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Materials Harvesting

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The views expressed in this presentation are those of the authors, not necessarily those of the U.S. NRC.

Topics

- Background
  - March 2017 Workshop
- Current Activities
  - Interests Prioritization
  - Opportunities Information Gathering
- Path Forward
  - Domestic Coordination
  - International Cooperation

Background

- Ex-plant materials are valuable because they have been exposed to actual in-service plant operating conditions
  - Can reduce the uncertainty associated with the applicability of the aging conditions
  - Insights from research on harvested materials can increase confidence for extended plant operation
- Greater opportunities for harvesting
  - Significant number of decommissioning plants worldwide
- Past harvesting efforts generally more reactive as opportunities arose, rather than proactively planned
  - Focused prioritization of interests and optimal plants from which to harvest can maximize value from harvesting

March 2017 Workshop

- U.S. and international participants discussed various aspects of harvesting:
  - Past harvesting experience / lessons learned
  - Motivation / interest in harvesting
  - Harvesting opportunities / information gathering
  - Practical challenges with harvesting
    - Logistical, schedule, budget, etc
- Key conclusion was that harvesting is time and resource-intensive, but can be very valuable
  - Cooperation and focus on highest priority interests are essential to achieve optimal value from harvesting

Recent and Ongoing Harvesting Activities

Country	Plant	Design	Size (MWe)	Years in operation	Components	Status	Organization(s)
Canada	NPD	CANDU	20	25	Concrete		AECL
	Gentilly-2	CANDU-6	675	29	Cables		
Japan	Hamaoka 1	BWR-4	540	33	RPV, concrete	Harvesting completed in 2018	CRIEPI, Chubu
Spain	Zorita	W 1-loop	160	37	Internals	Harvesting completed in 2013; DECON nearly complete	EPRI, NRC
Sweden	Barseback	ABB-II	615	28	RPV		Vattenfall
U.S.	Zion 1/2	W – 4 loop	1040	24/25	RPV, cables, neutron absorbers, electrical bus duct	Harvesting complete; DECON finished by 2020	DOE, EPRI, NRC
	Crystal River 3	B&W	860	36	Cables	Harvesting complete; Plant in SAFSTOR	EPRI, NRC
	Ginna	W 2-loop	580	42 (when baffle bolts removed)	Baffle bolts	Plant still operating	DOE

Materials Harvesting Strategy

- Objective
  - Harvest materials that are representative of the key degradation modes encountered in LWR components
  - Perform testing and characterization to assess degradation, inform future life predictions, and correlate with NDE inspections
- Approach
  - Identify and prioritize interests that should be addressed by harvesting
    - May include in situ observations or NDE, as well as physical removal of samples for testing and characterization
  - Identify the potentially available materials from global LWR plants that would be most suited to provide relevant materials for testing and characterization
  - Work with domestic and international organizations to identify funding and resources for harvesting, as well as characterization and testing of harvested materials

Harvesting Interests Prioritization

- Purpose: identify and prioritize materials degradation issues best addressed by harvesting to focus limited resources on highest priority needs
  - Organizations will likely have different priorities driven by varying criteria consistent with their missions and roles
- Regulatory and industry considerations may include:
  - Safety significance / state of knowledge,
  - Ease of lab replication / applicability of data to operating fleet,
  - Inspection methods for aging management
  - Cost / complexity
- PNNL report describes one approach in greater detail
  - Publicly available in ADAMS - ML19081A006

Harvesting Opportunities / Plans

- NRC and EPRI are aware of numerous opportunities and plans for harvesting in the U.S. and internationally
  - Japan – numerous plants
  - Korea – Kori 1
  - Spain – Garoña
  - Sweden – Ringhals and Oskarshamn
  - Switzerland – Muhleberg
  - United States – SONGS, Vermont Yankee, others
- Considering potential participation in these harvesting efforts within a broader harvesting strategy

