# Application of Remotely Operated Equipment for Cutting Pipelines in Reactor Subfloor Areas and Removing Radioactive Sources from Storage Facilities

Enhancing safety and efficiency in high-dose nuclear decommissioning operations at Ignalina Nuclear Power Plant

## Foreword

In 2021, the European Commission (EC) adopted a new proposal for a Council Regulation establishing a dedicated financial programme for decommissioning nuclear facilities and managing radioactive waste. This instrument covers the co-funding of the decommissioning programmes of Bulgaria, Slovakia, and the decommissioning of the Joint Research Centre (JRC). A separate Council Regulation was adopted for the decommissioning programme of Lithuania.

The EC JRC is mandated to foster the spread of decommissioning knowledge across all the European Union Member States and facilitate knowledge sharing arising from implementing the abovementioned decommissioning programmes, funded by the Nuclear Decommissioning Assistance Programme (NDAP).

The decommissioning operators from the NDAP (NDAP Operators) implemented and tested a knowledge management methodology in 2021 through Project ENER/D2/2020-273. Using this methodology, the NDAP Operators can develop Knowledge Products that are currently available to share with other European stakeholders. In addition, this methodology is being implemented by the JRC Nuclear Decommissioning and Waste Management Directorate (NDWMD), which has become a knowledge generator extracting the knowledge from the ongoing decommissioning activities across the JRC´s four different sites (Geel, Ispra, Karlsruhe and Petten).

The JRC´s NDWMD has the goal to become a Centre of Excellence in nuclear decommissioning knowledge management and aims to develop a decommissioning knowledge platform which allows exchanging information and building on the best practices in the EU through executing the multi-annual financial framework (2021 – 2027) strategy. The operational phase of the project started in 2024 with the objectives to: develop ties and exchanges among EU stakeholders and document explicit knowledge and make it available through multi-lateral knowledge transfers on decommissioning and waste management governance issues, managerial best practices, technological challenges, and decommissioning processes at both operational and organisational level, as well as to develop potential EU synergies.

# Knowledge Product Information

Application of Remotely Operated Equipment for Cutting Pipelines in Reactor Subfloor Areas and Removing Radioactive Sources from Storage Facilities

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| Approved by | Andrea Piagentini, NDKM team at the JRC |

# Remotely Operated Machines (ROMs)

This knowledge product "Application of Remotely Operated Equipment for Cutting Pipelines in Reactor Subfloor Areas and Removing Radioactive Sources from Storage Facilities" provides practical insights into using three different **remotely operated machines (ROMs)** for dismantling and waste management in high-dose environments; namely the BROKK models 110, 170 and 200 ROMs respectively. Noting that BROKK 110 was most recently employed in a cutting campaign.

## OBJECTIVE

The primary objective of using ROMs is to **reduce personnel dose levels** while improving **efficiency** in decommissioning tasks. This interactive presentation draws on the extensive experience gained at the Ignalina NPP by focusing on the **application of ROMs to dismantling pipelines**, as well as managing radioactive waste and concrete structures. The overarching aim is to share knowledge and best practices **to support decision-making** for those who need to select similar technologies.

