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Overview of Flood Barrier Testing Strategies Project

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Idaho National Laboratory
Idaho Falls, Idaho 83415

http://www.inl.gov

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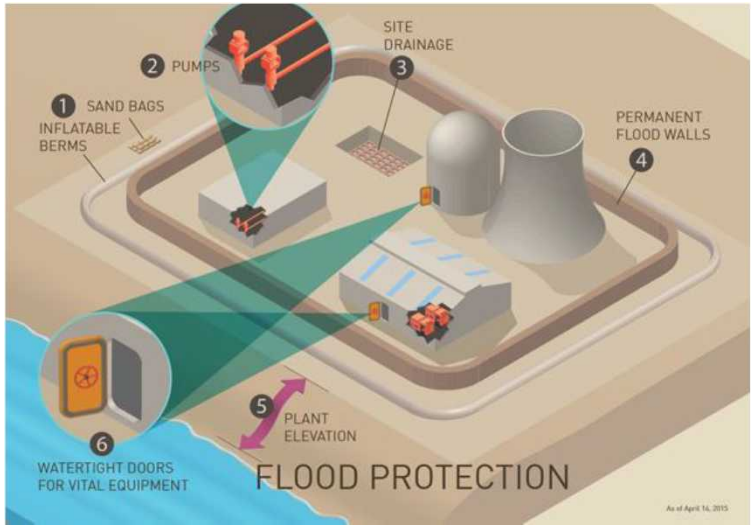
Zhegang Ma, Ph.D., P.E.
Sai Zhang, Ph.D.
Curtis Smith, Ph.D.

NRC Flood Barrier Testing Strategies Workshop
March 12, 2020
Rockville, MD, USA

Background

- Flood barriers are part of the nuclear power plant (NPP) flood protection features that prevent structures, systems, and components (SSCs) from experiencing flooding and mitigate the effects of flooding
- Flood barriers can be on-site or off-site, permanent or temporary, active or passive
  - Permanent: external and internal walls, watertight doors, and flood penetration seals
  - Temporary: sandbags, temporary walls, removable doors, and stop-logs



Background (cont'd)

- Operational experiences have shown that flood barrier performance could have significant safety implications, especially as the domestic reactor fleet ages
  - Inadequate design or installation
  - Non-functional due to aging and degradation
  - Inadequate inspection procedures or acceptance criteria for detecting deficient flood barriers
  - Deficient analyses associated with flood barriers
  - Discrepancies between tested flood barrier designs and plant-installed designs
  - Installed barriers modified but not evaluated or tested
  - Deficient flood barriers due to lack of fill or being composed of non-watertight materials
  - Missing penetration seals or internal conduit seals

Background (cont'd)

- Flood barriers must be adequately tested, inspected, and maintained to provide reasonable assurance that they can perform their intended functions in the event of flooding
- Project objective: to identify and assess options and develop strategies for testing NPP flood barriers
  - Investigate the current state of NPP decommissioning which impacts opportunities and challenges for harvesting
  - Consider technical and logistical challenges in harvesting and laboratory testing of flood barriers
  - Potential alternatives to harvesting, such as in-situ testing, enhanced inspection

Project Team

- INL
  - Curtis Smith, PI
  - Zhegang Ma
  - Sai Zhang
  - John Biersdorf
- Idaho State University
  - Chad Pope, Professor

Project Status

- Task 1: Review Available Information on Flood Barriers
  - Licensee walkdown reports
  - Previous NRC research
  - Nuclear Energy Institute (NEI), Electric Power Research Institutes (EPRI) reports
  - Information from vendors
  - Decommissioning info
  - Other government agencies (e.g., U.S. Army Corps of Engineers)
  - International organizations (e.g., Nuclear Energy Agency)
  - **Status – Task report drafted, reviewed, and revised**

Project Status (cont'd)

- Task 2: Flood Barrier Testing Workshop
  - Present preliminary results from the project
  - Engage industry stakeholders and technical experts to provide inputs and insights
  - **Status – Ongoing**
- Task 3: International Harvesting Workshop
  - **Cancelled**
- Task 4: Knowledge Transfer
  - Participate the NRC PFHA Research Workshop - **Completed**
  - Prepare a draft NUREG/CR report – **9/15/2020**

