RPI

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Institut für Kernchemie, TRIGA Forschungsreaktor Mainz (FRMZ)

Special Topic 2019: Aging management and decommissioning of research reactors.

Campus Tecnológico e Nuclear

- Inaugurated on April 27, 1961, as the Laboratory for Nuclear Physics and Engineering (LFEN).

- *"The essential objective of the activity of the LFEN is the creation of a technical-scientific infrastructure to address the national problems inherent to the use of nuclear energy and, at same time, contribute to the training of staff specialized in the domains directly or indirectly connected to it".*

- Former Nuclear and Technological Institute (a State Laboratory) integrated into IST on March 1st, 2012.

- Staff at time of integration: 68 researchers w/ PhD, 92 technicians.

Reorganization of former Nuclear & Tech. Institute

- Mission:
  - Laboratory for Radiological Protection and Safety;
  - Laboratory for Accelerators and Radiation Technologies;
  - Laboratory for Nuclear Engineering.
- R&D: Center for Nuclear Sciences & Technologies.
- E&T: Department for Nuclear Sciences & Engineering.

Government support to RPI (Decree-Law 29/2012)

- The Government is responsible for:
  - Funding decommissioning of the RPI;
  - Funding refurbishment, due to obsolescence or to improve safety of the RPI;
  - Funding acquisition and removal of fuel for the RPI.

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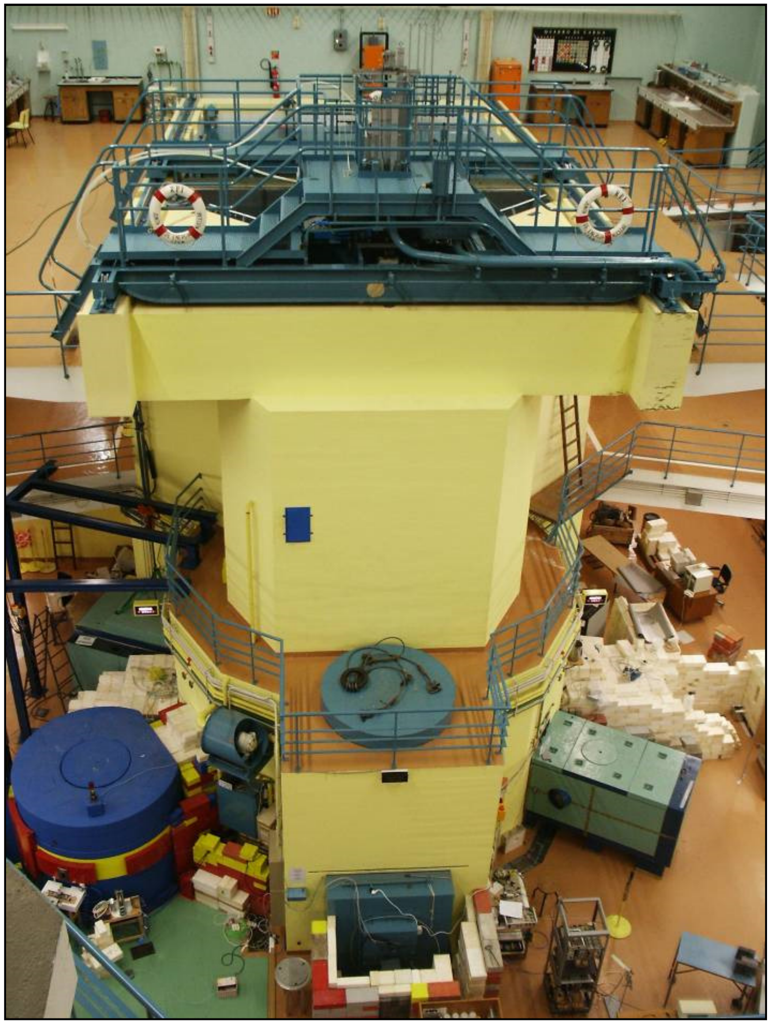
Portuguese Research Reactor (RPI)



- Pool type, 1 MW.
- Similar to FRM (Germany), HOR (The Netherlands), GRR1 (Greece), McMaster (Canada), PARR-1 (Pakistan), TRR (Iran), ...
- First criticality in 1961.
- Converted to LEU fuel in 2007, within IAEA's TC project POR4016.
- Thermal flux: 2×10^{13} n/cm^2/s.
- Fast flux: 0.5×10^{13} n/cm^2/s.
- Only remaining research reactor in the Iberian Peninsula.

