Clearance practices applied within Thetis & BR3 decommissioning projects

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To clear or not to clear, BVS-ABR, September 11th, 2015, Brussels
Clearance practices applied within Thetis & BR3 decommissioning projects

- Thetis & BR3: similarities & differences
- Clearance of solid materials
- Clearance of the buildings (including recent developments)
- Concluding remarks
Clearance practices applied within Thetis & BR3 decommissioning projects

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Different facility types might require different strategies. BR3 and Thetis are both reactors.

The Nuclear Fuel Cycle

Source: NRC

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## Operational data sheets for Thetis and BR3

### Differences in operation & size

<table>
<thead>
<tr>
<th></th>
<th>Thetis</th>
<th>BR3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Open pool</td>
<td>Pilot PWR</td>
</tr>
<tr>
<td><strong>Principle</strong></td>
<td>LEU, light water Graphite moderated</td>
<td>Various fuels (e.g. UO$_2$, MOX), various moderators, control rods</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>150 kW (max. 250 kW)</td>
<td>41 MWth (10.5 MWe)</td>
</tr>
<tr>
<td><strong>Size pool/reactor</strong></td>
<td>diameter = 3.0 m, height = 7.5 m</td>
<td>diameter = 1.4 m, height = 5.0 m</td>
</tr>
<tr>
<td><strong>Main use</strong></td>
<td>Production of radioisotopes (medical applications) Activation analyses</td>
<td>Demonstration Qualification of fuel elements Training Centre Development of new technologies</td>
</tr>
</tbody>
</table>
**Clearance practices**

**Important parameters to take into consideration**

<table>
<thead>
<tr>
<th></th>
<th><strong>Thetis</strong></th>
<th><strong>BR3</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of the facility</td>
<td>1967</td>
<td>1962</td>
</tr>
<tr>
<td>Type of installation</td>
<td>Open pool RR</td>
<td>Pilot PWR</td>
</tr>
<tr>
<td>Total size buildings/installations</td>
<td>Small</td>
<td>Rather small</td>
</tr>
<tr>
<td>Main use</td>
<td>Production of radioisotopes Activation analyses</td>
<td>Development of new technologies Electricity production</td>
</tr>
<tr>
<td>Important radionuclides</td>
<td>Typical contamination/activation (e.g. Cs-137, Co-60) Typical experiments labs (e.g. H-3)</td>
<td>Typical contamination/activation (e.g. Cs-137, Co-60)</td>
</tr>
<tr>
<td>Main process conditions</td>
<td>Aqueous, low temperature, atmospheric pressure</td>
<td>Aqueous, high temperature, high pressure</td>
</tr>
<tr>
<td>Radiation protection program during operation Zoning &amp; control measurements</td>
<td>Medium control measurements at room level (bigger laboratory environment)</td>
<td>Limited control measurements at room level (semi industrial scale environment)</td>
</tr>
<tr>
<td>Incidents during operation</td>
<td>None (limited)</td>
<td>Medium</td>
</tr>
<tr>
<td>Known contaminated areas in the building &amp; hazards</td>
<td>Rather limited</td>
<td>Medium</td>
</tr>
<tr>
<td>Examples of levels of contamination</td>
<td>Ion-exchange resins primary loop (Co-60-Mn-54) -&gt; x1000 Highest radiation level installation -&gt; x1000 Highest hotspot building structure -&gt; &gt; x1000</td>
<td></td>
</tr>
</tbody>
</table>
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- Thetis & BR3: similarities & differences

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Balances of solid materials removed from site excl. fuel, liquids, building

<table>
<thead>
<tr>
<th>Activity Bq.g⁻¹</th>
<th>HLW</th>
<th>MLW</th>
<th>LLW</th>
<th>Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1E+09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Thetis open pool**
- Status 2015 – after decommissioning
  - Relatively “clean” installation
  - No focus on decontamination necessary
- Activity distribution:
  - HLW: 3%
  - MLW: 5%
  - LLW: 92%

**BR3 pilot PWR**
- Status 2013 – advanced decommissioning
  - Medium “clean” installation
  - Focus on decontamination necessary
- Activity distribution:
  - HLW: 7%
  - MLW: 2%
  - LLW: 91%

**Total mass >30x**
Various release methodologies are being applied: > 2/3 generic & straightforward, but labor intensive.

- History surface contamination monitor (direct)
- Surface contamination monitor (direct 2 x 100%)
- Smear tests surface contamination monitor (fast scan) total gamma
- HR gamma spectrometry
- Sampling & DA HR gamma spectrometry (in situ)
- Surface contamination monitor (fast scan) total gamma HR gamma spectrometry
- Batch specific

Example: BR3 pilot PWR
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# Building release room & element categorization

## Thetis & BR3

<table>
<thead>
<tr>
<th>categorie</th>
<th>description</th>
<th>contamination</th>
<th>decontamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>contamination = excluded</td>
<td>0</td>
<td>not required</td>
</tr>
<tr>
<td>3</td>
<td>contamination = not likely</td>
<td>1</td>
<td>coating removal</td>
</tr>
<tr>
<td>2</td>
<td>contamination = possible</td>
<td>2</td>
<td>base material removal</td>
</tr>
<tr>
<td>1</td>
<td>contamination/activation = present</td>
<td>3</td>
<td>liquids possible migration</td>
</tr>
</tbody>
</table>

## BR3 pilot PWR

<table>
<thead>
<tr>
<th>category</th>
<th>contamination risk</th>
<th>decontamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>cold excluded</td>
<td>not required</td>
</tr>
<tr>
<td>1</td>
<td>suspected</td>
<td>not confirmed</td>
</tr>
<tr>
<td>2</td>
<td>contaminated</td>
<td>confirmed no migration</td>
</tr>
<tr>
<td>3</td>
<td>severely contaminated</td>
<td>possible migration</td>
</tr>
<tr>
<td>4</td>
<td>activated</td>
<td>activation</td>
</tr>
</tbody>
</table>
Building release working method simplified schemes for Thetis & BR3

**Thetis open pool**

- History ↔ Nuclide vector
- Control measurements during & after dismantling
- Final characterization
- Decontamination necessary
- Release of the Thetis building

**BR3 pilot PWR**

1. Inventory
2. Preliminary Classification
3. Detailed Characterization
4. Fine Tuning Classification
5. Determination Decontamination Technique
6. Decontamination
7. Characterization for Clearance
8. Denuclearization
BR3: detailed characterization prior to decontamination contamination depth: development of an NDA method

traditional

NDA & geostatistical data treatment

multiple photo peak method
Contamination depth recent developments

- HR-ISGS (HPGe), MR-ISGS (CZT, LaBr3), total beta, dose rate, gamma camera
- Geostatistical data treatment
The use of in-situ gamma spectroscopy in view of building release
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- Similarities in the implementation of clearance practices in different decommissioning projects are existing.

- However, the implementation can be very different depending on the installation, size of building & installation, main use, radionuclides involved, main process conditions & hazards (aerosol, aqueous liquids, strong acids/alkaline, radiation protection program during operation, zoning & control measurements, history of incidents, knowledge of the installation/incidents, etc.).

- Therefore, harmonization is only possible to some extent.

- Development is still ongoing.
Thank you for your attention. Questions?
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