# Experience of Ageing Management at 14Mw TRIGA Research Reactor from INR Pitesti, Romania

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# Research Reactor Utilization for Power Plant nuclear fuel and nuclear materials testing

- The 14 MW TRIGA Research Reactor was designed to accommodate several irradiation devices in core positions with significant flux spectrum for nuclear fuel and materials testing with maximum thermal neutrons flux 3.2 E+14 and fast flux 1.2 E+14
- The reactor core configuration is flexible and can be arranged in order to allow installation of 1 to 5 irradiation devices in vertical channels.
- The irradiation devices are natural convection (capsules) and forced convection loop operating with pressurized water at power reactors pressure, temperature and chemistry.
- The main irradiation programme for qualification of manufacturing technology for nuclear fuel and zirconium alloys was developed between 1982 till 1996. Starting from 1994 a new irradiation programme was designed and developed for irradiation of zirconium alloys
- An irradiation capsule for materials testing at high temperature and high fluence in inert atmosphere is also available
- A large and well equipped post irradiation laboratory is built in the same complex with reactor and connected through an underwater transfer channel.
- Testing of nuclear fuel and materials for CANDU NPP lead to building of the infrastructure of institute and appropriate competences for research reactor ageing management

# Ageing and safety of research reactors – actual perspective

- Ageing starts from design of research reactor as well the safety. In order to comply with principles of nuclear safety, a series of requirements are used in the early design stage several decades ago
- The additional measures are now provided in standards, guides, national law and regulations concerning defense in depth, reliability, safety analysis, operation, maintenance, modification, quality management and regulatory / safety supervision making the design basis obsolete in some extent
- Longer term operation versus shutdown and decommissioning decision have to be justified to be done safe and responsible well in advance of designed life expire, and any decision will be costly in terms of certain amount of money which were not anticipated during design.
- The Management of Ageing is a complex matter starting with understanding of real conditions of operation of SSC, behavior of materials in those conditions, mechanism of degradation and forecast of consequences
- The ageing management plan is complementary to routine maintenance programme, both being subject of a set of procedures and quality management as essential process which contribute to the safety of research reactor
- The management of ageing due to degradation will produce data and information about materials and components behavior in real time and in real conditions of utilization and maintenance, those data properly collected, processed and understood will reduce the probability of unexpected failure with safety consequences

# Ageing and safety of research reactors – actual perspective

**The main sources of differences may be related to understanding of ageing of materials due to loads, conditions of operation including improper maintenance and also due to Management of Ageing in the areas of the service inspection, surveillance, monitoring and in the area of mitigation activities**

## Management of Ageing

### Understanding of ageing

materials, loads, conditions of operation, results of maintenance

| Types | Sites | Safety concerns due to ageing |
|---|---|---|
| - corrosion<br>- irradiation embrittlement<br>- fatigue | Components, Systems | - loss of safety function<br>- reduced reliability<br>Research needs |

### Detecting / assessment

Service inspection, surveillance, monitoring, modeling techniques analysis, PSA, development of NDT
DT
Online monitoring
Training
Safety Culture
Quality Culture

### Mitigation

Mitigation
- redesign of components
- development of methods for reparation
- correct or modify condition of operation as chemistry, cycling

# Ageing and safety of research reactors – actual perspective

## Classification of SSC on perspective of ageing:

- **Risk of failure following a risk analysis**
  - **Very important for safety**
  - **Important for safety**
  - **Not important for safety**
  - **Not analyzed**
- **Trends of data failure analysis**
  - **Obvious trends of ageing**
  - **Not relevant trends of ageing**
- **Sensitive to ageing following the qualitative analysis**
  - **Very sensitive to ageing**
  - **Sensitive to ageing**
  - **Not sensitive to ageing / latent ageing**
- **Final classification following the combination of above criteria**

| Level of vulnerability to ageing | Importance of SSC | | |
|---|---|---|---|
| | LOW | MEDIUM | HIGH |
| LOW | L | L | M |
| MEDIUM | L | M | H |
| HIGH | M | H | H |

