurement. In order to determine the nuclide vectors on which the total gamma measurements by the clearance measurement device are based, core samples were drilled in advance from the reactor block at different positions. After the nuclide vectors had been confirmed by the official expert and clearance was given by the regulatory authority, the clearance measurement campaigns were started. The measured data are saved in a database system specially designed for dismantling.

Limits of Clearance Measurement

After the clearance measurement device had been put into operation in the MERLIN reactor hall, the limits of the clearance measurement procedure also became evident. With a view to the concrete representing the largest portion of the dismantled materials by volume, an additional homogenization step was required, since only in this way will it be possible to fulfil the homogeneity criterion as one of the clearance criteria. The homogeneity criterion implies that no inadmissibly high activity gradient may occur inside a waste package.

For the dismantled concrete, the homogenization step was realized in the form of a toggle jaw breaker modified for use in MERLIN. Special measures were required for filling and discharging the concrete rubble. After the jaw breaker had been installed, it was provided with a casing, which is exhausted by a separate ventilation system generating a directional flow from the reactor hall into the casing. After the jaw breaker had been put into operation, the concrete rubble from dismantling the reactor extensions could be reconditioned and measured for clearance. After the reactor extensions had been dismantled, the jaw breaker was moved from its original position on the ground floor of the reactor hall into the casing of the reactor block. This measure serves to optimize waste logistics, since the concrete structures measurable for clearance can now be conditioned immediately after dismantling and filled into the waste drums required for the clearance measurement device (see Fig. 4).

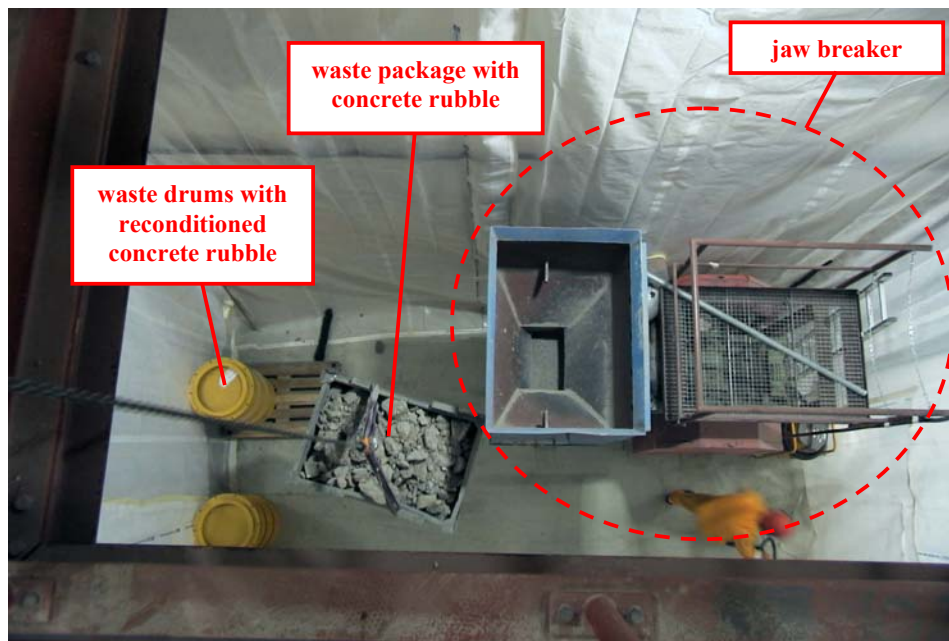


Fig. 4 Position of the jaw breaker in the casing

The jaw breaker will remain in this position until the dismantling of contaminated or activated structures can no longer be excluded. Since a contamination of the breaker exclusively provided for concrete structures measurable for clearance must be avoided by all means, repositioning will be necessary at this point in time, at the latest. The breaker will then be moved to the former position of the storage block on the ground floor of the reactor hall. This position was also selected to optimize waste logistics operations since there is a direct access from the ground floor to the reactor level. The waste packages loaded with concrete rubble can thus be directly unloaded into the jaw breaker with the aid of the hall crane.

The homogeneity criterion has proved to be especially problematic in connection with the clearance measurement of metallic structures. Due to the weight limitation of the clearance measurement device, a homogeneous filling of the waste packages with these waste parts is only possible with great additional effort. Experience has shown that a large number of these packages are classified as inhomogeneous, although the measured values were below the activity limits. These packages are deposited in a storage bay specially constructed for this purpose and must be reconditioned later.

Disposal

Material measured for clearance is discharged and loaded into rubble pits. These are waste containers with a volume of 7.5 m³.

The officially charged expert receives a defined quantity of representative samples for his own analysis. Furthermore, the complete waste documentation will be submitted to him and to the authority for examination. After clearance by the regulatory authority, the dismantled parts will then be conventionally disposed of (recycling, landfill).

Dismantled parts that cannot be measured for clearance will be transferred to the Decontamination Department of the Research Centre for further conditioning.

FURTHER PROCEDURE AND OUTLOOK

The detailed planning for dismantling the central and bottom section has meanwhile been completed and presented to the regulatory authority for approval. It may thus be expected that the dismantling activities at the reactor block can be continued without interruption. Whereas the biological shield in the upper and bottom section will probably be measurable for clearance, it is being assumed that the major part of the central region must be disposed of as radioactive waste. It is assumed that approx. 170 Mg of activated radioactive waste will arise, whereas approx. 750 Mg is probably measurable for clearance and can be granted clearance. Apart from the rock chisel for dismantling the concrete structures, mechanical and thermal cutting techniques will be used. Dismantling the central section will make the greatest demands especially with a view to the radiological situation. Most of the work in this region will probably have to be carried out by remote handling. For this reason, special tools for disintegrating the metallic structures in this region are required, which must in part be positioned by remote-controlled working robots. A set of tools has been specially designed and manufactured for disintegrating the inner steel liner and the thermal shield (see Fig. 1). This is currently in the testing phase. In addition, a special device for disintegrating the horizontal beam tubes in the installed condition from inside is being designed.

Unless any unpredictable events require new concepts or even tool developments, it is being assumed that the dismantling of the reactor block will be completed within the first six months of 2003.