Ageing Management for U.S. Research Reactors

William B. Kennedy, Project Manager
Research and Test Reactor Licensing Branch
U.S. Nuclear Regulatory Commission

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Introduction (1/1)

- This presentation will focus on the following aspects of ageing management for research reactors in the U.S.
  - Ageing
  - U.S. NRC rules and guidance
  - Examples of ageing and ageing management
- Ageing management begins with the design of the reactor and ends when the reactor is decommissioned

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Research Reactor Ageing (1/2)

- Ageing: General process in which characteristics of structure, systems, or components (SSCs) change with use or time.
- Ageing management: Engineering, operations, and maintenance actions to control of age-related degradation and wear of SSCs, including timely detection and mitigation efforts

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Research Reactor Ageing (2/2)

- Temperature
- Environmental factors
  - Radiation
  - Moisture
  - Chemically active liquids or gasses
- Service wear or corrosion
  - Changes in dimension
  - Changes in relative position
- Excessive testing
- Flawed design, improper installation or maintenance
- Obsolescence

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Ageing Management Rules (1/8)

- Part 50 of Title 10 of the U.S. *Code of Federal Regulations* (10 CFR 50)
  - 50.34, “Contents of Applications: Technical Information”
  - 50.36, “Technical Specifications”
  - 50.59, “Changes, Tests, and Experiments”
  - 50.90, “Application for Amendment of License, Construction Permit, or Early Site Permit”
  - Requirements to keep records

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Ageing Management Rules (2/8)

- 50.34, “Contents of Applications: Technical Information”

  A preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility and including determination of the margins of safety during normal operations and transient conditions anticipated **during the life of the facility**, and the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents.

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Ageing Management Rules (3/8)

- 50.36, “Technical Specifications”

  Limiting conditions for operation. Limiting conditions for operation are the lowest functional capability or performance levels of equipment required for safe operation of the facility.

  Surveillance requirements. Surveillance requirements are requirements relating to test, calibration, or inspection to assure that the necessary quality of systems and components is maintained, that facility operation will be within safety limits, and that the limiting conditions for operation will be met.

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Ageing Management Rules (4/8)

- 50.59, “Changes, Tests, and Experiments”

  Change means a modification or addition to, or removal from, the facility or procedures that affects a design function, method of performing or controlling the function, or an evaluation that demonstrates that intended functions will be accomplished.

  A licensee may make changes in the facility as described in the final safety analysis report, make changes in the procedures as described in the final safety analysis report, and conduct tests or experiments not described in the final safety analysis report without obtaining a license amendment only if a change to the technical specifications incorporated in the license is not required, and the change would not...

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Ageing Management Rules (5/8)

- 50.59, “Changes, Tests, and Experiments” (continued)

- Result in more than a minimal increase in the frequency of occurrence of an accident previously evaluated in the final safety analysis report
- Result in more than a minimal increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the final safety analysis report
- Result in more than a minimal increase in the consequences of an accident previously evaluated in the final safety analysis report
- Result in more than a minimal increase in the consequences of a malfunction of an SSC important to safety previously evaluated in the final safety analysis report

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Ageing Management Rules (6/8)

- 50.59, “Changes, Tests, and Experiments” (continued)

- Create a possibility for an accident of a different type than any previously evaluated in the final safety analysis report
- Create a possibility for a malfunction of an SSC important to safety with a different result than any previously evaluated in the final safety analysis report
- Result in a design basis limit for a fission product barrier as described in the FSAR being exceeded or altered
- Result in a departure from a method of evaluation described in the FSAR used in establishing the design bases or in the safety analyses.

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Ageing Management Rules (7/8)

- 50.59, “Changes, Tests, and Experiments” (continued)

The licensee shall maintain records of changes in the facility, of changes in procedures, and of tests and experiments. These records must include a written evaluation which provides the bases for the determination that the change, test, or experiment does not require a license amendment

The records of changes in the facility must be maintained until the termination of an operating license. Records of changes in procedures and records of tests and experiments must be maintained for a period of 5 years.