# Ageing and safety of research reactors – actual perspective

**In addition to service conditions there are conditions not related to processes which can lead to obsolesce and could affect nuclear safety:**

- **Technology changes;**
- **Safety requirements and regulation changes;**
- **Obsolesce of documentation;**
- **Inadequacy of design proven during operation and/or maintenance;**
- **Improper maintenance or testing;**
- **Lack of safety supervision;**
- **Lack of feedback and return of experience.**

# Ageing and safety of research reactors – actual perspective

## Ageing and obsolesce

- are challenging nuclear safety special for systems with nuclear safety significance.
- Monitoring and configuration control of repair is critical and yet many of original components are not longer manufactured and some of original manufacturers are no longer on the market.
- The life of an standard industrial product and/or manufacturer is shorter than the designed life of a Nuclear Installations.
- The Nuclear Power Industry and Nuclear Regulators are decided to improve and rise the requirements of safety standards without being sure that industry and manufacturers could follow the requirements in terms of standards, reliability, safety and economy.

## Ageing and safety related documentation

- Continuous improvement of requirements of radiation protection, standards and recommendations of nuclear safety reflecting trends in accomplishment of safety objective made the design and safety analysis of a research reactor several decades ago obsolete.
- Updating the safety related documentation of research reactor is the first step to cope with ageing of facility, being a major source of information based analysis to proceed to close the gap between facility performances and standards requirements through specific methods of Ageing Management.
- Peer review and INSARR mission at 14 MW TRIGA Research Reactor revealed the necessity of completely update the Safety Analysis Report (SAR)

## Ageing and advances in technology and safety requirements

- Refurbishment of modernization of instrumentation and control of research reactor which will be used in the next decade is a necessity and a safety requirement.
- An internal network of process computers allows the control of continuous operating systems and data acquisition and processing.

# Ageing and safety of research reactors – actual perspective

## Monitoring of physical conditions of operation of SSC

- ***Radiation*.**
- ***Temperature and Pressure***
- ***Vibration***
- ***Cycling of materials***
- ***Corrosion effects***

## Inadequacies in design

- **The control rod absorber claded in square aluminum alloy boxes was provided with a method of periodic inspection of tightness but without any possibility of maintenance and reparation.**
- **Due to leaks of cladding by internal corrosion, the control rods become unsafe.**
- **The initial design was modified using discrete absorbers claded in zirconium alloy tubes**

# Prevention and mitigation of ageing effects

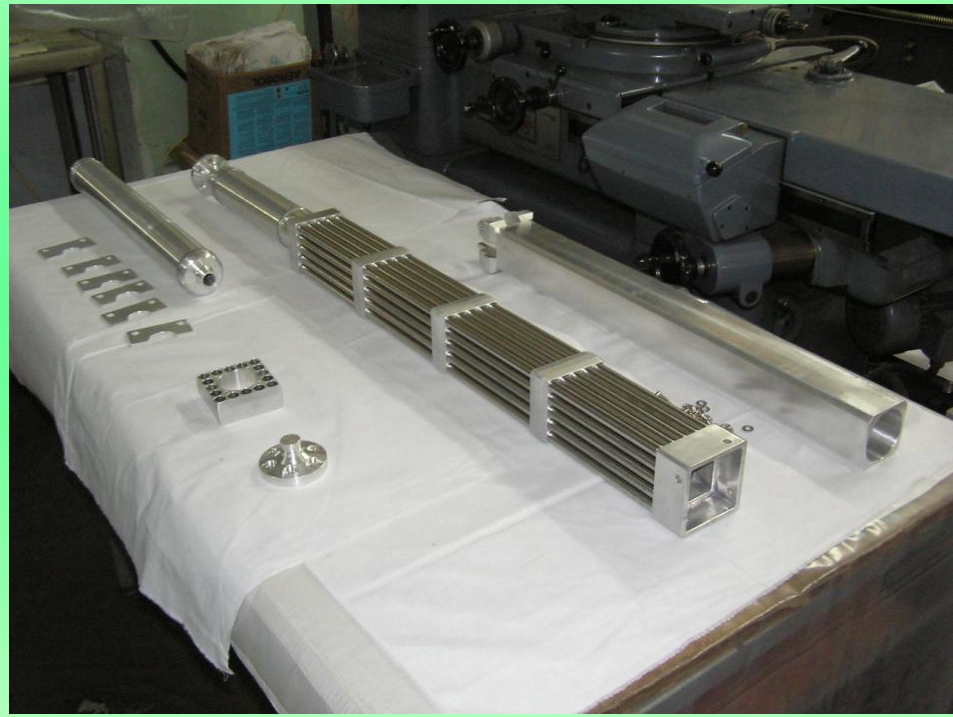
- **Prevention through design.**
- **Prevention through surveillance and testing.**
- **Preventive maintenance.**
- **Preventive maintenance**
- **Periodic evaluation of operational experience**
  - ***This is performed for Annual Report of operation of 14 MW TRIGA research reactor which is submitted to Regulatory Body in first quarter of coming year;***
  - ***Operational experience is also evaluated in the assembly of analysis performed by the management of processes supervised through yearly Quality Management Plan;***
  - ***The Nuclear Installation Safety Committee of institute is a permanent forum which systematically analyze the safety of operation, events reports, and determine the root causes, being entitled to establish new proposals for ageing effects mitigation***

