Post Fukushima safety assessments of the Hungarian research reactor

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Outline of presentation

• Hungary
• Hungarian nuclear programme
• Nuclear Safety Requirements, regulatory body
• Post-Fukushima Stress Tests in Hungary
• Periodic Safety Review and Post-Fukushima reassessment results of Budapest Research Reactors
Basic data on Hungary

• Republic
• Area: 93,000 km²
• Population: 10 million
• Capital: Budapest (1.8 million)
• Highest point: 1015 m
• Largest lake: Balaton (cca. 75 x 3 km)
Agriculture
Vineries
Thermal spas
Hungarian nuclear programme

• Paks NPP
  – four VVER-440/213 type reactors
  – 500 MWe after power uprates
  – commissioned in 1983, 84, 86, 87
  – 20 years design lifetime extension
  – 40-50% of domestic electricity

• Interim spent fuel storage facility
  – dry storage for 50 years
  – next to the NPP
Hungarian nuclear programme

- 100 kW training reactor
  - Budapest University of Technology and Economics
  - Education

- Radwaste storage facilities
  - For institutional waste since 1977, Püspökszilágyi
  - For NPP waste since 2012, Bátaapáti
Budapest Research Reactor

• Commissioned in 1959
• Type: 10 MWth VVER-SM after two upgrades
• tank-type reactor
• Light water cooled and moderated
• fuel: VVR-SM and VVR-M2, 36% to 20% conversion
• Operated by Institute for Energy Research (former KFKI)
• Main use: research, neutron source
Regulatory background
Hungarian Nuclear Safety Regulations

Safety code: shall

Non mandatory: „should”
Explanations, recommendations, interpretations, methods
Licensee shall justify any deviation from guidelines

Other regulations

Safety Guidelines

Local Regulations

Nuclear Safety Code Volumes 1-10

Gov. Decree No. 118/2011

Act No. CXVI/1996 on Atomic Energy

Hungarian Nuclear Safety Regulations

Hungarian legal pyramid
Structure of the Nuclear Safety Code

- **Volume 1.** - Nuclear safety authority procedures of nuclear facilities
- **Volume 2.** - Management systems of nuclear facilities
- **Volume 3.** - Design requirements for operating NPPs
- **Volume 3A.** - Design requirements for new NPPs
- **Volume 4.** - Operation of NPPs
- **Volume 5.** - Design and Operation of Research Reactors
- **Volume 6.** - Design and Operation of Spent Fuel Storage Facilities
- **Volume 7.** - Siting of Nuclear Facilities
- **Volume 8.** - Decommissioning of Nuclear Facilities
- **Volume 9.** - Construction of New Nuclear Facilities
- **Volume 10.** - Terminology
Latest revisions of the nuclear safety code

- Post-Fukushima revision
  - Issued at the end of 2014
  - Stress tests
  - IAEA review
  - WENRA review
Nuclear Safety Authority: Hungarian Atomic Energey Authority

- Established in 1991, independent government office
- Regulation (drafting laws, regulations, guides)
- Regulatory oversight: licensing, inspection, assessment, enforcement
- Scope of authority
  - nuclear facilities
  - waste management facilities
  - nuclear and radioactive materials
  - transport
- 3S: safety, security, safeguards
- Public information
- Coordination of nuclear safety research
- International relations (IAEA, EU, OECD, bilateral)
Post-Fukushima stress tests in Hungary

- European Council (of Prime Ministers): reassess the robustness of all NPPs in EU against extreme natural hazards

- Scope
  - Issues corresponding to external natural hazard factors
    - design basis review and margins for BDB, potential for cliff-edge effects
  - Loss of electric power supply and loss of ultimate heat sink or combination
    - margins of safety functions,
    - timeframes and tools availability to recover
  - Severe accident management
    - preparedness and tools after an extreme natural disaster including multi-unit scenario

- International peer review
  - expert teams reviewed national reports,
  - dedicated missions visited the countries and the plants
  - national review in the 3 topics above

- National Action Plan
  - Also reviewed and discussed in a workshop, updates every two years
• Confirmation of design basis compliance
• Many modifications to improve robustness
  – Alternative cooling opportunities
  – Power supply by bunkered SA DGs
  – Reinforcement of shelters and command centres
  – Sheltered vehicle for emergency response
  – Communication and computer systems
• National action plan: 51 items till end of 2018
Stess tests for Budapest Research Reactor

• No European effort, but methodology could apply

• Possible occasion
  – Periodic Safety Review that was due in 2012

• PSR practice in Hungary
  – All nuclear facilities are obliged every ten years
  – For research reactors: basis of operation license
  – Detailed regulations + specific guideline on the PSR
  – Scope: reassess compliance with DB including external and internal hazards
  – Results: action plan on identified gaps (risk factors) and place for improvement

