NTP Radioisotopes (Pty) Ltd

Conversion Experience Regarding Transition of $^{99}$Mo Production from HEU to LEU in South Africa

G Ball

1st Annual Mo-99 Topical Meeting
Santa Fe, New Mexico, USA, 4-7 December 2011
Outline

- Background
- Conversion Project
- Current Status
- Impact of Conversion
- Challenges
- Concluding Remarks
Background

Map of South Africa

Rossing Uranium Mine
Pelindaba
NNR
Vaalputs
Koeberg

Uranium Mining and Processing
• Established site at Pelindaba in the mid 1960s

• Pelindaba is the Zulu word for “done talking”

• Pelindaba site is 2 361 ha

• 140 Permanent Buildings on the site

• Ecological reserve
Background

- Enriched Uranium Inventory
- Fuel Production Plant
- Nuclear Fuel Assemblies
- Target Plates
- Irradiated plates
- Radiochemical Production Plant
  - Chemical Extraction and purification of Mo-99
- Waste
- Nuclear Waste Management
- Waste Disposal & Storage Facilities
- SAFARI-1 Reactor
  - Target Plate Irradiation
- Local & International Users
- International Market
- Transport Container
  - Design
  - Manufacture, License
- NTP Generator Production
- Depleted Uranium Inventory
- Nuclear Fuel Assemblies
Background

- Development work on HEU process commenced in late 1980’s
- First hot runs (20Ci) took place in 1992
- Tc99m generator tests performed in 1993
- First 100 Ci Mo99 runs performed in 1993
- First generators with NTP Mo99 sold in Q2 1994
- First 200Ci Mo99 runs performed in Q3 1994
- First export Mo99 sales in Q4 1994
Background

– Pilot plant commissioned in 1992 but underwent various changes up to 1994
– New production line comes online in 1995
– Second production line comes online in 2000
– First production line upgraded in 2005
– Third production line under construction
(Required due to conversion)
Conversion Project

Mo-99 Target Conversion Strategic Considerations

- Minimum changes to target, irradiation, handling & chemical processes
- Retention of production capacity
- No interruption in current production
Conversion Project

Conversion to LEU to take place in 2 phases:

Phase 1: Known target technology;
minimum changes at reactor facilities;
minimum process changes.

Phase 2: New target;
changes at reactor facilities and process;
significant benefits

U-Al Dispersion target

Probably higher density target;
retrievable from clad
## Conversion Project

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LEU</th>
<th>HEU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat</td>
<td>Dispersion</td>
<td>Alloy</td>
</tr>
<tr>
<td>Enrichment</td>
<td>19.75%</td>
<td>45.0%</td>
</tr>
<tr>
<td>Uranium density (g.cm⁻³)</td>
<td>2.75</td>
<td>1.42</td>
</tr>
<tr>
<td>Dimensions (mm)</td>
<td>200/50/1.66</td>
<td>200/50/1.66</td>
</tr>
<tr>
<td>Cladding</td>
<td>Alloy</td>
<td>Pure aluminium</td>
</tr>
<tr>
<td>U-235 Loading</td>
<td>Maintain</td>
<td>(or minimise decrease)</td>
</tr>
</tbody>
</table>
Conversion Project

- Theoretical feasibility studies
- Cold experiments on depleted uranium targets
- Test Irradiation Program in SAFARI-1
- Process development and tests on irradiated LEU targets
- Process validation
- Licensing approval process
## Conversion Project

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>2007</td>
<td>Theoretical feasibility studies</td>
</tr>
<tr>
<td>2008</td>
<td>Cold and depleted uranium experiments</td>
</tr>
<tr>
<td>Oct 2009</td>
<td>NNR approval received for test stage and first hot runs commence</td>
</tr>
<tr>
<td>Mar/Apr 2010</td>
<td>Process validation runs performed</td>
</tr>
<tr>
<td>Jun 2010</td>
<td>Submission to NNR for routine LEU $^{99}$Mo production</td>
</tr>
<tr>
<td></td>
<td>Submission of DMF to Medical Regulators commenced</td>
</tr>
<tr>
<td>Jul 2010</td>
<td>Customer tests and validation runs commenced</td>
</tr>
<tr>
<td>Sep 2010</td>
<td>NNR approval received for routine operation with LEU</td>
</tr>
<tr>
<td>Sep 2010</td>
<td>US FDA approves LEU $^{99}$Mo for a customer in the US</td>
</tr>
<tr>
<td>Dec 2010</td>
<td>First large scale commercial FDA approved batch of LEU $^{99}$Mo produced and shipped to US for patient use</td>
</tr>
<tr>
<td>Jun 2011</td>
<td>Routine commercial supply of LEU $^{99}$Mo commenced to some customers</td>
</tr>
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</table>
Current Status

- Commercial supply to customers authorized to use LEU $^{99}$Mo
- Supply of LEU $^{99}$Mo to customers for testing/validation
- Significant investment in infrastructure (primarily due to significantly increased uranium residue volumes)
Current Status

New Dissolution Cell (currently under construction)

(Designed specifically for LEU $^{99}$Mo production)
Current Status

Percentage of LEU 99Mo Runs Performed

Data for 1 Jul – 31 Dec 11 estimated
Impact of Conversion

- Loss of in-house ability to manufacture fuel assemblies and target plates
- Decrease in $^{99}$Mo Production capacity due to less U235 loaded into the targets
- New uranium residue storage facility and additional dissolver line required

True impact

- Increased costs
- Decreased production capacity

BUT it is feasible
Challenges

Customer appetite

– Qualification of $^{99m}$Tc generator manufacturer is significant and costly

– Customers generally see no benefit to themselves in sourcing LEU $^{99}$Mo

– Mixed response to conversion

Political will

– Lacking in some countries but strong in others

– Clear, unambiguous and well communicated political support yields results
Challenges

**Regulatory Complexities**

– The regulatory framework in some countries is complex and cumbersome

– Generator manufacturers have to qualify their products with the individual regulators of each country in which they operate
Challenges

*Logistics*

- Production with both HEU and LEU targets while minimising disruption to supply is a challenge

- $^{131}$I production using LEU targets and the validation and individual medical regulator approval thereof is a major challenge
Challenges

*Economically sustainable $^{99}$Mo production*

- NTP is a full-cost recovery company with no state subsidization
- The sustainability of the $^{99}$Mo market depends on full cost recovery – irradiation, processing and waste
Concluding Remarks

- Wonderful technological success achieved at large scale production volumes
- Great team effort with support from NNSA and AREVA/CERCA
- Solving the technical challenges of large scale $^{99}$Mo production with LEU is but the beginning of conversion
Concluding Remarks

- Market will only be sustainable if the playing fields are level:
  - True full-cost recovery (including cost due to conversion) must be implemented
  - Irresponsible behavior of some producers and governments must cease
  - Generator producers must be prepared to pay the increased prices (and thereby ensure a long-term sustainable supply)
Thank you for your attention