Safety assessments of the Tehran research reactor

AEOI, NSTRI

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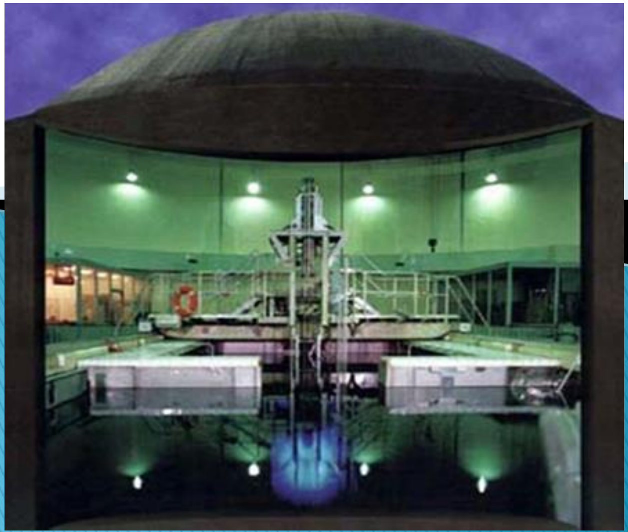
Workshop on Safety Reassessment of Research Reactors in the Light of the Lessons Learned from the Fukushima Daiichi Accident
Sydney, Australia , 4–7December 2017



Content of presentation

- **Introduction and description of TRR**
- **Major modification of TRR in recent years**
- ***Gap / Problem / Need Analysis***
- ***Activities for safety enhancement TRR***
- **Safety reassessment of TRR in the light of the lessons learned from Fukushima accident**