PLANNED or POTENTIAL Harvesting

Country	Plant	Utility	Design	Size (MWe)	Years in operation	Shutdown Date	Harvesting or Decommissioning Plan / Timeline
U.S.	Vermont Yankee	Entergy	BWR-4/Mk-1	605	42	2015	Active decommissioning from 2021-2030
	SONGS 2	SCE Edison	CE 2-loop	1070	31/30	01/10/2012	Active decommissioning begins in mid-2019
	SONGS 3	SCE Edison	CE 2-loop	1070	31/30	01/31/2012	Active decommissioning begins in mid-2019
	Oyster Creek	Exelon	BWR-2/Mk-1	619	49	2018	Active decommissioning from 2020-2028
	Pilgrim	Entergy	BWR-3/Mk-1	677	47	2019	Active decommissioning from 2020-2028
	Palisades	Entergy	CE 2-loop	805	47	2022	Still operating
	Indian Point 2	Entergy	W 4-loop	1020	48	2020	Still operating
	Indian Point 3	Entergy	W 4-loop	1040	46	2021	Still operating
	Diablo Canyon 1	PG&E	W 4-loop	1138	40	2024	Still operating
	Diablo Canyon 2	PG&E	W 4-loop	1118	40	2025	Still operating
	Three Mile Island 1	Exelon	B&W	819	39	2019	Still operating
	Fort Calhoun	OPPD	CE	478	43	10/24/2016	SAFSTOR
	Kewaunee	Dominion	W 2-loop	566	39	05/07/2013	SAFSTOR until 2069

Harvesting Opportunities

- Purpose: Capture plant-specific information needed to identify preferred harvesting sources for different components or degradation mechanisms
- Tables indicate the important characteristics of plants that are decommissioning to help determine the optimal components for harvesting
  - Essential information on reactor design and operation, harvesting plan / timeline, and partner organizations
  - Key material (alloy, etc.) and environment (dose, temp, etc.) data

RPV Beltline			PWR RPV Head Penetrations / BWR Instrumentation Penetrations			Baffle Plate			Internals Bolts			Core Shroud / Barrel Welds			Lower Support Column (if made of CASS)		
Material (Alloy & Fabrication Method)	Environment (dpa, temp, water chemistry)	OpE or other info	Material (Alloy & Fabrication Method)	Environment (EFPY, temp, water chemistry)	OpE or other info	Material (Alloy & Fabrication Method)	Environment (dpa, temp, water chemistry)	OpE or other info	Material (Alloy & Fabrication Method)	Environment (dpa, temp, water chemistry)	OpE or other info	Material (Alloy & Fabrication Method)	Environment (dpa, temp, water chemistry)	OpE or other info	Material (Alloy & Fabrication Method)	Environment (dpa, temp, water chemistry)	OpE or other info

- EPRI and NRC working to improve / populate these tables, but support and involvement of utilities/plant owners is critical to ensure accuracy

Domestic Coordination

- Harvesting coordination meeting held on Monday, May 20 at NRC HQ
  - Participants included DOE, EPRI, NRC, and industry stakeholders
  - Parallel working meetings on metals, electrical, concrete, and flood barriers
- Summary of Discussion
  - Alignment on highest priorities and interests for harvesting
  - Strategy for identifying the optimal components to harvest to address identified priorities
  - Strategies for domestic and international cooperation options to maximize value to all parties
  - Objectives and scope of an international harvesting workshop being considered for fall 2019

International Cooperation

- **Vision**: international cooperation on harvesting to minimize overlap / duplication and maximize value for all stakeholders
  - Leverage plans in individual countries to improve technical knowledge of materials aging during extended plant operation
- Identify the most valuable harvesting opportunities
  - Based on materials and aging conditions (temperature, fluence, time, etc.) from shutdown plants
  - Target opportunities that are representative or reasonably bounding of operating LWRs
- Implement international cooperation to enable and support harvesting on the most valuable opportunities
  - Greater challenges with aligning interests and priorities internationally, but also the potential for greater value
- NRC considering organizing an international workshop in the fall 2019 timeframe

Summary

- Harvesting can be time and resource-intensive, but can provide valuable information on materials behavior in highly representative environments
- Several harvesting projects have been performed, from which lessons can be learned to improve efficiencies
- Key to ensure value is to harvest components that best address identified interests
  - Gathering information from utilities and plant owners on components available for harvesting is **essential** to this process
- Domestic and international cooperation optimize value of harvesting for all research organizations