


Status of decommissioning in Denmark

An aerial photograph of a coastal industrial or utility site. The site is situated on a peninsula or island, surrounded by a large body of water. The land is covered with green trees and grass. Several industrial buildings with grey roofs are visible, along with a tall, thin chimney stack. The water is a deep blue-grey color, and there are some small islands or sandbars in the water.

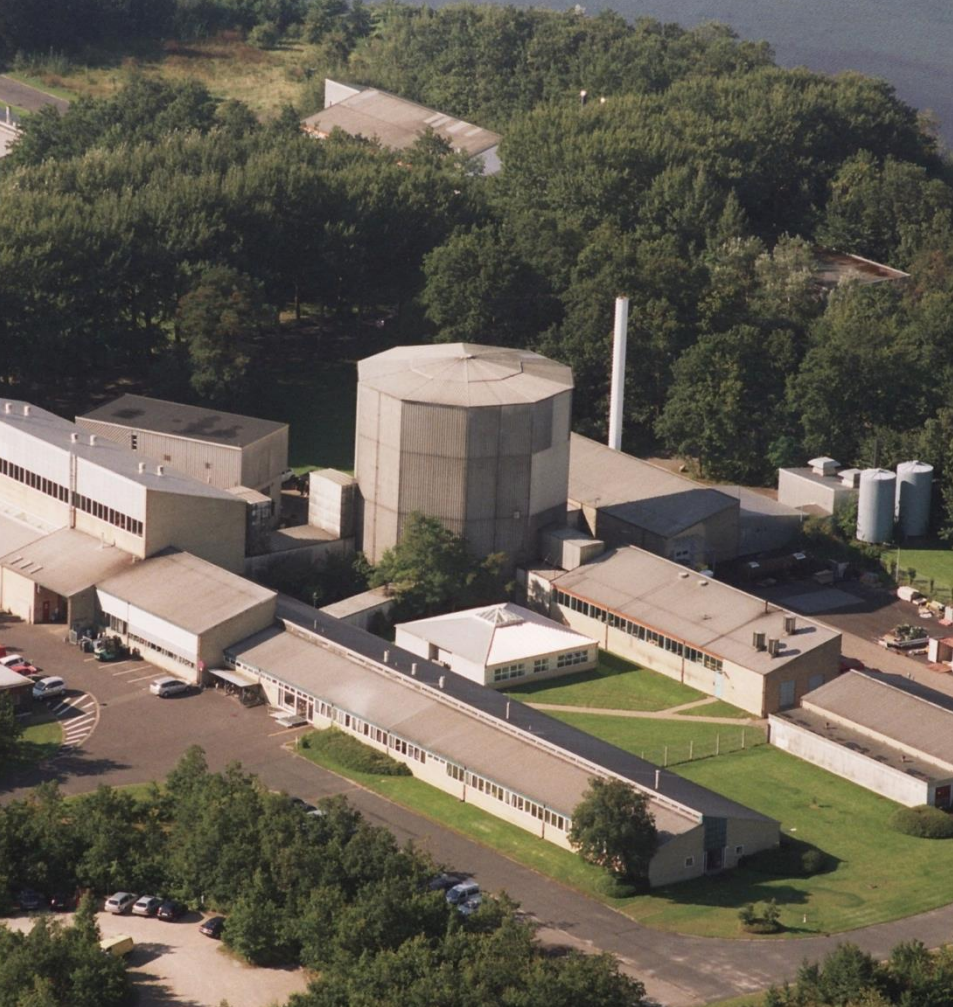
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- 1. General introduction to DD**
2. DR 3 decommissioning
3. Hot Cells decommissioning



Risø history

- 1956-58: Risø National Laboratory was established
- Aim: To prepare for the introduction of nuclear power in Denmark
- Research areas in the first 20-25 years: Reactor physics and technology, physics, chemistry, health physics, electronics, metallurgy



Risø history

- 1976: Scope broadened to include research in other energy sources (wind, oil/gas)
- 1985: Parliament decided that nuclear power should not be introduced in Denmark
- Subsequently, RNL's nuclear related research was reduced
- 2000: DR 3 reactor closed; decommissioning planning started



DD

- Established in 2003 as a separate organisation under Ministry of Science, Technology and Innovation
- Tasks:
 - Decommission RNL to "greenfield"
 - Receive, treat and store Danish radioactive waste
 - Assist in a long-term solution for waste





DD

- Time frame for the decommissioning: up to 20 years from 2003
- Estimated total cost: ~1.8 billion DKK (~260 M\$ ~240 M€) (2017 price level)
- Excluding costs for a long-term solution for the waste

Government decision 2018

- Intermediate storage of waste continues at Risø for a period of up to 50 years. Storage facilities will be upgraded and moved onto higher grounds to ensure safekeeping of the waste
- Efforts to find an international solution for the 233 kg of special waste are continued
- Geological survey of the Danish possibilities for a deep facility for all waste is initiated
- A thorough political process involving municipalities and other relevant stakeholders is planned and executed

To be decommissioned

- Reactor DR 1 ✓
- Reactor DR 2 ✓
- Reactor DR 3 – ongoing until 2022
- Hot Cell facility – ongoing until 2022
- Fuel Fabrication Plant – work completed in 2015, contamination in basement to be removed in 2020
- Waste Management Plant – in operation – planning of decommissioning is ongoing