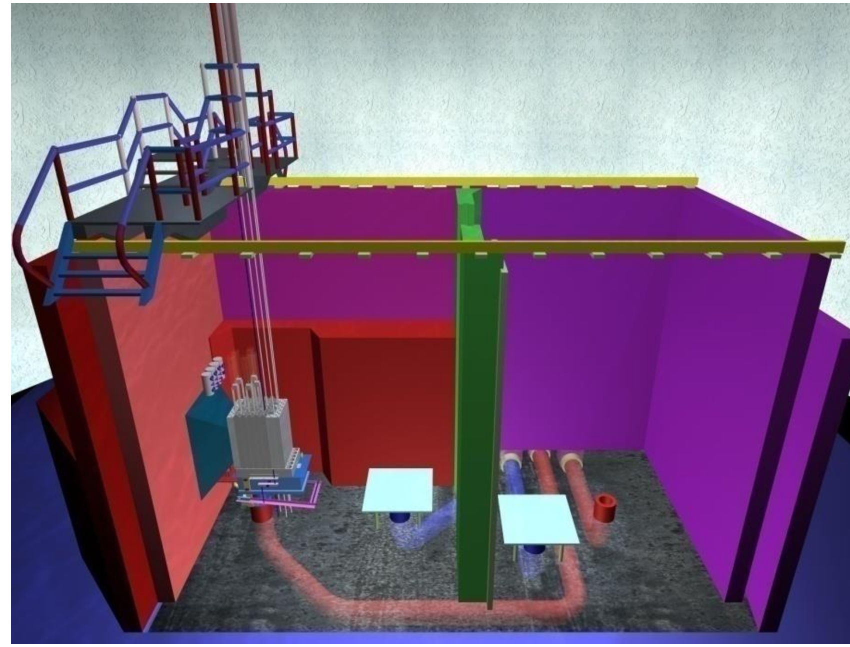
Introduction of TRR

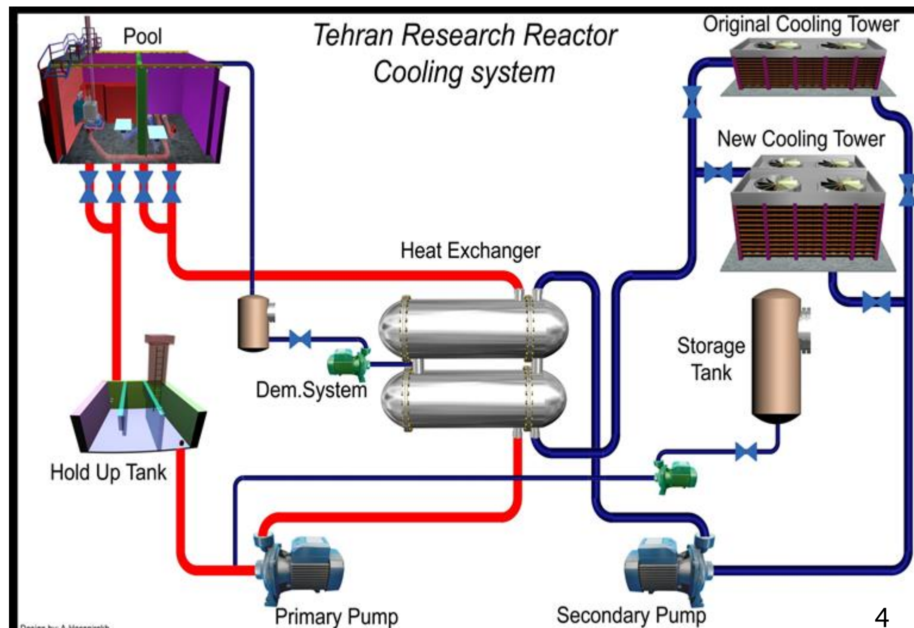
- Tehran Research Reactor (TRR) became critical using Highly Enriched Uranium 1967

- In later years, based on the International Atomic Energy Agency Non- Proliferation Treaty (IAEA-NPT), the new fuel with Low Enriched Uranium (LEU) was used.

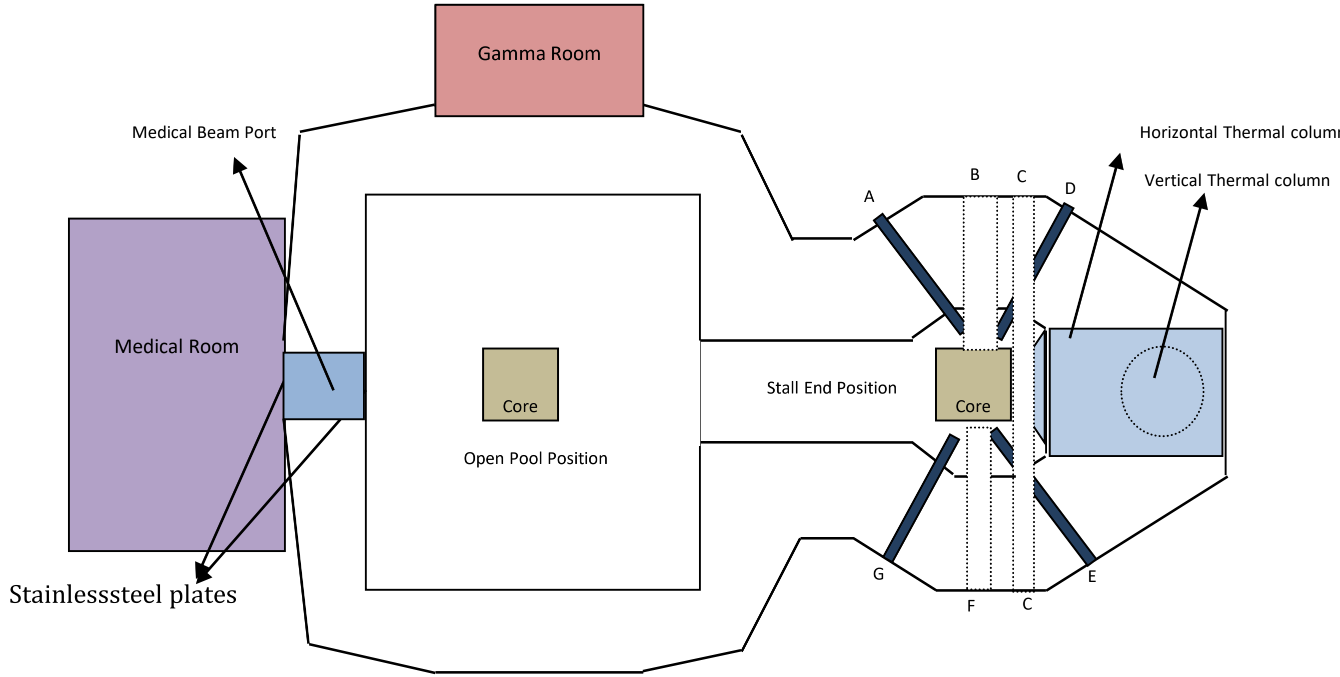
- TRR is pool type, light water moderated research reactor, in which the light water is also used for cooling, shielding and reflecting.
- The reactor has been designed and licensed to operate at maximum thermal power level of 5 MW with forced cooling mode

