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Westinghouse Experience in Reactor Vessel Dismantling Projects

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Agenda

• Introduction
• Latest reactor internals segmentation projects across Europe
• Graphite plant dismantling expertise
• Waste storage and disposal facilities
• Conclusions
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Reactor Vessel Internals Segmentation

• Scope: project management, cutting and packaging plan, tooling design, manufacturing & testing, on-site activities (cutting, packaging, handling, cleaning, ...)

• Proven experience since 1985 on all types of reactors: PWR’s, BWR’s, GCR’s, Sodium

• Used all types of cutting tools: PAC, AWJC, MDM, mechanical

More than 30 year experience in dismantling different types of reactors worldwide with various cutting techniques
## Latest Segmentation References (Mechanical)

### Segmentation Performed

<table>
<thead>
<tr>
<th>Plant</th>
<th>Component</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forsmark 2</td>
<td>Core Shroud</td>
<td>2000</td>
</tr>
<tr>
<td>Forsmark 2</td>
<td>Core Support Grid</td>
<td>2000</td>
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<tr>
<td>Forsmark 1</td>
<td>Core Shroud</td>
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<tr>
<td>Forsmark 1</td>
<td>Core Support Grid</td>
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<tr>
<td>Oskarshamn 2</td>
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<td>Oskarshamn 2</td>
<td>Feed Water Spargers</td>
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<td>Core Spray Riser Pipes</td>
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<td>Test Channels</td>
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<td>Olkiluoto 2</td>
<td>Steam Separators, 19 pcs</td>
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<tr>
<td>Olkiluoto 2</td>
<td>Core Support Grid</td>
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<td>Core Shroud Cover</td>
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<td>Forsmark 3</td>
<td>Core Spray Piping &amp; Support</td>
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<td>Olkiluoto 1</td>
<td>Steam Separators, 19 pcs</td>
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<td>Olkiluoto 1</td>
<td>Core Support Grid</td>
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### Segmentation Contracted

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<tr>
<th>Plant</th>
<th>Component</th>
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<tr>
<td>Chooz A</td>
<td>RPV, Upper &amp; Lower Internals</td>
<td>2016</td>
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<tr>
<td>Barsebäck 1 &amp; 2</td>
<td>All Reactor Vessel internals</td>
<td>2016</td>
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<td>Philippsburg I</td>
<td>All Reactor Vessel internals</td>
<td>2017</td>
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<tr>
<td>Neckarwestheim I</td>
<td>Upper &amp; Lower Internals</td>
<td>2017</td>
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<tr>
<td>Bohunice V1 (2 units)</td>
<td>Full Primary System</td>
<td>2019</td>
</tr>
<tr>
<td>Unterweser</td>
<td>All Reactor Vessel internals</td>
<td>2019</td>
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<tr>
<td>Grafenrheinfeld</td>
<td>All Reactor Vessel internals</td>
<td>2021</td>
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<td>Gröhnde</td>
<td>All Reactor Vessel internals</td>
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<td>Isar 1</td>
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<td>Brokdorf</td>
<td>All Reactor Vessel internals</td>
<td>2027</td>
</tr>
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</table>

13 reactors currently under contract
José Cabrera plant (Zorita): Segmentation and Packaging of Reactor Internals

- 418 meters of cutting, 432 cut pieces, total weight = 59.5 T

Mock-up testing

Lower internals cutting
Zorita Reactor Vessel removal from the pit and segmentation

- 240 meters of cutting, 140 cut pieces, total weight segmented = 114 T
- Project completed in May 2015
On-going cutting activities

Chooz A: Reactor cave (general View)

Barsebäck 1: Core shroud

Neckarwestheim 1: Segmentation of upper core plate and baffle bolt removal

Bohunice V1: Reactor Shaft Protection Lid Handling
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Fort St Vrain Nuclear Power Plant

- Power: 330 MWe
- Construction: 1968-1976
- Operation: 1976-1989
- Decision for final shutdown: August 29, 1989
- Reasons: technical problems, low capacity factor (15%)
- Consortium W/MK selected for reactor dismantling: June 26, 1990
- Total project duration: 6 years (4 years on site)
Fort St Vrain Reactor Structure

- Penetrations
- Top Head

Core

Core support floor

Steam Generators (12)

Barrel

Top Head cutting into 12 pieces of 110 T

- Removal of 3,754 graphite blocks (313 columns)
- Barrel cutting and metallic structures

Cut into 10 pieces of 270 T

Side walls cutting (1,050 T)

Steam Generator removal

Fort St Vrain reactor
- 32 m high
- 15 m diameter
- Cavity: 9.5 x 23 m
- 2.75 to 4.7 m wall thickness

