Radiation Safety Program Overview

Focus: Cavity Decontamination Sourcebook

Phung Tran, Radiation Safety Program Manager

2016 NATC ISOE ALARA Symposium
January 11-13, 2016

Overview

- EPRI Mission and Radiation Safety Program Structure
- Prior work in cavity decontamination
- Cavity Decontamination Sourcebook Highlights
  - BWR highlights
  - PWR highlights
- Cavity Activity Characterization Protocol
- Summary

EPRI Mission

Advancing ***safe***, ***reliable***, ***affordable*** and ***environmentally responsible*** electricity for society through global collaboration, thought leadership and science & technology innovation

Independent

Objective, scientifically based results address reliability, efficiency, affordability, health, safety and the environment

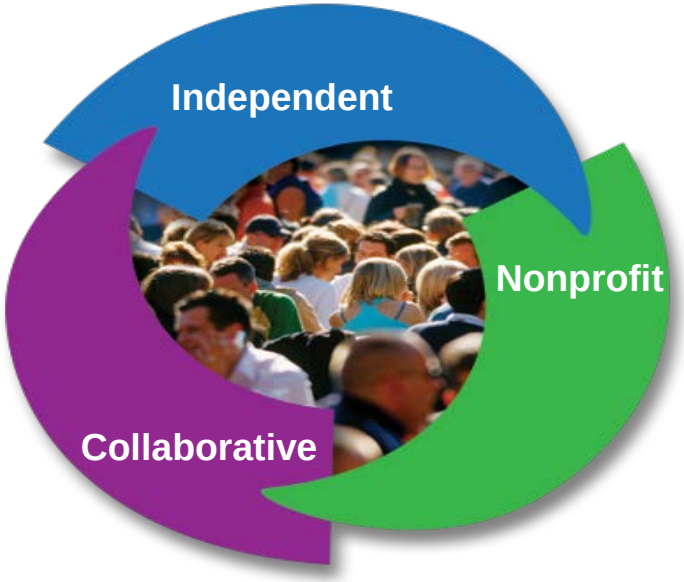
Nonprofit

Chartered to serve the public benefit

Collaborative

Bring together scientists, engineers, academic researchers, industry expert

<u>450+ members in 30+ countries</u>



Founded in 1972

Major offices in Palo Alto, CA; Charlotte, NC; Knoxville, TN

Conducting Research Today

Power Delivery and Utilization

- Transmission Lines and Substations
- Grid Operations and Planning
- Distribution
- Energy Utilization
- Cross-Cutting Technologies
- Information and Communication Technologies

Nuclear

- Advanced Nuclear Technology
- Chemistry and Radiation Safety
- Equipment Reliability
- Fuel Reliability
- Long-Term Operations
- Materials Degradation/Aging
- Nondestructive Evaluation and Material Characterization
- Risk and Safety Management
- Used Fuel and High-level Waste Management

Generation

- Advanced Fossil, Carbon Capture, Utilization and Storage
- Combined Cycle
- Environmental Controls
- Major Component Reliability
- Materials and Chemistry
- Operations and Maintenance
- Power Plant Water Management

Environment and Renewable Energy

- Air Quality
- Energy and Environmental Analysis
- Land and Groundwater
- Occupational Health and Safety
- Renewable Energy
- T&D Environmental Issues
- Water and Ecosystems

EPRI Organization
Fuels & Chemistry

Nuclear Power Council (NPC)

Director Nuclear Fuel & Chemistry

Randy Stark

Action Plan Committee (APC)

Fuels

High Level Waste

Rick Reid

Chemistry-Radiation Safety

Lisa Edwards

Technical Advisory Committee (TAC)

Chemistry

Dan Wells

Radiation Safety

Phung Tran

Base

Technical Strategy Groups (TSGs)

PWR Chemistry

BWR Chemistry

Radiation Mgmt & Source Term

Low Level Waste

Radiological Environmental

Radiation Safety TSGs

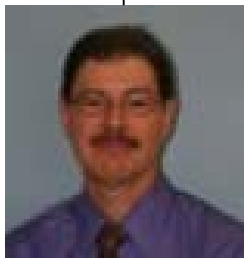
Program

Decommissioning

Supplemental

Radiation Safety Team

Phung Tran
Program Manager
650-855-2158
ptran@epri.com



Dr. Donald Cool
Technical Executive
704-595-2541
dcool@epri.com

Dr. Carola Gregorich
Sr. Technical Leader
650-855-8917
cgregorich@epri.com

Karen Kim
Sr. Technical Leader
650-855-2190
kkim@epri.com

Nicole Lynch
Project Engineer
650-855-2060
nlynch@epri.com

Radiation Safety Program

✓ RFA with projects funded

- Program Goals:
  - Develop tools, technologies, and improvements to operational practices that can
    - Enhance public and worker safety
    - Reduce risks associated with waste management