Location of DD facilities





DR 1

- 2 kW thermal power
- In operation 1957-2001
- Primarily used for demonstration/instruction
- Decommissioned 2004-2005
- Reactor building and surrounding areas released for unrestricted use in January, 2006



DR 2

- 5 MW effect, open pool tank
- In operation 1959-1975
- Physics experiments and production of isotopes
- Decommissioned 2006-2008
- Now used by DD to handle large units of radioactive waste

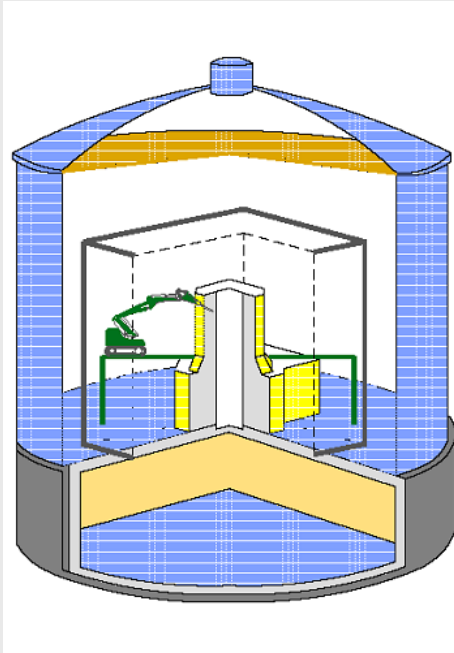
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DR 2 decommissioning



- Plasma cutting of the lead nose of the thermal coulomb

Demolishing the DR 2 reactor block



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Fuel Fabrication

- The plant produced fuel elements for DR 2 + DR 3
- Decommissioning work finalised, Release from regulatory control expected in 2018
- Mainly decontamination of walls/floors and removal of equipment, ventilation and drainage systems
- Unexpected contamination in part of the basement

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Fuel Fabrication Plant



Wall shaver during shaving the ceiling
in the powder room



Sawing of the floor in the
powder room

Removal of the concrete floor by milling



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Decommissioning planning

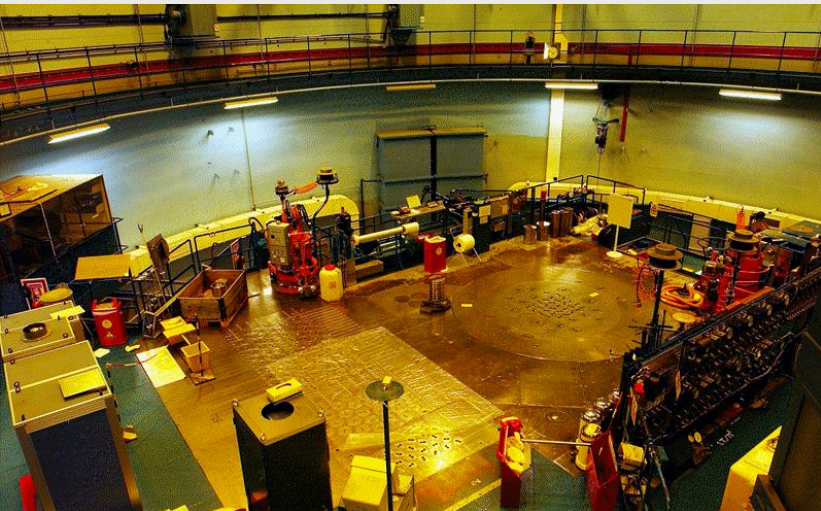
- Gather historical informations
- Characterize
- Brainstorming
- Option analysis (for large and complex tasks)
- Project description (to be approved)
- Sub project descriptions (to be approved)
- Work plans

Executing

- We primary use our own workers
- Contractors for special tasks
 - ❑ Lift of heavy components (TSP, TSR, Shutters)
 - ❑ Complex constructions (MTS, DR 3)
 - ❑ Demolishing of concrete
- No outsourcing of whole projects

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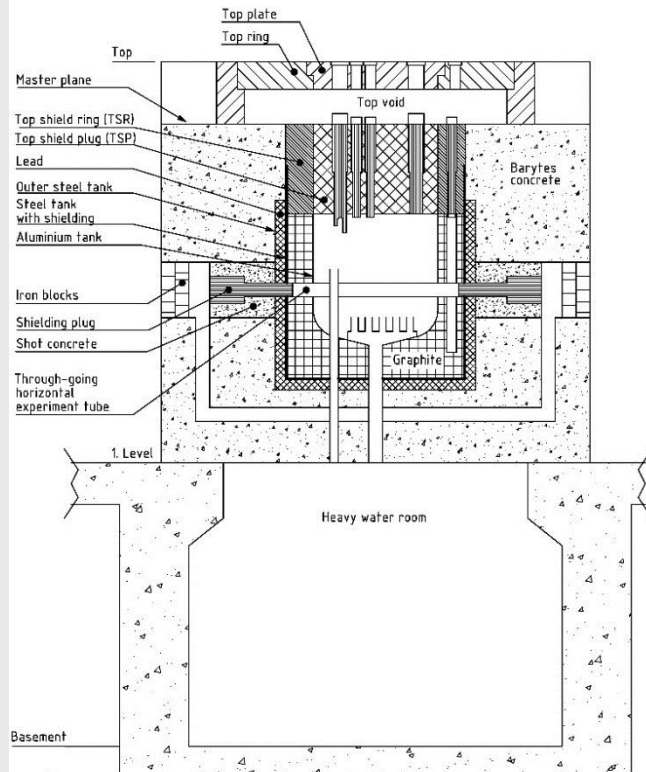
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DR 3