## SCOPE

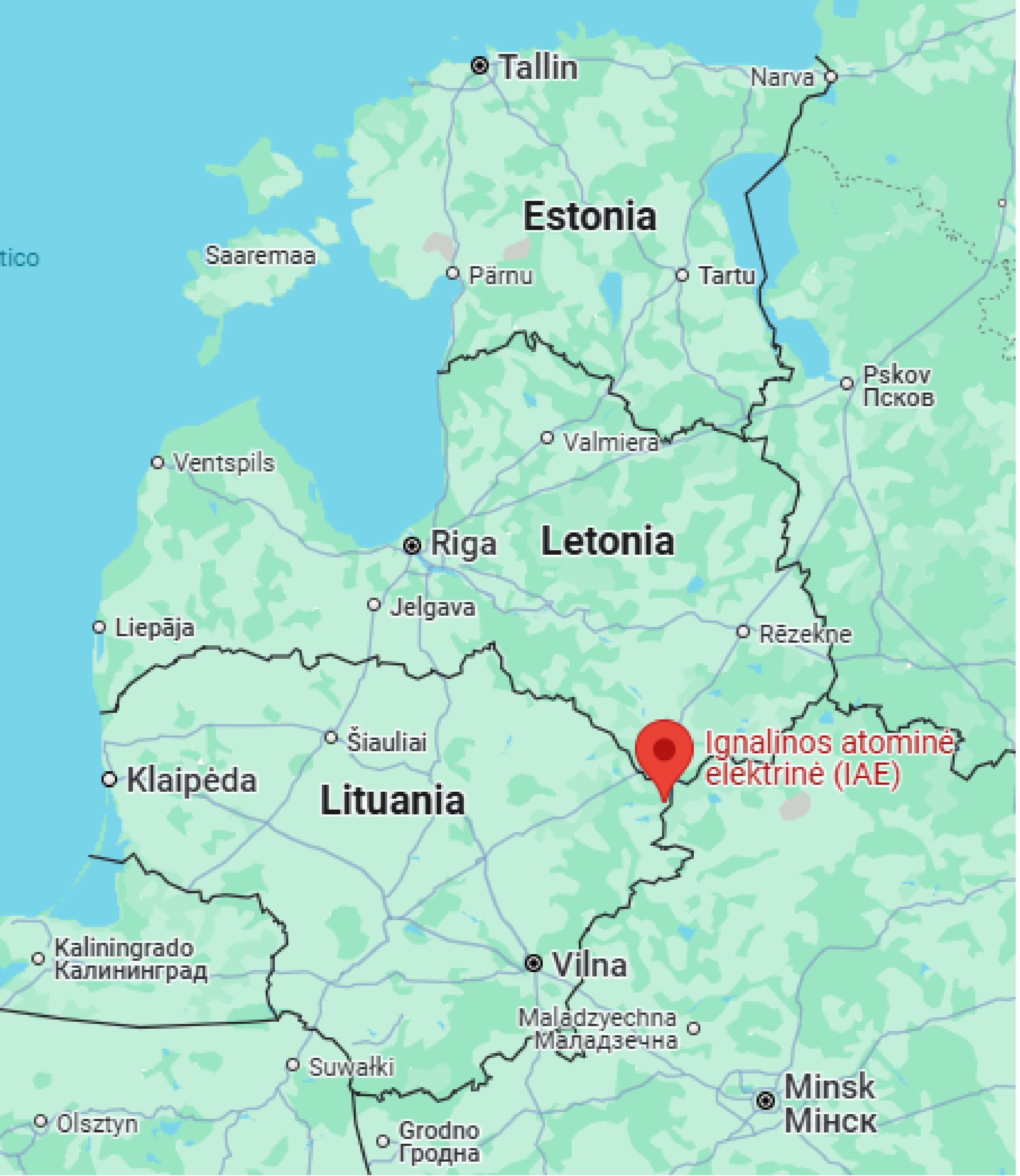
This knowledge product **showcases the BROKK 110 model** which can be used to reduce radiation dose levels during dismantling and waste management activities. This inlcludes a **comparison with other BROKK models**, **advantages**, **limitations**, **challenges** and **lessons learnt** gained from the use of the aforementioned machine.

## AUDIENCE

Actionable insights have been provided for **decommissioning operators**, **contractors**, **technologists** and **other entities**, such as project managers and technical teams, **involved in decommissioning** nuclear power plants.

## RELEVANCE

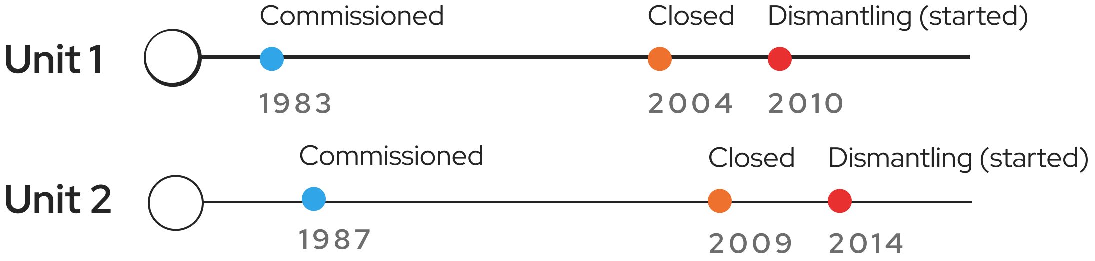
Challenges faced in high-dose areas and lessons learnt at Ignalina NPP to improve safety, performance and technology application elsewhere are addressed based on **current best practices**.



