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Harvesting of Materials from Operating and Decommissioning Nuclear Power Plants

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Motivation for Harvesting

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- US utilities are interested in extending operating lifespans from 60 to 80 years:
  - Key technical areas for aging management
    - RPV embrittlement, irradiation-assisted degradation of internals, concrete structures and containment, electrical cables
- Plant shutdowns provide opportunities to harvest components during decommissioning
  - Harvesting can provide valuable information on aging mechanisms to increase confidence in aging management
- Limited budgets make cooperation for new research, including harvesting, essential:
  - Important to align interested parties
  - Leverage resources for maximum benefit

NRC Harvesting Experience

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- NRC has participated in several programs:
  - RPV, CRDM penetrations, RCS piping, RPV internals, neutron absorbers, and cables
  - Materials harvested from unfinished, operating and decommissioning plants
  - US and international programs
- NRC experience has demonstrated that is there is significant value in using harvested components to confirm data from other research programs

Lessons Learned

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- Technical
  - Provides highly representative aged materials for research
  - Important to gain as much background information on material and component as possible before committing to specific harvesting project
- Logistical
  - Expensive and time-consuming effort
  - Leveraging resources helps mitigate cost challenges
  - Transportation of irradiated materials is cumbersome and time-consuming

Ex-Plant Materials Harvesting Workshop

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- Overview
  - **Purpose**: Discuss benefits and challenges associated with harvesting
  - Held at NRC HQ on March 7-8, 2017
  - Participants included U.S. and international utilities and researchers
- Technical sessions
  - Motivation, data needs, sources of materials, lessons learned and practical aspects of harvesting, and decision-making and planning
- Summary of discussion
  - Focused on the importance of clearly identifying the need and purpose for performing a harvesting project.
  - Harvesting is a complex and expensive proposition, but one that can be worthwhile if the need is clearly defined and addressed.
- Slides and summary report can be found at https://drive.google.com/open?id=0B5DWMLch5YSXcnpZZ0JOS055QUU

Current Work

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- Develop strategic approach to materials harvesting
  - Past efforts have been reactive to individual plants shutting down
  - Identify target harvesting candidates early in the shutdown process
- Prioritize data needs best addressed by harvesting, considering:
  - Applicability of harvested material for addressing gaps
  - Importance of harvested materials over laboratory aging
  - Fleet-wide vs plant-specific applicability of data
  - Regulatory considerations
  - Harvesting cost/complexity
- Database for sources of materials
  - Compilation of previously harvested materials and components from NRC-sponsored programs available at US national labs
  - NRC is interested in engaging with other organizations in developing a broader database

Ex-plant Materials of Interest - Metals

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- RPV
  - High fluence & highly embrittled vessel with well-established unirradiated properties (or a means to estimate them)
    - Through-thickness section to validate fluence & attenuation models
    - Measure fluence, toughness, & chemistry as a function of through-thickness position
  - Samples from virtually any vessel
    - Of sufficient size to enable measurement of both the Charpy transition curve and Master Curve transition temperature, T_0
    - Objectives
      - Enables demonstration of the conservatism of regulatory approaches for transition temperature prediction
      - Provides data supporting evolution from the use of correlative (Charpy-based) to direct measurement (fracture toughness-based) approaches

Ex-plant Materials of Interest - Metals

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- CASS and Internals
  - High fluence reactor internals
    - >50 dpa 304 SS from high core outlet temp plant
    - Bounding temperature and high fluence for void swelling
  - Thermally aged unirradiated CASS
    - >30 years at ~320°C; Validate accelerated aging data
  - Moderate fluence (1-2 dpa) CASS
    - Bolster technical basis for embrittlement in this fluence range
- Components with known flaws
  - Example: weld overlays over known flaws
    - Evaluation or NDE reliability
    - Assess effectiveness of mitigation techniques
- Components with limiting fatigue life
  - Confirm fatigue calculations are accurate by inspecting for flaws

Ex-plant Materials of Interest - Electrical

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- Cables
  - Low and medium voltage cables
  - Cables protected with fire retardant coating
- Electrical components
  - 1E MOVs from harsh and mild environments
  - 1E Air operated valves; 4160 1E breakers
  - 1E Molded case breakers 480V, 250V DC, 125 VDC,
  - 1E Relays from mild environment GE – HFA, Agastat timing relays, any from Westinghouse, Potter Brumfield, Stuthers Dunn etc.,
  - Electrical penetrations; Batteries
- Fire research interest
  - Electrical enclosures
    - Distribution : switchgear, MCCs, LCs | Control : Horseshoe, SSCP, ASP, etc.

Ex-plant Materials of Interest - Concrete

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- Structures exposed to high radiation
- Post-tensioned structures
- Corrosion of reinforcing steel, tendon, liner, embedment
- Spent fuel pool and transfer canal-boric acid attack on concrete in PWRs
- Alkali Aggregate Reaction
- Large structural sections for testing

Summary

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- Harvesting can yield highly representative and valuable data on materials aging
- A focused approach to choosing harvested materials is necessary to get best outcomes
- NRC is working on a sources of materials database and prioritizing data needs based on relevant criteria to inform decisions on specific harvesting opportunities
- NRC welcomes opportunities for cooperation and leveraging with other interested research organizations

Suggested NRC/NRA Collaboration

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- NRC is interested in the status of the planned work on harvesting RPV materials and concrete from Hamaoka 1 and, if it has been completed, if those results can be shared with the NRC.

- NRC wishes to learn about any other harvesting programs that NRA and/or CRIEPI are either planning or are already in progress
  - If such programs are in progress, NRC would be interested in obtaining any information that can be shared
  - If such programs are being planned, NRC would be interested in learning about any partnering opportunities that NRA foresees

- NRC would like to determine NRA's interest in participating in a harvesting project identified by the US or another country. If NRA is potentially interested in such a program, NRC can contact NRA and provide information if such harvesting opportunities develop