- 10 MWth, D₂O cooled and moderated MTR
- In operation 1960-2000
- Physics experiments, production of isotopes and neutron transmutation doped silicon
- Decommissioning of the reactor block started in 2012 and is scheduled to finish in 2022

The DR 3 Reactor Block



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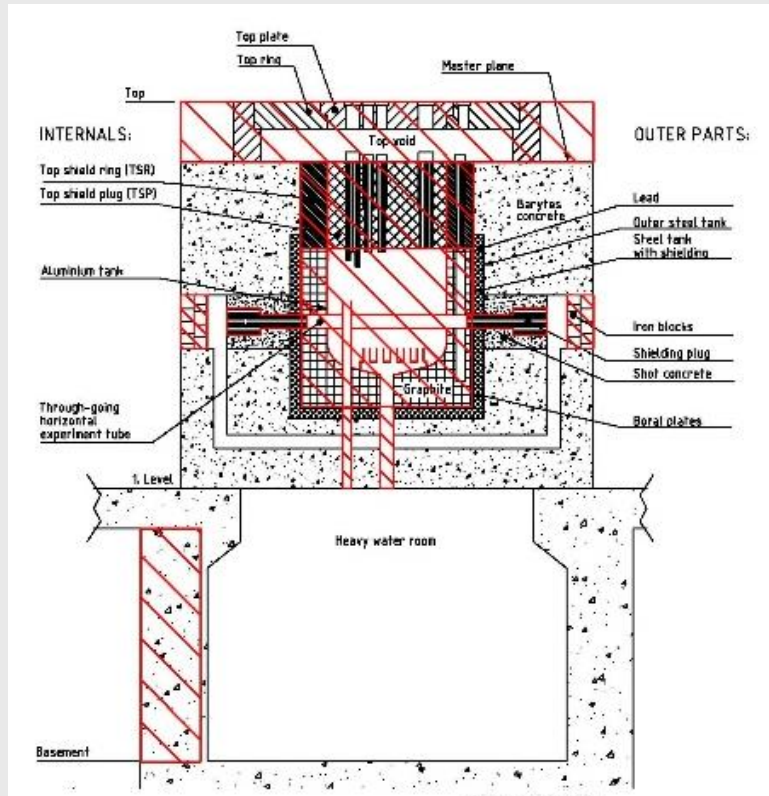
- Top Shield Plug (TSP)
- Reactor Aluminium Tank (RAT)
- Top Shield Ring (TSR)
- Graphite reflector
- Cast lead
- Boral plates
- Inner steel tank
- Lead shielding
- Outer steel tank
- Biological shield (baryte concrete with shot concrete around the core zone)
- D₂O plant room



Decom. strategy for DR 3

- Auxiliary systems removed (2011)
- Primary circuit (D₂O) removed (2012)
- Internals dismantled (2018)
 - Inside out
- Biological shield demolished (2020)
 - Top down

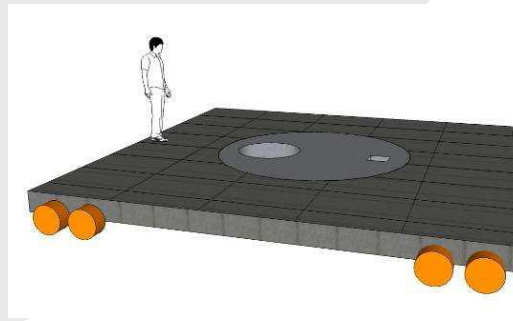
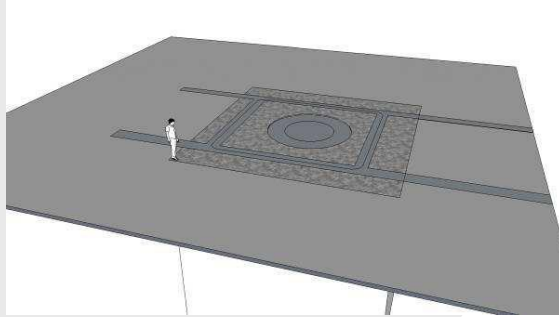
Current status



- The **red marked** areas have been removed:
- Internals:
 - TSP and TSR removed ✓
 - Reactor Aluminium Tank ✓
 - Graphite reflector – ongoing, last layer
 - Thin layer of lead – autumn 2018

Auxiliaries

Movable Top Shield (MTS)



