Objectives

The purpose of the meeting is to bring together owners, operators, designers and regulators of RRs in order to discuss issues related to the ageing, refurbishment and modernization of such facilities, including associated challenges, experiences and good practices.

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Until 1988 IPEN was called the Institute of Atomic Energy. The State of São Paulo was economically responsible.

1990 - goes to the federal government - Ministry of Science and Technology - federal grant.

Main gate of the Research Reactor Center
C- technical topics

• A.1 General Topics
  • a) General experience and activities performed to collect/comprehend and overcome the risks and drawbacks from ageing of RRs.
  • b) Ageing management programmes (AMPs) and experience related to their application.
  • c) IAEA-issued guidance documents and standards on RR ageing and their effect on national or facility specific AMPs, plus experience after nearly 15 years of application.
  • d) Preventive and predictive maintenance, warehousing of spares, periodic testing and in-service inspection, and other mitigation practices.
  • e) Proactive strategies for ageing management, including considerations of ageing and ageing management activities in different phases of RR lifetime (design, fabrication, construction, commissioning, operation, maintenance, utilization and modification and decommissioning).
  • f) Periodic safety reviews for RRs (including the evolution of regulations, applicable engineering codes and standards, ageing considerations in initial or updated licensing documents; in particular the safety analysis report, operational limits and conditions, etc.).
  • g) Prevention/delay of the need for promoting/launching new RRs through ageing management/mitigation measures.
  • h) Availability of data on ageing of materials/components and the consideration of ageing during design.
  • i) Design features for (easy) component replacement due to limited lifetime and lifetime surveillance features, e.g. test sample irradiation.
  • j) Combining ageing prevention/mitigation measures with performance upgrades.
  • k) Experience from component replacement projects due principally to ageing of their structures, systems and components (SSCs) (project experience, verification of predicted project schedules). How did ageing of the facility or the age of its SSCs challenge implementation of the project?
  • l) Ageing of staff/succession planning.
  • m) Ageing of documentation, including design documentation and configuration management issues.
  • n) Existing and future means to share experience related to RR ageing.

• A.2 Specific topics (examples only: not an exhaustive list)
  • o) Ageing (including obsolescence) of instrumentation and control systems.
  • p) Ageing of electric cables (power supply and signal cables).
  • q) Ageing of high-performance reflector/thermal column materials (beryllium, graphite) and related measures/services.
  • r) Radiation ageing of lubricants and related experience.
  • s) Ageing of pool liners and spent fuel storage tank pits, spent fuel bays (tile/brick lined) and related preventive measures (materials, welding, cleaning, repairs, chemistry).
  • t) Ageing of mechanical systems (cooling and containment systems).
  • u) Ageing of materials at very low temperatures (cold neutron source materials).
  • v) Experience in heat exchanger/delay tank ageing and related preventive maintenance and/or repairs.
  • w) Hot cell based equipment and procedures for investigating/testing of aged materials and components; availability worldwide.
  • x) Ageing of experimental facilities such as beam tubes and irradiation loops.
Ageing Management Programs (AMPs) strategies relate to future projects in two ways:

1. if you will build a new research reactor you will probably have to decommissioning the old reactor.

2. if you do not intend to build a new research reactor so early then you will manage the ageing, modernize it and improving it.

Example: Brazil has a project to become independent in the radiopharmaceuticals production. The IEA-R1 Reactor is limited in its power and neutron flux, therefore, does not satisfy these fully requirements.
Solution...
For it Brazil is building a multipurpose reactor of 30 MW.
IEA-R1 Research Reactor

- IEA-R1, MTR – type, is the largest research reactor in Brazil, with a maximum power rating of 5 MWth.

IEA-R1 is a pool reactor, with light water as the coolant and moderator, and graphite and beryllium as reflectors. The reactor was commissioned on September 16, 1957, when it achieved its first criticality, and it is located at the Institute of Nuclear Research and Energy (IPEN), in São Paulo city. Although designed to operate at 5 MW, the reactor operated only at 2 MW between the early 1960’s and mid 1980’s, on an operational cycle of 8 hours a day, 5 days a week.