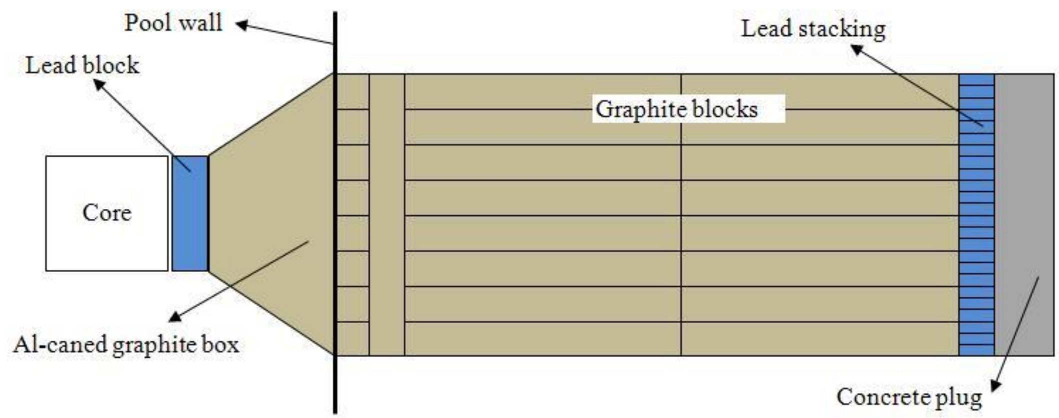
Reactor core parameters	Values	
Neutronics		
Fuel	MTR-U_3O_8Al	
Enrichment	19.75 %	
Moderator	Light water	
Reflector	Graphite-Light water	
Clad	Al-6061	
Thermal hydraulics		
Thermal power	5 MW	
Coolant inlet temperature	37.8 ^oC	
Operating pressure	1.7 bar	
Mass flow rate	500 m^3/hr	
Fuel plates		
Meat thickness	0.07 cm	
Cladding thickness	0.04 cm	
Water channel thickness	0.27 cm	
Meat width	6 cm	
Meat length	61.5 cm	
Fuel assemblies	SFE	CFE
Total dimensions	8.01×7.7×161.5cm	8.01×7.71×89.7cm
Number of fuel plates in	19	14
Control Rods		
Absorber Material	Ag-In-Cd	



