PWR RP/ALARA
ASSOCIATION

2018 Winter Meeting
Key West
January 23-25, 2018

PWR RP/ALARA
ASSOCIATION

2018 Board of Directors

Chairman
2017-2019 Term
Steve Lisi (704-875-5124) stephen.lisi@duke-energy.com – McGuire Nuclear Station

Vice-Chairman
2017-2019 Term
2019-2021 Term as Chairman
Jeff Fontaine (724-462-3423) fontainej@firstenergycorp.com – Beaver Valley

Secretary
2017-2019 Term
John Cuffe (620-364-8831 x8080) jocuffe@wcnoc.com – Wolf Creek

Treasurer
2017-2019 Term
Steve Edelman (717-948-8516) steven.edelman@exeloncorp.com – Three Mile Island

Steering Committee "At Large" Members
2017-2018 Term
Jim Fuller (423-762-3776) jwfuller@tva.gov – Sequoyah
Melody Gibson (479-858-7679) mgibson@entergy.com – ANO
Michelle Williams (706-828-4236) miwillia@southernco.com – Vogtle

Steering Committee "At Large" Members
2017-2019 Term
Joe Coughlin (815-417-2722) joseph.coughlin@exeloncorp.com – Braidwood

Past-Chairman / Advisor
2017-2019 Term
Dana Page (803-701-3596) dana.page@duke-energy.com – Catawba Nuclear Station

**** Terms begin/end after the Summer Meeting of the year indicated ****

PWR RP/ALARA ASSOCIATION

Key West, FL
January 23-25, 2018

MEETING BOOK INDEX

TAB	TOPIC
1	Meeting Agenda & Note Pages
2	Meeting Critique form
3	List of PWR Attendees by Plant Name
	List of Professional Organization Attendees by Company Name
	List of Vendors Attendees by Company Name
4	Meeting Presentations
5	High Interest Topic

PWR RP/ALARA Association Meeting Agenda
Key West, FL - January 2018

Monday, January 22

4:00 – 6:00 pm Steering Board Members - Pre-Meeting & Appetizers

Note To all the PWR RP ALARA Association Representatives:

This is to inform you that PWR RP/ALARA Association Meeting has been granted 1 Continuing Education Credit (CEC) per contact hour to a maximum of 20 CEC and assigned ID 2015-00-038. This credit applies to calendar years 2015-2018.

Please be advised that contact hours do not include meals or business meetings without technical content.

As credit was requested for all participants, this assignment will be posted to the AAHP website.

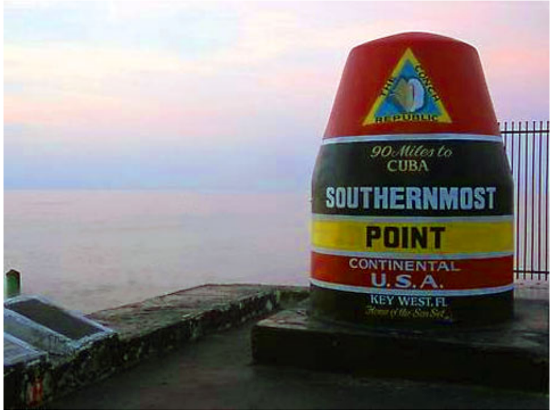
Tuesday, January 23

2:00 – 2:30 pm	Meeting Registration – Salon Foyer
2:30 – 3:15 pm	Opening Ceremonies & Introduction in Salon C:

- Welcome – Opening Remarks (Steve Lisi)
- Safety Review – Building Escape Routes (Jeff Fontaine)
- Safety Message – (Jeff Fontaine)
- Introduction of NSA Representative – (Rick McCormick)
- Introduction of "Host" Nuclear Plant Representative – (Steve Lisi)
- Introductions of Board Members (Steve Lisi)
- Introduction of Association Members (All)
- Association Secretary Report (John Cuff)
- Association Treasury Report (Steve Edelman)
- Establish Meeting Expectations/Review Agenda & Meeting Book Contents (Steve Lisi)
- Bench Mark Question Solicitation & High Interest Topic Sheets (Joe Coughlin)

3:15 – 4:15 pm	Presentation – EPRI Research in Support of Radiation Field Management during All Phases of Life of a Nuclear Reactor – (Dr. Carola A. Gregorich)
4:15 – 4:20 pm	Adjourn Day 1 (Steve Lisi)
4:30 – 4:50 pm	Steering Committee Meeting
5:00 – 6:30 pm	Opening Reception & Vendor Displays in Salon A & B

Wednesday, January 24



07:00 – 08:00	Breakfast with Vendors in Salon A & B
08:00 – 08:05	Meeting Overview (Steve Lisi)
08:05 – 08:10	Safety Message (Joe Coughlin)
08:10 – 08:20	ALARA Association Group Picture
08:20 – 09:40	Breakout Sessions by Plant Type (Document Successes & Challenges and a Golden Nugget) • 2 Loop & 3 Loop Westinghouse (Jeff Fontaine) • 4 Loop Westinghouse - will break out into 2 groups (Michelle Williams & Joe Coughlin) • 4 Loop ICE (Steve Lisi) • B & W, CE and Decommissioning Units (Steve Edelman)
09:40 – 10:00	**Break / Vendor Interface (Report to Break out Rooms after break)**
10:00 – 11:30	Breakout Session by Plant Type (Document Successes & Challenges and a Golden Nugget) • 2 Loop & 3 Loop Westinghouse (Jeff Fontaine) • 4 Loop Westinghouse - will break out into 2 groups (Michelle Williams & Joe Coughlin) • 4 Loop ICE (Steve Lisi) • B & W, CE and Decommissioning Units (Steve Edelman)
11:30 - 11:40	**10 Minute Break (Report to Salon C after break)**
11:40 – 12:30	Vendor Presentations

12:30 – 1:30	**Lunch**
1:30 – 2:30	Presentation – Zero Entry Nozzle Dams (Kinsey Boehl - Seabrook)
2:30 – 2:45	**15 Minute Break**
2:45 – 3:40	Vendor Presentations (Remaining vendors)
3:40 – 3:50	End of Day Comments / Adjourn Day 2
4:00 – 4:30	Steering Committee Meeting
5:00 – 6:30	Vendor Reception on the Beach

Thursday, January 25

08:00 – 09:00	Breakfast with Vendors in Salon A & B
09:00 – 09:05	Safety Message (Melody Gibson)
09:05 – 10:35	Breakout Session Review (Successes, Challenges and Golden Nuggets) • 4 Loop Westinghouse (Michelle Williams & Joe Coughlin)
10:35 – 11:00	**Break / Vendor Interface**
11:00 – 12:00	Breakout Session Review (Successes, Challenges and Golden Nuggets) • 2 Loop & 3 Loop Westinghouse (Jeff Fontaine)

12:00 – 1:10 **Lunch / Passport Drawing**

1:10 – 2:10 Breakout Session Review (Successes, Challenges and Golden Nuggets)

- 4 Loop ICE (Steve Lisi & Dana Page)
- B & W, CE and Decommissioning Units (Steve Edelman)

2:10 – 2:20 **Break**

2:20 – 3:00 Round Table Discussions

3:00 – 3:15 Closing Remarks and Update on 2018 Summer Meeting (Portsmouth, NH)

June 19-21, 2018

3:30 – 4:30 Steering Committee Post-Meeting

- Opening Remarks
- Welcome New Members
- Review Meeting Critique Sheets
- New Business

PWR RP/ALARA ASSOCIATION

Key West, FL

January 23-25, 2018

MEETING NOTES

PWR RP/ALARA ASSOCIATION

Key West, FL

January 23-25, 2018

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MEETING NOTES

PWR RP/ALARA ASSOCIATION

Optional
Name:________________________________
Utility: _______________________________

Winter 2018 Key West, FL January 23-25, 2018

MEETING CRITIQUE

The goal is to meet your expectations regarding this meeting. Please help us by providing your comments and suggestions regarding the following:

Plant Status Reports: N/A – only reported at summer meetings

Technical Content: ____

____

____

Vendor Participation: ____

____

Meeting Format (Breakout Session vs. Presentation, etc.): ____________________

____

____

Facilities (Meeting Room, Hotel Facilities, Location, etc.): ____________________

____

____

Please list any topics you would like to see the Board address in the future. Also include specific recommendations relative to the suggested presentation format, where possible (e.g. breakout session, technology presentation, survey, etc.): ____________________

____

____

____

Please provide suggestions for Board activities or actions which would help justify your company's continued participation in the PWR/ALARA Association: ____________________

____

____

____

Other Comments: ____

____

____

Do you anticipate your plant being represented by you or another representative at the Summer 2018 Meeting in Portsmouth, NH? _________ If not, why?

____

____

Return completed form to the Committee Secretary prior to the end of the meeting.