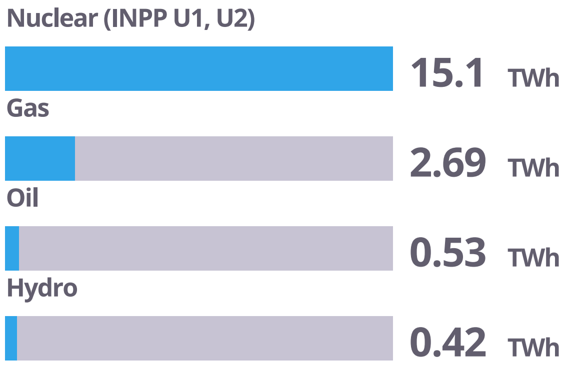

CONTEXT

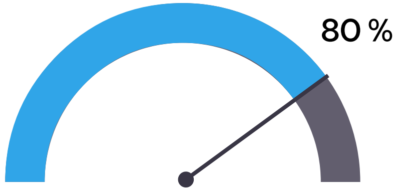
# Ignalina NPP Nuclear Decommissioning Plan

Ignalina NPP adopted the immediate dismantling strategy and closed its RBMK-1500 reactors in 2004 (Unit 1) and 2009 (Unit 2). The plan includes auxiliary facility dismantling, waste management and infrastructure development.




## ELECTRICITY GENERATION, 2004




INPP became the main electricity producer in Lithuania, with a share of 80 %.

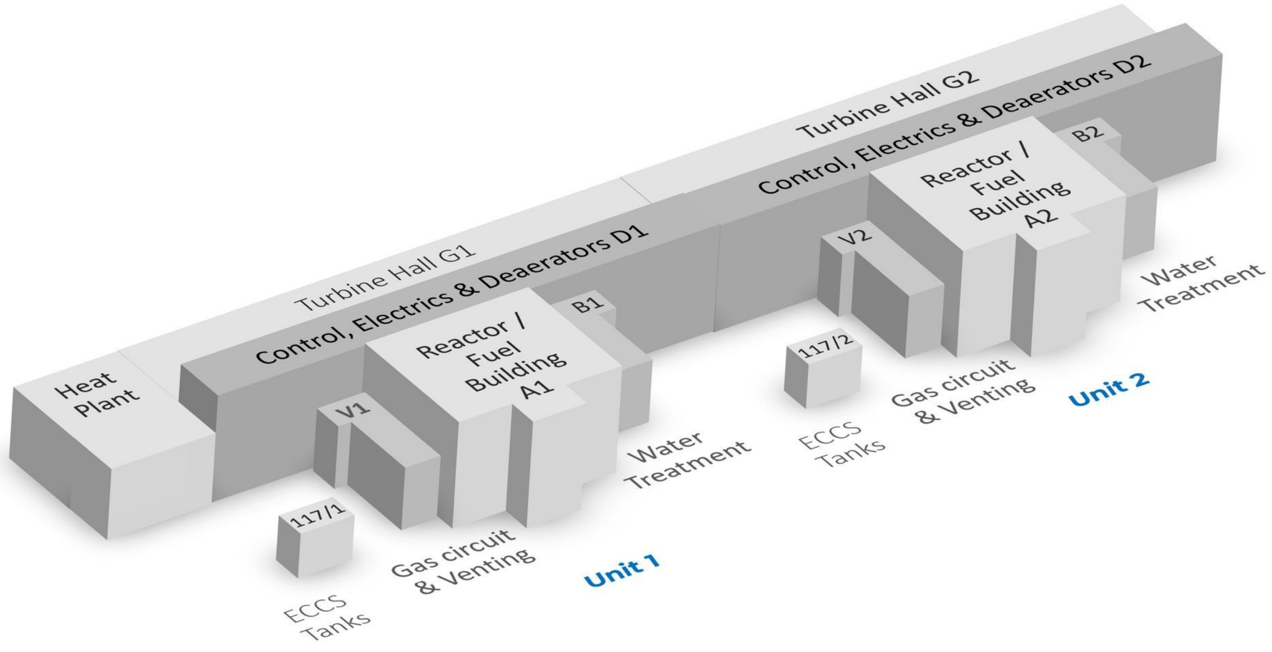
CONTEXT

# Ignalina NPP Nuclear Decommissioning Plan

The Ignalina Nuclear Power Plant, once a major electricity provider in Lithuania, is undergoing **immediate dismantling** as per the strategy adopted in 2002.