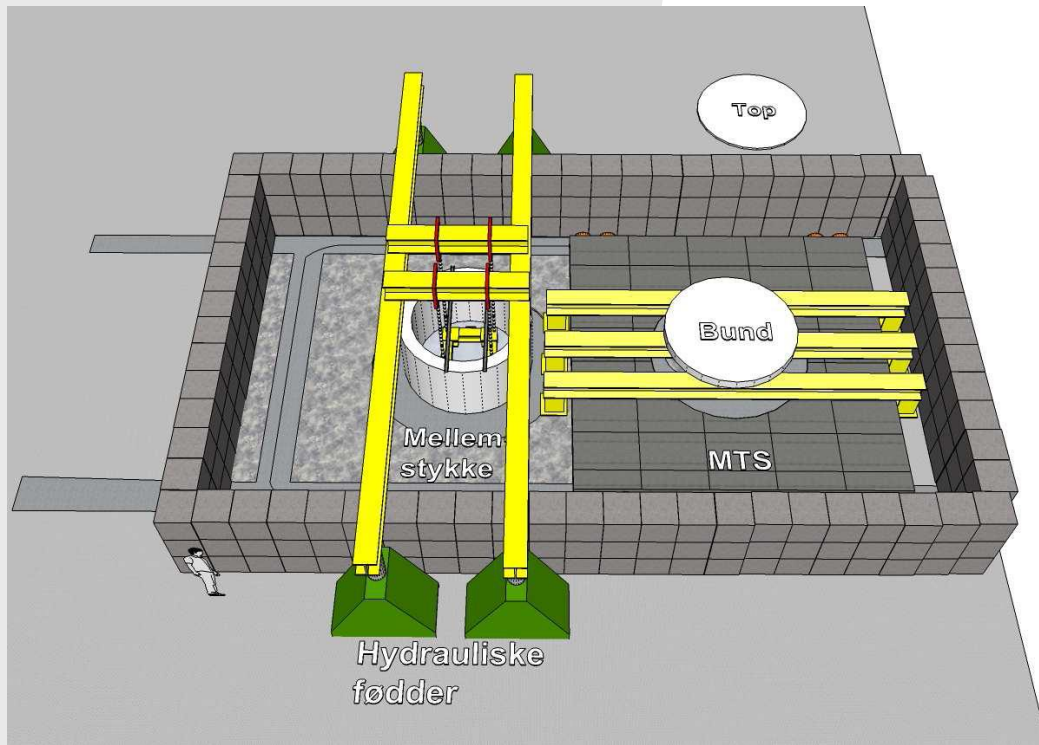
- Rail system on the reactor top
- MTS is able to move independently of the polar crane

Auxiliary equipment Movable Top Shield (MTS)



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Top Shield Plug (TSP)



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Removal of Top Shield Plug

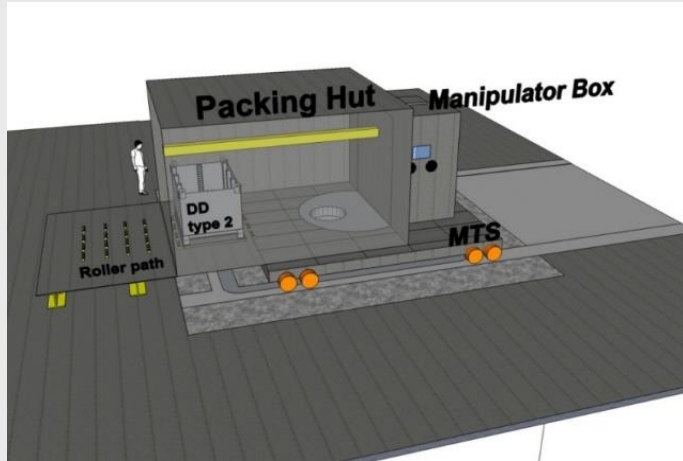


Lift of TSP from the reactor into the shielding

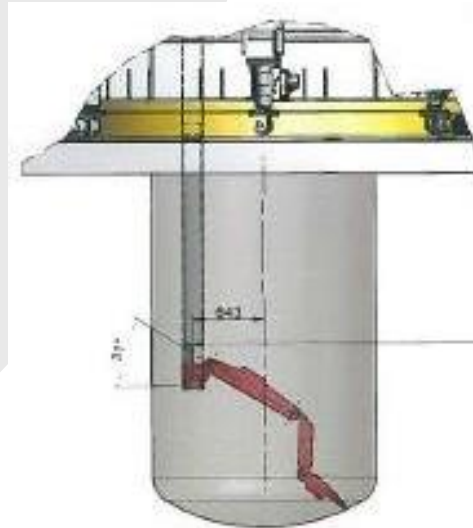
Transport of the TSP out from the reactor building



