Status of decommissioning in Denmark

By Kirsten Hjerrild Nielsen
Head of Department: Waste, Decommissioning and Operation
khn@dekom.dk
Contents

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
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
• 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.

NKS Radworkshop 8.-10. October 2018
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
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

NKS Radworkshop 8.-10. October 2018
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

NKS Radworkshop 8.-10. October 2018
DR 2 decommissioning

- Plasma cutting of the lead nose of the thermal coulomb
Demolishing the DR 2 reactor block

NKS Radworkshop 8.-10. October 2018
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
Fuel Fabrication Plant

Wall shaver during shaving the ceiling in the powder room

Sawing of the floor in the powder room

NKS Radworkshop 8.-10. October 2018
Removal of the concrete floor by milling

NKS Radworkshop 8.-10. October 2018
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

NKS Radworkshop 8.-10. October 2018
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
Contents

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

- 10 MWth, D$_2$O 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

- 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)
- \( \text{D}_2\text{O} \) plant room
Decom. strategy for DR 3

- Auxiliary systems removed (2011)
- Primary circuit (D$_2$O) removed (2012)
- Internals dismantled (2018)
  - Inside out
- Biological shield demolished (2020)
  - Top down

NKS Radworkshop 8.-10. October 2018
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)

NKS Radworkshop 8.-10. October 2018
Top Shield Plug (TSP)
Removal of Top Shield Plug

Transport of the TSP out from the reactor building

Lift of TSP from the reactor into the shielding

NKS Radworkshop 8.-10. October 2018
Packing Hut and Manipulator Box

- Room for taking out the cut up parts of the RAT and the graphite blocks with a manipulator arm
- Sealed and controlled area
- Forms a barrier between the reactor pit and reactor hall
- Prepacked steel containers with a good degree of filling
Packing Hut and Manipulator Box

NKS Radworkshop 8.-10. October 2018
Remote plasma cutting of the Reactor Aluminium Tank

NKS Radworkshop 8.-10. October 2018
Remote removal of the graphite reflector

NKS Radworkshop 8.-10. October 2018
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
  - Scabling
Contents

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

NKS Radworkshop 8.-10. October 2018
Decommissioning framework

• Neighbors ‘all around’
• Very limited space
• Dose rate too high for manual cleaning (~6 mSv/h)
• $\alpha$-, $\beta$-, and $\gamma$-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
Developement of mechanichal arms

1. Generating the idea
2. 3D compter model
3. 3D printed model
4. Construction in steel

NKS Radworkshop 8.-10. October 2018
Principle of the mechanical arms
Remote Blasting
Material extraction

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

NKS Radworkshop 8.-10. October 2018
Material extraction
Remote Blasting

Cell front

Blasting

Material extraction

Vacuum extractor

Filling drums

NKS Radworkshop 8.-10. October 2018
Remote Blasting

Risø Hot Cells 2017
Blast Cleaning

NKS Radworkshop 8.-10. October 2018
# Dose rates inside the cells

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

NKS Radworkshop 8.-10. October 2018
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

NKS Radworkshop 8.-10. October 2018
Thank you for your attention!

Questions?