Decommissioning includes Units 1 and 2, auxiliary facilities, and radioactive waste management infrastructure, and it is governed by the **Decommissioning Safety Requirements BSR-1.5.5-2015**. This approach ensures efficient dismantling while addressing safety, environmental and economic considerations.

The plan, supported by **European Union funding and national contributions**, prioritises in-house expertise and creates employment opportunities. Ignalina NPP's lessons learnt serve as a benchmark for similar projects across the EU.




- First RBMK decommissioning
- 2 x RBMK-1500 reactors
- Water-cooled, graphite-moderated
- Immediate dismantling strategy
- Completion by end of 2038
- Approximated cost: 3.4 billion €

STRATEGY

REGULATION

FINANCING

# National regulation (VATESI)

VATESI is the State Nuclear Power Safety Inspectorate

Order No. 22.3-216, November 30th, 2015, approved by the Head of State Nuclear Power Safety Inspectorate **"On the Approval of Nuclear safety requirements BSR-1.5.1-2019 "Decommissioning of Nuclear Facilities"**

Order No. 22.3-206, December 20th, 2016, approved by the Head of State Nuclear Power Safety Inspectorate **"On the Approval of Nuclear Safety Rules BST-1.5.1-2020 "The Evaluation of Compliance with Free Release Criteria of Buildings, Engineering Structures and Site of Nuclear Facilities"**

**Law on Nuclear Energy of the Republic of Lithuania**, 14 November 1996 No. I-1613; State Gazette, 11/12/1996.

**Law on the decommissioning of Unit 1 of the State Enterprise Ignalina Nuclear Power Plant**, 2 May 2000. No. VIII-1661; State Gazette, 22/06/2000.

**Ignalina Nuclear Power Plant Decommissioning General Requirements** (by VATESI)

**Treaty of Accession to the European Union 2003**. Protocol No. 4 on the Ignalina Nuclear Power Plant in Lithuania

**Legislation and relevant links**

# Ignalina NPP Decommissioning Program Funding

The decommissioning funds are administered by several organisations, each having its own funds allocation mechanism and its own management rules, so that each of these funding mechanisms can be considered as a conditional source of funding.

The funds allocated to the decommissioning of the Ignalina NPP can be broken down into external sources (granted by other entities, such as the EU) and funds at the disposal of the entities of the Republic of Lithuania (internal sources).

## Internal sources of funding

- Funds from the State Enterprise Ignalina Nuclear Power Plant Decommissioning Fund (ENF), administered by the Public Enterprise Lithuanian Energy Agency.
- Funds from the budget of the Republic of Lithuania:
  - Funds from the specific Ignalina Programme, administered by the Ministry of Energy of the Republic of Lithuania.
  - Ministry of Interior funds for physical protection and fire safety in INPP.
- Funds of the SE Ignalina NPP.

## External sources of funding

- Ignalina International Decommissioning Support Fund provided by the EC and the governments of 15 countries, administered by the European Bank for Reconstruction and Development (EBRD).
- The European Community Ignalina Programme Fund, administered by the Central Project Management Agency under the Ministry of Finance of the Republic of Lithuania.
- European Union Structural Funds, administered by the Environmental Project Management Agency (EPMA).

# Strategy: Immediate Dismantling

Immediate dismantling was selected by the government for technical, social and financial reasons.

### Why immediate dismantling?

- Use of new waste facilities
- Use of existing workforce
- Use of existing services
- Lower total cost
- No future burden

### Although compared to deferred dismantling...

- Higher initial cost
- No know-how from abroad
- Higher dose rates

### Staffing matters

- A key factor in immediate dismantling is that it is being implemented using INPP's own resources.
- INPP by far the main employer in the region.

# ROMs Examples and Features

A case study on the use of ROMs for dismantling and decontamination tasks in high-radiation areas at Ignalina NPP has been provided in the following slides. By **sharing specific operational insights**; this knowledge product seeks to assist operators and other relevant entities to understand and implement these technologies in similar environments.

Attachments


A **range of ROMs are employed at Ignalina NPP**, specifically the **BROKK models 110**, **170** and **200**. This section presents a summary of these machines' technical specifications to emphasise the capabilities utilised in the INPP Decommissioning Programme.