Radiation Management & Source Term

Radiological Environmental Protection

Low Level Waste

Low Dose Health Effects

Research Focus Areas (RFA):

- ✓ ALARA Strategies and Technologies
- ✓ Radioactivity Generation and Control (Source Term Reduction)
- ✓ Radiation Safety Guidance
- ✓ Accurate Dose Reporting for Workers and Public
- ✓ Radiation Safety Benchmarking and Trending
- ✓ Low Dose
- ❑ Integration of Industrial and Radiological Safety
- ❑ Radiation Detection and Measurement
- ❑ Environmental Monitoring and Remediation

Radiation Safety Research Focus Areas

ALARA Strategies and Technologies

- Combines source term reduction technologies with typical dose reduction tools and work planning improvements to provide a comprehensive strategy for reducing dose to workers.

Radioactivity Generation and Control (Source Term Reduction)

- Understanding radioactivity and radiation field generation and transport processes and tools/technologies for improved control of radioactivity for reducing radiation fields and effluents

Radiation Safety Guidance

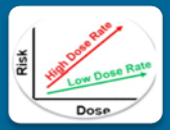
- Development and maintenance of guidelines, guides and sourcebooks for radiation protection, source term reduction, radiological environmental protection (which includes groundwater), and low level waste.

Accurate Dose Reporting for Workers and Public

- Provide more accurate dose assessment methodologies for determining worker dose and public dose due to effluents.

Benchmarking and Trending (Fundamental)

- Maintenance of databases for the Standard Radiation Monitoring Programs (SRMP/BRAC) and the industry low level waste benchmarking database, RadBench™.



Low Dose Radiation Health Effects

- Investigate health risks from exposure to low doses of ionizing radiation to inform development of radiation safety standards.

Integration of Industrial and Radiological Safety

- Develop technologies and strategies for comprehensive worker protection, addressing both radiological and industrial hazards.

Radiation Detection and Measurements

- Evaluate new measurement technologies for radiation detection and isotopic measurements.

Environmental Monitoring and Remediation

- Investigate improvements to environmental monitoring and remediation of groundwater and soil.

Radiation Safety R&D Portfolio (2016-2017)

ALARA Strategies and Technologies

- Decision Logic for Source Term Reduction
- Location Tracking for Dose Optimization
- SG Dose Optimization
- Top Ten ALARA Initiatives for New Builds

Radioactivity Generation and Control (Source Term Reduction)

- Micro-environments on Activity Transport
- Chemistry Strategies for Surface Passivation
- Hydrophobic Treatment of Surfaces
- Silver and Antimony on Radiation Fields
- Radionuclides and Chemicals Generated from Injected, New, or Foreign Materials

Radiation Safety Guidance

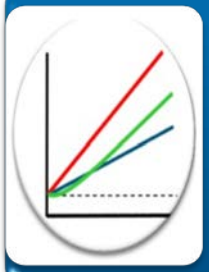
- Revision to On-site Storage Operating Guideline
- BTP Implementation Guide
- Long Term GW Monitoring & Decom. Planning
- Support of Regulatory Issues in LLW & REP

Accurate Dose Reporting for Workers and Public

- Improve Lens of the Eye Dose Monitoring
- Accurate Effluent Dose to Members of the Public
- EDEX Implementation Guide
- Hard to Measure Radionuclides in Effluents (BWRs)

Benchmarking and Trending (Fundamental)

- Radiation Field Monitoring (SRMP/BRAC)
- RadBench™



Low Dose Health Effects

- Low Dose Rate Cancer Risks: Meta Analysis of Influential Human Data and Analysis of Animal Data
- **Investigation of Cardiovascular Effects**
- Global Research Coordination: SAC and IDEA

2015 Radiation Safety Program Deliverables

Radiation Management & Source Term

- Incorporation of Co-58 and Co-60 into PWR Primary System Surface Oxides (3002005409)
- In-Plant Gamma Spectrometry: Isotopic Data Collection Experiences (3002005481)