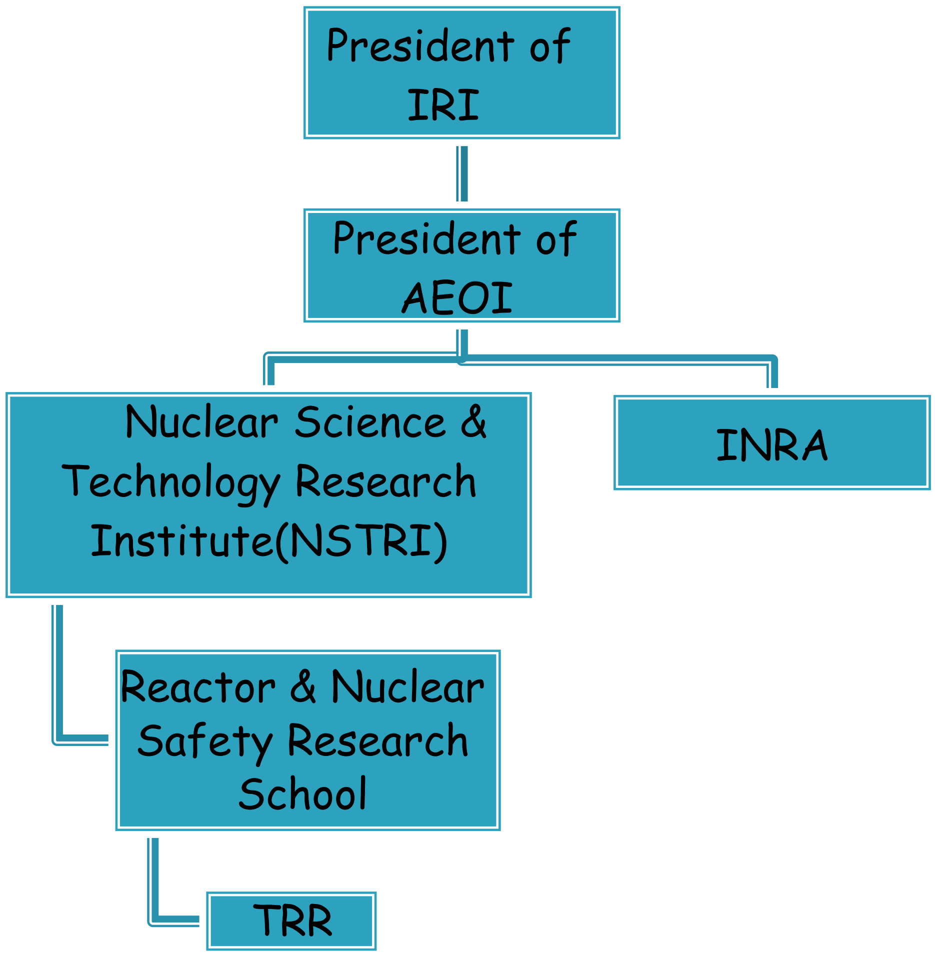


Reactor Experimental & Irradiation Facilities





Organization Chart

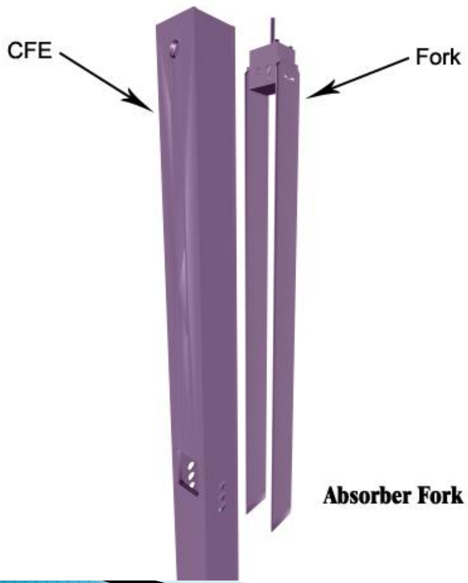


Strategy and objectives of the Tehran research reactor:

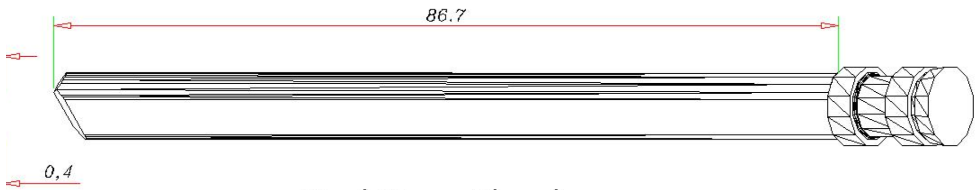
- ❖ Fundamental nuclear researches, mainly study of neutron reaction with materials, activation by means of neutron and investigation on its consequences.
- ❖ Radioisotope production, being utilized in medicine, industry and agriculture.
- ❖ Education and training of manpower in the field of nuclear technologies and providing facilities and infrastructures for Ph.D and M.s students projects**.**

Major modification and various projects have been performed in recent years

- Core conversion form HEU (93%) to LEU (20%) was carried out in 1993, causing a striking increase in utilization plan of the TRR.
  - Change of Absorber Type
  - Main Console modification

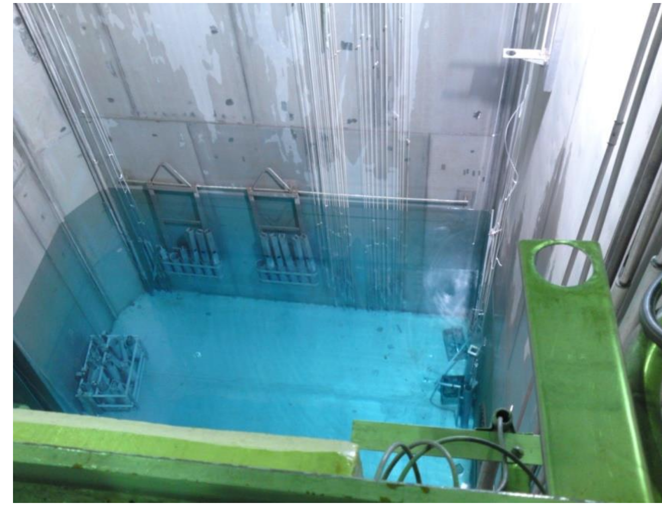


Absorber Fork and it's CFE



Oval Type Absorber

- Steel lining of the reactor pool and the underground Hold Up Tank, to mitigate the risk of radioactive liquids leaking into the environment