- RPI started with LEU fuel on lease.
- HEU fuel acquired in 1974 but only used after 1990.
- Agreement with DOE/USA for return of initial LEU fuel in 1999 and return of HEU until 2009.
- Converted to LEU in 2007 and returned HEU in 2008.
- Enough fuel for about 300 MWd of operation.
- Main fuel back-end solutions:
  - Return current fuel to USA;
  - Reprocess in France (would have waste returned);
  - Options approved by government in the national plan for safe management of spent fuel and radioactive waste (European Directive 2011/70/EURATOM).

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Current status

- This reactor is the only nuclear facility in the country and means to keep alive nuclear knowledge and technology in the country. IST (University) decided to shut down the RPI in May 2016 in order to keep the LEU fuel eligible for return to the USA in case the Portuguese Government decided to follow this disposal path.
- The decision to resume operation or proceed to decommissioning was taken one year later:
  - Proceed to **decommissioning**.
- The RPI only has a very preliminary decommissioning plan.
  - A huge effort is now in place for the near future.

General decommissioning options

- **Immediate dismantling** and removal of all radioactive materials from the site, allowing unrestricted release, to an option of in-situ disposal involving encapsulation of the reactor and subsequent restriction of access.

  •Immediate dismantling involves the decontamination, dismantling and removal of all equipment, structures and other parts of the facility that are contaminated, typically within three years after permanent shutdown.

  •This option normally has the fewest uncertainties, eliminates the risk associated with the facility in a small time scale, normally costs less than deferred dismantling, and allows the use of operational staff who knows the facility and its history.

  •However it may lead to higher worker doses, due to the relatively short decay time of the radioactive isotopes present.

General decommissioning options

- **Deferred dismantling** decommissioning strategy requires that the facility is placed and maintained in a safe, stable, and monitored condition for an extended period of time (some decades) until it is decontaminated or dismantled.

    - A certain number of activities still need to be done immediately after shutdown. This strategy minimizes the initial commitments of time, funds, radiation exposure, waste disposal capacity, and may reduce the quantities of radioactive waste produced.

    - However, there are additional costs associated with providing long term surveillance and maintenance, and the operator has to ensure that sufficient expertise and knowledge will be available at the time of decommissioning.

    - Funding and legislative uncertainties may also be higher. This option puts an undue burden on future generations, which may be socially unacceptable.

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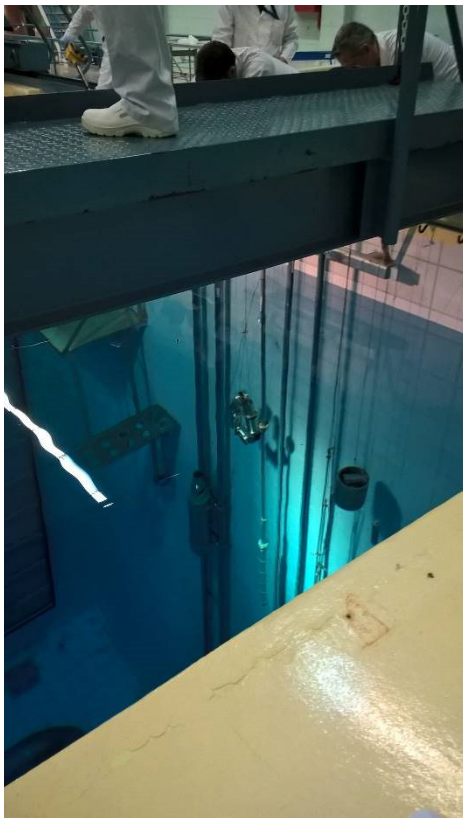
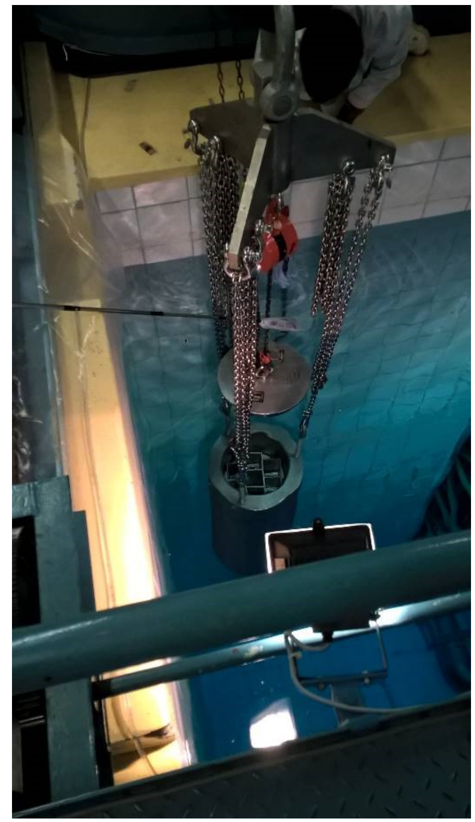
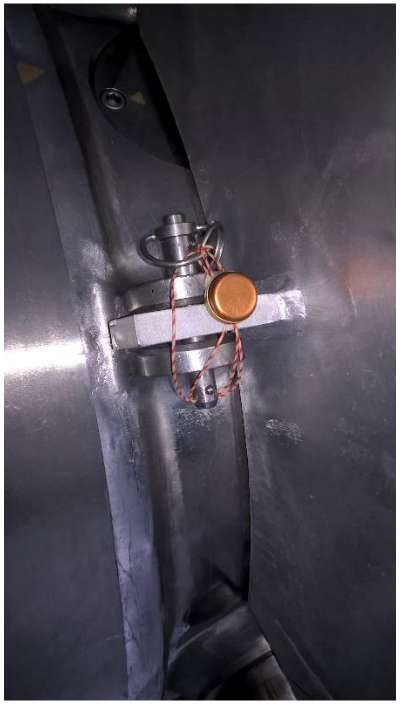
Main fuel back-end solutions