✓ Reactor Cavity Decontamination Sourcebook (3002005479)

Low Level Waste

- Technicium-99 and Iodine-129 Scaling Factors for Waste Manifest (3002005564)
- Chemical Engineering Evaluation/Feasibility Study of an On-Line Lithium Removal Process (3002006412)

Radiological Environmental Protection

- Groundwater Protection Risk Assessment and Mitigation for Work Practices and Systems, Structures, and Components (3002004881)
- Investigation of Hard to Measure Radionuclides in Nuclear Power Plant Effluents- Pressurized Water Reactor (3002005563)

✓ Discussed at 2016 NATC ISOE ALARA Symposium

Technical Strategy Group(s) – Available to TSG Members only

- Remote Monitoring Technology for Radiation Protection: Field Implementation Guide, 2015 Revision (3002005480)
- High-Efficiency Ultrasonic Fuel Cleaning as a Source Term Reduction Tool in Boiling Water Reactors- Results of Scoping Benefits Study (3002005482)

✓ EPRI Plant Source Term Assessments, 2015 Review (3002005484)

- Pressurized Water Reactor Shutdown Activity Releases – 2014 Summary (3002005483)
- Sampling and Analysis of Tritium in Soil (3002005565)

Reactor Cavity Decontamination Sourcebook

3002005479

Dennis Hussey

Prior Work in Reactor Cavity Decontamination

- "Development of a Reactor Cavity Decontamination Plan", EPRI Report 1009576, 2004
- Useful source for technologies and methods that weren't previously documented
  - Focused primarily on decontamination activities
  - 29 committee attendees, six U.S. sites responded to survey
- Update requested after 10 years

Cavity Decontamination Sourcebook Highlights

- US and non-US workshops held to exchange information
  - EDF partnered with EPRI to host workshops (Paris & Charlotte)
  - 76 committee members (utility and vendor)
  - 19 sites participated in survey
  - 8 United States, 11 non-US (three German sites)
- Content expanded to include shutdown chemistry and cavity water activity management
  - Inclusion of PWR and BWR cavity chemistry considerations
  - Activity transport mechanisms discussed

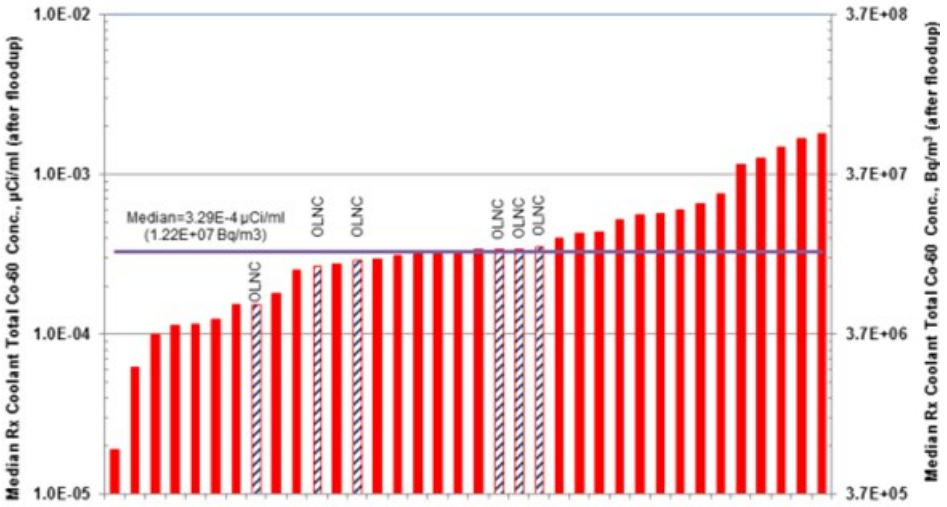
BWR Highlights: Benchmarking

- Large variance in cavity decontamination efforts
  - Olkiluoto (BWRs)
    - Short critical path, few workers
    - Low collective dose for job
    - Very low contamination
      - Before: 1600 Bq/cm^2 (96k dpm/cm^2)
      - After: 10 Bq/cm^2 (600 dpm/cm^2)
  - Limerick (BWRs)
    - Short critical path, large # of workers
    - High collective dose for job
    - Much higher contamination levels
- Cavity decontamination plans must be tailored to site characteristics and goals

