OPAL Decommissioning
Design Considerations

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Contents

• General Overview of OPAL Structure
• OPAL Decommissioning at Design Stage
• Material Selections
• Design Considerations for Dismantling
12/12/07 ACAM-2007: CNS at OPAL, S. Kim

HIFAR 10MW Shutdown Jan 2007

Moata 100 kW Shutdown May 1995

Buffer Zone, 1.6 km radius from HIFAR

OPAL, 20MW, Opened 20/4/07
Reactor Tank, H$_2$O, Stainless Steel

Reflector Tank, D$_2$O, Zicalloy

Leak Detection Channel

CNS

Fuel

Beam Tube
Built for Decommissioning

- 'Chapter 19' - Decommissioning
  - Part of OPAL Tender Specification
  - Based on lessons learnt from Moata/HIFAR and other overseas decommissioning examples
  - IAEA recommendations
- Dedicated System Level Coordinator
  - Independent to other OPAL System review team
- World’s first?
  - Plan Funeral before Birth: Complete Life-cycle.
<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Half-life</th>
<th>Decay Mode/Major radiation</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{24}$Na</td>
<td>15 h</td>
<td>$\beta/\gamma$</td>
<td>Aluminium</td>
</tr>
<tr>
<td>$^{27}$Mg</td>
<td>9.5 m</td>
<td>$\beta/\gamma$</td>
<td>Aluminium</td>
</tr>
<tr>
<td>$^{28}$Al</td>
<td>2.2 m</td>
<td>$\beta/\gamma$</td>
<td>Aluminium</td>
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<tr>
<td>$^{40}$Ca</td>
<td>163 d</td>
<td>$\beta/\beta$</td>
<td>Concrete</td>
</tr>
<tr>
<td>$^{51}$Cr</td>
<td>27.7 d</td>
<td>$\gamma$</td>
<td>SS 304, Aluminium</td>
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<tr>
<td>$^{54}$Mn</td>
<td>312 d</td>
<td>$\gamma$</td>
<td>SS 304</td>
</tr>
<tr>
<td>$^{59}$Fe</td>
<td>2.7 y</td>
<td>$\gamma$</td>
<td>SS 304, Concrete</td>
</tr>
<tr>
<td>$^{58}$Mn</td>
<td>2.8 h</td>
<td>$\beta/\gamma$</td>
<td>SS 304, Aluminium</td>
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<td>$^{59}$Fe</td>
<td>44.5 d</td>
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<td>$^{98}$Ni</td>
<td>76 y</td>
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<tr>
<td>$^{60}$Co</td>
<td>5.3 y</td>
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<td>SS 304, Zircaloy 4, Concrete, Steel</td>
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<td>$^{60}$Ni</td>
<td>100 y</td>
<td>$\beta/\beta$</td>
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<td>$^{65}$Zn</td>
<td>244 d</td>
<td>$\gamma$</td>
<td>Aluminium</td>
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<td>$^{93}$Nb</td>
<td>13.1 y</td>
<td>$\gamma$</td>
<td>Zircaloy 4</td>
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<tr>
<td>$^{92}$Zr</td>
<td>1.5 $10^9$ y</td>
<td>$\beta/\beta$</td>
<td>Zircaloy 4</td>
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<tr>
<td>$^{95}$Nb</td>
<td>35 d</td>
<td>$\beta/\gamma$</td>
<td>Zircaloy 4</td>
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<tr>
<td>$^{95}$Zr</td>
<td>64 d</td>
<td>$\beta/\gamma$</td>
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<tr>
<td>$^{97}$Nb</td>
<td>72 min</td>
<td>$\beta/\gamma$</td>
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<tr>
<td>$^{97}$Zr</td>
<td>16.8 h</td>
<td>$\beta/\gamma$</td>
<td>Zircaloy 4</td>
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<tr>
<td>$^{103m}$Ag</td>
<td>418 y</td>
<td>$\gamma$</td>
<td>Ag-In-Cd alloy</td>
</tr>
<tr>
<td>$^{109}$Cd</td>
<td>463 d</td>
<td>$\gamma$</td>
<td>Ag-In-Cd alloy</td>
</tr>
<tr>
<td>$^{110m}$Ag</td>
<td>250 d</td>
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<td>$^{122m}$Te</td>
<td>57.4 d</td>
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<td>$^{124}$Sb</td>
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<td>$^{132}$Eu</td>
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<td>$^{154}$Eu</td>
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<td>$^{208}$Pb</td>
<td>1.5 $10^7$ y</td>
<td>$\gamma$</td>
<td>Lead</td>
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C= Electron Capture  
$\beta+$= Positron  
$\beta$= Beta Particle  
$\gamma$ = Gamma-ray

Table 19.4/1  
Radionuclides Included for Activity Estimation  
After 40 years of normal operation at full power
Figure 19.4/1  Activity of the Dominant Radioactive Inventory

![Graph showing the activity of different radioactive isotopes over decay time. The x-axis represents decay time in years, ranging from 0 to 30. The y-axis represents activity in TBq, ranging from 1.0E-01 to 1.0E+05. The graph includes lines for Sb-125, Ni-63, Co-60, Ni-59, Eu-152, Eu-154, Nb-93m, and Fe-55.]
Example: Decay of Main Nuclides of Moata

Active Waste: 50% of Reactor Volume
25% Active Waste
1% Active Waste
Example: Dose Rate from Moata
Waste Classification

• Exempt Waste (Free Release)
  - Annual dose to public less than 0.01 mSv

• LLW and ILW:
  - higher than 0.01 mSv/yr
  - less than 2 kW/m³ thermal
  - Short lived: < 400 Bq/g total package
  - Long lived: > 400 Bq/g

• HLW: Not from OPAL
Material Selection

- Long-lived nuclides are minimised near the core
- Designed for 40 years
  - CNS: 10 years - Flange connection.
- Short decay period
Design Features - Easy Dismantling

• Modular sections
  ➢ No unnecessary cutting
  ➢ Can be unbolted using remote handling tool

• Space for dismantling
  ➢ Accessibility of remote handling tools
  ➢ Manoeuvrability of objects

• Underwater Storage & Cutting Facility

• Pipe design
  ➢ Easy to drain active fluids

• Decontamination
  ➢ No hard-to-access cavities
During Operations

- **Operations History**
  - Record - normal and abnormal conditions
  - Radioactive inventory list update

- **Decommissioning Plan**
  - Living Document
  - Update or revise as appropriate
  - Conform to New regulations (IAEA, ARPANSA, etc)
  - New technology in 50+ years time
What is R2-D2?

- **R2-D2 Specification**
  - It came from the peaceful world of Naboo.
  - R2-D2 served the elected monarch aboard the Royal Starship.
  - 0.96 m tall

- **Skills**
  - Arc Welding
  - Buzz Saw
  - Remote Handling
  - Decommissioning Contractor??

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**Australian Government**
The End

Thank you for your attention.
Long Live the OPAL Reactor....
and Happy R.I.P. afterwards

For more information or feedback:
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