Packing Hut and Manipulator Box

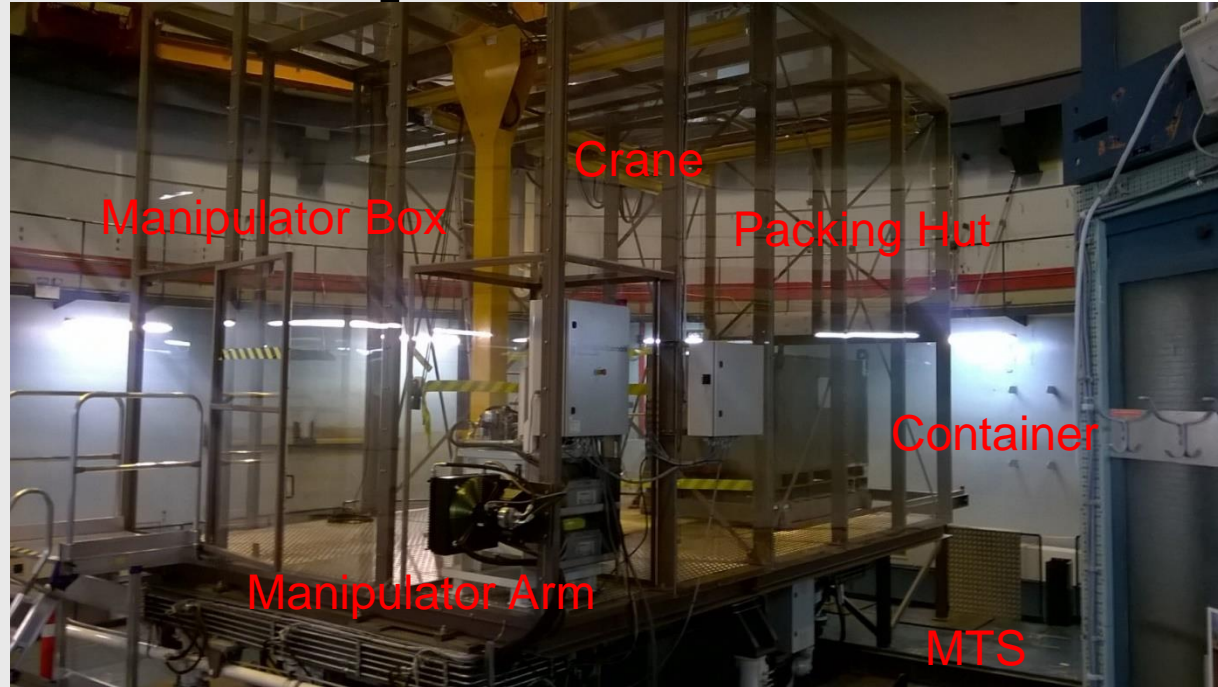


- Sealed and controlled area
- Forms a barrier between the reactor pit and reactor hall
- Prepacked steel containers with a good degree of filling



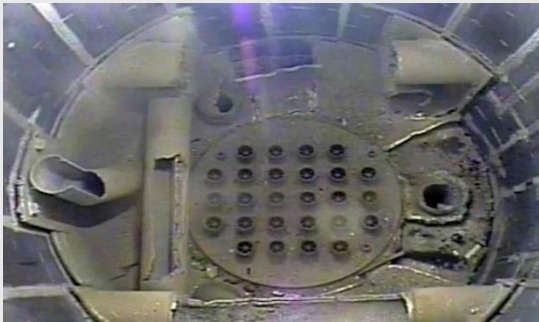
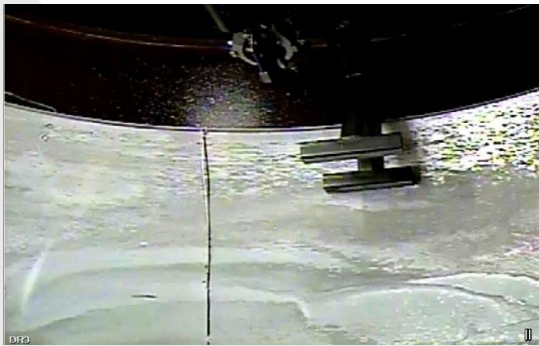
- Room for taking out the cut up parts of the RAT and the graphite blocks with a manipulator arm

Packing Hut and Manipulator Box



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Remote plasma cutting of the Reactor Aluminium Tank



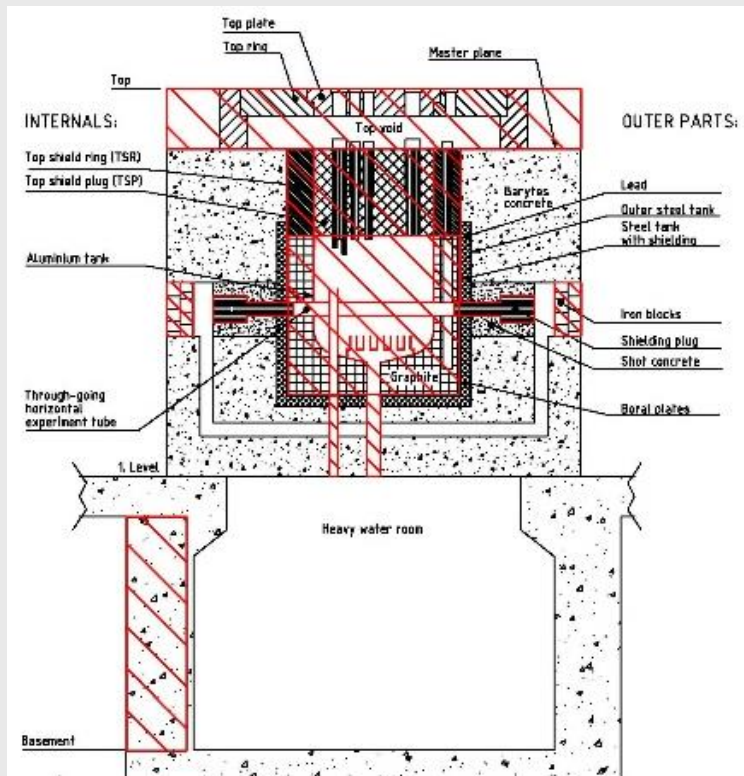
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Remote removal of the graphite reflector