Parameter	Limerick 1 and 2	Olkiluoto 1 and 2
Duration (hrs)	5	1.5 (pre-refuel) 3.0 (post-refuel)
Critical Path (hrs)	5	4.5
# Workers	38	6 – 8
Workload (man-hrs)	190	27- 36
Collective Dose mrem (mSv)	2400 – 5000 (24 – 50)	100 - 120 (1 – 1.2)
Max. Individual Dose mrem (mSv)	90 – 300 (0.9 – 3)	20 (0.2)

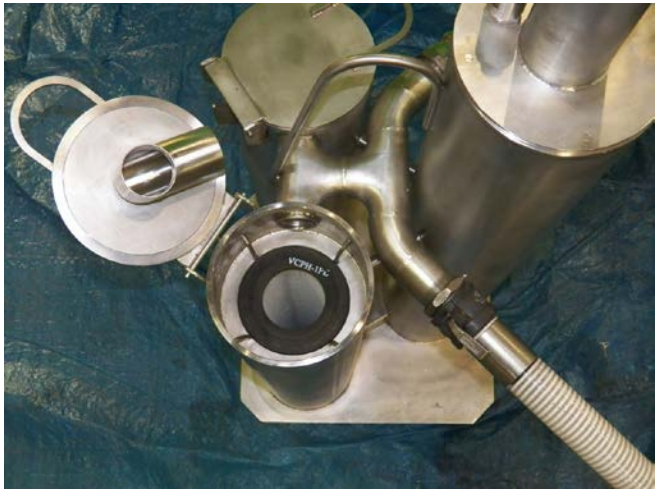
BWR Highlights: Cavity Water Radioactivity

- Median Co-60 activity in cavity varies considerably among plants, appears independent from mitigation strategy
- Outage operations can affect cavity water radioactivity
  - RHR and other system flushing prior to loop swaps is recommended to reduce activity transport to the cavity
- Supplemental filtration and ion exchange recommended when needed (e.g. submersible demins and filters)



Median Co-60 Levels after BWR Cavity Floodup through Cavity Drain

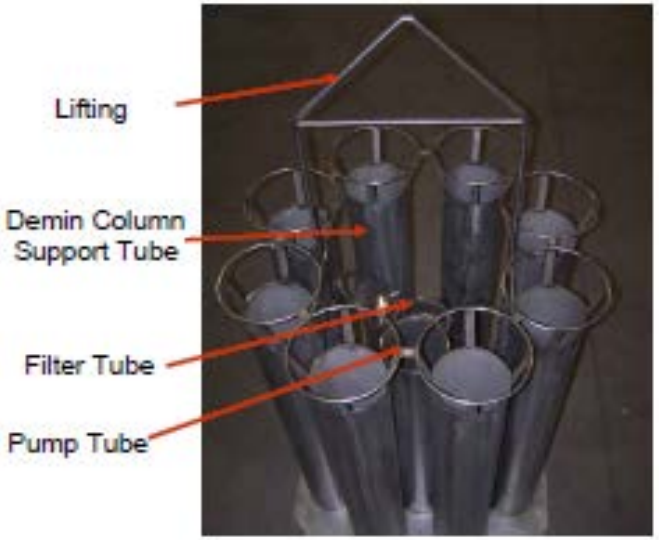
Supplemental Cleanup Systems



- Both plant types use submersible filters
- Submersible demineralizer used mostly in BWRs
- Slow adoption in PWRs due to handling issues

Submersible systems can improve water clarity and remove radioactivity that contribute to refuel bridge dose rates

