Czech Disposal Canister Programme

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WG-2 Canister Design
IGD-TP, Cordoba 10/2016
Content:

1. RD canister programme
2. Ideas / topics of interest
3. Cooperation - services
Disposal canister R&D

Current status of R&D:

• Canister design (double-walled, internal inbuild)
• Experimental approval of candidate materials
• Manufacturing the prototype: diameter 1:1, 1/2 the length

Candidate materials:

<table>
<thead>
<tr>
<th>Material</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon steel</td>
<td>EN 10222-4 P285QH, (ASTM A106 /A106M -15 Grade B)</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>EN 10088-2, 1.4462 (AISI 317 LN); Austenitic-feritic stainless steel EN 10088-2, 1.4404 (AISI 316L); Austenitic stainless steel</td>
</tr>
<tr>
<td>Copper</td>
<td>EN1652, Cu-OF, CW008A, (ASTM B152M – 13, UNS C10100)</td>
</tr>
<tr>
<td>Titanium alloy</td>
<td>ASTM B 265-15, Grade 7</td>
</tr>
</tbody>
</table>
Canister design

Two concepts of design:

**Corrosion acceptable**
- Outer shell - Carbon steel
- Inner shell - Stainless steel

**Corrosion resistant**
- Outer shell - Copper / Titanium alloy
- Inner shell - Carbon steel
<table>
<thead>
<tr>
<th>Canister type</th>
<th>Corrosion acceptable</th>
<th>Corrosion resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VVER 440</td>
<td>VVER 1000</td>
</tr>
<tr>
<td>Internals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spacing</td>
<td>170</td>
<td>300</td>
</tr>
<tr>
<td>Inner Ø</td>
<td>535</td>
<td>721</td>
</tr>
<tr>
<td>Outer Ø</td>
<td>555</td>
<td>741</td>
</tr>
<tr>
<td>Thickness</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Outer shell</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inner Ø</td>
<td>565</td>
<td>751</td>
</tr>
<tr>
<td>Outer Ø</td>
<td>805</td>
<td>1025</td>
</tr>
<tr>
<td>Thickness</td>
<td>120,0</td>
<td>137,0</td>
</tr>
<tr>
<td>Bottom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>180,0</td>
<td>206,0</td>
</tr>
<tr>
<td>Lid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>280,0</td>
<td>280,0</td>
</tr>
</tbody>
</table>
Canister design

Requirements

• Legislative requirements Decree No.317/2002 Coll. (criticality, mechanical resistance, radiation protection)
• Temperature <95°C,
• Pressure 20MPa

Calculations

• Inventory
• Criticality
• Radio-shielding
• Mechanical
• Thermo

Canister design

• Double walled
• Internal inbuild
Experimental approval

Aerobic corrosion experiments
Influence of contact with bentonite

- Material tested: – carbon steel
- Conditions: Ca-Mg bentonite, dry density 1.6g.cm\(^{-3}\), saturated with synthetic granitic water, temperature 70°C, pressure 5MPa

Anaerobic corrosion experiments
Influence of ionizing radiation

- Material tested: – carbon steel, Cu, Ti-alloy
- Conditions: samples were placed in synthetic bentonite pore water, temperature 90°C, emitter \(^{60}\)Co, absorbed dose approx. 2.5 kGy/a, dose rate 0.3Gy.h\(^{-1}\)
Experimental approval

Influence of contact with bentonite

- Materials tested: – carbon steel, Cu, Ti-alloy
- Conditions: Ca-Mg bentonite, dry density 1.6g.cm$^{-3}$, saturated with synthetic granitic water, temperature 70°C

Influence of different bentonite suspension and temperature conditions

- Material tested: – carbon steel, Cu
- Conditions: synthetic bentonite pore water, increased concentration of Cl$^-$, SO$_4^{2-}$ (3x, 33x, 100x initial concentration – 558.1mg/l Cl$^-$ and 2325mg/l (SO4)$_2$- ), temperature 40, 70, 90°C
Experimental approval

Stainless steel corrosion
• Materials tested: – stainless steel EN 1.4462, EN 1.4404
• Conditions: synthetic bentonite pore water
  ✓ DGR conditions
  ✓ Critical concentration of Cl-
  ✓ Corrosion cracking

Galvanic corrosion
• Conditions: synthetic bentonite pore water
• Materials tested: carbon steel / Cu
  carbon steel / Ti-alloy
  carbon steel / stainless steel

Embrittlement induced by hydrogen
• Materials tested: stainless steel, Ti-alloy,
• Conditions: synthetic bentonite pore water

MaCoTe experiment (Grimsel Test Site, partners: Nagra, RWM, NWMO, SURAO)
Manufacturing the prototype

- Detail design drawings

- Technological procedure of manufacturing
  - Internals
  - Inner shell + lid
  - Outer shell + lid

- Welding technology (welding dimension to 130mm)
- Anealing of welds
- Surface finishing
- Leak test
Ideas / topic of interest

- **Full-scale demonstration test**
  - Handling technologies
  - Long term behaviour in the DGR conditions

- **Welding technology**
  - Simulation of loaded canister with SNF- welding of the lid

- **Coating**
  - Technology of coating
  - Alternative coating (basalt ?)
Cooperation - services

Canister design

- Calculations (mechanical, thermo, shielding, criticality)
- Drop model calculations
- Detail design drawings

Demonstration of manufacturing technology

- Experience in the canister manufacturing (storage CASTOR casks)
- Patent on internal inbuild of the storage cask (SJS)
- Machining of canister components (body, bottom, lid)
- Welding
- Anealing of welds
- Surface finishing
Cooperation - services

- Experimental approval

**Laboratory** conditions (glove boxes, ionizing radiation)

**In-situ** – URL Bukov (corrosion tests, full-scale tests)

<table>
<thead>
<tr>
<th></th>
<th>URL Bukov (600 m)</th>
<th>Rozna (below 1000m)</th>
<th>Grimsel Test Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.23</td>
<td>9.44</td>
<td>9.6</td>
</tr>
<tr>
<td>Na [mg/l]</td>
<td>16.53</td>
<td>89.42</td>
<td>15.9</td>
</tr>
<tr>
<td>K [mg/l]</td>
<td>2.14</td>
<td>0.67</td>
<td>0.15</td>
</tr>
<tr>
<td>Mg [mg/l]</td>
<td>8.32</td>
<td>0.67</td>
<td>0.013</td>
</tr>
<tr>
<td>Ca [mg/l]</td>
<td>34.59</td>
<td>1.32</td>
<td>5.08</td>
</tr>
<tr>
<td>Sr [mg/l]</td>
<td></td>
<td></td>
<td>0.161</td>
</tr>
<tr>
<td>F [mg/l]</td>
<td>9.93</td>
<td></td>
<td>6.26</td>
</tr>
<tr>
<td>Cl [mg/l]</td>
<td>3.32</td>
<td>18.7</td>
<td>5.5</td>
</tr>
<tr>
<td>SO4 [mg/l]</td>
<td>20.98</td>
<td>10.47</td>
<td>5.5</td>
</tr>
<tr>
<td>HCO3 [mg/l]</td>
<td>168.66</td>
<td>163.52</td>
<td>25.62</td>
</tr>
<tr>
<td>CO2 suma [mg/l]</td>
<td></td>
<td></td>
<td>&lt;7E-10</td>
</tr>
</tbody>
</table>

Legend:
- SGW
- GRIMSEL GTS
- Bukov
- Rozna
Thank you for your attention

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