The BR3 Decommissioning project

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BR3: First PWR in Europe, First to be dismantled

- **Type**: Pressurized Water Reactor (Westinghouse)
- **Power**: $40.9 \text{ MW}_\text{th}$, $10.5 \text{ MW}_\text{e}$ (net)
- Started in 1962, shut down in 1987, i.e. a working life of 25 years
- 3582 EFPD in 11 operating campaigns
- Primary loop = 1.5 loop (1 SG, 2 pumps)
- Served as training center for future NPP operators and as test bench for advanced PWR fuel
Two sets of Internals were dismantled. This allowed to compare D&D strategies.

The "Vulcain" Internals: 8 years decay

The "Westinghouse" Internals: 30 years decay
Remote controlled underwater mechanical cutting has been extensively used.
All important operations started with: cold testing in a test tank

- Bandsaw
- Models
- Turntable
…followed by application in the reactor pool
Reactor Pressure Vessel Removal

- Disconnect RPV from primary loop
- Lift RPV into refueling pond
- Re-instate pond integrity
- Cutting of RPV
After one year preparation work, the RPV could be lifted
...without any problem!

And you could follow it directly through Internet: http://www.sckcen.be/webcam
General view of the RPV dismantling yard in the pool

- RPV
- Circular saw
- Cut rings storage
- Swarf filtration pumping station
The waste management varies from one category to the other:

- The HLW and ILW (contact dose rate >2mSv/h): require radiological protection and special evacuation ways & procedures.

- The LLW (important volume: about 5000m³): most of them can be decontaminated up to a "free release" level, or can be reused or recycled.

- The VLLW, representing the largest volume and including the decontaminated LLW, are intended to be free released.
Removal routes BR3
Certification

…all the material management is carried out under a QA system conform to ISO-9002
Up to now radwaste generated has been economically and safely reduced to a minimum activity $\text{Bq.g}^{-1}$

- Status after removing of the fuel & the main components (RPV, Primary loop, SG & PR)
  - 90% clearance (reuse or removal as conventional waste)
  - 8% low level radwaste
  - 2% medium & high level radwaste
Component clearance practices

clearance methodologies used: from simple to more complex

Conditional clearance

Clearance after melting

Direct clearance

about 450 tons of metals

about 700 tons of other materials
Component clearance practices

clearance methodologies used: from simple to more complex

about 140 tons of metals

clearance measurement based on sampling & analyses by Studsvik (S)
Component clearance practices

clearance methodologies used: from simple to more complex

- Conditional clearance
- Clearance after melting
- Direct clearance

about 40 tons of metals

Clearance measurements & Reuse in the nuclear sector by Duratek (USA)
We use mainly three decontamination processes on-site:

- hand wash and cleaning (for very slightly contaminated parts)
- wet sand blasting process and polishing (in a confined and ventilated booth)
- hard chemical decontamination (using the Cerium-IV process, called MEDOC (patented))
MEDOC hard decontamination: Only **one step** treatment

**Cerium solution**

\[ \text{Ce}^{4+} \rightarrow \text{Ce}^{3+} \]

**Ozone gaz**

\[ \text{O}_2 \]

**Regeneration of cerium IV**

**Decontamination**

**Contaminated Material**

**Free release**
Description of the MEDOC Chemical decontamination unit for metals

Decontam Loop

Rinsing loop

waste treatment

O3

O2

1

2

3
View of the MEDOC Installation
Thorough chemical decontamination

Results:
More than 85% free
Waste reduction ~95%
Clearance of the BR3 primary pipes

CORD
Decontamination of primary loop in 1991

18,000 Bq/cm²

$^{60}\text{Co}$

Co-60 decay of 10 years

1,800 Bq/cm²

$^{60}\text{Co}$

Decontamination with MEDOC Process

450 Bq/cm²

$^{60}\text{Co}$

Material cleared and sold to a scrap dealer

< 0.4 Bq/cm²

$^{60}\text{Co}$

$60\text{Co}$ decay of 10 years
BR3 Primary pumps decontaminated with MEDOC
Wet Sand Blasting decontamination in a ventilated booth: the ZOE unit

Roof opening for large pieces

Walk-in Booth

Operator at work
Decontamination of Building structures (mainly concrete)
Concrete decontamination: heavy manual operation
All surfaces…
### Building structure clearance practices element categorisation