# AGEING MATRIX

| Reactor Systems | Design | Standards | Ageing issues | | | | | | | Environmental requirements | Safety requirements | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Construction | Technology | Materials | Commissioning | Maintenance | Operation | Procurement | | Obsolescence of materials | Instrumentation obsolescence |
| Reactor core | | | | | X | | | | X | | | |
| Reactor safety systems | X | X | X | X | X | | X | | X | | | X |
| Reactor control systems | X | X | | X | | | | | X | | | X |
| Radiation protection | X | X | | | | | X | | X | X | | X |
| Radioactive releases monitoring | X | X | | X | | | | | | X | | X |
| Primary cooling systems | | | | | | | | | X | | X | X |
| Secondary cooling systems | X | X | | X | X | X | | | X | X | X | X |
| Confinement / ventilation | | X | X | | X | | X | X | X | X | X | X |
| Water purification | | | | | | | | | | | X | X |
| Liquid radioactive waste system | X | | | | | | | | | | X | X |
| Irradiation devices | | X | | | | | X | | X | | X | X |

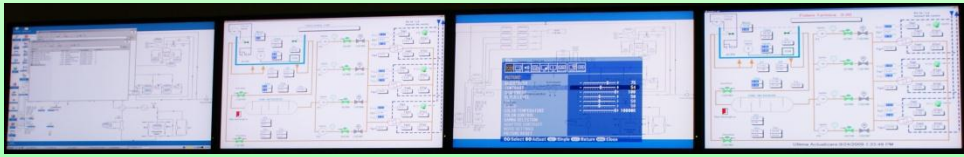
# Systems subject of modernization

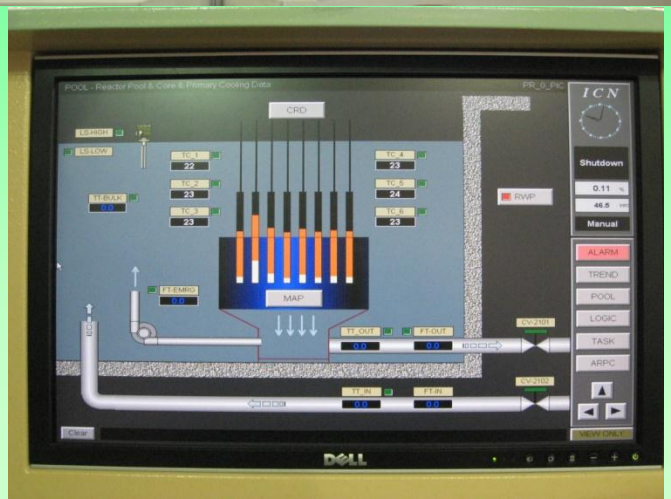
## control rods



# Systems subject of modernization

## Reactor control and monitoring system






# Systems subject of modernization

**Radiation protection System**

- Personnel monitoring was ensured with digital dosimeters, computer assisted, to provide dose monitoring and management, procured from international market.
- Area Monitoring System was designed and built by institute using wide range intelligent ionization chambers connected in a computerized monitoring and alarms system which ensure data acquisition, processing and correlation