PWR RP/ALARA Association Meeting
January 23-25, 2018
Key West, FL
Attendee List by Plant

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PWR RP/ALARA Committee Meeting
January 23-25, 2018
Key West, FL
Vendor List by Company

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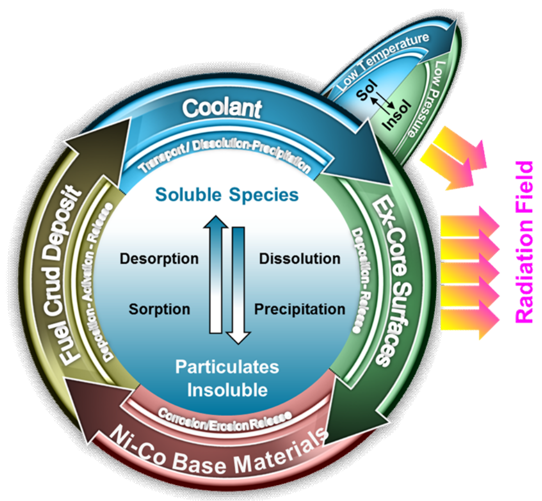
EPRI Research in Support of Radiation Field Management during All Phases of Life of a Nuclear Reactor

Carola Gregorich
EPRI Principal Technical Leader,
Radiation Safety – Source Term

PWR ALARA/RP Meeting
Key West, FL – Jan 23, 2018

A Plant's Source Term Cycle



Affects its Radiation Fields throughout its Life Cycle and Needs Collaboration of all Disciplines

Optimizing Plant Radiation Field Performance Throughout Plant Life

New Plant
- Material selection
- Pre-filming applications
- Plant Modifications
  - Monitoring Infrastructure including Sampling
  - Purification
  - Permanent Shielding/Scaffolding
  - Remote Monitoring Capabilities

Plant Startup/Commissioning
- Li/B/H_2/Zn
- Peroxide addition
- Close to operational chemistry

Adv. Nuclear Tech (ANT) Program

Power Operations
- Water Chemistry Guideline adherence
- Effective shutdowns
- Outage Decontaminations
- Outage Flushing
- Automatization
- Remote monitoring of worker and radiation fields

Water Chemistry & Radiation Safety Programs

End-of-Life Preparation
- When to stop applying some chemistries (Zn, H_2, etc.)
- Balancing cost with decommissioning impacts

Water Chem./ RadSafety Program

Decommissioning
- Final forced oxidation
- Extended soaks
- Aggressive flushing
- Full system decontamination
- Automatization of manual processes

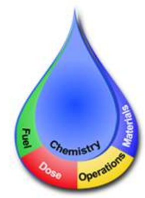
Decommissioning Program

New Plants

Water Chemistry for New Plants

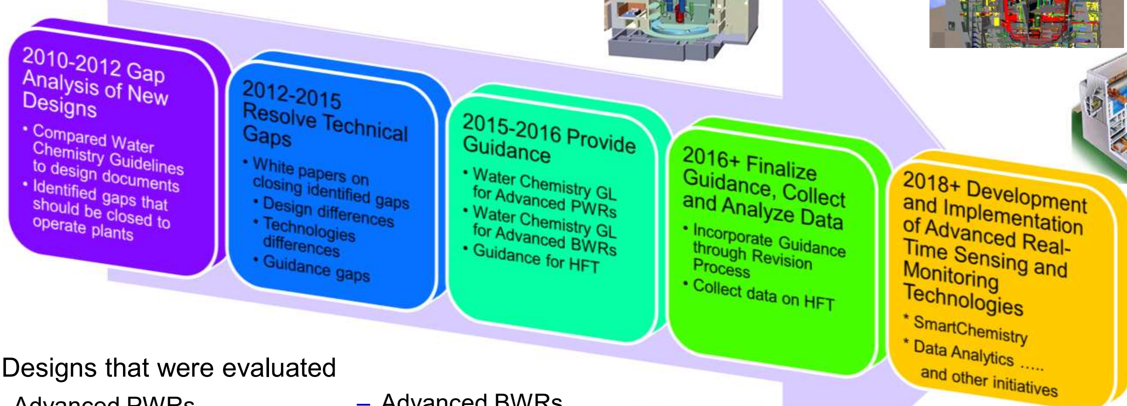
Co-funded with EPRI Advanced Nuclear Technology Program

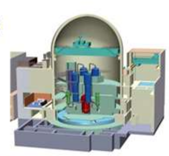
- Per NEI 03-08 and NEI 97-06, all US plants must follow applicable EPRI water chemistry guidelines
- Question: Are the existing guidelines applicable to new plant designs
  - Can the plants follow the Guidelines?
  - *Should* the plants follow the Guidelines?
  - What's missing from the Guidelines?



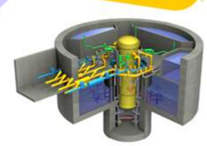
Goal: Ensure Existing Guidelines Fit The New Plant Designs

Research Scope and Timeline





- Designs that were evaluated
  - Advanced PWRs
    - Westinghouse AP1000™
    - AREVA US EPR™
    - MNES/MHI US APWR
    - KHNP APR1400
  - Advanced BWRs
    - Toshiba ABWR
    - GE-Hitachi ESBWR



"Top Ten" Criteria to Support a Strong ALARA Program

More criteria were identified – Listed criteria were seen as most relevant from fleetwide/general perspective:

1. Create and foster strong interdisciplinary plant ALARA and Source Term platform to sustain low radiation fields
2. Avoid materials of high cobalt* content
3. Create corrosion-resistance stable surface
4. Install permanent shielding and work platforms
5. Install infrastructure for and utilize remote monitoring
6. Establish and maintain ALARA planning tools
7. Ensure accessible and functioning sampling, monitoring, & operational stations
8. Automate and implement remote operations as much as feasible
9. Optimize coolant chemistry regime (hydrogen, platinum, zinc)
10. Maximize coolant cleanup and component flushing capabilities

* Other dose & contamination contributing elements need to be managed, too, such as chromium, nickel, silver, & antimony

Plant-specific criteria that create a strong ALARA program may differ

Plant Startup/Commissioning

Potential to impact radiation fields and corrosion products during plant life

Optimized Pre-Functional Chemistry Control - HFT

September 2016 Publication, 3002008296

- Primary purposes of Hot Functional Testing (HFT):
  - Demonstrate operability of plant systems
  - Satisfy regulatory requirements prior to operation

- Optimized chemistry control during HFT may improve long-term integrity and performance of plant systems
  - HFT is the first time plant systems are exposed to water at elevated temperature for an extended period of time (250-1000 hours)
  - Initial corrosion film characteristics may have a lasting effect film behavior, including corrosion and corrosion product release rates
    - Affects out-of-core radiation field development
    - Affects susceptibility to localized corrosion

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

Optimized Chemistry during HFT

Goals

1. Form a protective and stable passive film on plant surfaces
2. Removal of releasable corrosion products prior to operations to prevent subsequent activation

Factors influencing effectiveness beneficially:

- pH above 7.5
- Matching ECP operational conditions
- Matching dissolved hydrogen concentration
- Injecting zinc
- (forced oxygenation)

Unique opportunity to set stage for low radiation field life-time operations

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

Power Operations

EOC Boron

Hydrophobic Coatings

Real-Time Gamma-Isotopic Monitoring

Remote Monitoring for Routine Surveys

PCE Guideline Revision

Dose of the Lens of the Eye

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EOC Boron – A topic that keeps coming up

- Plant Operational Considerations
  - Cost – lost generation when boron is held > 0 ppm
  - Maintaining RCS pH target throughout the primary system with very low boron is challenging
  - Primary system dose rates
    - CVCS system responds different than primary system
- Past and current status is documented in
  - *Technology Evaluations and Operations Strategies for PWR Radiation Source Term Reduction*, 1016767 (2008)
  - *PWR Primary Water Chemistry Guideline*, 3002000505 (2014)
  - Exelon reports SG and CVCS dose tate benefits if EOC B > 5 ppm

Broader fleet data are needed to develop adequate guidance

PWR CMA and SRMC programs

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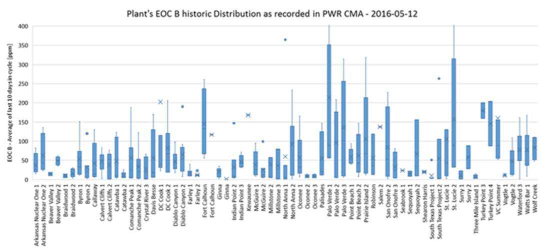
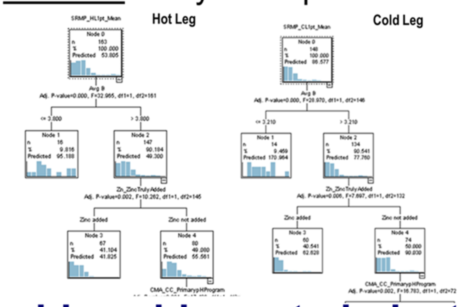
Current Data Explorations on EOC B – Dose Rate Relations

- Are inconclusive
  1. EOC B (if seen as average over last 10-at-power-days)
     - Is seldom zero (0) and
     - Each plant has its own range/approach
  2. EOC B should not be used as sole predictor because many other parameter influence as well



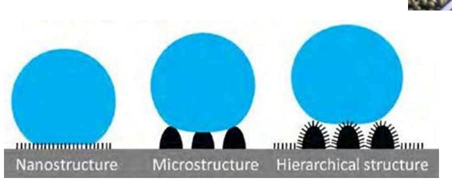


➢ **Detailed studies are needed to provide guidance to industry**

Hydrophobic Coatings Application – Reducing Contamination of Tools, Drains, Sample Sinks

Unique Tool with Limitations

- Air entrapment needed – likely impediments are:
  - Long submersion duration
  - Higher temperatures, and
  - Pressure



Objective

- Develop qualification protocol for application of coatings for smaller scale surfaces of tools, drains, and sample sinks that
  - Address aspects relevant to asset protection and fuel reliability
  - Develop criteria of performance acceptance
- Assess performance and durability of commercially available coatings

Reduce Particulate Surface Contamination and Time/Resources Needed for Radiation Field Reduction

What Gaps Exist in our Knowledge of Hydrophobic Coatings?