Project Preliminary Results

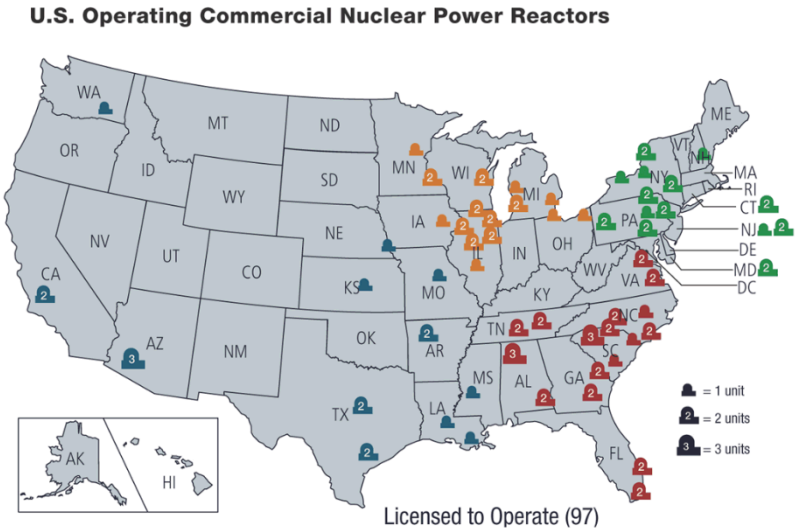
- **Literature Review** (presented separately)
  - Including plant flooding walkdown report review
- **Flood Barrier Categorization and Terminology**
- **Flood Barrier Overview**
- **Potential Flood Barrier Testing Facilities**
- **Previous Flood Barrier Tests** (presented separately)
- **Flood Barrier Testing Strategies**
  - Considerations in developing flood barrier testing strategies

Flood Barrier Overview

- **Categorization**
  - On-site vs. Off-site
  - Permanent vs. Temporary
  - Active vs. Passive
- **On-site Permanent**
  - Penetration Seals
  - Watertight Doors
- **On-site Temporary**
  - Disposable – absorbent pad, etc.
  - Reusable – floodgates, hydrostatic tarp, etc.

Potential Flood Barrier Testing Facilities

- **Operating Plants**
  - Nearly 100 licensed NPPs in the United States
  - Potential testing facilities for in-situ non-destructive testing or enhanced inspection
  - Testing must be carefully incorporated into plant's O&M schedule to avoid inadvertently impacting the safety and reliability of plant operations



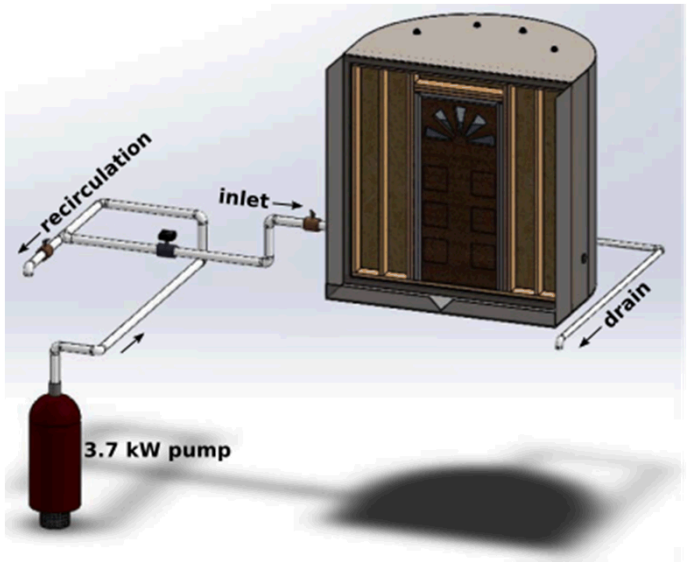
Potential Flood Barrier Testing Facilities

- **Decommissioning Plants**
  - About 20 power reactors undergoing decommissioning

- **Major Decommissioning Companies**
  - **Holtec Decommissioning International (HDI)**
    - Oyster Creek, Pilgrim
    - Purchase agreements for Palisades and Indian Point
  - **Northstar**
    - Vermont Yankee
  - **EnergySolutions**
    - Zion and La Crosse

