Workshop on
"Current and Emerging Methods for Optimising Safety and Efficiency in Nuclear Decommissioning“
Sarpsborg / Norway / 2017

SAFE DISMANTLING
OF THE SVAFO
RESEARCH REACTORS
R2 & R2-0 IN SWEDEN

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SVAFO R2 Dismantling Content

- Historical background
- Scope of Work
- Radiological Characterization
- Waste Routes
- Planned Sequence
- Safe Working Area
- Safe Dismantling
- (Un-) expected Challenges
- Preliminary vs. Final Packing Plan
- Results & Lessons Learned
SVAFO R2 Dismantling
Historical background

- AB Atomenergi ordered the facility by Allis-Chalmers (USA)
- Time of operation: 1960 to 2005
- Three sister facilities were built; whereof two facilities are still in operation: Safari (RSA) and Petten (NL)
- R2 and R2-0 reactors are in a three-part pond (150m³)
  - R2: 30MW, upgrade in 1969: 50MW
  - R2-0: 1MW
- Purpose: neutron experiments, material behavior
  - Test of fuel elements under BWR/PWR conditions
  - Isotope production for medical / industrial applications
  - BNCT radiotherapy
- 2010 Nuclear license transferred from Studsvik to SVAFO
- 2012 SVAFO R2 dismantling project started
- 2014 Decommissioning plan etc. approved by SSM
- 2014 Contract for dismantling and packing of the reactors (June)
- 2015 Completion. 3 pools were cleared from reactors R2-0, R2 and surroundings
Phase 1

- Dismantling / cutting of R2-0
- Removal of all R2 support equipment
- Dismantling / cutting of R2
- Emptying of pools
- Packaging, transport, documentation

Project features

- Experienced Swedish Partners
- Reliable technical solutions
- Combined FAT & Training with customer

Combining AREVA’s expertise in D&D with the knowledge of the former operators and with experienced Swedish on-site team securing effective performance
up to 100Sv/h expected
SVAFO R2 Dismantling Waste Routes

- **Waste Route 1**
  - DR: > 2 Sv/h
  - **Baskets for WR 1**
    - Size: Ø 160mm x 760mm
    - Weight: max. 25kg load
    - Loading of baskets under water
  - ► 7 baskets, 87kg

- **Waste Route 2**
  - DR: 2 Sv/h … 2 mSv/h
  - **Cassettes for WR 2**
    - Size: 810mm x 810mm x 800mm
    - Weight: max. 3.400kg
    - Loading of baskets under water
  - ► 24 cassettes, 8.753kg

- **Waste Route 3**
  - DR: < 2 mSv/h
  - **Handling according to WR 3**
    - Max. size: 2.5m x 1.0m x 1.0m
    - Lifting, rinsing and packing in plastics
  - ► 3.561kg
SVAFO R2 Dismantling Example for optimized Packaging

- **Waste Route 1**
  - DR: > 2 Sv/h
  - 1 TN® MW cask
    - AREVA TN
    - « All in One Solution »

- **Waste Route 2**
  - DR: 2 Sv/h … 2 mSv/h
  - 6 CBF-KB pack units
    - AREVA TEMIS

- **Waste Route 3**
  - DR: < 2 mSv/h
  - 3.561kg

Handling according to WR 3
- Max. size: 2.5m x 1.0m x 1.0m
- Lifting, rinsing and packing in plastics
Create a safe working arrangement

- Wall protection
- Bottom protection
- Working table

Dismantling of R2-0
Dismantling of R2
SVAFO R2 Dismantling Planned Sequence

- Dismantling of R2
SVAFO R2 Dismantling
Planned Sequence

Dismantling of R2
Dismantling of the SVAFO Research Reactors – Workshop Sarpsborg – Hans-Uwe Arnold - 07/02/2017 - AREVA GmbH – Back End Germany - © AREVA - p.23