- Methods of application of the hydrophobic coating including surface preparation
- Durability of the hydrophobic coating
- Release of contaminants with potential detrimental impact on primary system components
- Compatibility with various substrate materials of construction
- Methods of coating removal if required

- No standards for
  - Testing the viability of current or future coatings
  - Identifying a ‘degraded’ condition
  - Testing chemical and mechanical properties

UED - UltraEverDry

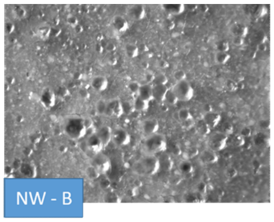
NW - NeverWet


<u>Plant Implementation – How-to?</u>
- Coating qualification protocol
- Evaluation methods of coating performance and degradation in plant environment

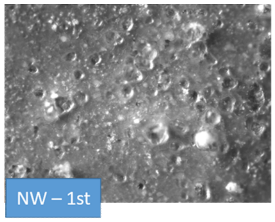
Testing Approach

Phase	Description	Variables
1	Coating Application	• Substrate Preparation • Coating Adhesion • Application Method and Coverage
2	Chemical Durability	• Leachable Chlorides • Leachable Sulfate • TOC • Silica
3	Mechanical Durability	• Process Stream Fluid and Velocity • Abrasion Frequency • Method and Material of Abrasion
4	Coating Removal, Repair, and Re-application	• Chemical Used for Removal • Mechanical Method Used for Removal • Surface Preparation Prior to Re-application
5	Radiation Durability	• Type of Radiation • Strength of Radiation Field • Total Dose Exposure • Degradation Products Produced

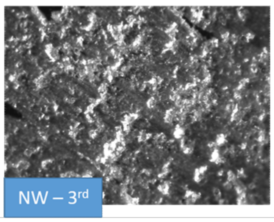
Abrasion Testing – 400 grit at 1.09 psi

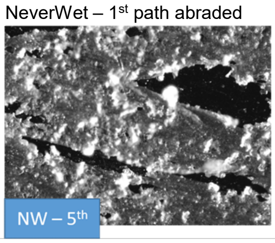


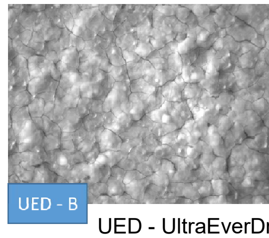
NW – B
NeverWet Base



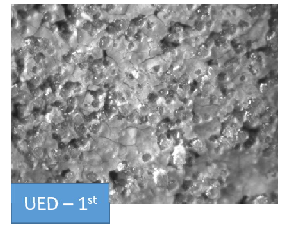
NW – 1st
NeverWet – 1st path abraded

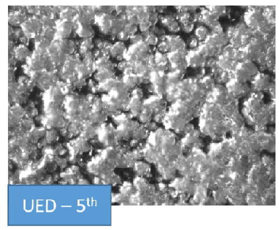


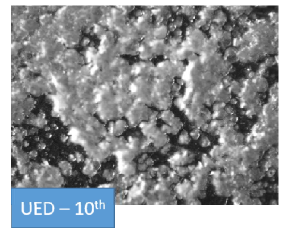




UED - UltraEverDry







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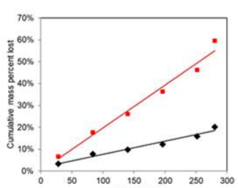
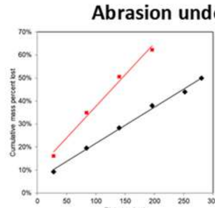
Abrasion Mass Loss Rate – Preliminary Results

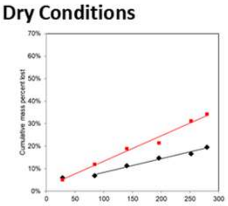
Abrasion under Dry Conditions



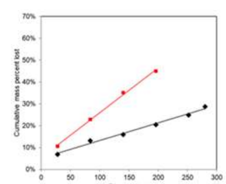
Never Wet (■) and Ultra-Ever Dry (♦) 220 grit, 0.79 psi



Never Wet (■) and Ultra-Ever Dry (♦), 220 grit, 1.09 ps

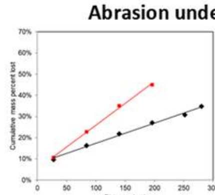


Never Wet (■) and Ultra-Ever Dry (♦), 400 grit, 0.79 psi.

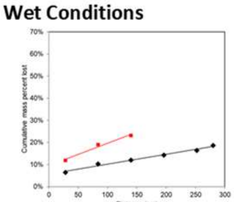


Never Wet (■) and Ultra-Ever Dry (♦), 400 grit, 1.09 psi.

Abrasion under Wet Conditions



Never Wet (■) and Ultra-Ever Dry (♦), 400 grit, 1.09 psi



Never Wet (■) and Ultra-Ever Dry (♦), 400 grit, 1.09 psi, pre-soaked coupon

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Analysis for Species Detrimental to Asset Protection

- Elemental analysis
  - Chloride:
    - UED top coat has 2% by mass
    - NW base detected by less than LLD
  - No sulfur detected in either coating
  - Bromine detected in UED top coat but less than LLD

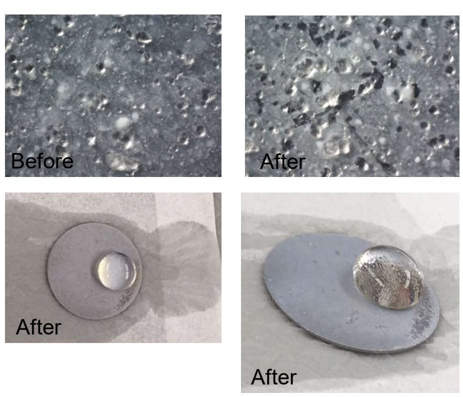
Sample	Mass Coating (g)	Mass Cl (g)	% Cl in Coating
UED Top 1	0.0207	4.03E-04	1.95
UED Top 2	0.0211	4.91E-04	2.33
UED Top 3	0.0200	4.27E-04	2.14
NW Base 1	0.0411	7.95E-06	0.02
NW Base 2	0.0422	4.66E-06	0.01
NW Base 3	0.0437	6.47E-06	0.01

- Static leaching tests performed at ambient and 50°C for a duration of 3 weeks
  - Some mass loss of coating
  - No chloride or sulfur detected in water

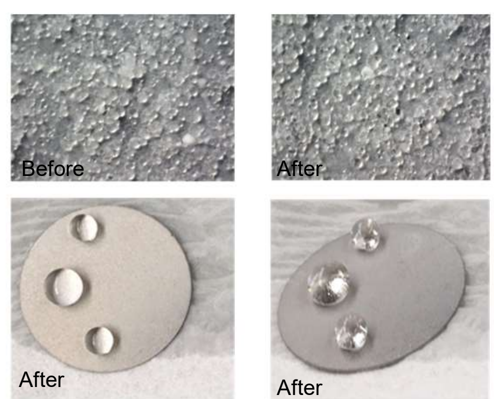
Table II. Coating Degradation Under Static Conditions

Sample	Initial Mass (g)	Final Mass (g)	Δm (g)	% change
UED-1	0.0101	0.0103	0.0002	+ 2.0
UED-2	0.0057	0.0059	0.0002	+3.5
NW-1	0.0119	0.0118	-0.0001	-0.8
NW-2	0.015	0.012	-0.0003	-2.0
UED_{50} -1	0.0128	0.0099	-0.0029	-22.3
UED_{50}-2	0.0077	0.0054	-0.0023	-29.9
NW_{50}-1	0.0131	0.0126	-0.0005	-3.8
NW_{50}-2	0.0137	0.0105	-0.0032	-23.3
Blank	2.4478	2.4477	-0.0001	> 0.1

Radiation Testing – 48,000 rad



NW retains hydrophobicity after radiation submerged in water



UED retains hydrophobicity after radiation submerged in water

✓ Both coating perform under gamma irradiation

Observations – Data Analysis to be finalized

✓ Coatings do work

- ✓ Retain hydrophobicity under submersion and gamma radiation

- Perform qualification testing of coating
  - ✓ Example analysis demonstrated
  - – Nuclide sorption test preformed – data analysis in progress
  - ➢ Feasible protocol is being developed

- When selecting a coating, its purpose should consider whether
  - Coating contain halides
  - Coating abrasion resistance
  - Coating heat sensitivity
  - Coating degradation when submerged for longer periods of time

Report publication is scheduled for mid-2018

Plant Demonstration of Real-Time Gamma-Isotopic Monitoring

Why real-time gamma-isotopic monitoring?