- Design and construction of a spent fuel storage pool to increase the overall safety of the installation

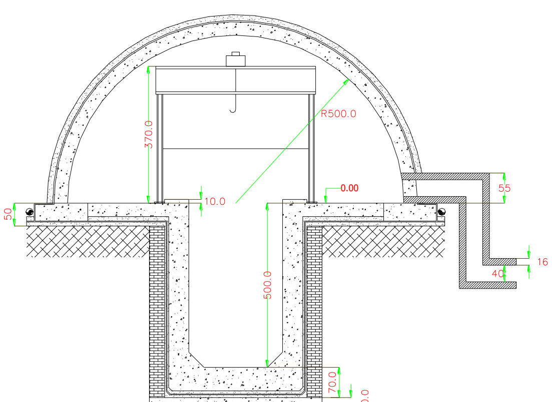
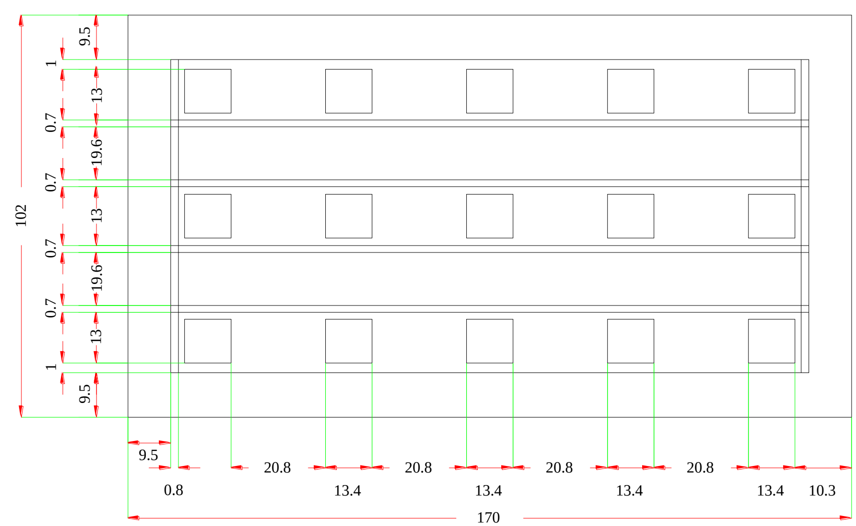
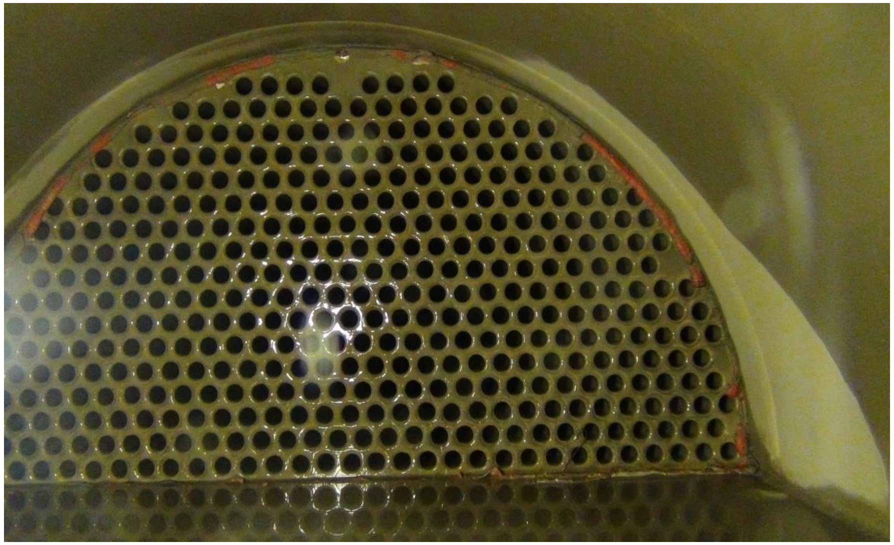