• Consequences
  – Authority reviews results and approve and supplement safety improvement actions
  – Revoke or limit the license or approve without limitation
Minimal contents of the PSR

- Design in FSAR
- Review of site features, parameters
- Decommissioning
- Conditions of System, Structures and Components
- Equipment qualification
- Ageing
- Safety analyses
- Hazards
- Safety indicators

- Evaluation and feedback of operational experience
- Use of experience of other nuclear facility
- Organisation and administration
- Procedures
- Human factors
- Emergency Preparedness
- Radiation exposure of environment
- Research equipment

+ detailed post-Fukushima guidance for the 2012 PSR
Results of post-Fukushima review

• Budapest Research Reactor was designed based on the defense in depth concept
  – Accident analyses covers BDBA and SA analysis

• Safety objective: prevent dry out of core

• Safety systems are protected against single failure
  – complete loss is not required

• Design feature: if both safety trains fail a diverse system can activate
  – Very conservative, this case was only part of PSA studies to develop the Emergency Response Plan
Results of post-Fukushima review

• PSR re-assessment covered
  – loss of ultimate heat sink
  – total loss of electric power supply (normal supply and emergency diesel generators)
  – severe accidents
  – accidents during fuel element storage
  – severe accident management and emergency preparedness

• Much simpler than for NPPs because of simpler configuration
Loss of ultimate heat sink

- Heat sink: atmosphere (via primary heat exchanger and secondary circuit)
  - Loss of regular path of coolant
  - Decay heat: removed via gravitational cooling/emergency pumps/gravitational tank
- Passive method cannot be lost, pumps can be lost if diesels are lost, third method needs only an operator intervention
  - Passive gravitational cooling would be provided
  - Later natural circulation + cooling by free water surface of reactor vessel and other surfaces (e.g. pipelines) until 3 hours, after which local boiling could no occur
  - Evaporation: 2.5 cm/h level decrease, sprinkler system needs to make up after 32 hours
- Spent fuel storage
  - very low decay heat, no cooling needed, intactness should be maintained
  - fuel cladding is aluminum: no hydrogen production
- Safety systems
  - diesel generators air cooled, loss of heat sink is not an issue
Total loss of electric power supply

• **Loss of normal supply**
  – Electric supply is from two directions, can be lost only in extreme natural disaster. Switching is a routine act

• **Loss of DGs too (very unlikely)**
  – Battery stations can supply for 24 hours (electric supply not required even if heat sink is lost)
  – LOCA: refilling systems should operate
    • LOCA + loss of electric supply was not even assumed for NPP stress tests
    • LOCAs are very improbable (pipelines of aluminum) and low pressure
    • Communal water system and fire water system are still available
    • Altogether: very improbable

• **Spent fuel cooling: no need for electric supply**
Severe accidents

• Can be practically excluded
• Extreme natural phenomena
  – strong earthquake is the only such hazard
  – Crash of a big aircraft and malevolent acts are not part of the analysis
  – Design PGA is 0.15 g (safe shutdown)
• Higher values: LOCA and reactor hall lost
  – core damage prevented if reactor under water for at least 4 hours after shutdown
  – core dry out will never cause complete core melt
  – If pipeline can be repaired then water level can be retrieved. Special repair methods are available and trained
  – If communal water lines are not available and reactor hall is destroyed due to earthquake: doses would not justify any off-site action, but the site should be evacuated
Fuel storage accidents

- Cooling of internal spent fuel storage is passive: no effect of loss of heat sink or electricity
- Critical phenomenon: loss of coolant what is excluded by material selection, construction
- But: fuel melt does not take place even if total loss of coolant, only some fuel elements would damage
- Timing: 1-1,5 hours, intervention is possible (make-up water (passive) system, closing outlet line valve. Feasible in 40 minutes
- Structure of storage will remain intact, but loss of coolant due to stronger earthquake cannot be excluded
- External spent fuel store: structure will remain intact
  - due to low decay heat, heat up is a very long process
Summary

• BRR is prepared for
  – coping with loss of ultimate heat sink
  – total loss of electric supply
  – managing severe accidents

• Severe accidents are extremely improbable
  – only due to extreme earthquakes or similar events
  – if reactor building is also lost: environmental impact within the site area

• Conclusion
  – Due to physical properties and former safety improvement the BRR was prepared for extreme hazards even before Fukushima
  – No additional safety improvement action is necessary
Regulatory conclusion

- Approach and methods accepted
- Supplementary Fukushima examinations sufficient and did not reveal new hazards or vulnerability
- FSAR chapters are still valid, conclusions of licensee accepted
  - Important: acceptance was made with a graded approach in relation to the depth of expectable analysis for the research reactor
Questions?

Thank you for your attention!