- ➢ Real-time response to changes – not cycle snap-shots of typical outage measurements
- ➢ Real-time identification of
  - ➢ Contributor – ability to evaluate impact and to mitigate proactively
  - ➢ Magnitude on impact of radiation field
- ➢ Ability to respond in near real-time and isotope adequately to radiation field changes

Value & Benefits

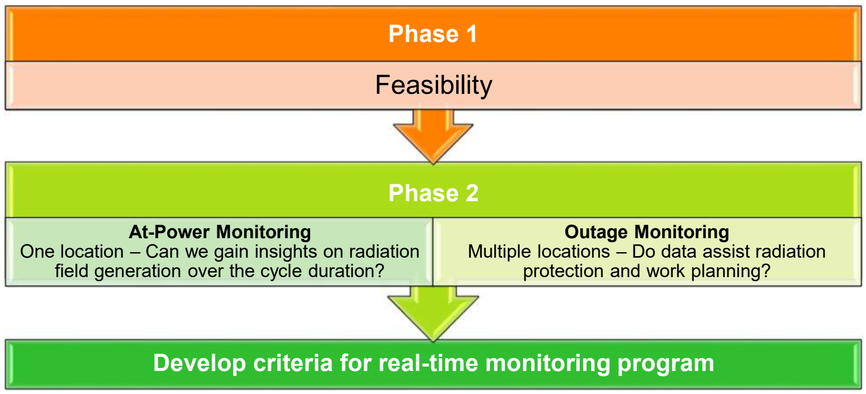
are in the insights gained for

- ➢ Optimizing ALARA and work planning
- ➢ Implementing targeted source term reduction/mitigation
- ➢ Improving radiation field control
- ➢ Developing criteria for improved radiation field monitoring programs
- ➢ Increasing understanding of radiation field generation and how coolant chemistry regimes and operational practices influence

Real-Time Gamma-Isotopic Radiation Field Monitoring is at Your Fingertip

Plant Demonstration

- Objective
  - Support members in implementing efficiently real-time monitoring technologies
  - Determine the cost, labor, and dose effectiveness of this monitoring technology
  - Evaluate feasibility to use this technologies in other areas of isotopic monitoring
- Approach



Good Understanding Requires Good Measurements

Current gamma isotopic strategies in the industry

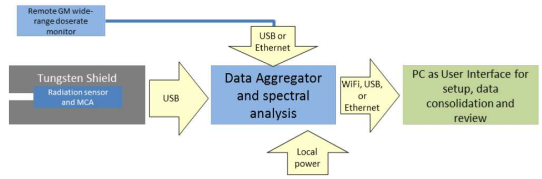
Method	Locations	NID quality	Activity quality	Deployment	Cost
Small CZTs in close geometry	Many, fixed locations	Marginal	Relative only [normally]	Easy	Low
Ge detectors in wide geometry	Several, flexible loc'ns	Excellent	Good, if proper calibration	Difficult heavy	High
Continuous on-line Ge measurements	Usually only one location	Excellent	Very good, well-defined geometry	Very difficult heavy, large	Very high

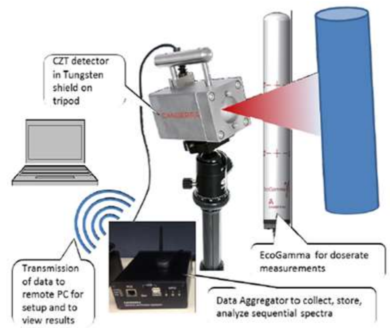
Objective is to understand radiation field generation – not visualize radiation fields.

Equipment in Current Feasibility Testing Phase

- Large CZT – 1000 mm^3
  - Better energy resolution [~2%] and peak shapes than small CZT
  - Large size has better efficiency, especially at high energy
- Easier deployment
  - Integrated MCA, allows smaller shield
  - Flexible tungsten shield and collimator set (~ 20 lbs)
  - ISOCS efficiency calibrations
  - New - Data Aggregator/Archiving system
    - Low power - USB or battery
    - Consolidates gamma spec and dose rate
    - PC used to set up and start - Then runs unattended
- Continuous spectrometry acquisition
  - One spectrum every pre-defined frequency, can be summed
  - Full data analysis package done on each spectrum from processor in box
  - Nuclide ID and Activity & spectrum stored
  - If PC connected, then use available software for trends, reanalysis, …

➢ Low cost –
about 4 units have similar cost of 1 shielded HPGe detector





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Phase 1: Feasibility Testing – Diablo Canyon April 2017

- Lessons learned
  - Power at a power plant is unreliable – UPS and batteries for backup have been integrated for Phase 2
  - ISOCS efficiency calibrations are working well
  - Good resolution and quantification of major dose contributing isotopes
  - Setup of nuclide identification routines requires a subject matter expert
  - Isotopic interferences can be resolves upon more detailed evaluation

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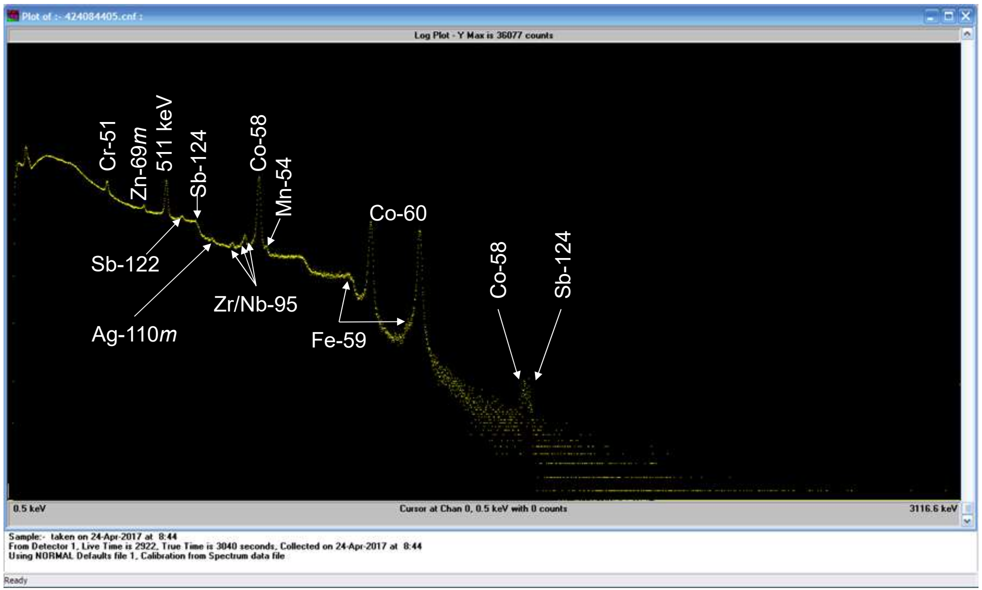
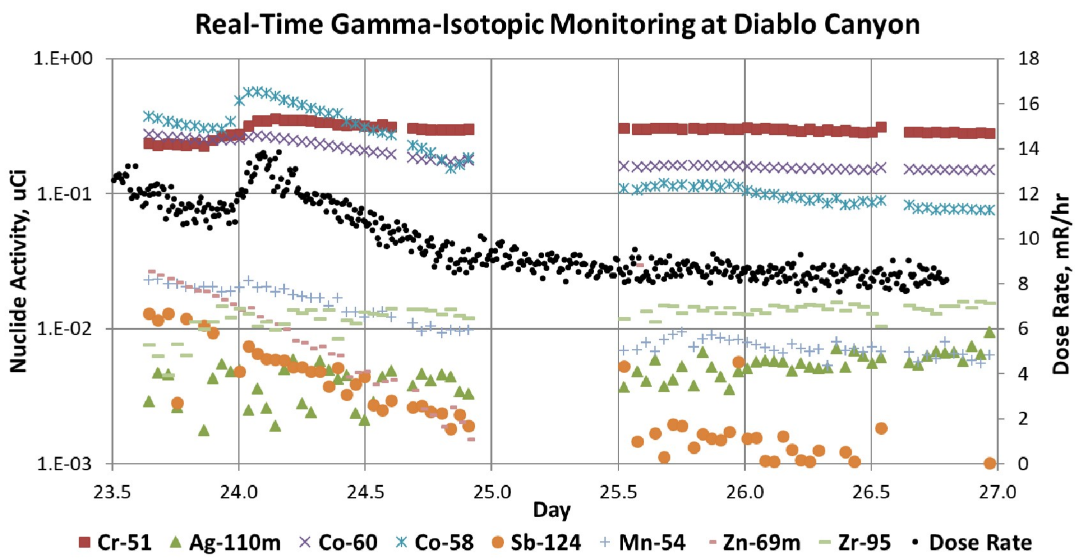
Example: Gamma Spectrum at Start of Forced Oxygenation