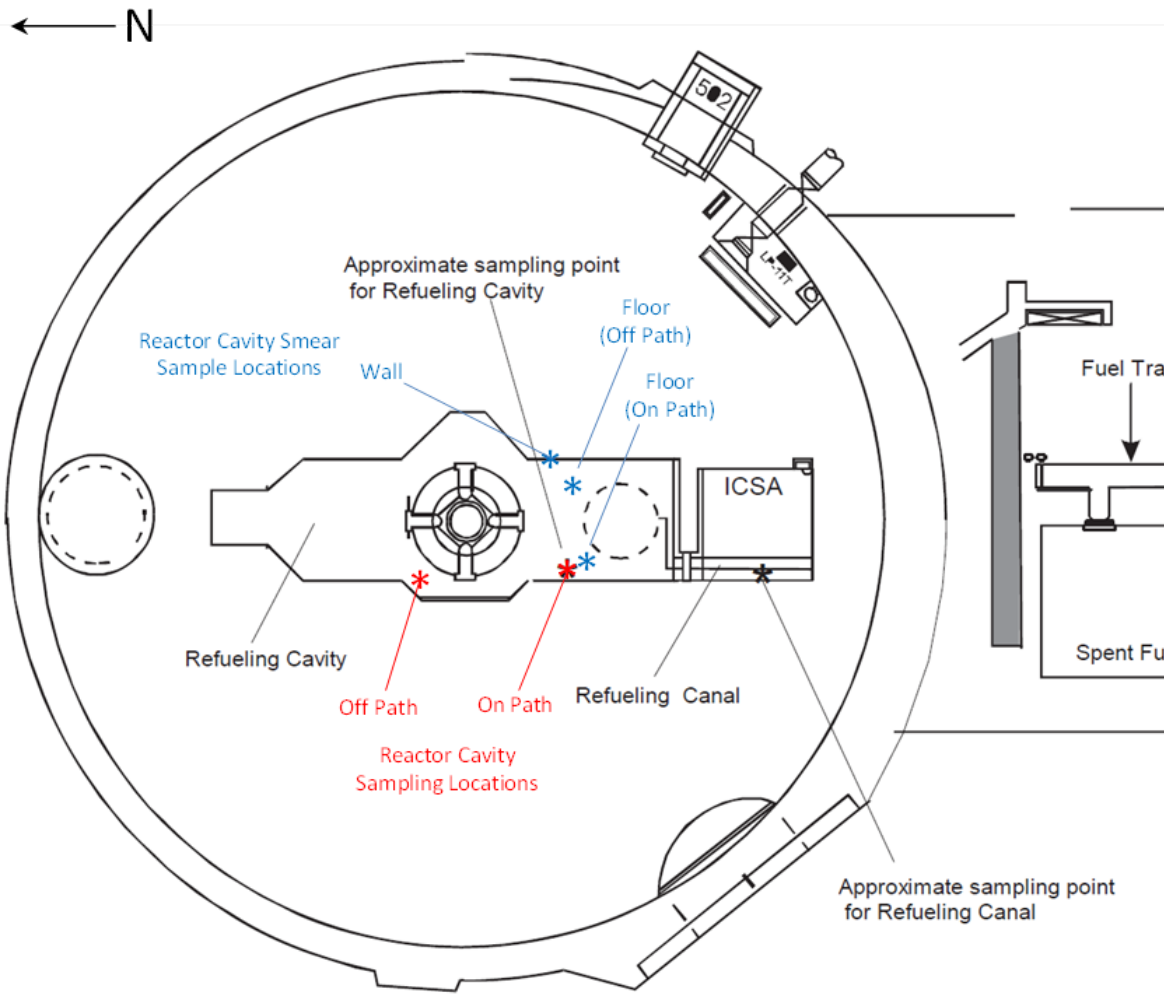
Typical Submersible Demineralizer



Seabrook's Tri Nuclear Demineralizer System

Cavity Activity Characterization Protocol

- Cavity activity characterization is needed to determine efficacy of decontamination technique
- Relationship between cavity water activity and cavity wall smears has not been investigated in prior work
- South Texas Project volunteered to provide support to test a comparison