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Location</th>
<th>Contamination Risk</th>
<th>Decontamination &amp; Characterization</th>
<th>Clearance Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&quot;Cold&quot;</td>
<td>Location: outside controlled area</td>
<td>Contamination risk: excluded</td>
<td>Decontamination (&amp;Characterization): not required</td>
<td>0 mm</td>
</tr>
<tr>
<td>1</td>
<td>&quot;Suspected&quot;</td>
<td>Location: inside or outside controlled area</td>
<td>Contamination risk: aerosols or dust (not confirmed)</td>
<td>Decontamination: coating or base material removal</td>
<td>1 mm</td>
</tr>
<tr>
<td>2</td>
<td>&quot;Contaminated&quot;</td>
<td>Location: inside controlled area</td>
<td>Contamination: aerosols or dust (confirmed), no migration</td>
<td>Decontamination: base material removal</td>
<td>~5 mm</td>
</tr>
<tr>
<td>3</td>
<td>&quot;Severely Cont.&quot;</td>
<td>Location: inside controlled area</td>
<td>Contamination risk: liquids, possible migration</td>
<td>Decontamination: case by case</td>
<td>~20 mm</td>
</tr>
<tr>
<td>4</td>
<td>&quot;Activated&quot;</td>
<td>Location: close to RPV</td>
<td>Contamination: activation</td>
<td>Decontamination: case by case</td>
<td>several dm</td>
</tr>
</tbody>
</table>

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0 mm | 1 mm | ~5 mm | ~20 mm | several dm
## Building Structure Clearance Practices

**Equipment & Clearance Methodology**

### Surface Control Measurements ($\alpha$, $\beta/\gamma$)

<table>
<thead>
<tr>
<th>Categorie</th>
<th>% Surface</th>
<th>Equipment</th>
<th>% Surface</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>25 - 100</td>
<td>Electra 600 (or ISOCS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25 - 100</td>
<td>Electra 600</td>
<td>50 - 100</td>
<td>ISOCS</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>Electra 600</td>
<td>100</td>
<td>ISOCS</td>
</tr>
</tbody>
</table>

### Bulk Control Measurements ($\gamma$)

<table>
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<th>Categorie</th>
<th>% Surface</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>GM</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>GM</td>
</tr>
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</table>

### Drilled Holes Control Measurements ($\beta/\gamma$)

<table>
<thead>
<tr>
<th>Categorie</th>
<th>% holes</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>GM</td>
</tr>
<tr>
<td>3</td>
<td>100</td>
<td>GM</td>
</tr>
</tbody>
</table>

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**Notes:**
- Electra 600
- ISOCS
- HPGe
- GM

**Measurements:**
- Surface Control Measurements ($\alpha$, $\beta/\gamma$)
- Bulk Control Measurements ($\gamma$)
- Drilled Holes Control Measurements ($\beta/\gamma$)
2 “interesting” cases:

1) the BR3 SG removal/dismantling/decontamination

2) encapsulated lead melting

Objectives: economical material management and safe clearance by technology combination
Handling of the SG before decontamination

The SG has been lifted and placed horizontally to allow complete filling of the primary side.
A quick view on the used installation (connection to the MEDOC loop)

MEDOC existing installation

Flexible connections
SG cutting using AWJC
SG cutting using Diamond wire
Lead melting

- 34 ton of lead
- 10 shielding pieces: Cs or SS shell filled up with lead
- Radiological resuming description: not contaminated lead inside contaminated containment
- “Separation technology” required
First piece being placed horizontally
Heating components
(third preparatory operation)
Insulation installation
(last preparatory operation)
Heating (few hours)
Melting operation almost ready
The melting
Sampling during operation

One sample per melted block
Cooling area
Removal of lead block
Final check of quantities
Measurements

- 10 pieces (7 with SS shell; 3 with CS shell)
- About 12 blocks for each piece
- One sample for each block
- One sample every two sent to gamma and alpha spectrometry
- Each last three samples of each piece also sent to spectrometry (top of liquid lead)
- 100% external surface lower than clearance limit
- 100% of lead can be cleared
Conclusions

- With this project, SCK•CEN acquired a quite broad know-how on D&D operations, technique, management, safety and costs
- Specific developments were carried out for optimizing the operations and reduce
  - the generated radwaste
  - the dose uptake and the environmental impact
  - the duration of specific operations
  - the costs
- Our experience is available for future project:
  “WE CAN DO IT !” because “WE DID IT”