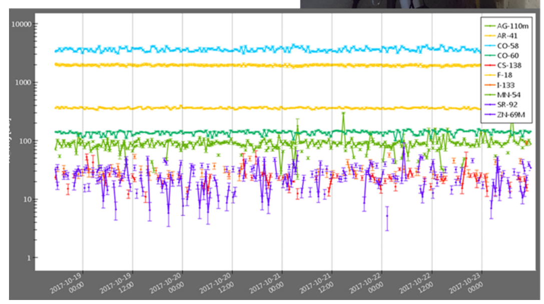


Preliminary Results – Analysis in progress



Phase 2 Demonstrations

- At-Power Monitoring:
  - In progress at Oconee – Letdown line
- Outage Monitoring
  - In preparation – Diablo U1 February Outage
  - Monitoring of system and general areas
- Evaluations focus also on
  - Dynamic range, reliability of operation, …
  - Locations where
    - transients are expected, and
    - work activities may be impacted
  - Identify modifications needed for extended deployment
  - Work w/ plant to address
    - Any plant change/implementation processes
    - Accessibility to equipment



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K. Kim

Application of Remote Monitoring Technology to Reduce Routine Surveys

- **Background:**
  - Developing a technical basis for using remote monitoring equipment to reduce or eliminate certain types of routine surveys could significantly enhance efficiency
- **Research Value:**
  - Answer the question of if, and when, remote monitoring can be used to reduce routine surveys
  - Improve radiation protection operational efficiency and reduce occupational exposures
- **Preliminary Findings:**
  - No regulatory or industry standard limitations on use of radiation RMT for surveys
  - Key aspects of surveys to consider:
    - Adequacy of surveys to understand radiological conditions is the primary objective
    - Types of surveys addressed: dose rate, surface contamination, air contamination
    - Need to ensure instruments are operating accurately (i.e., source checks)
    - Need to maintain records of survey data
    - Need to review site-specific commitments
  - Radiation RMT for dose rate measurements are readily available but not yet for contamination surveys
  - Need to compare the frequency of any needed source checks or battery changes outs for radiation RMT current frequency of physical surveys
    - Potential criteria for deciding where to deploy radiation RMT / which physical surveys to replace/reduce
    - May be more beneficial to replace the more frequent surveys (i.e., daily or weekly)

Working group will review final draft in March 2018; Publication scheduled for late 2018

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D. Cool

PCE Guidelines Update

- **Background:**
  - The EPRI Personal Contamination Event (PCE) Guideline Revision 1 in 2005.
  - Since then, there have been requests to assess action levels, measurement locations and further actions for facial and wound contamination.
  - Delivering the Nuclear Promise Initiative has resulted in additional focus on use of the guidelines (EB-16-03)
  - Revision 1.1 published December 2016 to address U.S. regulatory issue
- **Purpose:**
  - Revise the PCE Guidance to reflect operating experience, industry and regulatory feedback, lessons learned from Delivering the Nuclear Promise, and communication tools for low dose radiation effects.
- **Research Value:**
  - The PCE Guidelines are a key piece of implementing an effective and protective radiation protection program. A revision will provide members with guidance that is up to date, responds to industry and regulatory feedback, provides information on communication of risks, and is appropriately risk informed to ensure adequate protection.
  - Addition of low dose risk information will support use of the guidelines, and their communication with workers and family members.

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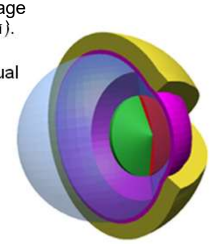
D. Cool

Lens of the Eye Dosimetry and Shielding Factors of Protective Equipment

- **Background:**
  - International Commission on Radiological Protection is now recommending a limit for the lens of the eye of an average of 20 mSv (2 rem) per year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv (5 rem). Many country are implementing these limits.
  - The National Council on Radiation Protection and Measurements has recently recommended a lowering of the annual dose limit for occupational exposures for the lens of the eye to 50 mGy (5 rad).
  - Any reduction in lens of eye dose limits will require a reevaluation of monitoring and protection practices.
    - No standard phantoms, dosimetry, or calibration protocols for lens dose equivalent
    - Various types of protective equipment such as safety glasses, face shields, and hoods
    - No methodology or quantification for determining protection factors is available



- **Recommendations:**
  - Aside from effective dose optimization, lens dose should be separately considered for optimization
  - Radiation field characterization - areas, situations, plant conditions, or specific jobs that will result in lens dose that is significantly higher than effective dose
  - Protection - areas where high energy beta/electrons are present, consider protective equipment
  - Investigate and utilize dosimetry capable of accurately measuring dose to the lens of the eye at 3 mm depth
  - Workers and Radiation Protection staff should be provided with information concerning the reduced lens dose limits, the biological effects of radiation on the lens, and any changes to the RP program based on these lower limits

***Lens of Eye Dose Guidance and Good Practices: Recommended Practices to Improve Readiness for Lens Dose Limit Changes at Nuclear Power Plants*, 3002010626, 2017**

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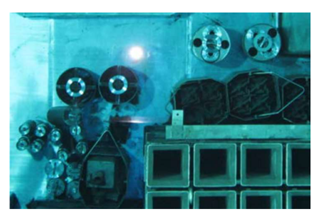
End-of-Life Preparation and Decommissioning

Rick Reid, EPRI Technical Executive
rreid@epri.com -

Considerations for Final Shutdown

- Carefully consider any changes to typical chemistry practices that affect source term
  - Zinc addition (BWRs and PWRs)
  - Forced oxidation (PWRs)
  - Hydrogen water chemistry (BWRs)
  - Online noble metal chemical addition (BWRs)
- Ensure documentation is available for all operational wastes
  - Ion exchange resins
  - Activated metal stored in the spent fuel pool
  - Hazardous and mixed wastes
- Ensure 50.75g file is up-to-date
- Assemble available radiological characterization data for systems, structures and components (SSCs), as well as for environmental areas
- Flush known hot spots, if practicable

May have an adverse effect on out-of-core dose rates



Miscellaneous Material Stored in Spent Fuel Pool

Bounding Analysis of RP Challenges
Maintenance Outages Compared to Decommissioning

Normal Maintenance Outage

- Generally stable and predictable radiological conditions
- Generally minimal potential for airborne contamination
- Generally similar tasks as conducted in past outages
- Experienced radiological work force
- Predictable and moderate collective and individual radiation exposure
- Short duration
- Minimal changes in plant configuration

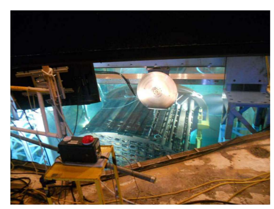
Decommissioning

- Radiological conditions may change rapidly as components are dismantled and removed
- Higher potential for airborne due to cutting, material movement, decontamination, etc.
- Typically first-of-a-kind operations
- Typically increased numbers of untrained workers
- High collective and individual radiation exposure
- Long duration
- Substantial changes in plant configuration

Decommissioning requires a major change in RP practices

General Observations of RP Challenges during Decommissioning

- Components containing sometimes high levels of internal contamination will be cut open
  - Increases potential for personal contamination events
    - Average of 50 or more PCEs during first several years of active dismantlement
  - Increases potential for “fleas”
  - Substantial concern if alpha contamination present
    - Major issue at Connecticut Yankee and Humboldt Bay
- Substantial handling of highly activated/high dose rate components and components located in high dose areas
  - For example, steam generators, pressurizer, reactor components



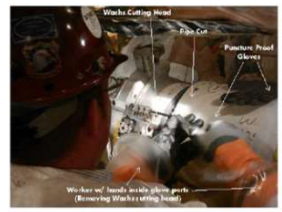
Segmenting Upper Internals

Lay Down of Steam Generator prior to Chemical Decontamination

General Observations of RP Challenges during Decommissioning

- Concrete, insulation and coatings containing legacy contamination may require removal
  - Typically by mechanical decontamination
  - Potential airborne concern
  - Potential for hazardous material exposure (asbestos, polychlorinated biphenyls, lead)
  - Increased potential for mixed-waste generation
- Complex ALARA plans required for certain high risk tasks
  - For example, reactor component segmentation and removal
- Effective DAC may be much lower due to airborne alpha
  - 2.39 E-12 µCi/cc at Humboldt Bay versus 6.0 E-9 µCi/cc at operating plant (Diablo Canyon)