IEA-R1 is currently operating at 4.0 MWth (until July 27, 2011) and 4.5 MWth (from August 01, 2011) with a 64-hour cycle per week.

The reactor originally used 93% enriched U-Al fuel elements. Currently, it uses 20% enriched uranium (U₃O₈-Al and U₃Si₂-Al) fuel that is produced and fabricated at IPEN. The reactor is operated and maintained by the Research Reactor Center (CRPq) at IPEN, Sao Paulo, which is also responsible for irradiation and other services.

- Since 2008, a concentrated effort has been made in order to upgrade the reactor power to 4.0 - 4.5 MWth 2011/12/13/14 and 5 MWth to 2015/2016. One of the reasons for this decision was to produce $^{99}$Mo at IPEN, thus minimizing the cost and reliance on only one or two international suppliers.
"Atoms for Peace" was the title of a speech delivered by U.S. President Dwight D. Eisenhower to the United Nations General Assembly in New York City on December 8, 1953.

The United States then launched an "Atoms for Peace" program that supplied equipment and information to schools, hospitals, and research institutions within the U.S. and throughout the world. The first nuclear reactors in Iran and Pakistan were built under the program by American Machine and Foundry.

On September 1955, under the program’s umbrella, both US and Brazilian governments agreed to construct a swimming-pool type research reactor in São Paulo, Brazil and the task was concluded on 1957. (MTR - type)(Babcock& WilcoxCo.) First reactor operating in the southern hemisphere
1958 - Official Inauguration
Juscelino Kubitschek
Janio Quadros
Prof. Marcelo Damy
1977-1978 – replacement of the original ceramic tiles pool lining by stainless steel plate.
1977-1978 – renewal of the reactor control system, designed by G.A.
1995-1996 – due the corrosion damages occurring over all surface of the silica inner lining, a full spectrum substitution of secondary circuit piping was implemented.
1999 – The storage racks were almost full, however based on the US policy to accept (Research Reactor Spent Nuclear Fuel Acceptance Program) the MTR fuel assemblies originally enriched in the United States, IPEN negotiated with DOE (Department of Energy/USA) and returned 127 spent fuel assemblies (SFA) in 1999 and additional 33 assemblies in 2007.
2004 – Replacement of four reactor control rods.
2004 – Pool water treatment and purification system.
2007 – new heat exchange. Studies regarding ageing program were conducted according to IAEA procedures described in the TR 338 (2001) and Technical document 792 (1995).
• - Replacing All auxiliary instrumentation racks at the reactor control room.
2012 – Exchange of the secondary circuit pumps (2).
2012 – Reactor pool floor adjustment to the standards of radiation protection (epoxy floor)/
   – reform of the engine room (basement).
   – Repair of the emergency stairs and signaling of fire.
   – exchanging of the cooling tower due to loss of heat exchange efficiency to 5 MW.
   – exchanges of guy wires and tensioning of the ventilation and exhaust system chimneys due to corrosion.
2014 – exchange the pipe primary cooling circuit.
2016 – replacement the new control console. manufacturing phase.
2016 – New design for the next year - four control rod plated with stainless steel, produced at IPEN – stage testing and commissioning.
Almost twenty years after the reactor first criticality, operational staff start noticing severe primary water leakages, because a huge number of the original ceramic tiles lining become not functional and were no more fixed at the pool walls.

Then, great effort was done that culminated with a complete removal and replacement of the original ceramic tiles pool lining by stainless steel plates, as well as a full renewal of the reactor control system, designed by General Atomic Company, USA.

Original control console - 1956

• Area Monitors - Geiger Muller
• Monitors Air - scintillators
• Treatment and Retreatment Pool Water.
• Ventilation System - Normal and Emergency Exhaustion
• Vibration System
• Sinoptic Pool Water Level
• Safety Valves Control
The modernization of the control room is the first phase of the project to exchange the main console where is located the nuclear instrumentation.
1991

- Water treatment system boundaries were covered with a lead radiological shield, significantly reducing radiation exposure during the system’s maintenance by trained personnel.