Main fuel back-end solutions





Main fuel back-end solutions



Decommissioning options for the RPI

No real final decisions are still made on the decommissioning of the RPI.

Two basic options for decommissioning are foreseen, depending on the desired endpoint:

- Option 1: Complete dismantling of the pool and re-use of the reactor building;
- Option 2: Demolition of reactor building, with return to green field.

The first phase of the decommissioning for both options, of the order of 2-3 years, ends with the removal of the spent fuel assemblies from the site.

As the operation of the reactor has ceased, the fuel assemblies were taken from the core into the storage racks inside the pool. The pool's water purification system continues in normal operation, with the same water quality control. It is expected that the assemblies will be removed from the site after a cooling period up to 3 years (~~May 2019~~ Feb/March 2019). Free-release materials will be removed where possible during those two years.

Option 1

The first option entails the dismantling of the pool (circa 530 m^3) of concrete, the separation of low and intermediate level wastes (LLW and ILW), with its storage in the Campus, as IST is responsible (Decree-Law nr. 156/2013) for the storage of radioactive waste in the country under the regulatory supervision of COMRSIN. Decree-Law nr. 156/2013 supports the implementation of the concepts of exemption and clearance, with reference levels expected to follow Safety Guide RS-G-1.7 of the IAEA.

Option 2

The second option includes the first and, additionally, entails the dismantling of the reactor building, which is to be taken as a conventional demolition, as all contaminated materials will have been removed by then. Estimates for the costs of these options have not been made.

The Transition Phase

The time period between facility shutdown and the implementation of the decommissioning strategy

Estimated amounts of radioactive waste from the RPI

- The pool of the RPI is large for an AMF reactor with 530 m3 of concrete corresponding to 1855 t. Pool section I of the RPI is lined with stainless steel (AISI 304, 3 mm thick). The area covered by the lining is 185 m2 (167 m2 for the walls, 18 m2 for the floor). A total of 6 t was used for the lining; about 4 t of stainless steel was used for the anchorage points for the plates. Considering the zone surrounding the core and up to 2 m height, one can estimate that about 20 m2 of the lining will be activated, plus 20% of the anchorage points. The dominant isotopes are expected to be 51Cr and 59Fe. The activities can be estimated using the Monte Carlo model of the core that was used for the safety analysis for conversion to LEU fuel.

- Pool section II of the RPI is lined with ceramic tiles, glued with epoxy resin in the 1980s. The area covered by the tiles is 230 m2. No activation of the tiles is expected, as the core has not operated in this section of the pool since the start of the HEU cores and it is not foreseen that it will. Only some surface contamination of the tiles is expected, which should be removed by washing.

- The thermal column of the RPI had a total of 3 m3 of nuclear grade graphite. Approximately 1 m3 of graphite was taken out after some months of operation of the reactor and is in storage, wrapped in polyethylene. The extension of the thermal column (inside the pool) has approximately 0.2 m3 of graphite. The graphite in the extension of the thermal column will be the one most activated.

- Aluminium 6061 alloy is used (i) in structural components, such as the bridge, guide tubes and core grid, (ii) in irradiation facilities such as the beam tubes, the box of the thermal column and the windows of the gamma irradiation facility and of the animal's cage, and (iii) in scattered items such as storage racks. The total amount is estimated at 2 m3.

- The Be reflectors started being used with the HEU cores. The RPI has a total of 7 single reflectors and 4 quadruple reflectors, encased in aluminium. The total volume of the Be reflectors is 1.2 m3. Given the dangers associated with handling of Be, the disposal of these reflectors will probably entail encasing them in custom-made containers. The impurities in Russian-origin Be are generally known (Al, Si, O, Mg, Fe, Cu, Ni, Mn, Cr) and these were considered in the MCNP model of the core.