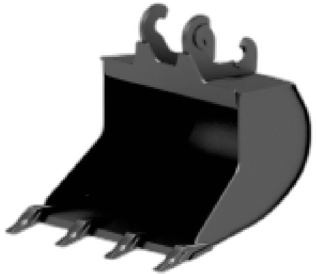
| Feature | BROKK 110 | BROKK 170 | BROKK 200 |
|---|---|---|---|
| Slewing speed | 10 s/360º | 10 s/360º | 10 s/360º |
| Transport speed, max | 2.5 km/h | 2.1 km/h | 2.1 km/h |
| Climbing inclination, max | 30º | 30º | 30º |
| Hydraulic system capacity | 40 l | 85 l | 85 l |
| System pressure | 18 MPa | 18 MPa | 18 MPa |
| Pump flow, 50 Hz | 54 l/min | 69 l/min | 85 l/min |
| Power | 19.5 kW | 24 kW | 27.5 kW |
| Width, min | 780 mm | 780 mm | 780 mm |
| Height, min | 1147 mm | 1254 mm | 1351 mm |
| Weight | 990 kg | 1600 kg | 2100 kg |
| Horizontal reach | 3700 mm | 4400 mm | 5100 mm |
| Vertical reach | 4300 mm | 4800 mm | 5450 mm |

Breaker

Concrete crusher

Metal shear

Drum cutter



Bucket

Clamshell bucket


Cutoff saw

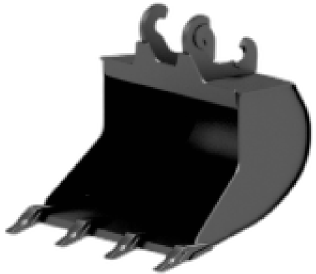

Sorting & demolition grapple

**Breaker**

**Concrete crusher**

**Metal shear**

**Drum cutter**



**Bucket**

**Clamshell bucket**


**Cutoff saw**


**Sorting & demolition grapple**

Case Study

# Cutting Pipelines in Reactor Subfloor Areas and Removing Radioactive Sources from Storage Facilities

The use of robotic cutting machines and remote control ensures precise cutting, segmentation and safe extraction of pipelines, structural elements and contaminated soil. The process includes pre-cutting, extraction, decontamination, packaging and further disposal of pipeline segments, concrete structures and radioactive sources.


**The Case**

**Advantages**

**Limitations and challenges**

**Operational experience and lessons learnt**

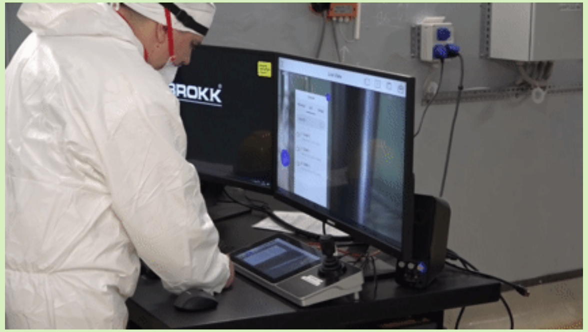
**Conclusions and future outlook**

# The Case

In this case, the partial dismantling of the primary circuit pipes was carried out. This involved complex layouts and significant radiation hazards. Therefore, it was important to minimise human presence in these areas.

For this purpose, the operator employed a ROM that was capable of being equipped with different tool attachments. The tools included hydraulic scissors and a circular saw, for cutting through metal pipes and other elements, as well as a mulifunctional gripper for grabbing and loading waste into containers.


- RBMK
- The Pipes


**Remote control system activation**

Stage one: The operators powered on and calibrated all the ROM´s remote control systems. The systems consisted of two modules or control systems. The larger one, shown in this animation, is the fixed station, which allowed for more precise control from a distance.

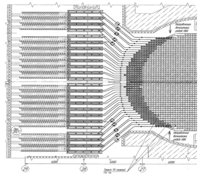
In addition to this, there was a second manual control system, which consisted of a handheld remote controller. This is better suited for operating the robot in environments where the operator can be physically present.

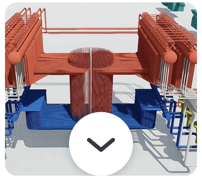
**Cutting and removal of pressure pipes**

In this second phase, the robot was maneuvered and directed to the work area. There, using a specialised circular saw head and a shear cutting head, it proceeded to cut the pressure pipes, which were then deposited on the ground. Afterwards, the robot switched to a gripper-type head to collect all the extracted material from the operation, which were then stored in designated locations.

**ROM removal from the work area**

**Cutting pressure pipes**





Photograph of the pipes

## The Pipes

The cut pipes were pressurised conduits that had been used to transport cold water to the reactor's fuel channels.