Concrete Decontamination by Shaving



Glove Box for Pipe Cutting

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RP Experiences during Maine Yankee Decommissioning

- Thermal and mechanical cutting can create substantial airborne contamination
  - Levels observed from 0.3 to 2.0 DAC
  - May include hazardous materials (e.g., chromium)
- Cutting of piping results in constant shifting of high radiation area boundaries
- Removal of contaminated tanks located outside presents unique contamination control challenges
  - Reactor water storage tank contamination levels of 50,000 dpm/100cm^2
- Fewer experienced radworkers – requiring enhanced training, briefings and oversight
- Some Radiation Protection Program areas required upgrading because of alpha contamination
  - Additional RP personnel and equipment required
  - Alpha surveys and monitoring
    - Area-specific alpha to beta/gamma ratios enhance accuracy of continuous area monitors for identifying high airborne areas
    - Use of sensitive gamma detectors to identify low energy Am-241 gamma in lieu of alpha spectroscopy for transuranics

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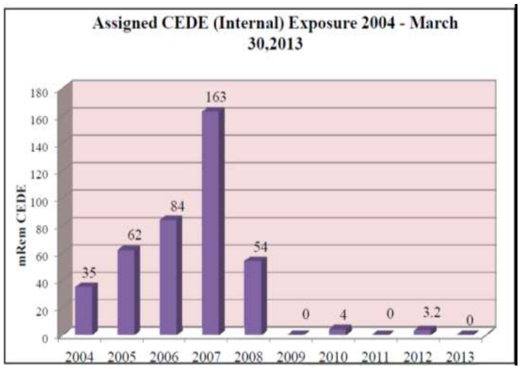
RP Experiences during Humboldt Bay Decommissioning



- Plant operated with failed fuel
- While during long shutdown period, much of the short-lived gamma activity decayed but high level of alpha activity remains
- Very low beta/gamma to alpha ratios (<50 to 1)
- Increasing trend for internal dose assignment prior to decommissioning (See Figure)

Humboldt Bay Success: Internal Dose Potential Greatly Reduced

- Radiological controls instituted at start of decommissioning:
  - Two barriers used for contaminated system removals (i.e., glove bags, HEPA ventilation, fixatives and/or respirators)
  - Incorporation of lessons learned
    - Use of lapel air samplers
    - Rinsing materials from pool
    - Capping, foam filling and fixatives in pipes
    - Mechanical cutting

System Automation for Reactor Internals Segmentation

- Typically one of the most challenging nuclear power plant decommissioning tasks
  - Cutting of the various assemblies typically must be performed underwater to minimize exposures
  - High personal exposure, long project duration, and high total costs.
- Current work: conceptual development of system automation approach to reactor internals segmentation
  - Use of underwater laser cutting, automated indexing and waste handling
- 2018 to 2019: pilot scale, full scale and field testing of coordinated system
  - Assumes additional collaborative industrial partners can be confirmed to participate in these test programs
- **Research Value:** Identification of improved technology that results in a reduction in the time required to segment the reactor internals during decommissioning
  - The reactor internals project typically falls on the critical path of the decommissioning process and can take a year or longer in the field to complete

Equipment for Internals Segmentation At Jose Cabrera

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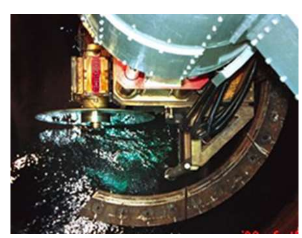
Collaborative Decommissioning Technology Development

- Project Overview:
  - Collaboration with global organizations to advance development of new technologies for decommissioning tasks
  - Includes US DOE, CEA, NEA/OECD, Halden
  - SHARE collaborative under development through EURATOM
- 2017 work includes:
  - Demonstration of LaserSnake
  - Participation in the formation of the SHARE project
- Work proposed for 2018 includes:
  - With the DOE, demonstrate the ArcSaw cutting technology;
  - With the CEA and others, demonstrate underwater laser cutting technology; and
  - Demonstrate technologies of advanced radiological characterization
- Research Value:
  - Technologies identified or demonstrated help to reduce cost of decommissioning.
  - Schedule reduction can amount to cost benefit in range of $70k to $300k per day.
  - Leveraging and contributing to research and development efforts of global organizations

LaserSnake



ArcSaw

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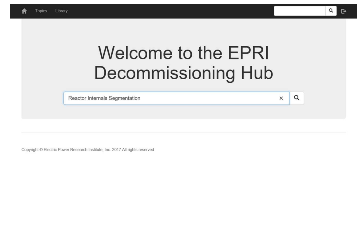
Online Decommissioning Database (Wiki)

- A wealth of experience is available from completed and ongoing decommissioning projects
- Experience largely captured in more than 30 EPRI reports
- There is a need for a searchable data base for decommissioning experience covering all areas (planning, execution, site characterization and release)
- Began development of Wiki-format database in 2016
  - Database rolled out in 2017 - 3002010606
  - Adding content in 2017 and additional functionality in 2018



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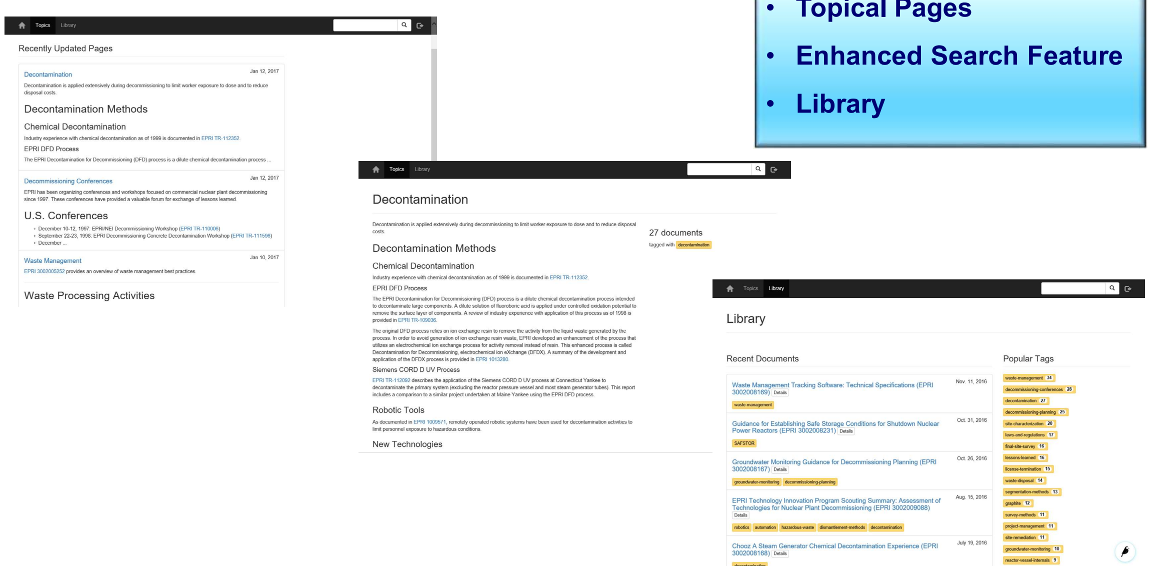
Screenshots

- **Topical Pages**
- **Enhanced Search Feature**
- **Library**



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Optimizing Plant Radiation Field Performance Throughout Plant Life

New Plant
- Material selection
- Pre-filming applications
- Plant Modifications
  - Monitoring Infrastructure including Sampling
  - Purification
  - Permanent Shielding/Scaffolding
  - Remote Monitoring Capabilities

Plant Startup/Commissioning
- Li/B/H_2/Zn
- Peroxide addition
- Close to operational chemistry

Adv. Nuclear Tech (ANT) Program

Power Operations
- Water Chemistry Guideline adherence
- Effective shutdowns
- Outage Decontaminations
- Outage Flushing
- Automatization
- Remote monitoring of worker and radiation fields

Water Chemistry & Radiation Safety Programs

End-of-Life Preparation
- When to stop applying some chemistries (Zn, H_2, etc.)
- Balancing cost with decommissioning impacts

Water Chem./ RadSafety Program

Decommissioning
- Final forced oxidation
- Extended soaks
- Aggressive flushing
- Full system decontamination
- Automatization of manual processes

Decommissioning Program

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Together…Shaping the Future of Electricity

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Documents Supporting New Builds