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Remaining tasks



- Outer parts (2019-2020):
 - Boral plates
 - Steel tank with lead
 - Shot concrete
 - Baryte concrete



External parts

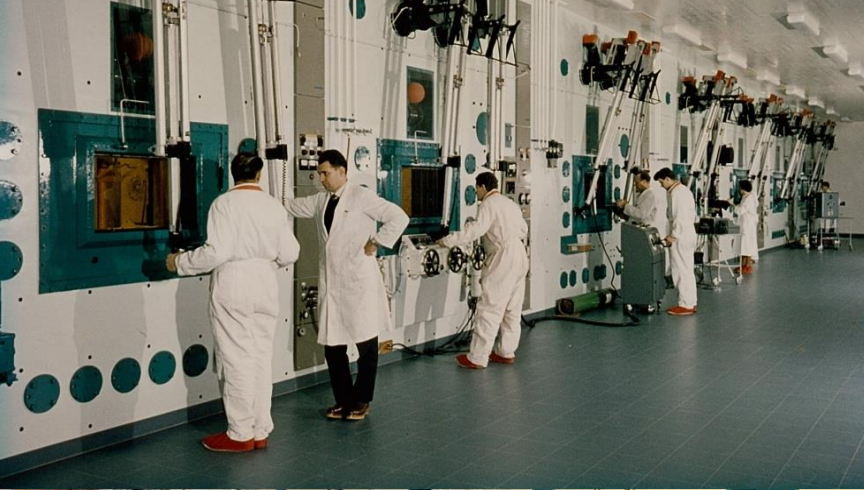
- Steel tank with lead and baryte concrete:
 - Wall saw cutting with different saw blades
- Steel ball concrete
 - Scabbling

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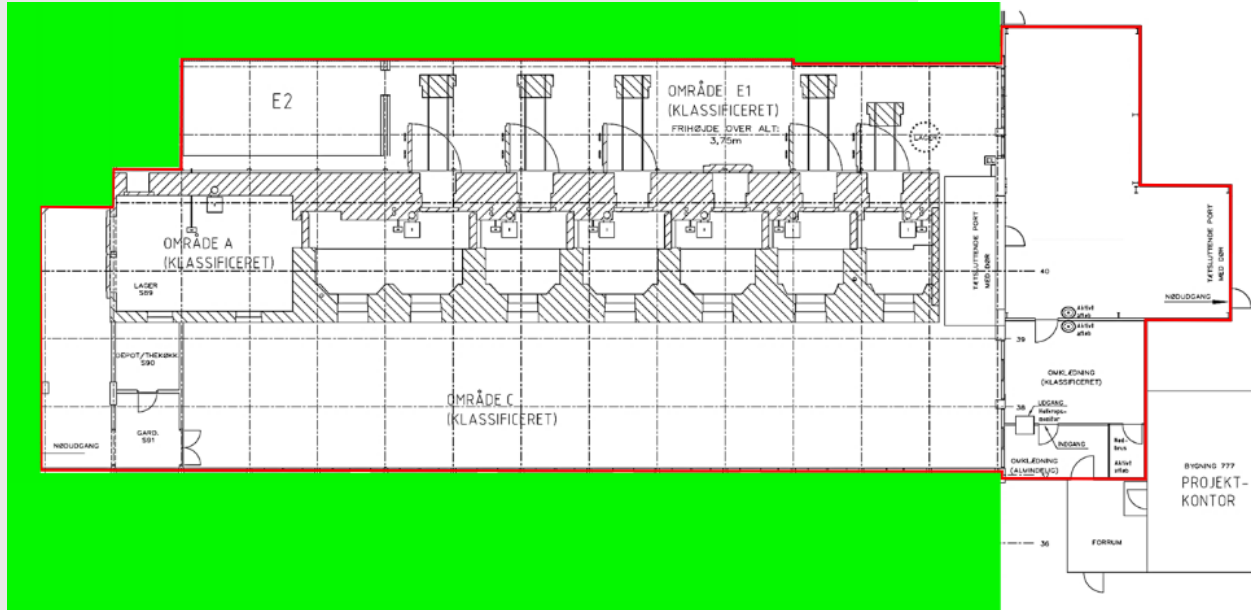
Hot Cells

- A row of six concrete cells remains in a building with other activities (DTU)
- In operation 1960-1989, partly decommissioned in 1990-1993
- Used for investigating of irradiated reactor fuel and for packaging of radioactive sources
- Final decommissioning started in 2008 and is scheduled to finish in 2022



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Plan of the Hot Cell Facility



White area inside the red line: Classified area with the hot cells
Green area: Offices and laboratories (Danish Technical University)