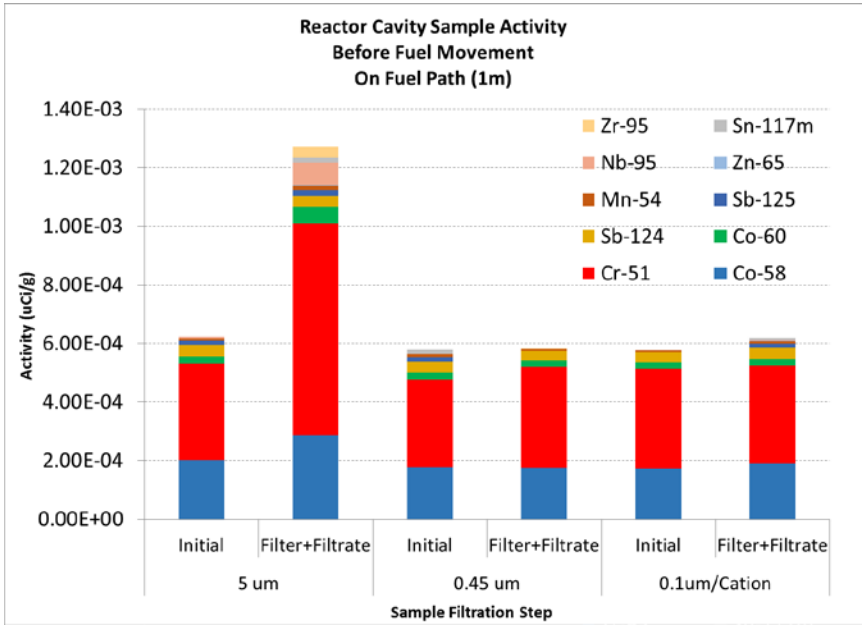


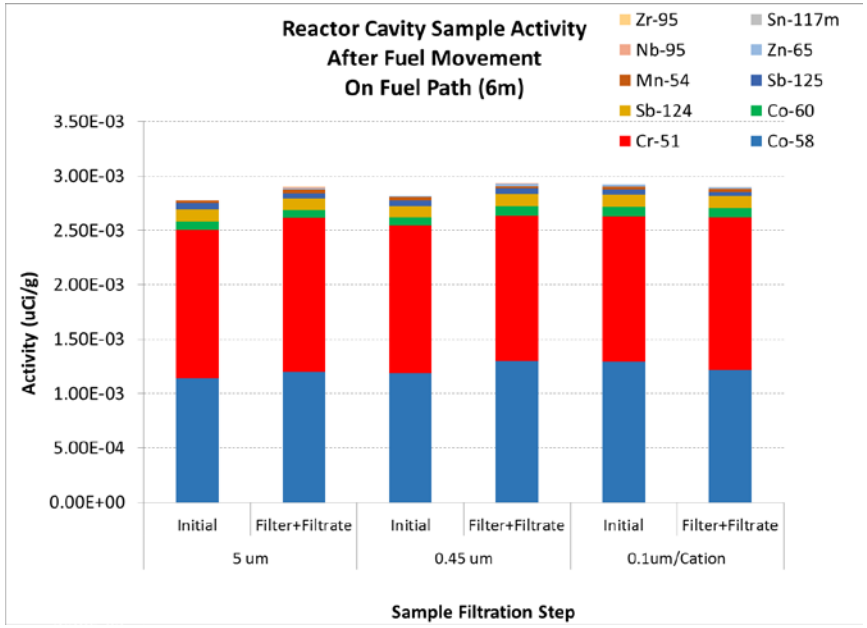
Red: water samples

Blue: smears

Cavity Activity Characterization Protocol

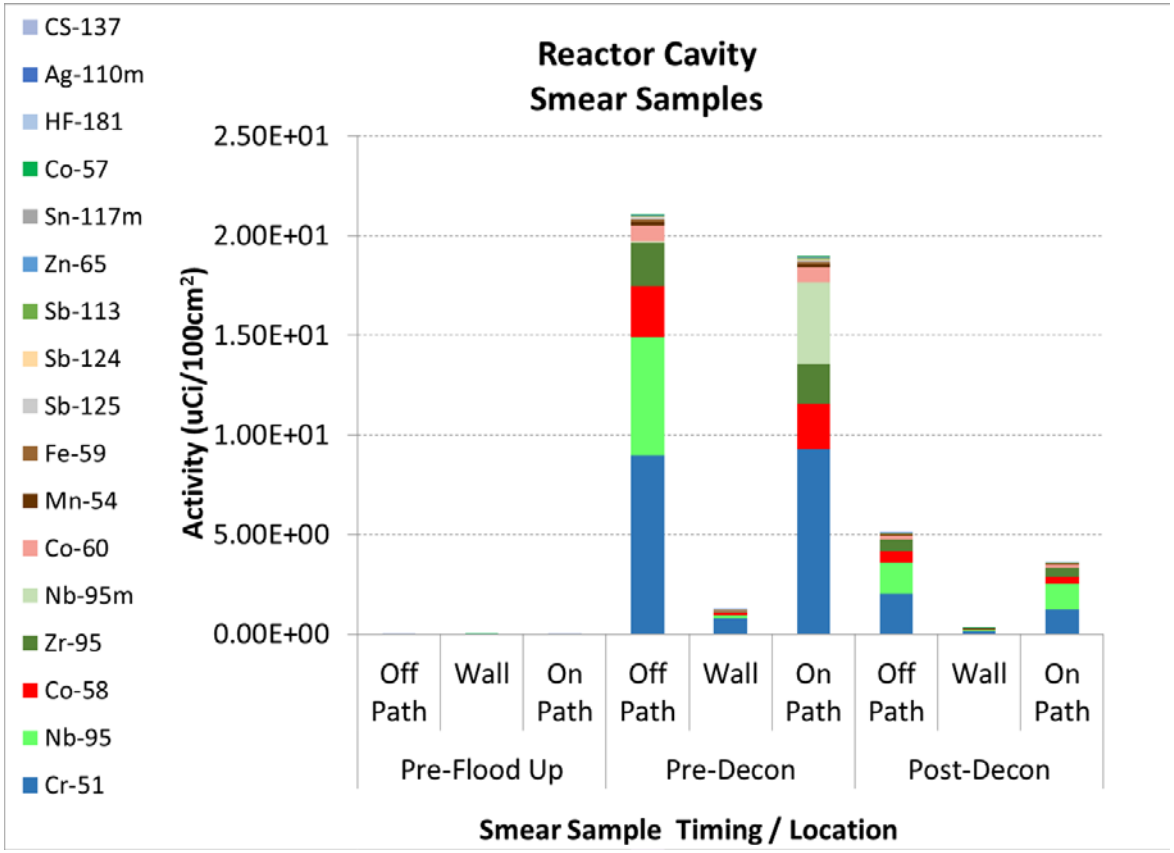
- In general, cavity water activity concentrations were uniform
  - Implies well-mixed system
  - Varied before and after fuel movement (more activity after fuel movement)
- Cr-51 and Co-58 were dominant nuclides
  - Cr-51 probably comes from Alloy 690 (SG tube source)
  - Very small amounts of Zr-95 and Nb-95 (fuel clad oxide products)