SVAFO R2 Dismantling Planned Sequence

Dismantling of R2

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank

D2O tank
SVAFO R2 Dismantling
Planned Sequence

Dismantling of R2

Transition area
Dismantling of R2
SVAFO R2 Dismantling
Planned Sequence

- Dismantling of R2

Core box

Lower vessel
Dismantling of R2

Lower vessel
SVAFO R2 Dismantling
Safe Working Area
Removal of R2 reactor connections to the bioshield, close wall penetrations, unbolt flange connections in Pool 1
SVAFO R2 Dismantling
Safe Working Area

- Protection of pool bottom & walls avoids leakages
Safe working distance = table inside platform
SVAFO R2 Dismantling
Safe Working Area

- Platform and working table in Pool 2
  - Handling rods
  - Rack for safe storage
Cutting of R2-0 in Pool 2
Dismounting work in Pool 1
SVAFO R2 Dismantling
Safe Dismantling

Cutting of Upper Vessel
SVAFO R2 Dismantling Challenges

- Dismounting work in Pool 1
  - confined working conditions, 73mm “free” space
  - Sensitive handling essential (Al liner)
Safety Measure

- Self-construction of a pneumatic balancer for sensitive lifting tasks
- Recognizes stuck or jammed load:
  - no damages
- Compensates the weight of the component:
  - gives feeling while handling
SVAFO R2 Dismantling Challenges

- Pendular hacksaw combined with shear
  - Application of Plan B solution
  - Removal of stainless restraint structure
  - Components with mechanical stress
SVAFO R2 Dismantling Challenges

- Pendular hacksaw combined with vacuum gripper plate
  - Planned Plan B solution
  - Removal of H1 channel
  - Confined working conditions
**Intervention tool**

- **Planned Plan C solution**
- **Contact Arc Metal Cutting (CAMC)**
- **Confined accessibility:** 90mm from bottom, 70mm from wall liner
- **Only solution:** cut through lamella with graphite electrode
SVAFO R2 Dismantling Challenges

- Inspection of as-build situation
  - Rod handled camera (12m long)
  - Cardanic wrench socket prolongation joined TV controlled
SVAFO R2 Dismantling Results

- No accidents
- Personnel dose below estimation
- Huge amount of small pieces
  - Container with bigger volume

### R2-0 & R2 masses

<table>
<thead>
<tr>
<th>Material</th>
<th>Mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>5.400kg</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>6.000kg</td>
</tr>
<tr>
<td>Peripheral equipment</td>
<td>1.000kg</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>12.400kg</td>
</tr>
</tbody>
</table>

### Reactor pieces

<table>
<thead>
<tr>
<th>Reactor</th>
<th>Pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2-0</td>
<td>88</td>
</tr>
<tr>
<td>R2</td>
<td>257</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>345</strong></td>
</tr>
</tbody>
</table>

### WR delta

<table>
<thead>
<tr>
<th>WR</th>
<th>WR</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>WR1</td>
<td>WR2</td>
<td>270kg</td>
</tr>
<tr>
<td>WR2</td>
<td>WR3</td>
<td>808kg</td>
</tr>
<tr>
<td>WR2</td>
<td>WR1</td>
<td>47kg</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.125kg</strong></td>
<td></td>
</tr>
</tbody>
</table>
SVAFO R2 Dismantling Results

- Originally planned layout (10pc.)
- Realized layout (28pc.)
- No detailed Preliminary Packing Plan necessary, one final only!

Lower vessel
No detailed Preliminary Packing Plan necessary, one final only!
SVAFO R2 Dismantling Lessons Learned

- Build a “Decommissioning Team”
- Prepare a thorough “Radiological Characterization”
- Replace the legacy operation systems with new, flexible “Decommissioning Support Systems”
- Close communication to the Back Office
- Use the wide AREVA experiences from D&D of PWR and BWR, which are also valid for RTR.
- Use AREVA services all along the D&D project avoiding interferences in the chain:
  - scenario definition - characterization - sampling - cutting - sorting - conditioning - cask supply - logistic
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