

Harvesting of Materials from Operating and Decommissioning Nuclear Power Plants

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Motivation for Harvesting

- 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

- 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 there is significant value in using harvested components to confirm data from other research programs

Lessons Learned

- 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

- 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

- 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

- 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

- 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

- 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

- 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

- 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

- 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