Fig 3 spent fuel pool cross section

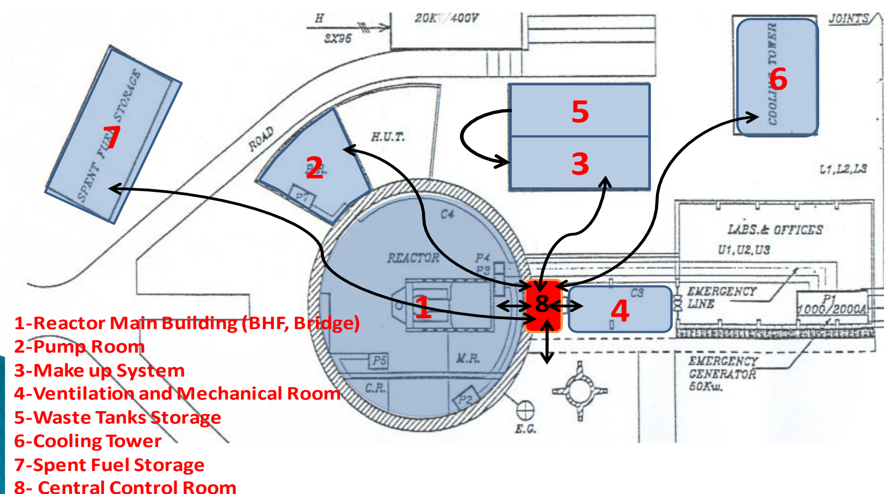


- Construction of a new cooling tower as well as replacement of the heat exchangers



Design and construction of new Control room

Design and build of new Console



Gap / Problem / Need Analysis

- TRR is an old research reactor which has been operating for the last 49 years and needs to be upgraded and improved to satisfy the up-to-date safety requirements in view of the planned lifetime extension.

- TRR needs to operate safely and efficiently for production of the required radiopharmaceuticals and industrial used radioisotopes according to the national plan. In this situation, the extension of the TRR lifetime through its safety enhancement is of vital importance.

Gap / Problem / Need Analysis

- Past efforts have addressed the TRR safety issues,
  - recommendations made by the Integrated Safety Assessment of Research Reactors (INSARR) mission in 2007
  - recommendations made by IAEA experts during implementation of TC project (IRA9022) for enhancing TRR safety (2014-2016)
  - Analysis of some experiences of other research reactors that reported in IRSRR and comparing with TRR
  - Use of our experiences in previous years during operation, periodic tests, inspections & maintenance, exercises and maneuvers, experiments, incidents and audits
  - Recommendations received from INRA site inspections, Audits and reviewing safety documents and procedures

Activities for safety enhancement TRR

- Establishing
  - Quality assurance program based on GS-R-3
  - Strategic plan for TRR utilization
  - Process map
- Updating of safety documents
  - SAR , OLC, AMP, ER, EP, RPP and Operating procedures
- Training and qualification of personnel

- Minimizing radioactive waste by
  - Training
  - Optimization of method & equipment

Updating ER for TRR

- **The Latest Changes that considered:**

1- some changes in population, transportation, number of structure and buildings around the TRR

2- assessment and analysis of probable accidents for another facilities on site simultaneously (gamma center, spent fuel storage pool and TRR.

3-some sampling and analyzing of soil, plant and air on-site around the TRR.

4- on-site environmental dose assessment using TLD detectors.

- **Future activities that have to be consider:**

1- Considering detailed population distribution around the TRR in analysis, simulations and dose estimations.

2- Using new detectors on-site for alpha-beta emitters.

3- Using online detectors on the top of TRR’s stack for online analysis of type and amount of releases from TRR.

Radiation protection

- Establishing an integrated radiation monitoring system for the reactor facility and in the vicinity of TRR in AEOI site that INRA can access online to this data.
- Preparation of RPP
- Establishing and implementing of contamination monitoring program

- Future plan:
  - Development of radiation monitoring system , renewing some monitoring equipment and implementation a post accident monitoring system

Emergency plan

- Establishing a committee for updating emergency preparedness and response of TRR facility in connection with crisis management committee of AEOI

- Reviewing emergency plan, Updating procedures and attachments, applying assessments of IAEA experts, considering suggestions of regulatory body

- Establishing alarm and notification system, renewing communication network
- Planning and performing training maneuvers

Safety reassessment of TRR in the light of the lessons learned from Fukushima accident

- The actions being taken after Fukushima accident in TRR
  - Refurbishment of Emergency Ventilation System
  - Design and installation of a new I&C system
  - Review availability of Emergency Power Supply An Emergency Core Cooling System(ECCS) for TRR
  - Enhancing Emergency Preparedness and Response, including Emergency Equipment, and Emergency Communication
  - Seismic Re-evaluation and reinforcement of the SSCs of TRR

Stress tests analyses for the Tehran Research Reactor (TRR)

- Identification of weak points of the reactor design, mainly due to external hazards – extreme weather, earthquakes, floods and fires are the stress test goals

- UJV/CVR Group will support NSTRI in performing stress tests for TRR.