# Systems subject of modernization

## Radioactive Releases Monitoring System

# Systems subject of modernization

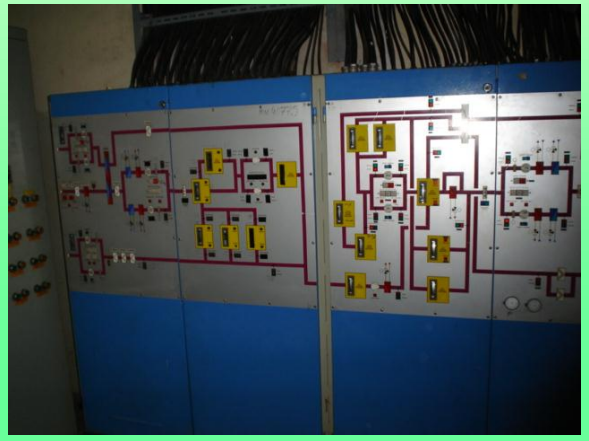
**Primary cooling system instrumentation**

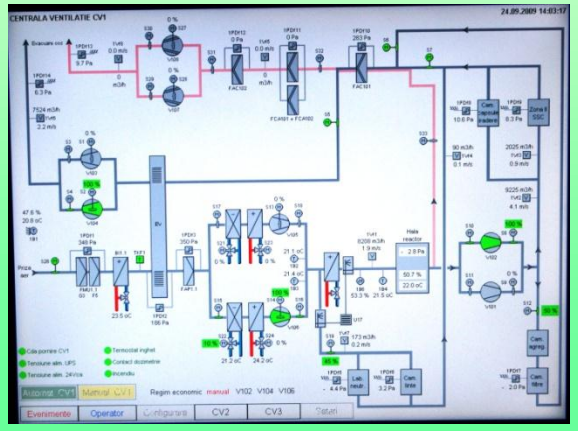
# Systems subject of modernization

**Secondary cooling system**

# Systems subject of modernization

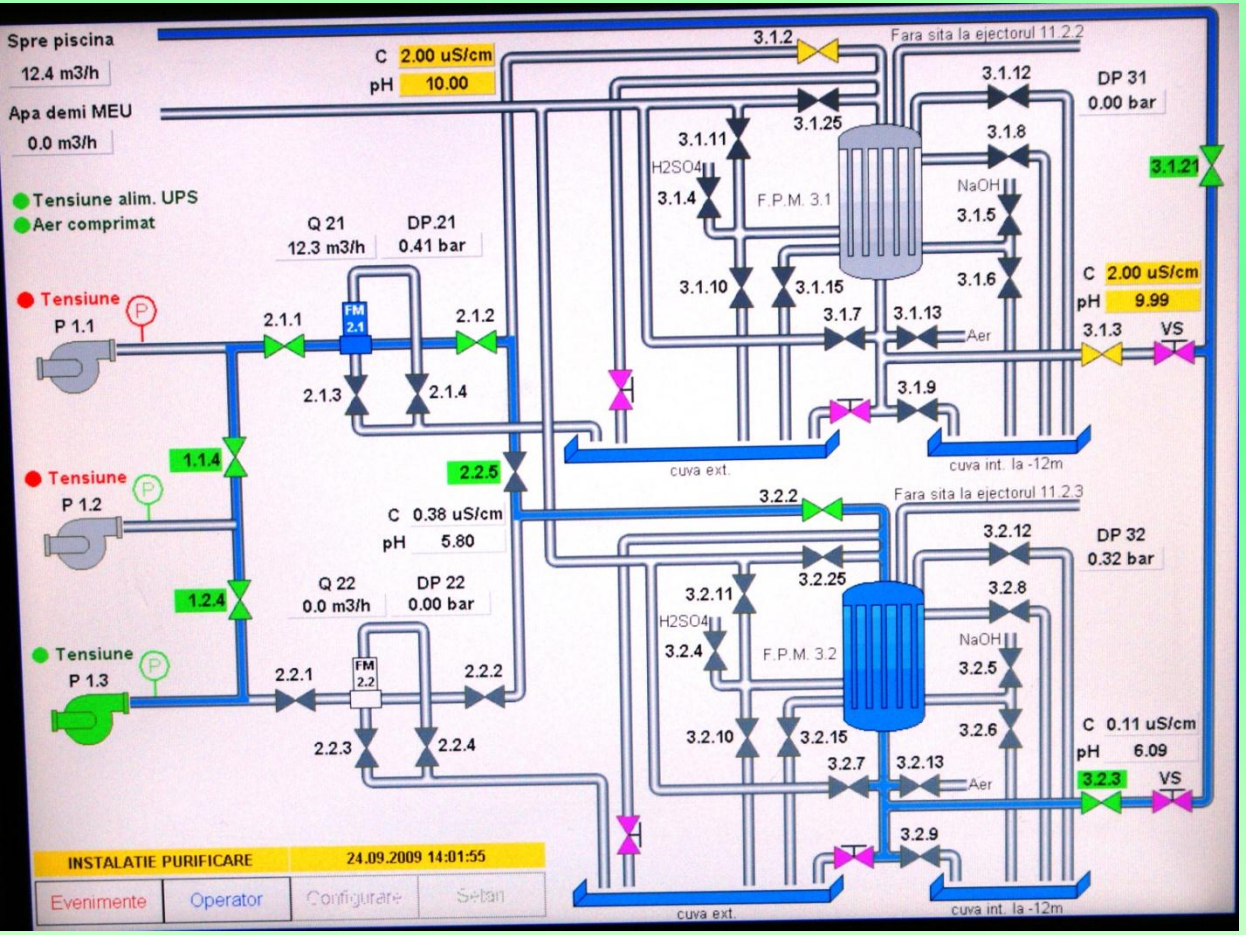
## Confinement and Ventilation System





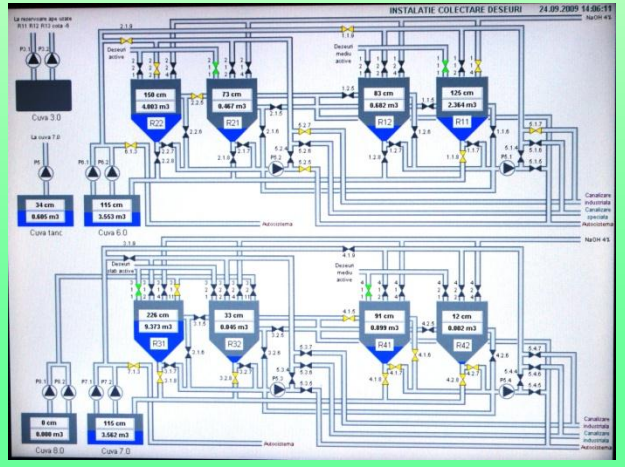

# Systems subject of modernization

## Water Purification System




# Systems subject of modernization

## Liquid radioactive waste system




# Systems subject of modernization

## Irradiation devices

# LESSON LEARNED

1. **Design of new systems and cost control should be implemented since the beginning of the project, many operations are not specialized in this field and following the case those activities should be subcontracted.**

2. **Solid references and experience in nuclear installation contractors / similar project / equipment should be accepted to diminish the risks.**

3. **Will be difficult for an organization without experience in radioactive waste handling, commissioning, and disposal to perform the activity without incident or environmental consequences.**

4. **Financing schedule should be flexible to accommodate delays or modification of project accomplished.**

5. **Training resources for continuous instruction of reactor staff for operation and maintenance of new modernized, modified systems should be provided as well training schedule and manuals.**

# CONCLUSION

**TRIGA - 14 MW Reactor is among youngest research reactors in Europe, after this project of modernization the reactor will remain only few research reactors for materials testing and radioactive production, which satisfy new regulatory requirements**