ID	Title
3002008028	ANT: Chemistry Control Guidance for Advanced Design Boiling Water Reactors (2016)
3002008295	ANT: Guidance for Chemistry Control in Advanced Pressurized Water Reactor Designs (2016)
3002008296	ANT: Optimum Hot Functional Chemistry Control Practices for Pressurized Water Reactors (2016)
3002008871	ANT: Review of Gaps and Issues Identified During Advanced Pressurized Water Reactor Design Chemistry Assessment (2016)
3002004709	ANT: PWR Primary Side Gas Management in Advanced Pressurized Water Reactors (2015)
3002004711	ANT: Chemistry Sampling Programs at Advanced Pressurized Water Reactors: AREVA US-EPR™ Design Westinghouse AP1000™ KHNP APR1400 MNES/MHI US-APWR (2015)
3002004710	ANT: Assessment of New Technologies for Water Chemistry Controls in Advanced Pressurized Water Reactor Designs (2015)
3002002922	ANT: Preliminary Guidance for Chemistry Control in Advanced Pressurized Water Reactor Designs (2014)
1026540	An Assessment of PWR Water Chemistry Control in Advanced Light Water Reactors: APR1400 (2012)
1024502	An Assessment of PWR Water Chemistry in Advanced Light Water Reactors: US-APWR (2012)
1024499	An Assessment of PWR Water Chemistry Control in Advanced Light Water Reactors: U.S. EPR™ (2011)
1021090	An Assessment of PWR Water Chemistry Control in Advanced Plants: AP1000™ (2011)
1023002	An Assessment of BWR Water Chemistry Control in Advanced Light Water Reactors: Economic Simplified Boiling Water Reactor (ESBWR) (2011)
1021091	An Assessment of BWR Water Chemistry Control in Advanced Plants: Advanced Boiling Water Reactor (2010)

Top EPRI Must Have's on CY/RP Bookshelves

Chemistry

- 3002002922 - ANT: Preliminary Guidance for Chemistry Control in Advanced Pressurized Water Reactor Designs
- 3002000505 - Pressurized Water Reactor Primary Water Chemistry Guidelines: Revision 7
- 3002002623 - BWRVIP-190 Revision 1: BWR Water Chemistry Guidelines
- 3002001796 - Boiling Water Reactor Zinc Addition Sourcebook
- 3002001942 - BWRVIP-225 Revision 1: BWR Shutdown and Startup Chemistry Experience and Application Sourcebook
- 1025316 - Pressurized Water Reactor Primary Zinc Application Sourcebook Revision 1
- 1021112 - Corrosion Product Transport during Boiling Water Reactor and Pressurized Water Reactor Startups

Radiation Safety/ALARA

- 3002005480 - Remote Monitoring Technology Guide for Radiation Protection: Field Implementation of Remote Monitoring
- 3002003165 - Guidance for Optimal Performance of Shielding Programs
- 3002000268 - Evaluating Indoor Location Tracking Systems in a Nuclear Facility: Experimentation with Different Techniques in an Industrial Environment
- 3002000032 - 3D Radiation Field Estimation Algorithm v1.0
- 1025309 - Dose Reduction Options for Refueling Tasks
- 1021101 - Evaluation of an Advanced Radiation Shielding Material for Permanent Installation at an Operating Nuclear Reactor
- 1021102 - Scaffold Program Optimization and Dose Reduction Guide

Source Term

- 1021103 - Cobalt Reduction Sourcebook
- 1003390 - Radiation Field Control Manual
- 3002005377 - LWR Ex-Core Surface Conditioning for Radiation Field Reduction
- 3002005479 - Reactor Cavity Decontamination Sourcebook
- 3002005484 - EPRI Plant Source Term Assessments--2015 Review
- 3002005481 - In-Plant Gamma Spectrometry: Isotopic Data Collection Experiences
- 3002003157 - EPRI BWR Radiation Level Assessment and Control (BRAC) Program: 2014 Revision
- 3002003155 - EPRI Pressurized Water Reactor Standard Radiation Monitoring Program: 2014 Revision
- 1025305 - Impacts of PWR Operational Events on Particulate Transport and Radiation Fields
- 1016766 - High Activity Crud Burst Impacts and Responses

Knowledge transfer and retention is key to sustainable ALARA

EPRI References - Decommissioning

- *Characterization and Management of Cutting Debris during Plant Dismantlement, 3002005410. (available to EPRI decommissioning program members)*
- *Proceedings: Decommissioning Decontamination, ALARA and Worker Safety Workshop*, 1000648 (publically available)
- *Alpha Monitoring and Control Guideline, Revision 2*, 3002000409 (publically available)
- *Nuclear Plant Decommissioning Lessons Learned*, 1021107 (available to EPRI decommissioning program members)

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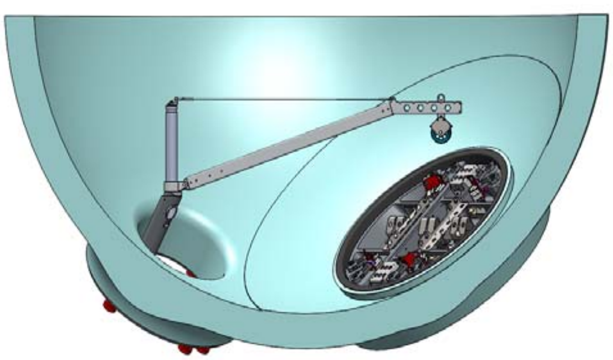
Seabrook Station
Zero Entry Nozzle Dams
Operational Experience

1

What is it?



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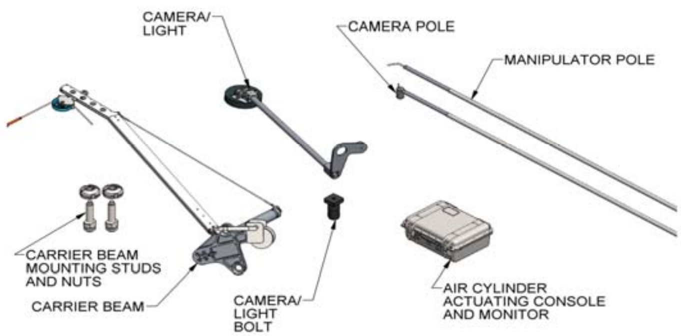
ZEND Installation Components



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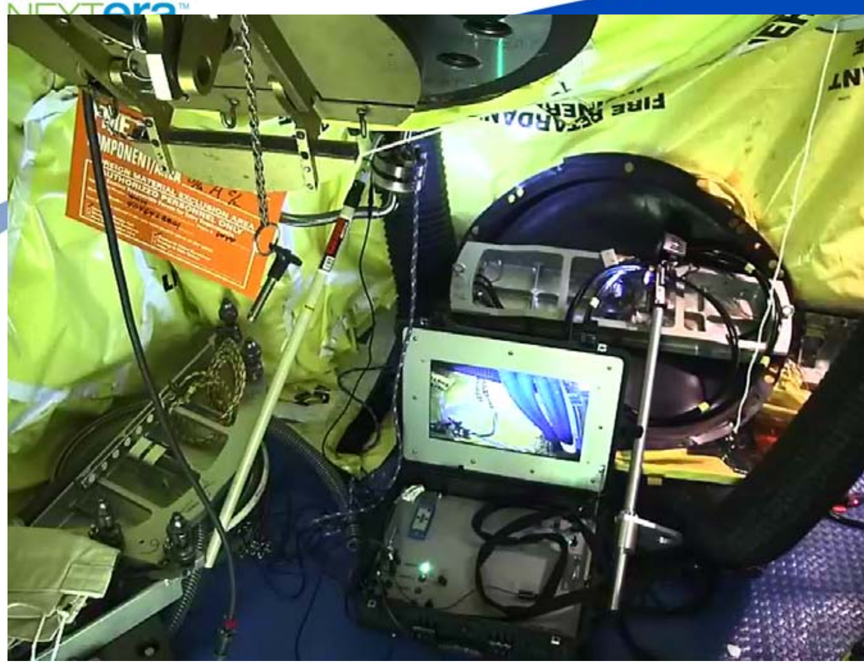

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OR 18: SG Primary Task Estimate				Actual	Difference	Percent	
Task	Description	Est	Challenge	mrem	mrem	Goal	Hrs
1	Install, Remove Drain Spools, Drain Channel Head	0.120	0.108	0.0919	-0.028	85%	28.4
2	Rad Waste Support	0.579	0.521	0.5645	-0.014	108%	545.8
3	Job Setup and Breakdown(Vendor and Maintenance)	0.363	0.327	0.3234	-0.040	99%	421.2
4	Remove Manways, Inserts, Clean Stud Holes and Seating Surface	0.555	0.500	0.8656	0.311	173%	128.9
5	Install Nozzle Dams/Inspect Bowl Drain	1.535	1.382	1.8658	0.330	135%	92.2
6	Perform ECT and Plugging	2.310	2.079	1.3664	-0.944	66%	713.1
7	Tube Plug Removal, FME Installation and Stabilization	0.000	0.000	0	0.000	100%	0.0
8	Remove Nozzle dams	0.809	0.728	0.6847	-0.125	94%	77.4
9	Install Manway Inserts and Manways	0.580	0.522	0.8641	0.284	166%	140.5
10	HP Support, Includes Bowl Survey Installation of HEPA/Air Mon and Rad Controls	1.179	1.061	0.619	-0.559	58%	668.2
	Total	8.030	6.986	7.245	-0.784	90%	2815.7

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•Seabrook performed the first industry use of Zero Entry Nozzle Dams(ZEND). ZEND consists of a system of long handled tools and carrier beams to manipulate the Nozzle Dams into place from outside the manway. Total estimated dose savings for ZEND was 2.115 rem.