Major items

Material	Total amount		Estimated amount to be disposed of as LLW or ILW	
	m^3	t	m^3	t
High density concrete (pool)	530	1855	11	37
Stainless steel (lining)	1.2	10.4	0.2	1.4
6061 aluminium alloy	2.0	5.4	1.5	4.0
Graphite	3.0	4.8	3.0	4.8
Tiles	1.0	3.0	0	0
Beryllium reflectors	1.2	2.2	1.2	2.2

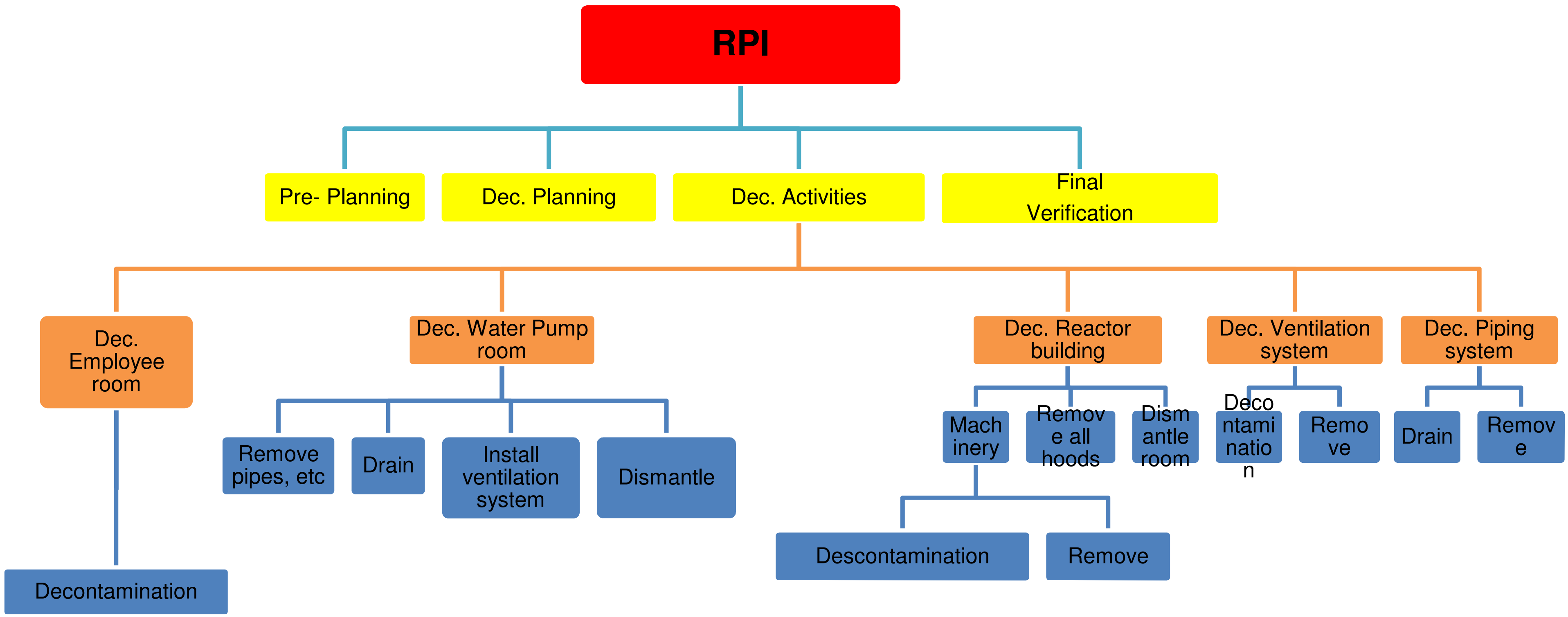
Minor specific items

Material	Number of items	Amount (m^3)
Fission chambers	9	< 0.1
Ion chambers	5	< 0.1
Neutron sources	2	< 0.1
Control rods	10	< 0.1
Shock absorbers	23	< 0.1

Operating organization for decommissioning

- Project management - Management exists
- Finance - Government is responsible
- Human resources – Exists (local)
- Historical Site Assessment - Exists, promote meeting with older staff
- Neighbourhood - Interested parties, to be contacted
- Safety (Radiological Exists (local) and industrial safety aspects To be contracted)
- Engineering - To be contracted
- Licensing – Not yet
- Facility plant and systems - Exists
- Quality assurance - Not complete
- Waste management - To be contracted
- Physical protection - To be contracted
- Emergency preparedness - Not fully complete
- Environmental monitoring - Exists

WBS – Preliminary – since decommissioning plan in under construction



Thank-You