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Ageing Management Rules (8/8)

- 50.90, “Application for Amendment of License, Construction Permit, or Early Site Permit”

  Whenever a holder of a license, including a construction permit and operating license under this part, desires to amend the license or permit, application for an amendment must be filed with the Commission fully describing the changes desired, and following as far as applicable, the form prescribed for original applications.

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Ageing Management Guidance (1/3)

- NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors”

- The applicant should take into account the various deterioration mechanisms for the components and systems under consideration and note which mechanisms are applicable for those components and systems.
- The applicant should determine and justify acceptable levels of deterioration for the components and systems under consideration.

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Ageing Management Guidance (2/3)

- NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors”
- Analysis should show that unacceptable levels of deterioration will not be reached during the license period. If analysis cannot show this, tests and measurements to gauge deterioration should be discussed. For components and systems that must be tested or measured, the applicant should propose technical specifications that state the frequency of the test or measurement and give performance standards for the component or system under consideration.

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Ageing Management Guidance (3/3)

- NUREG-1537, “Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors”

- The facility maintenance program should be an organized, systematic approach considering the issue of prior use of components and systems and should be based on analyses, tests, measurements, or manufacturer‘s recommendations to carry out maintenance.
- The applicant should show that components significant to the safety of the non-power reactor will function satisfactorily for the license period.

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Examples of Ageing (1/1)

- Coated surfaces in pools (Penn State TRIGA)
- Replacement of electrical cable (Many)
- Heat exchangers (MIT license amendment)
- Thermal shield (NIST)
- Aluminum cladding of TRIGA reactor fuel elements
- Buried water drainpipes
- Replacement of experimental facilities (University of Texas)
- Water leaks of tank (North Carolina State)
- Cracking of beryllium (Missouri University)
- Aluminum piping in concrete (University of Florida)
- Safety system circuitry (MIT)

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Penn State Pool Coating (1/8)

- Pennsylvania State University reported an unusual amount of water loss from the reactor pool on 9/10/2007
- Major release pathway was through the pool divider wall
- Actions required
  - Draining reactor pool
  - Hydro-lazing (high pressure water cleaning) to remove pool wall and floor surface material and deteriorated concrete and sealer
  - Concrete remediation, and resealing (surface coating with impermeable barrier)

