Strategic Aspects on Waste Management in Decommissioning

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Background

• O1/O2 early retirement due to current market situation
• OKG decided to perform a waste management strategy investigation (2016)
• A decision base for the global strategy
• The investigation includes all material and waste from decommissioning, based on the decommissioning studies of O1 and O2.
## Waste Led Decommissioning

### Important principles

| Prior to dismantling and demolition — mandatory with a plan for materials and waste arising |
| Zero tolerance for waste streams without defined and accepted disposition route |
| All radioactive and potentially radioactive materials must be registered in accordance with a defined procedure |
| Data shall immediately be registered and quality assured. |
| Traceability throughout the process up to disposition (confirmed end-state) |
| The Material and Waste Management should not be a limiting factor during dismantling and demolition. |

Do not bottleneck the waste routes!
Waste Led Decommissioning

- The cost for management of radioactive waste is not proportional against the radioactivity content
  - “Extremely Low Risk” is very low cost (material value)
  - “Low Risk” is low cost
  - “Risk” can be low cost
  - LLW is expensive due to large volumes
  - ILW is expensive due to high handling costs
- A weak waste management process drives “hidden costs”
- Frequent and fast removal of material and waste will increase the performance in the decommissioning project
- Reconditioning is expensive – make it right the first time
Decommissioning Waste Strategy

Process overview

1. Define End-States
2. Define Initial State
3. Describe the Waste Routes
4. Evaluate the alternatives
5. Risk Analysis
6. Conclusions
   Recommendations
Step 1: Available End-States

- **General clearance**
  - Reuse
  - Recycling
  - Disposal as conventional waste

- **Conditional clearance**
  - Reuse, recycling or disposal with conditions
  - Significantly higher clearance levels

- **Disposal in VLLW repository (Landfill)**
- **Disposal in the geological repository**
Step 2: Initial State

• Take benefit of operational history and the available characterisation information. The more you know – the better

• Categorisation of material and waste based on radiological and non-radiological properties

• Strategic decisions on large components

• Quantify volumes and masses

May have to be revisited several times throughout the strategy process
## Waste Categories

<table>
<thead>
<tr>
<th>Waste Category</th>
<th>Specific activity [Bq/g Co-60]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extremely Low Risk</strong></td>
<td>Contamination <strong>cannot</strong> occur</td>
</tr>
<tr>
<td><strong>Low Risk</strong></td>
<td>Contamination of significance for clearance <strong>should not</strong> occur</td>
</tr>
<tr>
<td>Risk</td>
<td>&lt; 0,1</td>
</tr>
<tr>
<td>LLW-1</td>
<td>0,1 – 1</td>
</tr>
<tr>
<td>LLW-2</td>
<td>1 – 20</td>
</tr>
<tr>
<td>LLW-3</td>
<td>20 – 100</td>
</tr>
<tr>
<td>LLW-4</td>
<td>100 – 1 000</td>
</tr>
<tr>
<td>ILW</td>
<td>&gt; 1 000</td>
</tr>
</tbody>
</table>
### Amounts of Materials and Waste

<table>
<thead>
<tr>
<th>Waste category</th>
<th>Total [Mg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely low risk</td>
<td>221 400</td>
</tr>
<tr>
<td>Low risk</td>
<td>Not quantified</td>
</tr>
<tr>
<td>Risk</td>
<td>11 400</td>
</tr>
<tr>
<td>LLW-1</td>
<td>6 540</td>
</tr>
<tr>
<td>LLW-2</td>
<td>1 350</td>
</tr>
<tr>
<td>LLW-3</td>
<td>997</td>
</tr>
<tr>
<td>LLW-4</td>
<td>1 805</td>
</tr>
<tr>
<td>ILW</td>
<td>2 440</td>
</tr>
</tbody>
</table>

- **Extremely low risk + low risk**: Green
- **Risk**: Orange
- **LLW 1-4**: Pink
- **ILW**: Red
Low Level Waste

Activity distribution

Waste type

- Large components
- Other metal
- Incinerables
- Other

LLW-1  LLW-2  LLW-3  LLW-4
Step 3: Alternative Waste Routes

- Dispose waste as is after dismantling i.e. no treatment
- On-site waste treatment centre inside facility
- On-site waste treatment centre outside facility but on site
- Ship to dedicated external waste treatment facility

Large waste volumes for disposal
Logistical challenge
Low investment
High investment
Minimum impact on dismantling process
Transfer of risk
Less volume for disposal
Step 4: Evaluate the Alternatives

Quantify

• Direct costs
• Indirect costs (including estimate of hidden costs)
• Investments in facilities and equipment
• Investments in competence
• Utilisation of organisation over time
• Utilisation of available disposal volume

• Impact on project performance (schedule)

Evaluate and compare

The major cost driver in a D&D project
Distribution of costs for Low Level Waste
Step 5: Risks - Risk analysis

• Uncertainties
  – Known Knowns (low uncertainty)
  – Known Unknowns (possible to estimate)
  – Unknown Unknowns (impossible to quantify)

  ➢ Reduced by additional characterisation activities of Known Unknowns
  ➢ Mitigated by wider acceptance window for treatment/disposition

• Practical considerations
  – Availability of waste routes and disposition alternatives
  – Efficiency in processes
  – Where and how to recondition prior to future disposal, if needed

  ➢ Reduce risks by keeping at least two waste routes and disposition alternatives open for each waste category
## Risk analysis (excerpt)

<table>
<thead>
<tr>
<th>Risk description</th>
<th>Probability</th>
<th>Consequence</th>
<th>Cost impact</th>
<th>Mitigation to reduce risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor characterisation/categorisation of radiological and non-radiological properties</td>
<td>U-L</td>
<td>Additional efforts which delays the project</td>
<td>L-H</td>
<td>Robust processes, Record management, Quality assurance</td>
</tr>
<tr>
<td>Non-clearable waste to clearance station</td>
<td>E</td>
<td>Re-routing of waste. Failure investigation</td>
<td>L</td>
<td>Education, Eng. barriers Quality assurance</td>
</tr>
<tr>
<td>New requirements for final disposal of waste</td>
<td>L</td>
<td>Opening of waste packages, Additional sampling Reconditioning</td>
<td>L-M</td>
<td>Reversibility, Precaution measures, Record management, Dialogue with repository owner</td>
</tr>
</tbody>
</table>

Unlikely – Likely - Expected    Low – Medium - High
Conclusions - Example

INITIAL STATE ➔ Facilities ➔ WAC ➔ Availability ➔ END - STATE

- Route 1
- Route 2
- Route 3
- Route 4

Availability: WAC

Risk: Cost
Conclusions – Specific O1/O2

STRATEGIC ASPECTS ON WASTE MANAGEMENT IN DECOMMISSIONING - WORKSHOP IN SARPSBORG, NORWAY

Stakeholders

Initial State

Surface repository

Off-site treatment

Local clearance

SFR

Facilities

WAC

Availability

Risk

Cost
Summary

- Secure End-states and understand Initial state
- Characterisation
- Minimize “Known Unknowns”
- Do not bottleneck Waste Routes
- More than one waste route - where possible

Implementation of Waste Led Decommissioning – a way to success

Thank you for your Attention!