- Underwater dismantling
- Short planning
- Proven techniques from reactor services
Installation of a Rotary Platform

Main Functions:
- Rotation
- Shielding and confinement
- Handling during reactor dismantling (internals, graphite, concrete side walls)
- Basket filling and waste removal

Dose Rate on Refueling Floor <10 μSv/h
Dose Rate on Work Platform <20μSv/h
Water
Air Inflow
Approx. 12′ (3.6m)
43′=13m
To Reactor Building exhaust
To Reactor Building Exhaust
Graphite Block Removal

5,000 graphite blocks removed
Reactor Dismantling

Top cap: 110 T/piece, total thickness=4.7m

Plasma Arc cutting

Side wall cutting

Heat Exchangers dismantling

Total weight= 270 T
Thickness= 1.5 m
Bugey 1 Reactor Dismantling

- Westinghouse prepared a detailed offer, including a conceptual design for dismantling the Bugey 1 reactor.
- After removal of the top cap, the innovative solution was underwater dismantling by using a floating platform that was naturally lowered while lowering the water level.
- The Westinghouse proven mechanical cutting technology was proposed for dismantling the reactor.
Vandellós I Nuclear Power Plant

- 508 MWe plant located in Vandellós (Spain), operated by Hifrensa
- Carbon dioxide gas cooled reactor based on Saint Laurent A NPP (EDF)
- Shut down on July 31, 1990, following a fire in one of its two turbo-generators in October 1989
Westinghouse Involvement at Vandellós I

1967 - 1972: Construction

1972 - 1989: Operation

1989 - 1998: Planning and Postoperational Activities

1998 - 2002: Decommissioning Level II

2002 - Present: Dormancy

1993-1996: Retrieval of operational waste

Westinghouse involvement

- Engineering and Licensing
- Supervision of D&D activities
- Engineering support and Level III Concept
Westinghouse activities at Vandellós I

- **1994 to 1997:** Graphite silos retrieval (together with other partners):
  - Civil design
  - Integration
  - Works supervision
  - Licensing documentation

- **1992 to 1997:** Decommissioning Plan and licensing documentation
  - Decommissioning plan
  - Licensing documentation
  - Environmental impact report
  - Application for the Euratom Art. 37
  - Engineering project for works license
  - Health and Safety plan
  - Project scheduling

- **1998 till 2003:** Level 2 dismantling
  - Works supervision
  - Licensing support
  - On-site engineering support

- **2003 till now:** Care and Maintenance
  - Systems update and as built documentation
  - Surveillance
  - Licensing support and update of licensing documentation
  - Site Restoration Plan
  - Preparatory activities for Level 3 dismantling
Preparatory activities for Level 3 dismantling

- Optioneering, based on:
  - Caisson characterization
  - Activation calculation model
  - Model calibration with sampling results
  - Integrated model for level 3
    - Structural
    - Activity inventory
    - Level 3 design

- Optioneering: three stage process
Optioneering for Level 3

1st stage:

- Multi-attribute qualitative analysis of five alternatives (wet, dry top/lateral/bottom openings, ex-vessel wet cutting)
2nd stage: quantitative assessment of 2 selected alternatives (top opening dry, and wet)

- Alternatives activities list
- Identification of differentiating or exclusive activities
- Quantitative assessment
- Several cutting techniques
Selected: dry alternative (top opening):

- Dry takes slightly longer and is a bit more expensive than wet
- Operational doses are smaller in dry (use of teleoperated tools)
- Secondary wastes are higher in wet
- Uncertainties and accident risks are higher in wet
Optioneering for Level 3: conceptual design

Clearance 79%

LILW 4%
VLLW 8%
HLW 9%
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Westinghouse Experience in Interim Waste storage and Disposal facilities

- **Centralized Interim Storage for SNF, Spain**
- **Comanche Peak** SNF storage facility, USA
- **El Cabrill** LILW Repository, Spain

- Detailed facility design, licensing support, safety analysis report
- Engineering and construction for a mile long heavy haul road and on-site SNF storage facility at the two unit PWR located in Texas
- Design, licensing, construction supervision and operational support
Conclusions

- Westinghouse brings more than 30 years of proven experience in reactor dismantling on different types of reactors (PWR’s, BWR’s, GCR’s, Sodium).
- Westinghouse has currently on-going segmentation contracts on 13 reactors in Europe.
- Westinghouse has dismantled the first graphite plant (Fort St Vrain) and continues to be involved in other similar reactors (e.g. Vandellós I).
- Westinghouse has developed skills for performing optioneering studies and selecting the optimum dismantling scenario.
- Westinghouse has also a deep knowledge in designing interim waste storage and disposal facilities.
- Westinghouse is used to collaborate with local partners.
Thank You for your Attention… Any Questions?