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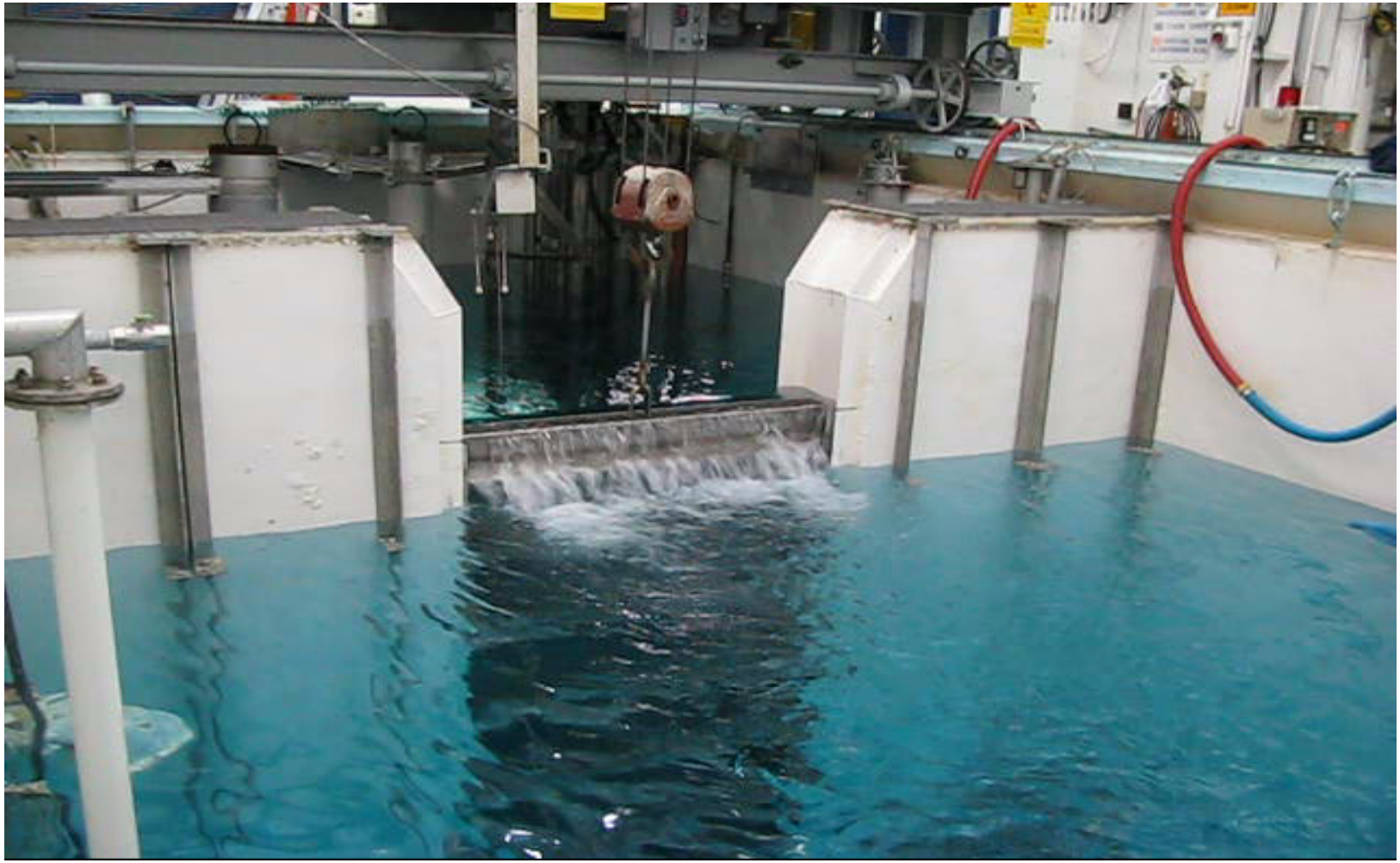
Penn State Pool Coating (2/8)



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Penn State Pool Coating (3/8)

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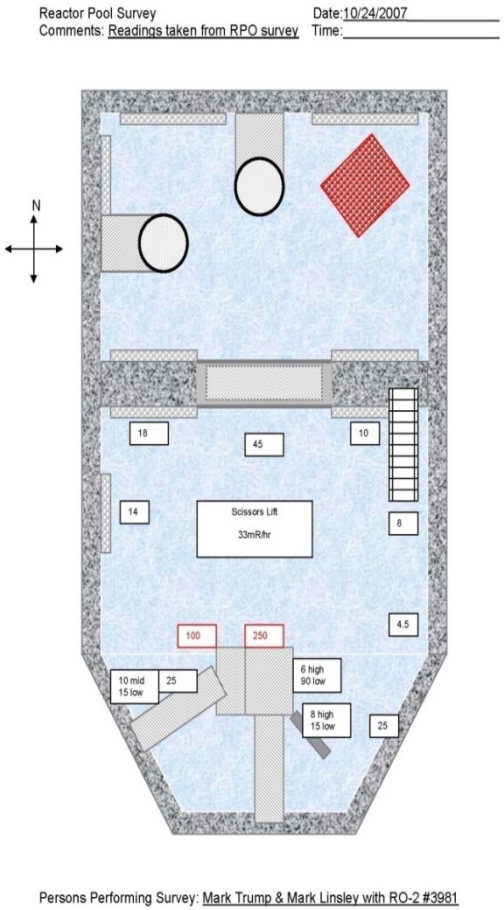
Penn State Pool Coating (4/8)



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Penn State Pool Coating (5/8)

- Visually inspected pool penetrations
- Hammered and chipped off loose surfaces
- Removed old repair work around gate and floor

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Penn State Pool Coating (6/8)

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Penn State Pool Coating (7/8)

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Penn State Pool Coating (8/8)

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NIST Lead Shield Cooling Pipes (1/3)