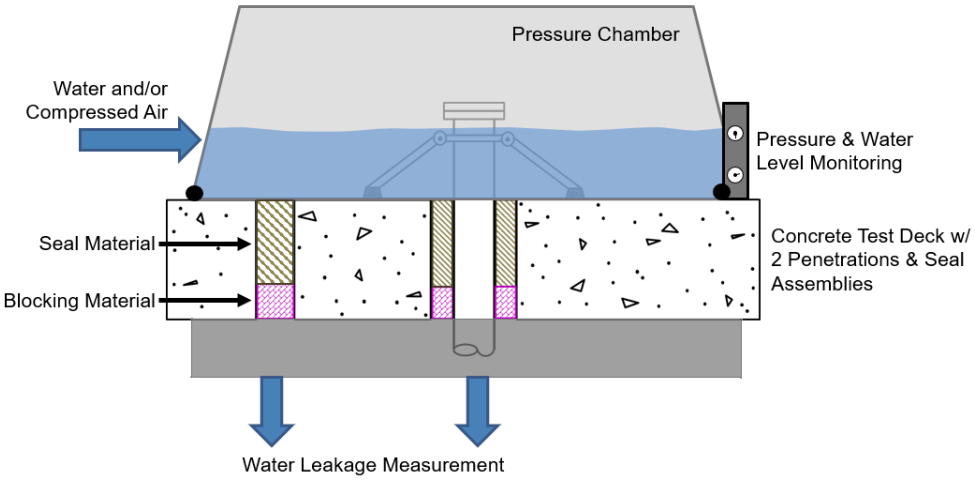
Potential Flood Barrier Testing Facilities

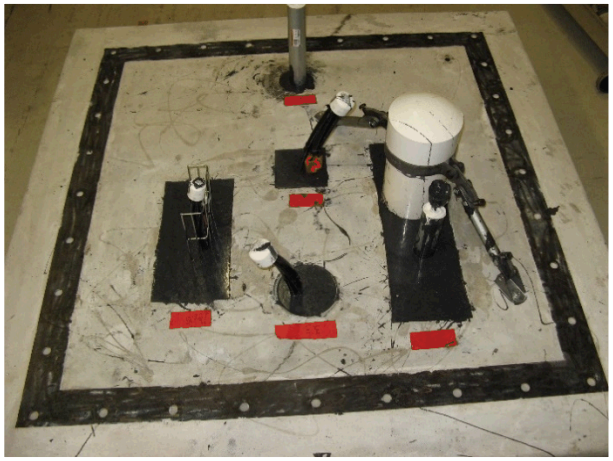
- **Other Testing Facilities - Idaho State University Flood Testing Facility**
  - Portal Evaluation Tank (PET)
  - A steel, semi-cylindrical tank with a height and diameter of 8 ft, can hold up to 2,000-gal of water
  - 5 HP submersible pump inside a 8,000-gal water reservoir
  - Inlet electromagnetic flow meter, ultrasonic depth sensor, and pressure transducer, pressure and air relief valves and a digital pressure gauge



Potential Flood Barrier Testing Facilities

- **Other Testing Facilities - Framatome Laboratory Flood Testing Facility**
  - Test apparatus for research on penetration seal testing protocol
  - Three main components
    - Pressure chamber
    - Concrete test deck
    - Water leakage measurement system





Flood Barrier Testing Strategies Considerations

- **What to be tested?**
  - Hundreds of flood barriers
  - Risk/Safety ranking
  - Location (i.e., Accessibility)
- **Type of Flood Barriers for Testing**
  - Seals, Doors, Walls, Floors, Temporary Barriers
- **Codes and Standards**
  - Penetration Seals
    - UL 1479 and UL 2079 for pressure testing of fire barriers
  - Doors
    - Door testing standards, e.g., ASTM E331
    - Analytical methods
  - Base Structures

Flood Barrier Testing Strategies (Cont'd)

- **Protocols and Plans**
  - **Testing Locations**
    - In-situ (in plant, in place)
    - Ex-situ but on-site (not in place, but on-site)
    - Ex-situ and off-site (off-site testing facilities)
  - **Flood Effect and Failure Modes**
    - Hydrostatic pressure, hydrodynamic pressure, debris impact
    - Excessive leakage, loss of integrity, displacement, overtopping
  - **Mediums**
    - Water, air, steam
    - Standing (without pressure) - static pressure testing
    - Under pressure (via pump or air) - dynamic pressure testing

Flood Barrier Testing Strategies (Cont'd)

- **Protocols and Plans**
  - **Parameters**
    - Input Parameters: test pressure, water levels, flow rate, duration of applied pressure, rate of pressure change, debris size
    - Output Parameters: leakage rate, maximum pressure before loss of integrity
    - Other Parameters: water temperature, test duration, time history
  - **Acceptance Criteria**
    - In accordance with the functional requirements
    - No/neglect leakage, maintained integrity under static and/or dynamic pressure
  - **Other aspects**
    - Destructive vs non-destructive, sample vs actual flood barriers

Flood Barrier Testing Strategies (Cont'd)

- **We want to engage industry stakeholders and technical experts for insights and inputs**
  - During the workshop
  - After the workshop

Thomas.Aird@nrc.gov

Curtis.Smith@inl.gov

Zhegang.Ma@inl.gov