1995 - 1996

- Due to corrosion damages occurring over all surface of the silica inner lining, a full spectrum substitution of secondary circuit piping was implemented, achieving a reasonable safety operational level for the secondary circuit.
Ageing Management

IAEA
Division of Nuclear Fuel Cycle and Waste Technology
Research Reactor Group

Reactor Details

<table>
<thead>
<tr>
<th>Name</th>
<th>IEA-R1</th>
</tr>
</thead>
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<tr>
<td>Operator</td>
<td>IEA-R1</td>
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<tr>
<td>Country</td>
<td>Brazil</td>
</tr>
<tr>
<td>Power (MW)</td>
<td>5,000</td>
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</tbody>
</table>

Affected system(s) (indicate on following page)

1.8 Beam tube heads (in pool)

Ageing Mechanism(s) (see list on following page)

Corrective maintenance of beam holes (BH4 and BH14): piping substitution, valves and general cleaning; shielding substitution; implementation of a water reservoir to improve neutron shielding.

Description of issue(s) (Please limit facility descriptions and details to the minimum required to explain the issues / events.)

IEA-R1 beam holes (BH's reactor irradiation system) deteriorated during the last few years (since 2005), showing small primary water leaking points. Risk analysis showed that the worst scenario could occur with the tangential beam hole and it was decided to proceed a general maintenance of this BH.

Description of mitigating or corrective action(s) (technical, administrative, preventive, organisational, etc.)

It was done an internal disassembling of this BH and later the substitution of the hole cladding.

Contact detail

If someone is available to discuss and/or share additional information with staff of other research reactors, please provide their contact information below.

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Comments

Thank you for your support of this effort. If you have any additional comments or related information to share regarding the IAEA's work on research reactor Ageing Management, please use the field below. In particular, descriptions of specific Ageing Management practices (inspection, tests, preventive maintenance programmes, etc.) would be very valuable. If copies of Ageing Management procedures or programmes can be shared, electronic copies may be mailed to the responsible officer listed in the footer of this template.

none
Beam Hole problem

- Old pneumatic system
- New pneumatic system
- Beam hole
- Tangential Beam Hole
Problem 1
In July 2013 it was found a high degree of corrosion in the primary cooling system pipe supports.
Bolts of flanges also had some corrosion.
**Corrective Actions:**
1. visual inspection of all piping and flanges;
2. gammagraphy;
3. preparation of new supports;
4. exchange of all screws of the flanges;

Problem 2
Some screws had to be taken with blowtorch and a lot of strength. With this they appeared in the weld flanges of micro fissures.

**Corrective Actions:** the problem was discussed in the internal reactor security committee together with the Nuclear Engineering Center staff.
The decision was the exchange of all piping and flanges. Improvement the entire shelter and resize the shield.
NEW SUPPORTS PROJECTS

Heat exchange A and B

ISOLATION VALVES

WATER FLOW DIRECTION

Decay tank
Modernization and Refurbishment

1971 - Full replacement of the air ventilation system, assuring negative pressure inside containment building.
1979 - update - pneumatic irradiation system.
1980 - 1981 - core conversion (93% to 20% grade of U235) to Low Enrichment Uranium (LEU).
1982 - IPEN metallurgical department concluded that could be fabricated the fuel element for IEA-R1.
1985 - Improvement in the control instrumentation
1987- 1988 - implementation of two separate operational areas inside the reactor containment building, allowing a better response in eventual radiological emergencies and in compliance with Radiological Emergency Plan procedures.

