RESEARCH REACTOR
DECOMMISSIONING PLAN

Clédola Cássia O. de Tello
Pablo Andrade Grossi
Brazil

Contents

■ General Aspects
■ Ongoing Activities
■ Decommissioning Plan
■ Conclusion
TRIGA IPR-R1 REACTOR

Four research reactors are operated by the federal research institutes.

<table>
<thead>
<tr>
<th>FACILITY</th>
<th>POWER (kW)</th>
<th>TYPE</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARGONAUTA</td>
<td>0.20</td>
<td>ARGONAUTA</td>
<td>Oper.</td>
</tr>
<tr>
<td>IEA-R1</td>
<td>5,000.00</td>
<td>POOL</td>
<td>Oper.</td>
</tr>
<tr>
<td>IPEN-MB 01</td>
<td>0.10</td>
<td>ZPR TANK</td>
<td>Oper.</td>
</tr>
<tr>
<td>IPR-R1</td>
<td>250</td>
<td>TRIGA-Mark I</td>
<td>Oper.</td>
</tr>
</tbody>
</table>
Reactor Location

Federal University Campus

CDTN (site)

RR Building

Reactor Building

Reactor Facility

Laboratories

Library

Offices

Cafeteria

Restricted Area

Unrestricted Area
Decommissioning options (Priority)

1) Protective storage in an intact condition after removal of all fuel assemblies and readily removable radioactive components and wastes (safe enclosure);
2) Removal of all radioactive materials and thorough decontamination of the remaining structures to permit unrestricted use (immediate dismantling);
The main option is use the area for nuclear proposes since this reactor area is at CDTN’s site, and there are often demands for new nuclear facilities.

- (as a historical museum of a TRIGA technology)

After some decades the final goal will be the unrestricted use of the place, after the full decontamination.

A good solution was adopted by FZK – Forschungszentrum Karlsruhe. The FR2 reactor was decommissioned and the auxiliary installation and rooms were completely decontaminated, so that the area is now a museum of nuclear science [TREN/05/NUCL/S07.55436, 2007].
End State of Decommissioning Activities

Brazilian ongoing activities

- Disassembly procedures and equipments
  - review and updating

- Spent fuel safe storage/transport package (cask in development / dry storage)
  - IAEA regional project
  - prototype performance tests
  - correction of the non-conformities
Latin American Cask

2 basket types (78 TRIGA or 21 MTR elements)  US$ 60,000.00

Prototype – external view  Prototype – internal view

IPR-R1 Lifetime Estimation

- **Codes:**
  - MCNP transport;
  - ORIGEN 2.1 burn-up;
  - MONTEBURNS radioactive decay.

- **Parameters for numerical simulations:**
  - 68 fuel elements inserted on TRIGA core (note: there are 5 fresh stainless-steel elements that have never been used);
  - operation at 250 kW (conservative hypothesis);
  - average work demand based on the past 48 operation years,
IPR-R1 Lifetime Estimation

**Actual Status:**
- reduction of 96 g of $^{235}\text{U}$ mass, regarding to initial mass of 2.3 kg;
- a total burn-up near to 4.17% or 2000 MWh until June 2008.

**Results of Lifetime estimation:**
- The estimated lifetime for the IPR-R1 is of more 34 years with a total burn-up of 3500 MWh.
- The final burn-up of 12.1 % (mean of 68 elements) were observed, indicating a reduction of 307 g of $^{235}\text{U}$ mass.
- The total burn-up of the central elements would be less than 20% (as recommend by the manufacturer).

---

Assessment of type and amounts of RadWaste

- Buried Reactor Pool
- NC
- PC
Assessment of type and amounts of RadWaste

- This simulation will give the first approach for the characterization plan:
  - grid map;
  - equipment;
  - sampling program;
  - radiation protection planning for this tasks.

- Waste management strategy
- Waste and cost minimization.

Brazilian ongoing activities

- Internal and National Standards
  - Joint Convention and decommissioning policy

- Waste management
  - Brazilian Nuclear Program
    - Budget PAC
  - Interministerial Committee
  - National Waste Management Program
    - WM Brazilian Agency
    - Repository for LLRW and ILRW
    - Repository for HLRW
DECOMMISSIONING PLAN

- **QA plan**: there are Quality Assurance Program and a Team that takes care of this subject. For the decommissioning activities will be developed specific procedures, including audits.

- **Radiation Protection, Health and Safety plan**: additional procedures will be developed for the surveillance, characterization, demolishing and decontamination activities, including radiological and non-radiological risks.

- **Characterization plan**: description of characterization (deepness of sampling, grid, number of samples, analysis, etc).

- **Decontamination plan**: radiological criteria for clearance level; decontamination; classification, recycling and reuse of the material.

- **Waste management plan**: segregation and collection procedures, processing options, packaging, storage and disposal routes for the radioactive waste.
Decommissioning Plan Contents

1. INTRODUCTION
2. OBJECTIVE
3. TRIGA IPR-R1 DESCRIPTION
   - Historical
   - Properties and construction aspects
   - Lifetime estimation
   - Location and using area description
   - Drawings and maps
4. DECOMMISSIONING STRATEGY AND END STATE
5. RESPONSIBILITIES

Decommissioning Plan Contents

6. FINANCIAL ASPECTS
7. QUALITY ASSURANCE PROGRAM
8. RELATED DOCUMENTATION
   - Federal Standards
   - CNEN Standards and Procedures
   - CDTN Procedures
   - Environmental Standards
   - IAEA Recommendations
   - Other relevant documents
9. CHARACTERIZATION PROGRAM
- Maps of the installation
- Contamination Level Approach
- Gridding for Sampling and number of samples to be taken
- Clearance Values
- Analysis and Results (Standard Values)
- Destiny of the samples (release or stored as witness)
- Classification of the material as non-radioactive or radioactive waste, recyclable, reusable material

10. TEAMS AND ACTIVITIES (FLOWSHEET)
- Reactor Operation
- Health & Safety
- Radiological Protection
- Waste Management
- Infra-structure & General Maintenance
- Administrative and Financial
- Legal
- Environmental
- Risk, Burn-up and Waste Approach Assessment
- Audit and QA
- Communication
Decommissioning Plan Contents

11. EQUIPMENT AND INSTRUMENT
12. ROUTES
   - Personnel
   - wastes
   - Other Materials
13. EMERGENCY PLAN
14. TIMETABLE
15. CONCLUSION
16. TABLE OF REVISION
17. ANNEXES

KNOWLEDGE DIFFUSION

- “IPR-R1 TRIGA Research Reactor Decommissioning: Preliminary Plan”.
  - International Congress in Santos, Brazil, in October 2007.
- “IPR-R1 TRIGA Research Reactor Decommissioning Plan”
  - IRPA 12 – Buenos Aires, Argentina, October 2008
CONCLUSION

- The Brazilian regulatory body so far do not have a decommissioning policy established, but after some discussion this subject is being addressed.

- IPR-R1 decommissioning planning will be a model used to develop the national regulatory standards on this issue and applied to Brazilian RR and other nuclear facilities.

- The existent individual efforts are being integrated to establish a Decommissioning Group (matrix structure) to perform the decommissioning planning and activities.

THANKS

SALAMAT