- The expected dose savings for the installation on the ZEND is 1.013 rem. The actual dose savings for the installation of the ZEND was 0.679 rem. There was one RCA entry for cleaning of the A HL bolt holes due to problems with ZEND support which logged 153 mrem.
- Due to misconfiguration of ZEND manipulation tool, an additional installation and removal of the A HL dam was performed. This is estimated to have cost the project 260 mrem.
- Nozzle dam removal is estimated to have saved 0.527 mrem.
- **For Nozzle Dam related tasks, comparing OR17 to OR18. It is estimated that the ZEND tooling saved Seabrook Station 2.115 rem total dose.**
- The project also benefited from contamination control due to ZEND. Significantly less decontamination resources were used during SG ECT Inspections.
- A contingency plan to perform Channel Head entries did not need to be executed.
- Extensive mockup training was used. Westinghouse crews trained at Curtis Wright Scietech.
- Seabrook purchased and trained on a mockup.
- **The use of multi-badge EDEx is estimated to have more accurately measured whole body dose. A single dosimeter placed on the thorax would have overestimated the actual whole body dose by 494 mrem.**

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Multi Badge

•Multibadge dosimetry and finger rings was issued for ZEND operators. Platform workers are issued finger rings. Time and motion studies of mockup training.
•The use of multi-badge EDEx is estimated to have more accurately measured whole body dose. A single dosimeter placed on the thorax would have overestimated the actual whole body dose by 494 mrem.

Weighting Factors	Location	Total Dose	EDEx
0.1	Head	1412	141
0.38	Thorax	2101	798
0.5	Abdomen	1284	642
0.005	Right Upper Arm	1292	6
0.005	Left Upper Arm	1672	8
0.005	Right Thigh	1125	6
0.005	Left Thigh	1072	5

7 Badge

Total EDEx	1607
Total w/o EDEx	2101
Savings	494 mrem

Max Exposure (Thorax)	2101
Min Exposure (L Thigh)	1072
Ratio	0.51

•RP could reduce the number of multibadge packs in future outages by combining the right/left upper arms into the thorax and the left/right thighs into the abdomen. A seven badge pack was used in OR18 to capture the appropriate data to make informed decisions about maximum exposure. A three badge pack would have over represented whole body exposure by 8 mrem in OR18.

Location	3 Badge Wt	3 Badge EDEx
Head	0.1	141.2
Thorax	0.39	819.39
Abdomen	0.51	654.84

3 Badge

Total EDEx	1615.43
Total w/o EDEx	2101
Savings	486
7 Badge vs 3 Badge	8 mrem

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SEABROOK

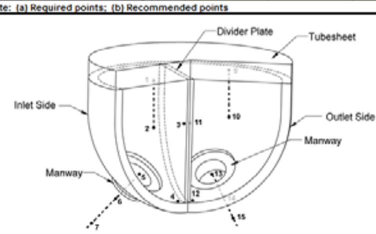
Site Mockup

SEABROOK

SRMP

Dose Rate at Survey Point (R/hr)					
Survey Point	Location	Steam Generator 1	Steam Generator 2	Steam Generator 3	Steam Generator 4
	Survey Date for Each SG	4/10/2017	4/10/2017	4/10/2017	4/10/2017
	Survey Time for Each SG			2:13:00	
Inlet Channel (Hot Leg)					
Pt 1	Midpoint of Tubesheet (a)	4.1	3.25	3.45	3.2
Pt 2	Channel Head Center (a)	2.2	2.44	2.41	2.2
Pt 3	Center Divider Plate (b)	4.4	4.95	4.1	4.8
Pt 4	Bottom of Channel Head (b)	2.9	4.14	2.66	3.1
Pt 5	Manway Entrance (b)	2.2	0.85	0.7	2.4
Pt 6	30 cm from Manway (b)	0.475	0.34	0.33	0.45
Pt 7	One meter from Manway (b)	0.2	0.11	0.7	0.17
Outlet Channel (Cold Leg)					
Pt 9	Midpoint of Tubesheet (a)	5.6	5.35	4.9	6
Pt 10	Channel Head Center (a)	3.5	3.73	3.47	3.3
Pt 11	Center Divider Plate (b)	5.1	6.72	8.81	6.5
Pt 12	Bottom of Channel Head (b)	3.6	4.47	3.63	4
Pt 13	Manway Entrance (b)	2.7	1.2	1.2	3.2
Pt 14	30 cm from Manway (b)	0.6	0.5	0.4	1
Pt 15	One meter from Manway (b)	0.35	0.18	0.13	0.43

Note: (a) Required points; (b) Recommended points



NEXTera ENERGY SEABROOK

Contingency Plans

Activity Scope / Problem Statement:
The following Plan outlines the course of action required to install nozzle dams should the Zero Entry Nozzle Dam delivery system prove incapable of safely deploying the nozzle dams.

Impact Risk: MEDIUM
The inability to use the Zero Entry Nozzle Dam delivery system would require the use of SG "jumpers" to manually deploy the dams. This would result in a schedule impact to the steam generator project, and a resource drain on RP, but is not likely to adversely impact the overall outage duration.

Probability Risk: HIGH
OR18 is the first outage where Zero Entry Nozzle Dams will be used. The likelihood of successful deployment will be directly influenced by the rigor of the preparation activities, including mockup training.

Detailed Scope and Contingencies:
Pre-Outage:
During the design and fabrication of the new delivery system, Seabrook personnel will be involved with the design and testing of the system to ensure the delivered system can, consistently and effectively, deploy the nozzle dams prior to acceptance of the new equipment on site.

Following delivery of the new equipment, site specific mockup training for use of the ZEND will be completed with all personnel that are anticipated to be part of the deployment of the system, including RP resources whenever possible.

The current contract release for Westinghouse includes provisions to provide personnel to perform SG "jumps" as if the ZEND equipment is non functional for any SG's. As such, sufficient personnel and qualifications will be maintained to allow Seabrook to deploy ALL steam generator nozzle dams using the traditional installation method. The dams themselves are deployable both using the ZEND and manually. No modifications to the dams will be necessary if they are to be deployed by "jumpers". Pre-outage mockup testing of the traditional, manual method of deployment will also be completed.

During the Outage
If during the outage, any specific ZEND equipment does not perform as designed, representative from the manufacturer (Curtiss Wright) will be on-site to assist in rectifying any issues that arise. Seabrook Project Management will inform the OCC of the progress and will make determinations if SG "jumping" will be necessary for deployment in a timely manner to minimize any adverse schedule impact.

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HIGH INTEREST TOPIC AND QUESTIONNAIRE

PWR ALARA Association Key West, FL January 23-25, 2018

Topic:

Name: Contact Info:

Contact (Name)	Plant	NSSS	Comments
	ANO 2,1	CE, B&W	
	Beaver Valley 1,2	3LW	
	Braidwood 1,2	4LW	
	Byron 1,2	4LW	
	Callaway	4LW	
	Calvert Cliffs	CE	
	Catawba 1,2	4LW	
	Davis Besse	B&W	
	DC Cook 1,2	4LW	
	Diablo Canyon 1,2	4LW	
	Farley 1,2	3LW	
	Ft. Calhoun	CE	
	Ginna	2LW	
	Harris	3LW	
	Indian Point 2,3	4LW	
	Kewaunee	2LW	
	McGuire 1,2	4LW	
	Millstone 3,2	4LW, CE	
	North Anna 1,2	3LW	
	Oconee 1,2,3	B&W	
	Palisades	CE	
	Palo Verde 1,2,3	CE	

Return completed form to the Committee Secretary prior to the end of the meeting so that it may be included in the meeting report.

HIGH INTEREST TOPIC AND QUESTIONNAIRE

PWR ALARA Association Key West, FL January 23-25, 2018

Topic:

Name: Contact Info:

Contact (Name)	Plant	NSSS	Comments
	Point Beach 1,2	2LW	
	Prairie Island 1,2	2LW	
	Robinson	3LW	
	Salem 1,2	4LW	
	San Onofre 2,3	CE	
	Seabrook	4LW	
	Sequoyah 1,2	4LW	
	Sizewell B	4LW	
	South Texas 1,2	4LW	
	St.Lucie 1,2	CE	
	Surry 1,2	3LW	
	TMI	B&W	
	Turkey Point 1,2	3LW	
	VC Summer	3LW	
	Vogtle 1,2	4LW	
	Waterford	CE	
	Watts Bar	4LW	
	Wolf Creek	4LW	
	EDF		
	AREVA		
	BWXT		

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