- The stress tests will be focus on the evaluation of the TRR reactor resistance to internal and extreme external conditions

The following activities to be performed by NSTRI

- The basic design characteristics of the nuclear facility
- History of earthquakes in Iran and in TRR site
- Flooding& Potential sources of flooding in the neighboring area of TRR
- Resistance of building structures and technological equipment of TRR against flooding
- Loss of Internal sources electric power

The following sections to be performed by UJV

- Resistance of building structures and technological equipment of TRR against earthquakes
- Resistance of building structures and technological equipment of TRR against Extreme weather condition
- Disintegration of external grid
- Loss of AC/DC electrical power
- Internal and External Extreme Hazards including Fire, Explosions, Lighting, etc.
- Terrorist Attack (including Aircraft Crash, Missile hit, Software obstructionism)

The following analyses to be perform by CVR

- SBO analysis for TRR
- Loss of ultimate heat sink (UHS)
- SBO analysis and simultaneous loss of UHS
- Analysis of potential severe accident in TRR and accident management.
- Conclusions, the proposed measures

Conclusion

- TRR is an old research reactor and needs to be upgraded and improved to satisfy in light of the lessons learned from Fukushima accident
- the extension of the TRR lifetime through its safety enhancement is of vital importance.
- Although TRR in comparing with Fukushima N.P.P is very safe but we need to analyses stress tests for the Tehran Research Reactor
- The stress test will focus on the evaluation of the TRR reactor resistance to internal and extreme external conditions.

Thank you for your time and attention

Thanks for your attention

Achievements

- The knowledge gained during the established EMs is currently used in TRR and in our point of view , the project performance is in good situation.
- Due to the renewal of some of the mechanical equipment and I&C system of TRR, the number of alarms and scrams due to equipment malfunctions are reduced.
- Safety features of Tehran research reactor are improved. In addition, periodic tests and inspections as well as maintenance programs have been updated.
- The audit process is developed which increases the possibility of detecting any deviation from OLCs or any equipment malfunction.

Comments and Recommendations

- We are going to improve and promote some operating programs such as: AMP, QAP, EP, SAR and ER in 2016 and we need to be supported by IAEA for training of personnel and application of safety standards.

- In recent years some of the new activities is added to the TRR such as fuel testing, It is necessary for our personnel to be familiar with safety standards related to these fields.

Safety advantages of TRR

- Passive core cooling system
- Flow direction is compatible with decay heat
- Downward flow aids the scram
- N16 doesn't reach pool surface

Key points in Fukushima in comparison with TRR

Loss of Power supply

In Fukushima NPP:

- The loss of offside power and onside AC power, led to a complete station Blackout, which in turn led to fuel overheating and damage

In TRR:

- Downward flow provided by gravitational head continues until natural convection establishes

Key points in Fukushima in comparison with TRR

Hydrogen Production

In Fukushima NPP:

- Overheating of fuel and rapid oxidation of Zirconium cladding led to generation of large amount of hydrogen

In TRR:

- MTR fuel has Al cladding, and hence Hydrogen explosion is not a forceable scenario

Key points in Fukushima in comparison with TRR

Spent Fuel Storage

In Fukushima NPP:

- Lack of the SFS cooling due to loss of power supply resulted in the release of radionuclides

In TRR:

- The stored energy and radionuclides inventory are considerably lower than a NPP
- SFS is separated from the reactor building with the passive SF cooling
- The TRR dispersed fuel has a significantly different behavior in terms of fission product retention

Key points in Fukushima in comparison with TRR

Containment Venting

In Fukushima NPP:

- Due to the station blackout, the operators had to vent the containment to avoid containment over - pressurization

  some vented gases leaked into the reactor building, resulting in hydrogen explosion

In TRR:

- The containment is vented directly to the stack by the ventilation system with back up power supply
- It should be emphasized, for a prolonged blackout+ radionuclides release safety function of containment could be threatened

Key points in Fukushima in comparison with TRR

Site Layout

In Fukushima NPP:

- Due to the site's compact layout, problem at one unit created negatively safety-related situations at adjacent units

In TRR:

- Only one unit