Cavity Activity Characterization Protocol

- Cavity smear samples had some differences from cavity water
  - Cr-51 remained dominant
  - Nb-95 and Zr-95 had larger fraction than coolant (fuel clad oxidation products)
  - Differences between wall and off/on path need explanation



Summary

- Cavity Decontamination Sourcebook updates and improves previous efforts
  - ✓ Document offers many highlights and best practices
  - ✓ Discusses most current technologies
  - ✓ Provides a protocol for characterizing cavity water and surface contamination
- Recommendations for Sites
  - Compare site practices to best practices indicated in report to identify opportunities for optimization
  - Consider implementing sampling protocol to inform decontamination decision
    - Right solution for the problem
  - Continue benchmarking efforts

2016 EPRI Radiation Safety Meetings

Meeting	Location	Date	Contacts
Radiation Induced Cataracts: Science, Policy, and Impacts to Radiation Protection Workshop	Charlotte, NC	June 1-3, 2016	D. Cool & P. Tran
Dose Reduction for Scaffolding, Insulation, and Shielding Workshop	Charlotte, NC	June 14-16, 2016	D. Cool
ASME/EPRI Radwaste Workshop	Orlando, FL	June 20-21, 2016	K. Kim
EPRI International LLW Conference	Orlando, FL	June 21-23, 2016	K. Kim
Groundwater Workshop (with Underground Piping and Tank Integrity)	Pittsburg, PA	July 13-15, 2016	K. Kim
Source Term and Radiation Field Reduction Workshop	Charlotte, NC	September 12-14, 2016	C. Gregorich
Remote Monitoring Technology Workshop	TBD	TBD	D. Cool

Chemistry and Radiation Safety Department Contacts

Name	Email	Phone
Sam Choi	schoi@epri.com	+1 650-855-8747
Donald Cool	dcool@epri.com	+1 704-595-2541
Lisa Edwards	**ledwards@epri.com**	**+1 469-586-7468**
Paul Frattini	pfrattin@epri.com	+1 650-855-2027
Keith Fruzzetti	kfruzzet@epri.com	+1 650-855-2211
Susan Garcia	sgarcia@epri.com	+1 650-855-2239
Carola Gregorich	cgregorich@epri.com	+1 650-855-8917
Karen Kim	kkim@epri.com	+1 650-855-2190
Nicole Lynch	nlynch@epri.com	+1 650-855-2060
Joel McElrath	jmcelrath@epri.com	+1 650-714-4557
Mike Snyder	msnyder@epri.com	+1 650-855-8591
Phung Tran	**ptran@epri.com**	**+1 650-855-2158**
Daniel Wells	**dwells@epri.com**	**+1 650-855-8630**

Together…Shaping the Future of Electricity