New tower
1988 – Conversion HEU to LEU has started with the introduction of the first Brazilian made fuel element of U3O8-Al. In order to optimize the neutron flux and to have enough reactivity for continuous operation profiles strategy, the size of the core was changed from 30 to 25 fuel assemblies with 2.3gU/cm3.
1991 - 1992 - water treatment system boundary were covered with a lead radiological shield.
1995 - reactor will operate continuously 64 hours per week with a 6 hour shifts.
1996 - new fire-detection and fire-fighting equipment like smoke detectors, sprinklers, hydrants.
• Major maintenance job in the old cooling tower,
• change of pipe lines,
• installation of new air conditioning and exhaust system,
1996 –Installation 2 drawer type valves and 02 ball valves type isolation of the reactor pool. They are able to move from fully open to fully closed in 20-60 seconds, or vice versa.
1997 – replacement of area and duct radiation monitors.
1997 - Installation of new ventilation and air conditioning system.
1997 - Installation of an emergency spray core cooling system, spray water directly into the core to prevent meltdown.
1997 - four isolation valves in the Primary Cooling System to prevent accidental drainage of the pool water
1999 – introduction the beryllium device at the center of reactor core.
2000 - Data Acquisition system – SAD - implementation of an online data acquisition system with full capabilities.
2001 - Development of a reliability data base – IAEA Co-ordinated Research Project (CRP)
2001 – Vibration monitoring system
2001 –mapping of neutron flux using SPND.
2001 -Use of reatímetro (matlab software) for configuration changes, rod calibration and reactivity gain.
2003 - A huge amount of improvements were done by operational staff, including a new water treatment system (primary and secondary coolants).
2003-2004 - substitution of the former safety rods by new absorbing devices fabricated on-site.
2005 - Replacement of 13 graphite reflectors with Beryllium.
2007 - Replacement of primary heat exchanger.
2007 - Evaluation of Trellis support plate of the fuel elements.
2006 - 2007 new pneumatic irradiation system.
2006 - Replacement of several radiation detectors
2008 - Installing a voltage stabilizer for protection of the control console and auxiliary systems.
2010 - With cooperation of the Nuclear Engineering department and considerable effort from Nuclear Metallurgy staff, the first fuel element with fixed instrumentation for collecting thermal parameters inside and outside cladding was placed inside reactor core, allowing continuous online surveillance during operation.
2011 - In another set of improvements, reactor’s operational thermal power was increased to 4.5 MW, allowing irradiation of fuel plate mock-ups with varying fuel densities.
• At the same time, another goal was the upgrading of electronic racks settled at the Control Room,
• as well as the initial operation of a meteorological tower that provide the Emergency Planning staff with accurate real time data regarding atmospheric conditions.
2012 - Reactor pool floor adjustment to the standards of radiation protection (epoxy floor)/
• floor retrieval engine room in the basement (basement) of the reactor and distress signals for the event of fire.
2013 - Modernization of the main gate of the Research Reactor Center to better personal control, emergencies and physical protection.
• Modernization of reactor mechanical workshop
• Structural and electrical modernization of the diesel generators building.
2014 – Improvement to the electrical discharges ground for reactor building.
OPERATIONAL HISTORY HIGHLIGHTS
1974 - stages of modernization and improvements.

diesel power generators

New cooling tower

Second heat exchanger

N-16 decay tank
Cooling Primary Circuit Pump - INERTIAL WHEEL.

Decay tank installation
Replacement of control rods CB4 by bar type fourchette composed of Ag, In and Cd.

Pneumatic System Improvement
Radiological Protection Plan – PER / Physical Security Plan - PSF

2012 - Entrance and exit controlled by badge and cameras.
Beryllium irradiation device
Reactor Modernization Program for 2016

- 2016 - New design for the next year is four control rod plated with stainless steel, produced at IPEN.
- 2016 - Replacement of control console, commissioning and operation - 2016.
- 2016-2017 - new storage racks baskets.
- 2016 - New project for storing waste liquid from the reactor building.
  - Repair and modernization of the reactor holding tank. This tank is able to receive all the water from the reactor pool in case of accidents through loss of coolant.
Thank you for your attention