As shown in the images, these pipes were located at the bottom of the reactor.

Because they were part of the primary circuit responsible for cooling the nuclear fuel, they exhibited high radiological activity.

## Key Design Features

- **Graphite Moderator:** The core contains graphite blocks that act as a neutron moderator.
- **Fuel:** The reactor uses slightly enriched uranium dioxide fuel, contained in zirconium alloy fuel rods.
- **Boiling Water Reactor:** The RBMK 1500 uses water as a coolant. The water boils directly in the reactor core, generating steam that drives the turbines to produce electricity.
- **Channel Type:** Each fuel assembly is contained within a separate pressure tube, allowing for individual cooling channels, which enables on-line refueling.

# Advantages

The use of ROMs resulted in several key advantages to the project.

Safety First

Adaptability in Confined Spaces

Efficiency and Precision

# Adaptability in Confined Spaces

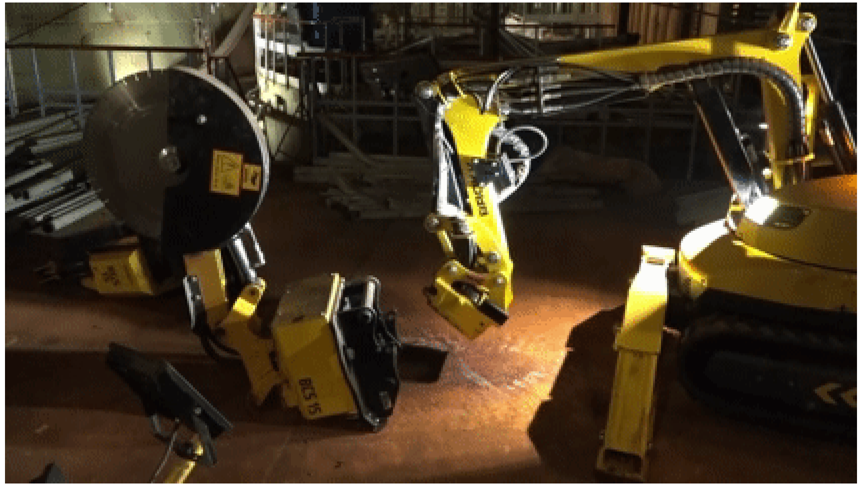
Compared to larger models like the BROKK 200, the BROKK 110's compact design made it ideal for narrow corridors and tight work zones.

110

200

# Efficiency and Precision

The ROM tools enabled fast and accurate dismantling, even in complex layouts. This translated into shorter operation times and reduced labor costs.



# Safety First

One of the most critical advantages was the reduction in radiation exposure. By operating remotely, the robot enabled personnel to stay at a safe distance from hazardous zones.

# Limitations and Challenges Faced

Despite its success, the project encountered several limitations and challenges.

1

**Physical Constraints**

2

**Design Limitations**

3

**Operational Complexity**

# Operational Experience and Lessons Learnt

The operational phase provided valuable insights into both the capabilities of the BROKK 110 and the practical aspects of deploying ROMs in nuclear facilities.

**Preparation and Setup**

**Training and Safety**

**Maintenance and Monitoring**

# Maintenance and Monitoring

Regular inspections of hydraulic, electrical, and mechanical systems were conducted. Spare parts were kept in stock to minimise downtime and all operations were documented meticulously.

## Training and Safety

Operators underwent a week-long training program covering both theoretical knowledge and hands-on practice. Special attention was given to remote control techniques and safety protocols in radiation zones.

## Preparation and Setup

Work zones were audited to assess compatibility with each ROM's system and components. Equipment was cleared, access paths widened and hydraulic tools were tested for functionality and safety.

The configuration of the pipelines in the work zones made it crucial to properly model the operation beforehand.

# Conclusions and Future Outlook

The deployment of ROMs at INPP proved to be a highly effective solution for dismantling tasks in radiation-hazardous zones. Compact designs, remote operation capabilities and powerful tools of smaller models presented clear advantages with respect to performance when compared to larger models.

The case study demonstrated that ROMs can be applied efficiently across all dismantling stages when the application of each ROM is tailored to a specific activity.

Looking ahead, the continued use of remote-controlled dismantling mechanisms will play a vital role in enhancing worker safety, reducing operational costs and improving the overall effectiveness of nuclear decommissioning projects.