- National Institute of Standards and Technology (NIST) reactor thermal shield is located between the biological shield and the reactor core
  - Reduces heating in the concrete biological shield
  - 188 copper pipes embedded in lead (9.5 mm (3/8″) inner diameter)
- Pipes began leaking in the 1980's
- NIST flushed a sealant through the pipes to plug the holes, but repeated sealant treatments led to the pipes clogging
- NIST designed a vacuum system to circulate the water through the pipes and reduce leakage

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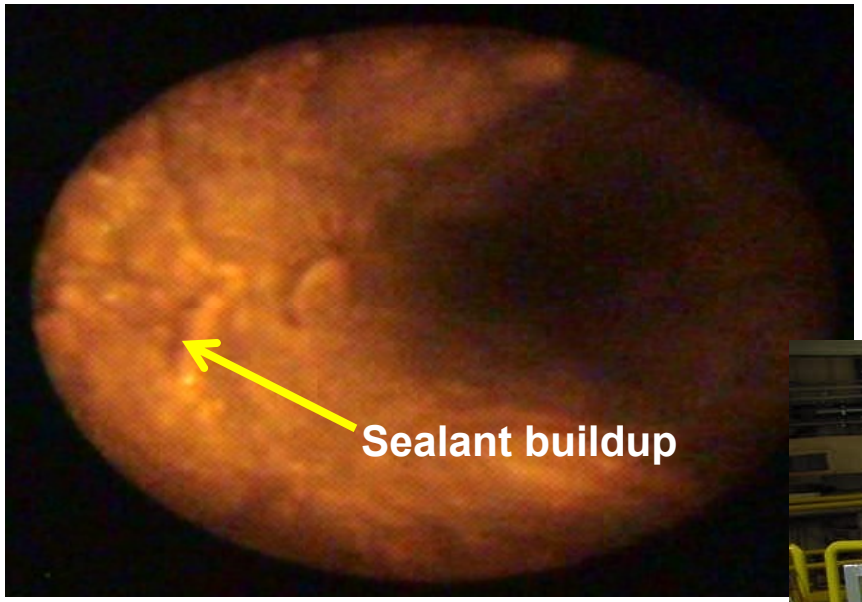
NIST Lead Shield Cooling Pipes (2/3)



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NIST Lead Shield Cooling Pipes (3/3)






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Inspections (1/2)

- Reactor tank, pool liner, and cooling systems
- Reactor internals
- Beam tube inner surfaces
- Pumps and valves
- Spent fuel pools, liquid storage tanks, other tanks
- Electrical cabinets, transformers and cables

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Inspections (2/2)

- Pressure retaining welds and construction welds
- Base material and welds subject to fatigue stresses, corrosion, erosion, high radiation, vibration, fretting, water hammer
- Bolting and support structures
- Equipment qualification records

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NIST Vessel Inspection (1/3)

- NIST test reactor
  - Began operation in 1967
  - 20 megawatt licensed power level
  - Heavy water primary coolant
  - Aluminum reactor vessel
- Licensee performed a voluntary visual inspection of the vessel in 2000 and 2002 using a remotely operated radiation hardened camera
- Inspections results were summarized in the license renewal application in 2004

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NIST Vessel Inspection (2/3)

- Interior inspection
  - Tip welds on experiment facilities
  - Vessel penetration welds
  - Vessel fabrication welds
  - Grid plates
  - Emergency cooling components
  - Structural members for internal components
- Licensee found that the welds were in good condition
- Licensee found no other defects that affect the design function of the inspected components

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NIST Vessel Inspection (3/3)

- Exterior inspection
  - Vessel wall
  - Primary coolant outlet piping
  - Primary coolant outer plenum
  - Refueling transfer pipe
- Licensee found no material conditions that could lead to failure of the vessel or primary coolant system
- Vessel inspection to be repeated every 6-8 years

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Operating Experience (1/1)

- Research reactors have a long history of operation in the U.S. and world-wide
- Many U.S. NRC rules require documentation and record retention for the life of the reactor
- Licensees also have corrective action programs and maintenance and surveillance program records
- The recorded operating experience can inform ageing management at a single reactor or across a group of similar reactors

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Conclusion (1/1)

- Questions?

- Thank you for your attention.