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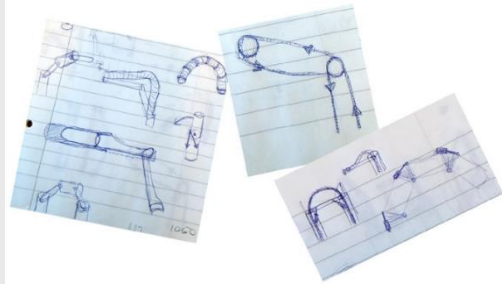
Decommissioning framework

- Neighbors 'all around'
- Very limited space
- Dose rate too high for manual cleaning (~6 mSv/h)
- α -, β -, and γ -contamination
- Decommissioning to greenfield
- Method chosen: Decontamination by remote blasting with steel grit

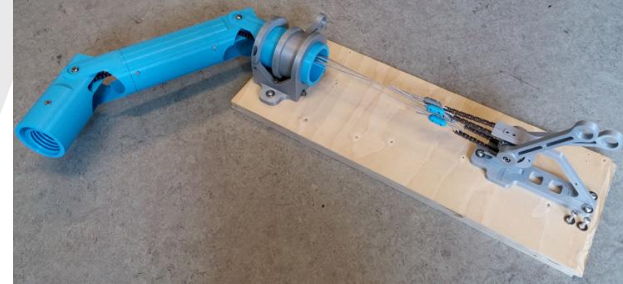
Rebuild of the ventilation system

- ISO 17873: "Nuclear facilities – Criteria for the design and operation of ventilation systems for nuclear installations other than nuclear reactors"
- Overview:
 - Depression of cells: -150-220 Pa
 - Air velocity in openings: 1 m/s
 - Depression nearest surroundings: -50 to -100 Pa
- Necessary to vacate DTU-offices to the south
- Moving filters from the roof

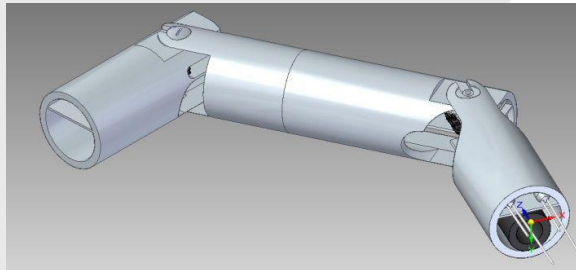
Development of mechanical arms



1. Generating the idea



3. 3D printed model



2. 3D computer model



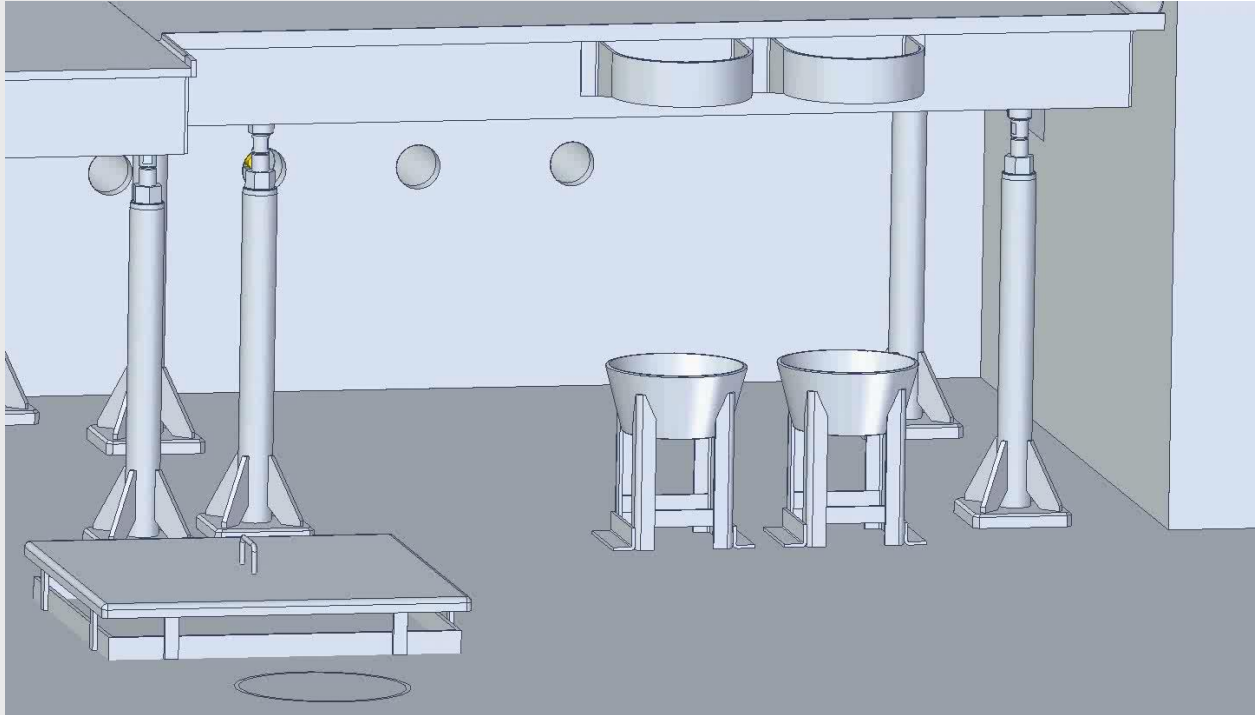
4. Construction in steel

Principle of the mechanical arms



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Remote Blasting



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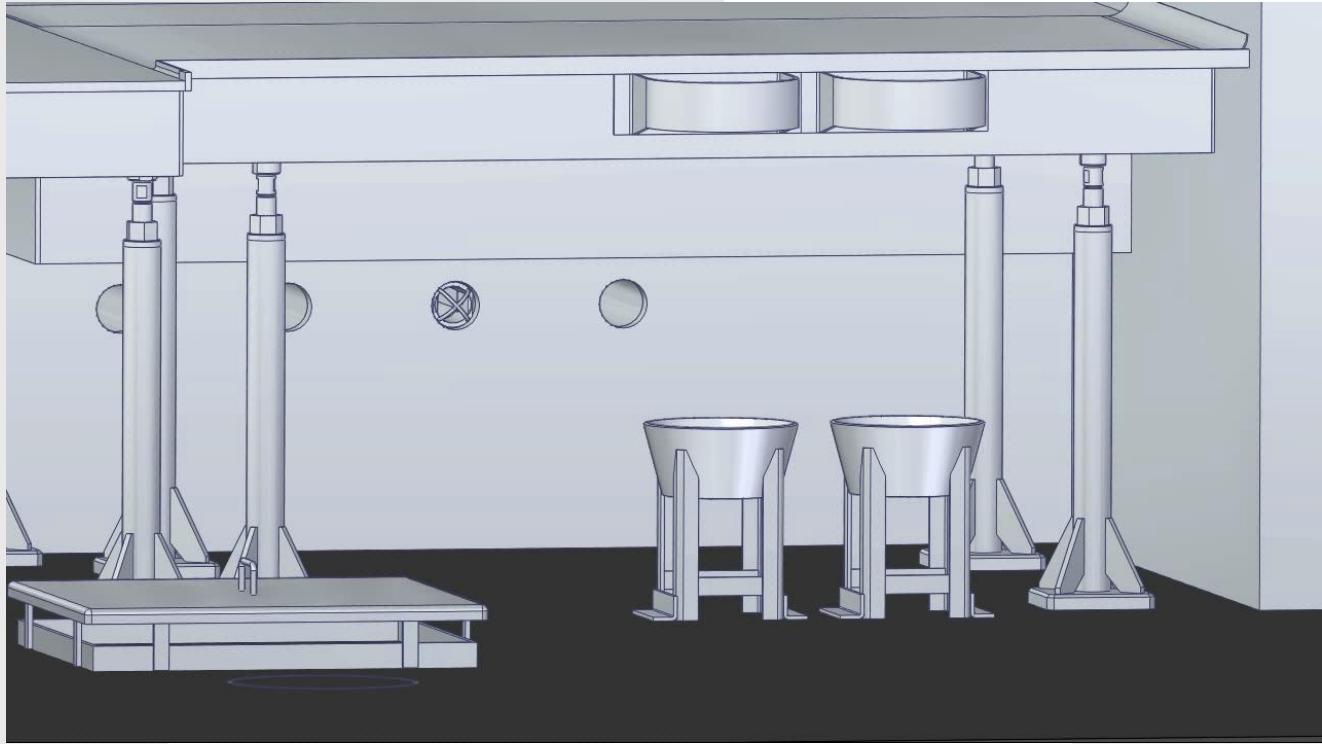
Material extraction

- Main challenge:
Limited by a 50mm extraction hoze
- Flexibility to reach all horizontal surfaces
- Developing the arm almost done and is being tested
- Mock up tests



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Material extraction



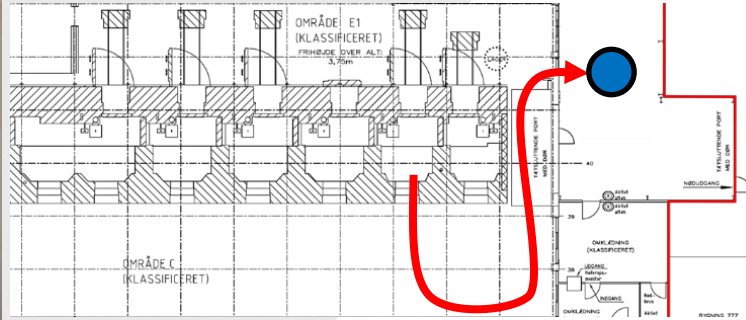
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Remote Blasting

Cell front



Blasting



Material extraction



Vacuum extractor



Filling drums



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Remote Blasting

Risø Hot Cells 2017
Blast Cleaning

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Dose rates inside the cells

	Cell 6	Cell 5	Cell 4	Cell 3	Cell 2	Cell 1 (double cell)
Initial average dose [mSv/h]	0,1	0,5	0,1	1,9	1,65	2,1 + two hotspots (15,5+23,1)
Average dose rate after remote blasting [mSv/h]	0,03	0,2	0,04	0,27	0,25	Ongoing
Hotspot left after remote blasting [mSv/h]	0,2	1,3	None	0,8	0,8	Remote blasting has not been completed yet

Hot Cells – future tasks

- Removal of hot spots
- Removal of interior (tables etc.)
- Intermediate remote blasting (robot)
- Removal of heavy interior (doors, shutters etc.)
- Manual “fine cleaning” for clearance



Thank you for your attention!

Questions?

